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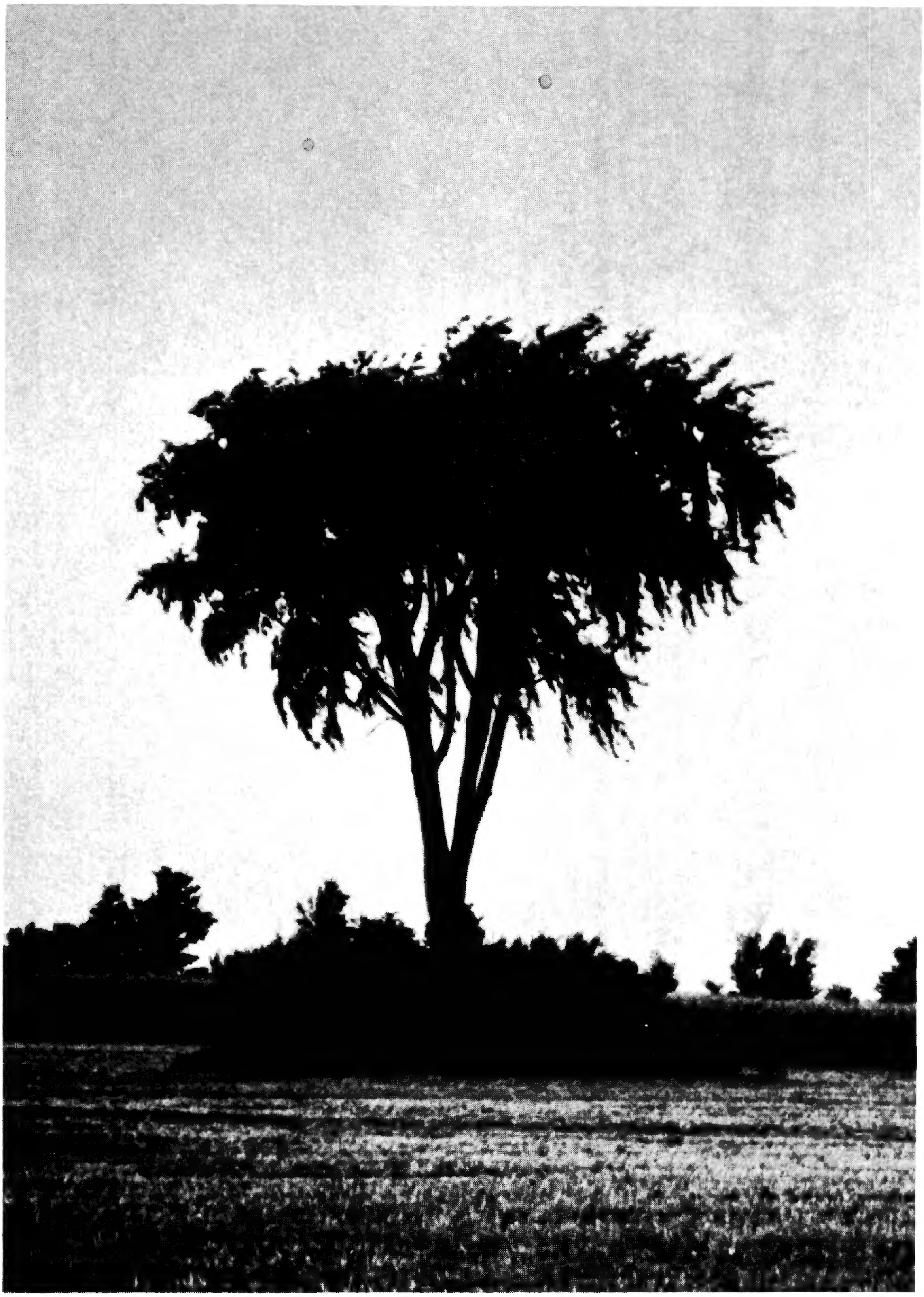

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Cover illustration

The American elm (*Ulmus americana* L.), official state tree of Massachusetts, has been a familiar sight for decades throughout the Northeast. The largest known living specimen in Mass. is located in Stockbridge. In 1982, it was 119′ high, had a crown spread of 118′, and was 232″ in circumference. In recent years, many of these stately trees have succumbed to Dutch Elm disease, a fungus accidentally introduced from Europe. The article by Ellmore and Phair (Rhodora Vol. 89, No. 857) contains the latest information of the status of this once dominating tree in our flora. Photo courtesy of Rhoda Vanderwall.

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THE REPRODUCTIVE BIOLOGY OF *SAXIFRAGA STELLARIS* VAR. *COMOSA* ON MT. KATAHDIN, MAINE.[1, 2]

W. DONALD HUDSON, JR.

ABSTRACT

Saxifraga stellaris L. var. *comosa* Retz. is disjunct on Mt. Katahdin at the extreme southern periphery of its Arctic distribution. Failure of megasporogenesis and degradation of pollen tetrads requires this proliferous variety of *Saxifraga stellaris* L. to be an obligate apomict on the mountain. Breakdown of normal sexual reproduction is more complete on Mt. Katahdin than in Greenland where the variety also occurs. Location of bulbils on axillary branches of the reproductive axis and production of aberrant proliferations from placental tissue within ovaries suggests that vegetative proliferations arise from floral meristems. The evolutionary relationship between proliferous *Saxifraga stellaris* var. *comosa* and sexual *S. stellaris* var. *stellaris* is unresolved.

Key Words: *Saxifraga stellaris* var. *comosa*, apomixis, arctic/alpine, Mt. Katahdin, Maine

INTRODUCTION

The Arctic element in the flora of New England mountains has been of interest to local botanists for more than a century. Mt. Katahdin in Maine has drawn particular attention as a station for species with restricted distribution south of Newfoundland and Labrador. Fernald (1901) compiled a flora of the mountain to which few additions have been made (Stebbins, 1927, 1929; Ewer, 1930). A notable curiosity in the flora is *Saxifraga stellaris* L. var. *comosa* Retz., the Star-like Saxifrage, collected in 1856 during the first botanical expedition to the summit (*J. Blake s.n.* GH). Subsequent floristic surveys of the mountain yielded two additional localities for this plant (Fernald, 1901; Harvey, 1903; Ewer, 1930).

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[1] Contribution #3-85 of the C. E. Allen Natural History Center.

[2] Based on work done for the degree of Master of Science, University of Vermont.

Saxifraga stellaris var. *comosa* reproduces in part by means of leafy proliferations called bulbils. The position of the bulbils in the axes has led some to believe that the proliferations are deformities derived from floral meristems (Linsbauer, 1913; Harmsen, 1939). Linsbauer (1913) noted "greening" of some flowers, apparently a description of vegetative proliferations among the perianth parts. Bulbils of some plants from Greenland were found to have rudimentary stamens (Harmsen, 1939).

Variations in the reproductive biology of *Saxifraga stellaris* var. *comosa* and related species of section *Boraphila* Engler & Irmscher have been the basis of a nomenclatural debate that is still unresolved (Hultén, 1958). According to Engler and Irmscher (1916), *S. stellaris* var. *comosa* is included in this section with *S. stellaris* var. *stellaris* and *S. ferruginea* Graham. *Saxifraga ferruginea* occurs along the southern coast of Alaska and in the western cordillera. It is characterized by a spectrum of forms that includes flowering plants as well as proliferous plants that bear a single terminal flower. These graded forms have been assigned various taxonomic ranks (Engler and Irmscher, 1916; Johnson, 1923; Hitchcock et al., 1961; Hultén, 1958, 1968; Calder and Taylor, 1968; Rhandawa and Beamish, 1969).

Typical *Saxifraga stellaris* var. *stellaris* has an amphi-Atlantic distribution (Hultén, 1958), and does not grow far north of the Arctic Circle in Norway, Iceland, and Greenland. It has a diffuse panicle of spreading secondary axes that bear flowers. Some specimens of *S. stellaris* var. *stellaris* have bulbils scattered in place of some flowers on the secondary axes (*Sandberg and Leiburg 1893* VT; *Brainerd 1875, 1897* VT). Polunin (1940) made a similar observation based on specimens from the eastern Canadian Arctic.

Although some authors credit Poiret (1804) with valid publication of *Saxifraga stellaris* var. *comosa*, Retzius (1779: p. 79) completed the components for valid publication when he distinguished var. *comosa* and cited Linnaeus's (1737: t.2, f.3) illustration of this taxon. Linnaeus (1737: p. 137) clearly associated his description of a proliferous, dentate-leaved, scapose *Saxifraga* with the plant he illustrated in Table 2, Figure 3. Robert Brown collected specimens during Parry's first expedition to the Arctic and described them in 1824 as *S. foliolosa* R. Br. *Saxifraga foliolosa* is considered as synonymous with *S. stellaris* var. *comosa* (Hultén, 1958; Polunin, 1959). Both are characterized by a reduced inflorescence and replacement of most flowers by abundant leafy proliferations. In the course of an anatomical investigation of *S. stellaris* var. *comosa* at the Danish Arctic Station in Greenland, Harmsen (1939) demonstrated that the ovules are unitegmic. All other saxifrages, including *S. stellaris* var. *stellaris* have bitegmic ovules. On the basis of the unitegmic integument and the predominant vegetative habit, Harmsen accepted the taxonomic distinction of Robert Brown and referred the plants to *S. foliolosa.* Porsild (1964) and Bocher et al. (1966) accepted the nomenclatural decision of Harmsen (1939), but Polunin (1959) and Fernald (1970) preferred to consider the proliferous form a variety of *S. stellaris.*

Hultén (1958) also referred the proliferous forms to *Saxifraga foliolosa,* but regarded the polymorphic section *Boraphila* Engler and Irmscher to which these plants belong as taxonomically unclear. Hultén (1958) pointed out that the morphological distinction between the proliferous variety of *S. ferruginea* and *S. foliolosa* (= *S. stellaris* var. *comosa*) is not clear. Nevertheless, the distinct single integument of *S. stellaris* var. *comosa* is not observed in the proliferous variety of *S. ferruginea,* and the two are not synonymous. I have chosen to refer to the proliferous Star-like Saxifrage on Mt. Katahdin as *S. stellaris* L. var. *comosa* Retz., since the value of the single integument character in making distinctions at the species level is unclear (Takhtajan, 1969; Cronquist, 1981).

Darlington and Wylie (1956) reported a basic gametic chromosome number of 8–14 for *Saxifraga.* Löve and Löve (1948) recorded a gametic chromsome number of 14 for *S. stellaris* var. *stellaris;* they gave a gametic count of 28 for *S. stellaris* var. *comosa* from Lapland, and they corroborated this determination for material from Greenland. Harmsen (1939) observed a gametic count of 32 for *S. stellaris* var. *comosa* from Greenland.

The evolutionary relationship of proliferous *Saxifraga stellaris* var. *comosa* to typical *S. stellaris* var. *stellaris* is not known, but it hinges on an understanding of apomixis and replacement of normal sexual reproduction by vegetative means. The bulbils or plantlets of *S. stellaris* var. *comosa* are apomictic proliferations (*sensu* Winkler, 1908; Stebbins, 1941) that are not viviparous (germinating or sprouting from seed or bud while attached to the parent plant), but appear to be the result of transformations of floral meristems (Linsbauer, 1913; Harmsen, 1939).

The present study of *Saxifraga stellaris* var. *comosa* on Mt. Katahdin evaluates the reproductive biology of the taxon primarily from chromosomal and embryological data. The extent of vegetative reproduction and the condition of the sexual apparatus was previously unknown for plants on Mt. Katahdin. The information is compared to similar information provided for Greenland populations of the variety by Harmsen (1939). The comparison contributes to our understanding of the peculiar nature of vegetative proliferation and the evolutionary relationships of *S. stellaris* var. *comosa.*

MATERIALS AND METHODS

Three populations of *Saxifraga stellaris* var. *comosa* were located during a floristic survey in 1977 and 1978 of Mt. Katahdin, Piscataquis County, Maine. Observations of morphology, phenology, and ecology at each locality were made from mid-June to early August, 1978. Specimens of flowers, fruits, and bulbils were collected periodically for cytological and embryological analysis. Bulbils, flowers, fruits and rosettes were collected from each locality on the mountain at weekly intervals throughout the summer. Specimens were fixed in FAA [100% ethanol:glacial acetic acid:formaldyhyde (37–40% solution in H_2O)] and water (10:1:2:7 v/v), dehydrated, and embedded using standard techniques (Berlyn and Miksche, 1976). Ten-micron sections were made and stained in safranin-fast green following the technique outlined in Berlyn and Miksche (1976), altered by substituting cedarwood oil and xylene (1:1 v/v) for carbolxylene as a clearing agent. Permanent slides were made using Permount.

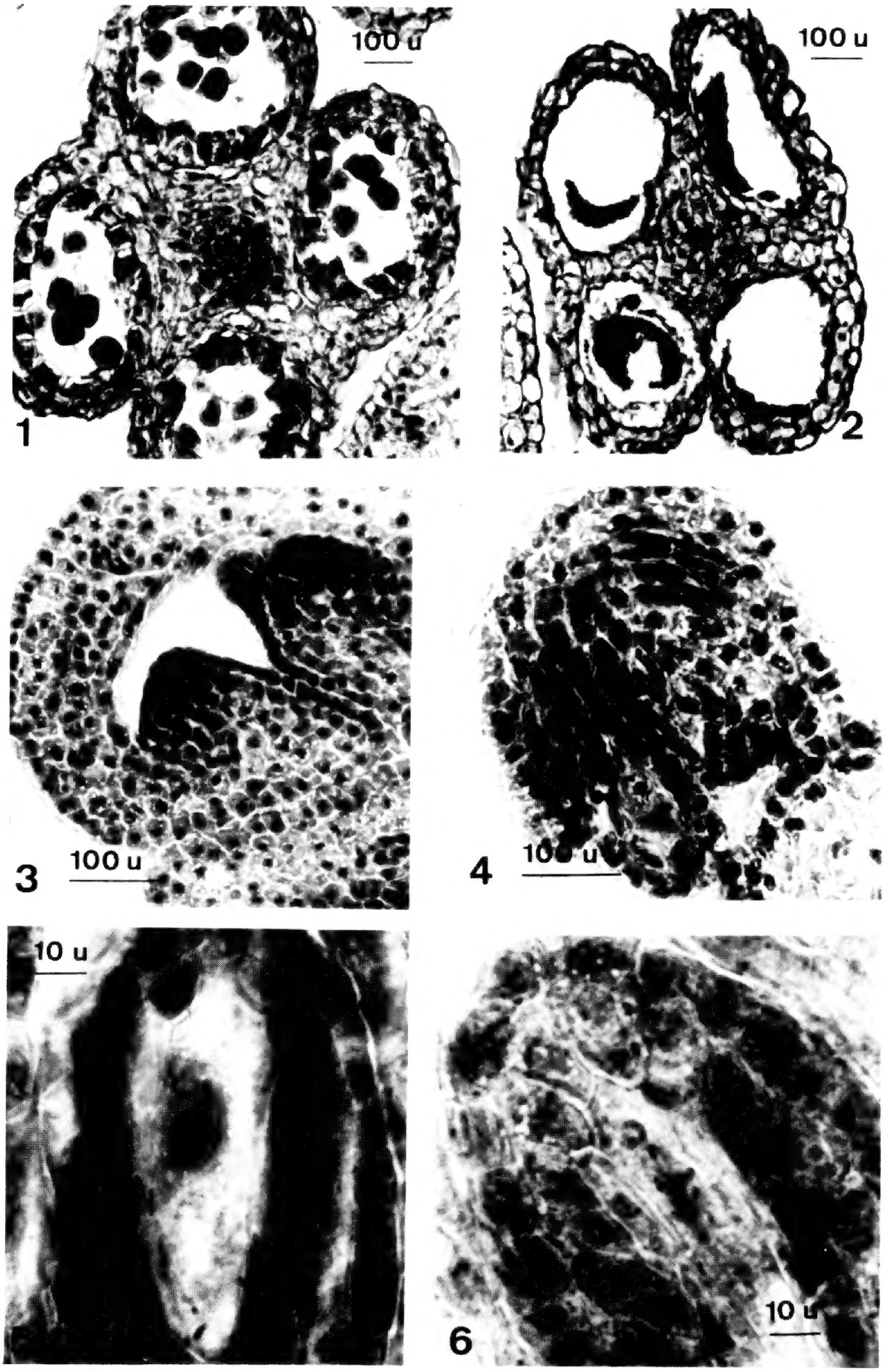
Collections of root tips from germinating bulbils were made during the field study and prepared for laboratory analysis. Bulbils were placed in three ml of spring water to which was added one drop of 100% l-alphabromanaphthalene. Roots were transferred after three to five hours into glacial acetic acid and 100% ethanol (1:3 v/v) and left overnight (12–18 hours). The samples were then transferred to 70% ethanol and stored at 0° C.

Excised root tips were washed in distilled water and placed in snail cytase for five to ten minutes. Roots were then washed in distilled water and placed in 0.2 N HCl at 60° for 10 minutes to reduce staining of the cellular background. After thorough washing, the roots were squashed and stained using standard technique (propiocarmine was substituted for acetocarmine as the stain).

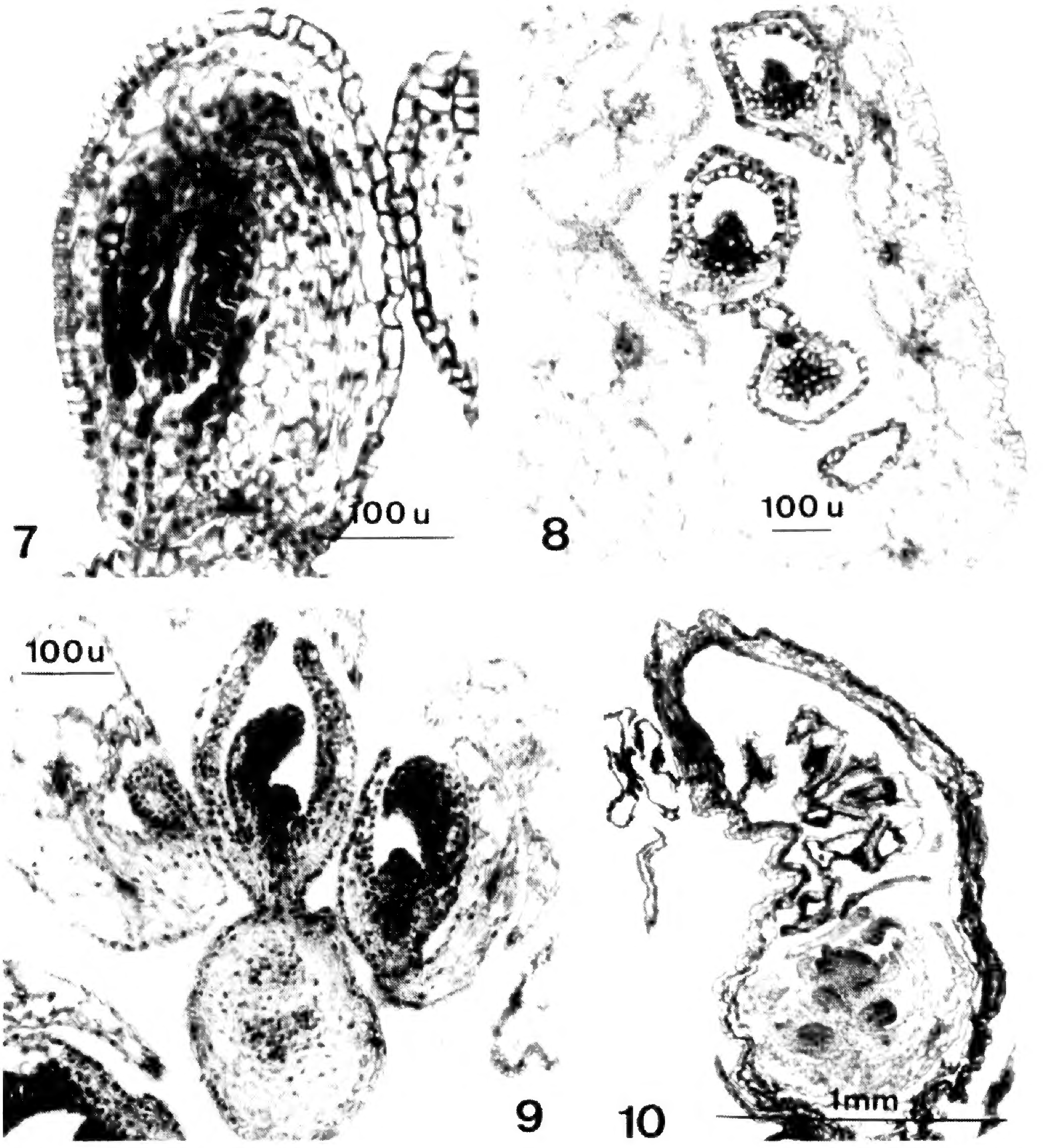
Squashes were analyzed with a Zeis Photomicroscope III utilizing phase contrast optics. Drawings were prepared with a camera lucida.

RESULTS

Field observations of phenology indicate that the flowers of *Saxifraga stellaris* var. *comosa* on Mt. Katahdin are protandrous. Filaments elongate prior to active growth of the pistil. The style begins



Figures 1–6. Anatomical studies of floral development in *Saxifraga stellaris* var. *comosa*. **1.** Pollen tetrads in developing anther. **2.** Degenerated pollen in undehisced anther. **3.** Ovule primordia emerging from septum. **4.** Single integument visible as the megasporocyte begins to enlarge. **5.** Metaphase in megasporocyte. **6.** Possible chromosomal laggards visible in anaphase of meiosis I of megasporocyte. (Scales of measurement as shown.)



Figures 7–10. Anatomical studies of floral development and apomixis in *Saxifraga*. **7.** Cavity in nucellus left by degenerated megasporocyte. **8.** Integument of ovule developed into seed coat; nucellus degenerating. **9.** Bulbil attached to the pedicel of a terminal flower. **10.** Apomictic shoot developing within a mature capsule. (Scales of measurement as shown.)

to elongate rapidly after the filaments are fully elongated. Within 24 hours the filaments begin to wither and fold inward towards the enlarging ovary. The maroon anthers do not dehisce, but shrivel as the fruit ripens. No pollen grains were observed on the stigmas.

Anatomical preparations revealed that the epidermis and endothecium of the anther wall remain intact, whereas the middle cell layer degenerates and is crushed by the expanding pollen grains as are the tapetal cells (Figure 1). Pollen tetrads are formed, but no mature pollen grains are found in any anthers, even the undehisced anthers from flowers with apparently ripe ovaries (Figure 2).

The ripe ovaries of *Saxifraga stellaris* var. *comosa* are also deep maroon. Carpel number is normally two, but two of the 22 sampled individuals that flowered in the South Basin had a three-carpellate ovary and one ovary had a single carpel.

The earliest stage of megasporogenesis observed in the anatomical preparations is that of ovule primordia emerging from the placenta of an immature ovary (Figure 3). The hypodermal archesporial cell is not prominent in this material. Megasporogenesis in *Saxifraga stellaris* var. *comosa* is initiated in a normal fashion with a periclinal division of the archesporial initial into a primary tapetal cell and a megasporocyte (Maheschwari, 1950; Wardlaw, 1955). The parietal cell, which arises from the primary tapetal cell, then forms a four-cell-thick nucellus in the anatropous ovule. The single integumentary primordium typical of the variety (Harmsen, 1939) is visible as the megasporocyte begins to enlarge (Figure 4). Development of the anatropous ovule is complete when prophase of meiosis I begins. Apparently normal metaphase plates are formed, but irregular anaphase and telophase take place and no diads are formed (Figures 5 & 6).

Abortion of the megasporocyte precedes formation of diads that normally result from meiosis I. Slightly older flowers bear ovules with nucellus and integument intact, but with degenerated megasporocytes (Figure 7). A seed coat develops from the single integument, but the four-cell-thick nucellus atrophies into a mass of dark-staining debris (Figure 8). The normal *Polygonum* type of embryo-sac development and the Solanad type of embryogenesis typical of *Saxifraga* are absent in plants from Mt. Katahdin.

Vegetative reproduction of *Saxifraga stellaris* var. *comosa* is accomplished by means of bulbils and stolons. Each secondary axis bears several bulbils, and one or more bulbils can be found on the pedicel subtending the terminal flower. Numbers of bulbils produced by individuals is variable among the three populations. Mature plants produce an average of 20 to 35 bulbils.

Bulbils growing on the secondary axes comprise two to many leaves and an apical meristem (Figure 9). They are photosynthetic, but turn reddish-orange when exposed to long hours of sunlight. Field observations reveal that most bulbils are dispersed in the fall through abscission before the stem dies and collapses, but live bulbils can be found attached to the dead stem the following spring. If dispersed during the summer of their production, bulbils remain inactive and do not root until the following spring.

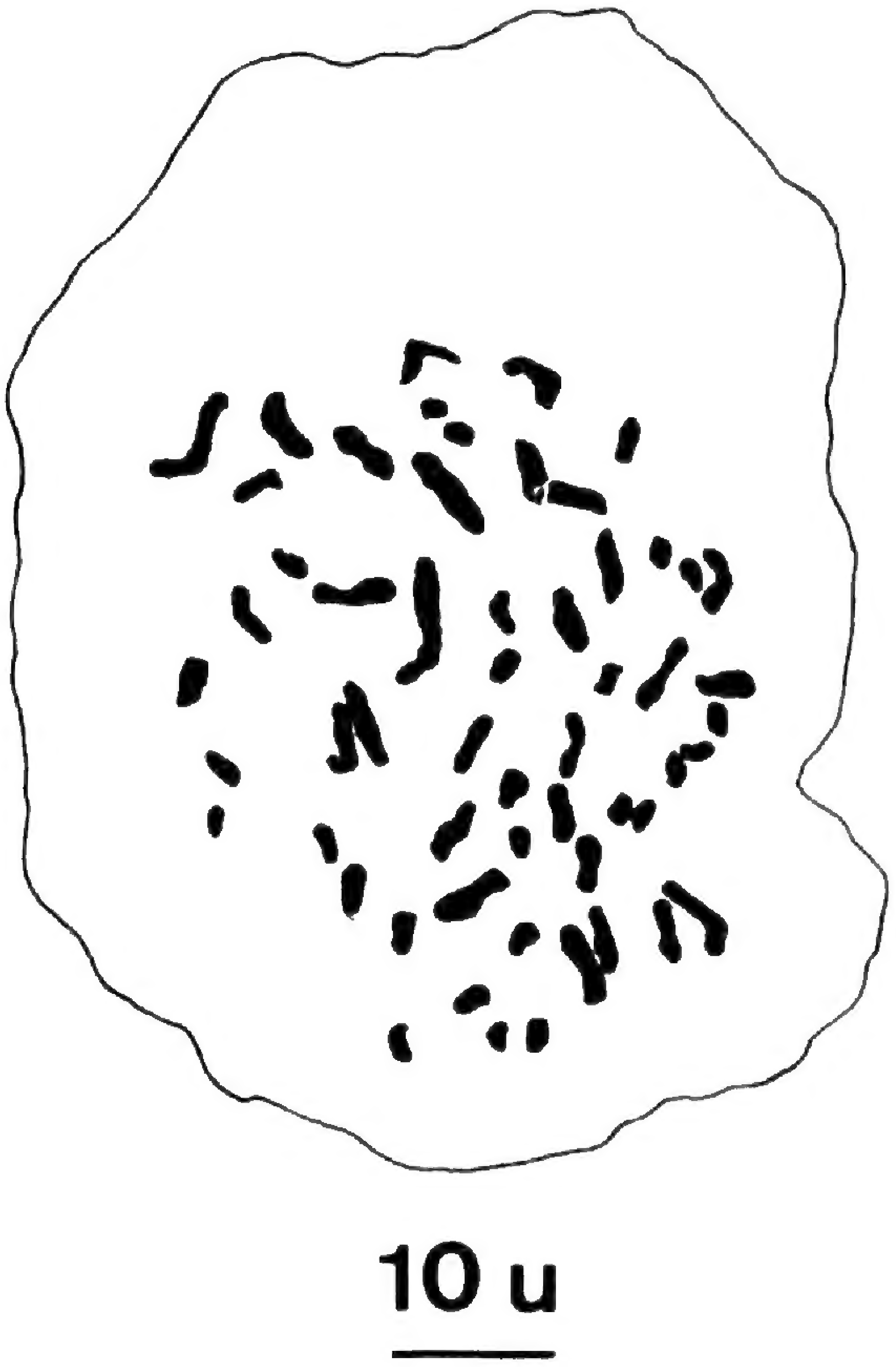


Figure 11. $2n = 56$. Camera lucida drawing of root tip squash in early prophase.

Leafy proliferations are not restricted to secondary axes and pedicel of the terminal flower. Mature ovaries were observed in anatomical preparations with aberrant growths consisting of young shoots with buds and secondary axes growing within the capsule (Figure 10). One such shoot included a terminal flower bud in which anthers and carpels were developed. These apomictic shoots cannot be considered as viviparous since they arise from the base of the ovary and not from a zygote or embryo.

A somatic count of $2n = 56$ was made from root tip squashes in early prophase (Figure 11).

DISCUSSION

Developmental investigations demonstrate that *Saxifraga stellaris* var. *comosa* is an obligate apomict on Mt. Katahdin. Flowers are produced, but pollen and ovules degenerate. Mature anthers contain no viable pollen grains. The first signs of ovulary degeneration appear during meiosis I and may be the result of incomplete separation of chromosomes at anaphase. The complete absence of viable pollen and embryo-sacs in the Mt. Katahdin material suggests that fertilization is very rare or absent. Complete degeneration of the sexual apparatus was not observed in Harmsen's (1939) study of Saxifrages in Greenland, although he noted abnormalities in both pollen and ovules. Tetrads were formed and young embryos were visible. Harmsen (1939) described young seeds in which the embryo had apparently developed to maturity, but he suspected that degeneration of all embryos ensued since no ripe seed of this variety had ever been found in Greenland. Fertilization was not observed among the Greenland plants.

Among the plants observed from Mt. Katahdin, a number of mature capsules bear shoot-like growths within the locules. The shoots differ from the ordinary bulbils in degree of development. These vegetative phenomena associated with the floral meristem support the broader theory that all proliferations on *Saxifraga stellaris* var. *comosa* arise from floral meristems (Linsbauer, 1913; Harmsen, 1939), even though proliferations originating inside the carpel were not observed by Harmsen (1939). The disparity in megasporogenesis and embryogenesis and the differences in proliferation suggest that the Greenland and Mt. Katahdin populations of *S. stellaris* var. *comosa* are genetically dissimilar, although a purely environmental influence on development cannot be completely ruled out.

The origin of *Saxifraga stellaris* var. *comosa*

Morphological derivation of vegetative reproduction and loss of normal sexual reproduction in *Saxifraga stellaris* var. *comosa* are the key to understanding the relationship of the proliferous variety to typical *S. stellaris* var. *stellaris.* Gross morphology of these plants is similar, but the proliferous Saxifrage produces bulbils where the typical variety produces flowers. Some reproductive axes of typical *S. stellaris* var. *stellaris* have bulbils scattered among the more abundant flowers. In addition, discovery of stamens in bulbils of plants in Greenland (Harmsen, 1939), and discovery of reduced shoots inside capsules of some plants from Mt. Katahdin suggests that leafy proliferations and floral primordia are homologous.

A cause for the change from sexual to vegetative reproduction in some populations of *Saxifraga stellaris* remains unknown. However, degeneration of normal reproduction and apomixis among arctic species have been linked with polyploidy (Gustafsson, 1946; Flovik, 1938a,b; Hagerup, 1931; *fide* Löve and Löve, 1957). *Saxifraga stellaris* var. *stellaris* has a gametic chromosome number of 14, but the variety is included in that group of *Saxifraga* which supposedly has a base number of 8 (Darlington and Wylie, 1956). The two different, acceptable gametic counts for *S. stellaris* var.

comosa from Lapland ($n = 28$) and Greenland ($n = 28$, $n = 32$) suggest that these apomictic populations may have arisen as a result of several polyploidization events involving *S. stellaris* var. *stellaris*.

Failure of meiosis in *Saxifraga stellaris* var. *comosa* on Mt. Katahdin might be described as unequal segregation of homologous chromosomes, and, together with morphological characters, suggests the autoploid origin of tetraploid *S. stellaris* var. *comosa* from diploid *S. stellaris* var. *stellaris*. However, it is not possible to determine whether *S. stellaris* var. *comosa* is either an auto- or amphiploid by cytological data alone. A complete understanding of derivation of *S. stellaris* var. *comosa* requires further analysis.

Lack of sexual reproduction does not interfere with adaptability of *Saxifraga stellaris* var. *comosa* to arctic or arctic-alpine environments. Gustafsson (1947) suggested that asexual reproduction increases with higher ploidy level in the Arctic. In addition, Gustafsson (1946) postulated that one-sided allocation of energy and nutrients to rapidly growing vegetative propagules robs the plants of resources required for complete development of sexual organs. Rapidly developing bulbils may drain the resources of a parent plant and starve the developing buds. Flowers that develop on the lower secondary axes of the determinate inflorescences of *S. stellaris* var. *comosa* are regularly abortive. Interruption of development in flower buds by leafy proliferations may be a result of nutrient deprivation. Conversely, abortive sexual structures could mean that resources are being diverted to vegetative structures.

Ability to produce bulbils is the key to survival of *Saxifraga stellaris* var. *comosa* in the high Arctic and on Mt. Katahdin. However, polyploidy is not a prerequisite for vegetative proliferation as seen in *S. stellaris* var. *comosa* since some herbarium specimens of *S. stellaris* var. *stellaris* can be found with a few scattered bulbils. Morphological and embryological disparity between Greenland and Mt. Katahdin populations could be the result of independent autoploid derivation from morphologically distinct diploid races of *S. stellaris* var. *stellaris*, or it could result from different environmental influences on the development of genetically similar populations. A more complete understanding might be obtained by a thorough examination of diploid and tetraploid plants in the Arctic.

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A NEW SPECIES OF *BELOGLOTTIS* (ORCHIDACEAE) FROM OAXACA

P. M. CATLING

An unfamiliar terrestrial orchid was found on open rocky ridges in pine woodland at 3150 m elev., east of the town of Oaxaca, Mexico. Subsequent study indicated it to be a distinctive new species belonging to the genus *Beloglottis.* The distinguishing features of this genus include a stigmatic surface located beneath a shortly bilobed or emarginate rostellum, a free dorsal sepal, an ovate anther sac, and a ventrally inflated column base (clinandrium). The genus contains 8 species, all of which are neotropical (Garay, 1980).

Beloglottis laxispica Catling *sp. nov.*

Herba terrestris erecta 15–30 cm alta., inferne glabra, superne trichomatibus capitatis copiose obsita. Radices tuberoso-incrassatae usque ad 1 cm diam. Folia fugacia. Caulis gracilis usque ad 1 mm diam., bracteis 7–10, vaginantibus instructis, 8–20 mm longis. Spica laxa, 5–9 cm longa, bracteis floriferis scariosis acuminatis 8–15 mm longis. Flores 5–9 in spiram laxam contorti, periantho horizontali, sepalis et petalis albis ad basim nervis viridibus, labello albo ad basim nervis viridibus, sepalis lateralibus 6–6.5 mm longis, 0.9–1.1 mm latis, lanceolatis, acutis, uninervis, sepalo dorsali 6–7 mm longo, 1.8–2.1 mm lato, lanceolato, acuto, trinervi, petalis 5–5.5 mm longis, 0.9–1.1 mm latis, oblanceolatis, falcatis, uninervis, labello 6.5–7.2 mm longo, 2.3–2.7 mm lato, oblongo, pandurato, curvituberculis basalibus humilibus, rostello emarginato. Folia matura ignota.

Herb, terrestrial, erect, 15–30 cm tall, glabrous below, pubescent above with numerous capitate trichomes. Roots tuberously thickened, up to 1 cm in diam. Leaves absent at anthesis. Stem slender, to 1 mm thick, bearing 7–10 loosely sheathing bracts 8–20 mm long. Spike lax, 5–9 cm long. Floral bracts scarious, acuminate, 8–15 mm long. Flowers 5–9, in a loose spiral; perianth horizontal; sepals and petals white with green nerves at the base, lip white with green nerves at the base. Lateral sepals 6–6.5 mm long, 0.9–1.1 mm wide,

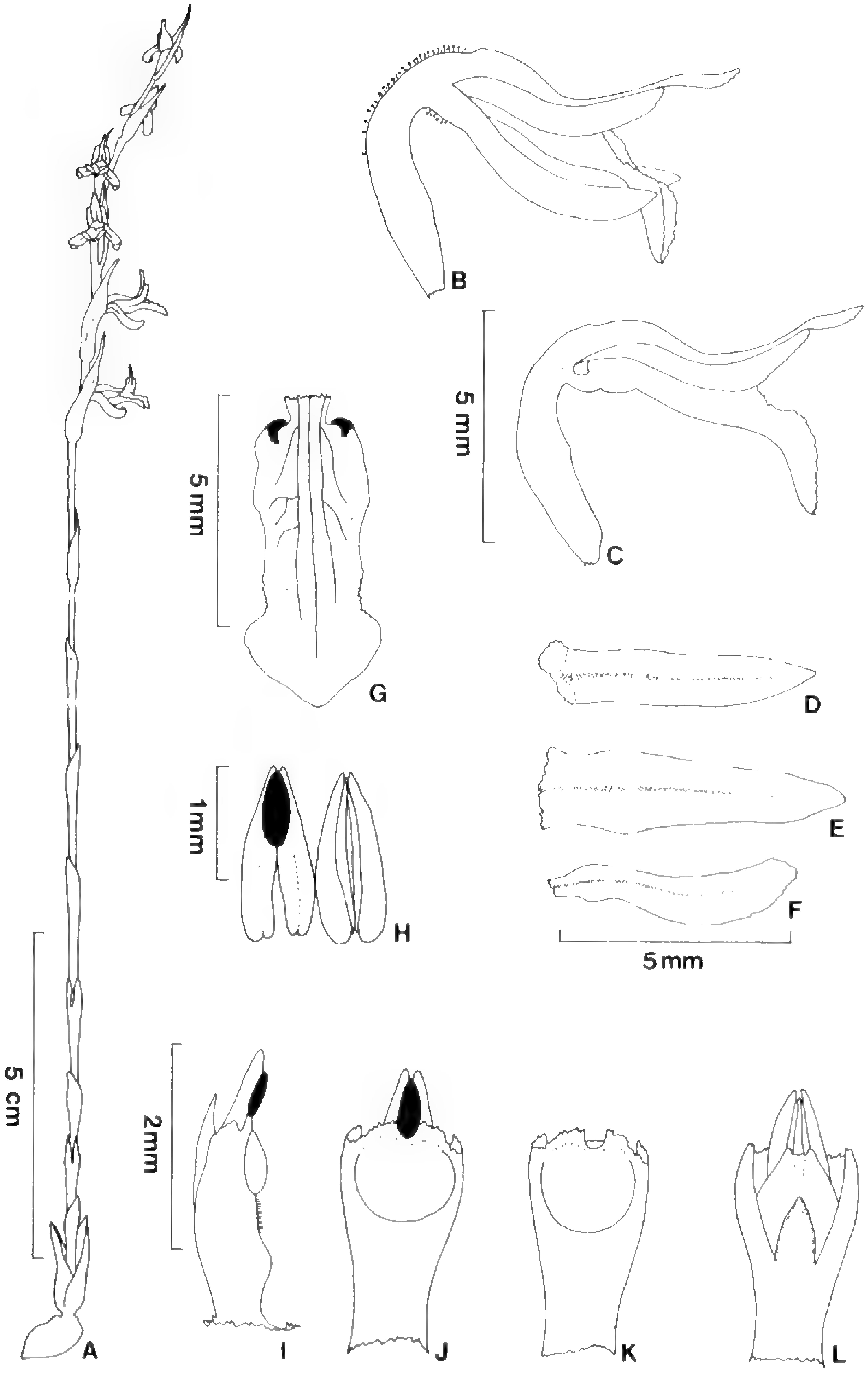

Figure 1. Drawing based on the holotype of *Beloglottis laxispica* Catling (*Catling M-17* and *Greenwood,* AMES). **A,** plant; **B,** lateral aspect of flower; **C,** lateral aspect of flower with the lateral sepal removed; **D,** lateral sepal; **E,** dorsal sepal; **F,** petal; **G,** lip; **H,** pollinia, ventral aspect (left) and dorsal aspect (right); **I,** column, lateral aspect; **J,** column, ventral aspect; **K,** column, ventral aspect with the pollinia removed; **L,** column, dorsal aspect.

lanceolate, acute, 1-nerved; dorsal sepal 6–7 mm long, 1.8–2.1 mm wide, lanceolate, acute, 3-nerved. Petals 5–5.5 mm long, 0.9–1.1 mm wide, oblanceolate, falcate, 1-nerved. Lip 6.5–7.2 mm long, 2.3–2.7 mm wide, oblong, pandurate, basal calli low, incurved. Rostellum emarginate. Mature leaves unknown.

TYPE: MEXICO. Oaxaca: 27 km from Diaz Ordaz on the road to Cuajimaloya, approx. 30 km east of Oaxaca, at 3150 m elev., 5 April 1982, *P. M. Catling M17* and *E. W. Greenwood* (HOLOTYPE: AMES; ISOTYPE: DAO).

Beloglottis laxispica differs from all other Central American *Beloglottis* spp. in its larger lip (more than 6.5 mm long instead of less than 5.5 mm long), absence of leaves at anthesis, laxly-flowered spike (the dorsal sepals not overlapping the ovaries of the flowers above), and the tendency for the distal portion of the pandurate lip to be wider than the proximal portion.

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TRILLIUM RECURVATUM BECK FORMA *ESEPALUM F. NOV.*, A NEW SEPALLESS FORM OF THE PRAIRIE WAKEROBIN

JOHN D. FREEMAN AND THOMAS E. HEINEKE

ABSTRACT

A sepalless floral variant of *Trillium recurvatum* Beck (prairie wakerobin or recurved-sepal trillium), a sessile-flowered species, is described as forma *esepalum*. The new form is distinguished from f. *recurvatum* and previously named aberrant forms (f. *foliosum* Steyerm. and f. *petaloideum* Steyerm.) by a floral phyllotaxy in which the calyx is represented by petals; other alternating floral whorls appear as normal stamens (3 outer and 3 inner) and a pistil of 3 fused carpels. Absence of a whorl of perianth segments accompanied by a 60° shift in the phyllotaxy of the remaining floral parts was previously noted in the genus *Trillium* only among the Asiatic species, where a petalless condition characterizes one tetraploid pedicellate-flowered species, *T. apetalon* Makino.

Key Words: *Trillium*, floral phyllotaxy, abnormal flowers

Trillium recurvatum Beck forma **esepalum** Freeman & Heineke, *f. nov.*

Trillium recurvatum Beck forma *esepalum* Freeman & Heineke, *f. nov.*, a f. recurvato f. petaloideo Steyerm. et f. folioso Steyerm. sepalis per petala et petalis per stamina exteriora substitutis differt; flos typicus est praeter sepala absentia et verticillos florales ab angulis normalibus per 60° mutatos.

TYPE: UNITED STATES: Tennessee: Shelby Co.: Meeman Shelby Forest State Park; mesic oak-hickory forested slope with *Erigenia bulbosa, Podophyllum peltatum, Claytonia virginica,* and typical forms of *T. recurvatum*, 15 Apr 1984. *T. E. Heineke 3781* (HOLOTYPE: MO; ISOTYPE: AUA). Paratype: same locality and habitat as the type collection, 20 Apr. 1985. *T. E. Heineke 4423* (Herbarium of the Memphis District Corps of Engineers).

Trillium recurvatum Beck forma *esepalum* differs from f. *recurvatum*, f. *petaloideum* Steyerm., and f. *foliosum* Steyerm. by having no sepals and all the remaining floral whorls typical in form but rotated by 60 degrees from their normal insertion.

Many unusual and aberrant forms of *Trillium* have been given formal names. Most of those named on the basis of peculiar phyllotaxy have been representatives of pedicellate-flowered taxa, particularly *T. grandiflorum* (Michx.) Salisb. (Farwell, 1918; Louis-Marie, 1940). Among sessile-flowered species, flower color variants that are likely to attract notice and thus possibly generate taxonomic confusion usually have received the most attention (Beyer, 1927; Clute, 1922; Palmer and Steyermark, 1935; Freeman, 1975; Soukup, 1982). Steyermark (1959) recognized two forms of *T. recurvatum* based upon aberrant morphology: f. *petaloideum,* a form in which sepals are transformed into petaloid structures; and f. *foliosum,* a form in which all floral parts are represented as foliar structures that resemble the foliaceous bracts (commonly called simply "leaves"). Both perianth whorls are represented by petaloid appendages in f. *petaloideum,* and such plants bear a superficial resemblance to the present new form. A single whorl of petaloid perianth segments instead of the sepals and an altered phyllotaxy clearly distinguish f. *esepalum* from f. *petaloideum,* the holotype of which (at the Southeast Missouri State University Herbarium) was examined by the authors. The petaloid "sepals" are erect in both these forms, whereas typical sepals are strongly reflexed.

Our decision to name still another *Trillium* form is based upon two observations. First, the condition we recognize herein as f. *esepalum* is not limited to just a single plant. Following the initial discovery in 1984, it was observed again at the type locality in April of 1985 in two separate groups of plants approximately 15 feet apart. Possibly representing progeny developed from individual fruits, one group comprised 8 flowering individuals and the other 5. Thus, it is not simply a unique or seasonal phenomenon; it seems to be genetically fixed and apparently may be increasing in numbers at this site. Second, loss of one floral whorl (the corolla) distinguishes a distantly related species, *T. apetalon* Makino, of Japan. Samejima and Samejima (1962) describe the "apetalon type" of *Trillium* flower as one "caused by suppression of the carpel, namely, the petal changes into the outer stamen, the outer stamen to the inner one, the inner stamen to the carpel, and the carpel[s] have disappeared. Consequently, the situation of the carpel...is rotated by 60°." This description seems to agree well with the phyllotaxy of *T. recurvatum* f. *esepalum* (Figure 1). Although it is the sepals that are missing in this form, a comparison of the floral diagrams (Figure 1, A–C) suggests that appendages are truly missing in f. *esepalum* at the positions normally occupied by carpels. Except for being rotated

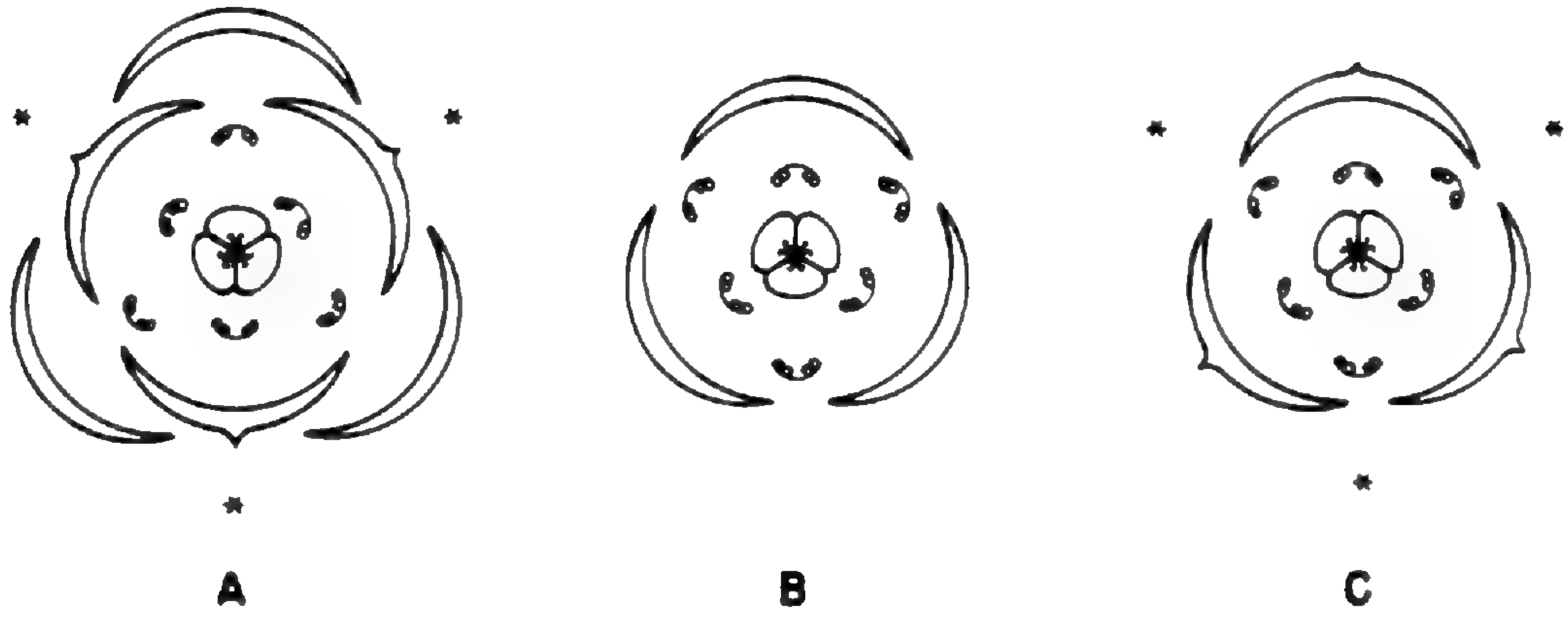

Figure 1. Floral diagrams for *Trillium:* **A**, typical liliaceous type; **B**, *T. apetalon* type; **C**, *T. recurvatum* f. *esepalum* type. Asterisks (*) denote the positions of bracts in the sessile-flowered species.

60° in relation to the foliaceous bracts (a shift that would not be as readily apparent in a pedicellate-flowered species), petals and inner floral parts appear in their normal positions of insertion relative to each other in *T. recurvatum* f. *esepalum*.

It is an intriguing possibility that the genetic basis for the abnormal phyllotaxy of this new form might be closely similar to that which determines the phyllotaxy of *T. apetalon* (a tetraploid) and certain other Asiatic *Trillium* polyploids that contain the "apetalon" genome. Since *T. recurvatum* is a diploid with $2n = 10$, identification of the specific gene or genes involved, characterization of the DNA sequences, etc. should be considerably less complicated in this form than in the polyploid taxa. Naming of this new form may provide a means of furthering basic studies on the controls of floral phyllotaxy and floral development in general, with *Trillium* taxa serving as the experimental subjects.

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OBSERVATIONS ON LAKE ERIE POPULATIONS OF *ANKYRA JUDAYI* AND *A. LANCEOLATA* (CHLOROCOCCALES)

LOUIS L. LIPSEY, JR.[1]

ABSTRACT

Morphological variability in two populations of Lake Erie planktonic algae, *Ankyra judayi* and *A. lanceolata*, is examined and compared. Although both species are similar in general size and form they are easily separated by shape and position of their binate "anchor-like" appendages.

Key Words: algae, Chlorococcales, *Ankyra*, Lake Erie

INTRODUCTION

Cells of the planktonic Chlorococcalean genus *Ankyra* Fott (1957) are characteristically fusiform, gradually narrowing to bristle-like apices. The posterior end is usually acuminate, while the anterior end bears a binate "anchor-like" appendage. The apex bearing the binate appendage in *Ankyra* was previously designated the anterior end by Swale & Belcher (1971) because it corresponded to the flagellar pole of the zoospores. Vegetative cells possess a single parietal chloroplast, and one pyrenoid. *Korshikoviella, Paradoxia,* and *Schroederia* are closely related genera distinguished from *Ankyra* by means of their preference for epizoic substrates, persistence of paired colonies, and the absence of binate appendages, respectively (Komárek & Fott, 1983).

Species of *Ankyra* are identified by the shape and relative size of their binate appendages, by shape of their chloroplasts, by presence of stigmata, and/or by presence of peripheral setae upon the cell walls (Komárek & Fott, 1983). Seven planktonic species have been recognized: *Ankyra ancora* (G. M. Smith) Fott, *A. calcarifera* (Kisel.) Fott, *A. inerme* Reymond & Druart, *A. judayi* (G. M. Smith) Fott, *A. lanceolata* (Korš.) Fott, *A. ocellata* (Korš.) Fott,

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Table 1. Morphological characteristics examined in *Ankyra judayi* and *A. lanceolata*.

Variable	*A. judayi*	*A. lanceolata*
Cell Length (μm)	7.5–60.0 ($\bar{x}$ = 28.83)	15.0–61.0 ($\bar{x}$ = 36.08)
Length of Main Body (μm)	4.0–34.0 ($\bar{x}$ = 11.16)	4.0–30.0 ($\bar{x}$ = 12.82)
Length of Anterior Bristle (μm)	1.5–12.0 ($\bar{x}$ = 7.74)	4.0–16.0 ($\bar{x}$ = 8.29)
Length of Posterior Bristle (μm)	1.0–18.0 ($\bar{x}$ = 9.89)	0–30.0 ($\bar{x}$ = 14.37)
Cell Width (μm)	1.0– 3.5 ($\bar{x}$ = 1.78)	1.0– 2.75 ($\bar{x}$ = 1.73)
Length of Binate Appendage (μm)	1.0– 4.0 ($\bar{x}$ = 2.38)	0.5– 3.0 ($\bar{x}$ = 2.19)
Number of Cells Measured (n)	76	83

Values presented in parentheses ($\bar{x}$) are population averages.

and *A. paradoxioides* Cirik (Komárek & Fott, 1983; Reymond & Druart, 1980). In the Great Lakes region of North America, only *Ankyra ancora* (under the synonyms *Schroederia setigera* var. *ancora* G. M. Smith and *S. ancora* G. M. Smith) and *A. judayi* (also under the synonym *Schroederia judayi* G. M. Smith) have been reported (Hopkins & Lea, 1982; Makarewicz, 1985b; Prescott, 1962; Smith, 1916, 1920, 1926, 1933).

Analyses of recent phytoplankton samples have shown that populations of *Ankyra* have a general distribution throughout Lake Erie. They are not dominant components of the current flora, with concentrations seldom exceeding 90.00 cells/ml (Makarewicz, 1985a). The purpose of this paper is to document more fully the extent of the morphological variability of *Ankyra judayi* and *A. lanceolata* observed in recent Lake Erie phytoplankton samples.

MATERIALS AND METHODS

During the 1984 Great Lakes National Program Office cruise season phytoplankton samples were collected aboard the RV *Roger R. Simons,* as one-liter splits from 8-liter Niskin bottles from 1m, 5m, 10m, and 20m, and composited. A one-liter split of the composite samples was preserved with acidified Lugol's iodine immediately following collection (10ml/L). Upon arrival in the laboratory, 10 ml of formaldehyde were added to the samples. Microscopic examination was performed under phase contrast illumination (at 500×) using a Leitz Diavert inverted microscope.

OBSERVATIONS

Morphological variables measured in the investigation include total cell length (bristle tip to bristle tip), cell width, length of main body of cell (minus bristles), anterior and posterior bristle lengths,

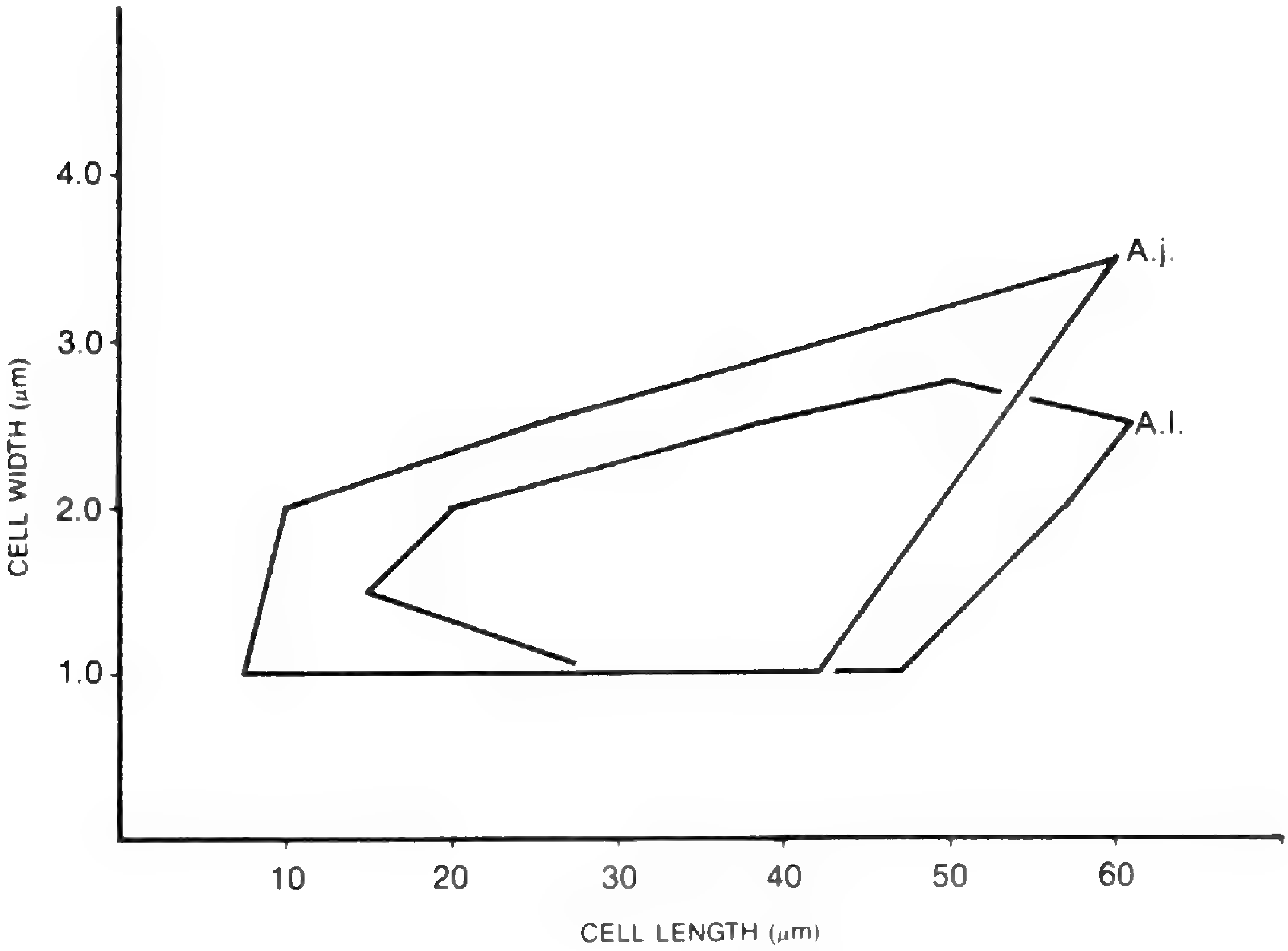
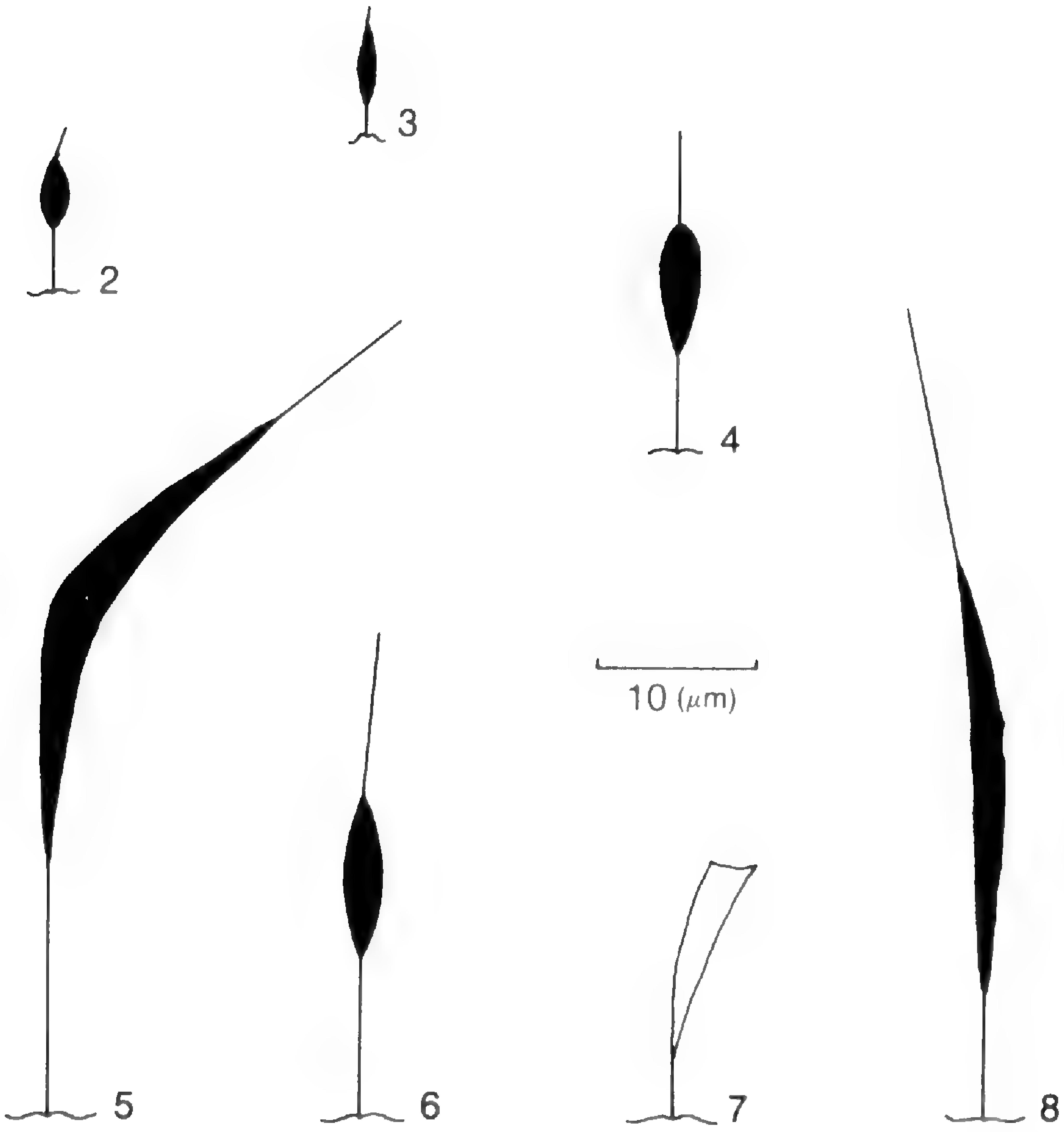


Figure 1. Cell size distributions. (A. j. = *Ankyra judayi;* A. l. = *A. lanceolata.*)

and length of the binate appendage. These data are presented in Table 1.

Cell size distribution is remarkably similar for *Ankyra judayi* and *A. lanceolata* (Figure 1). Cell length and width vary considerably for both taxa (7.5–60.0 μm × 1.0–3.5 μm versus 15.0–61.0 μm × 1.0–2.75 μm, respectively), although the average cell length is noted to be slightly higher in the *A. lanceolata* population (36.08 μm vs. 28.83 μm). Ranges and average length of the main body of the cell and the anterior bristle length are nearly identical for both species (Table 1). Ranges of the posterior bristle length are also similar, but the population average is slightly higher for *A. lanceolata* (14.37 μm vs. 9.89 μm).

The main body of both species is basically fusiform to narrowly ovate in outline (Figures 3–4, 6, 8–11), although elliptic (Figure 2) and arcuate (Figures 5, 8) cells of *Ankyra judayi* also exist in the population. The most distinctive characteristic which can be used to separate the two taxa is the shape of their binate appendages. In *A. judayi* the appendage is always robust, about 2.38 μm in length, and perpendicular to the main axis of the cell (Figures 2–6, 8). In *A. lanceolata* the appendages are forked and more or less parallel to the main axis of the cell. In most specimens the appendages are filiform in outline (Figure 9) and ca. 2.19 μm in length; however,

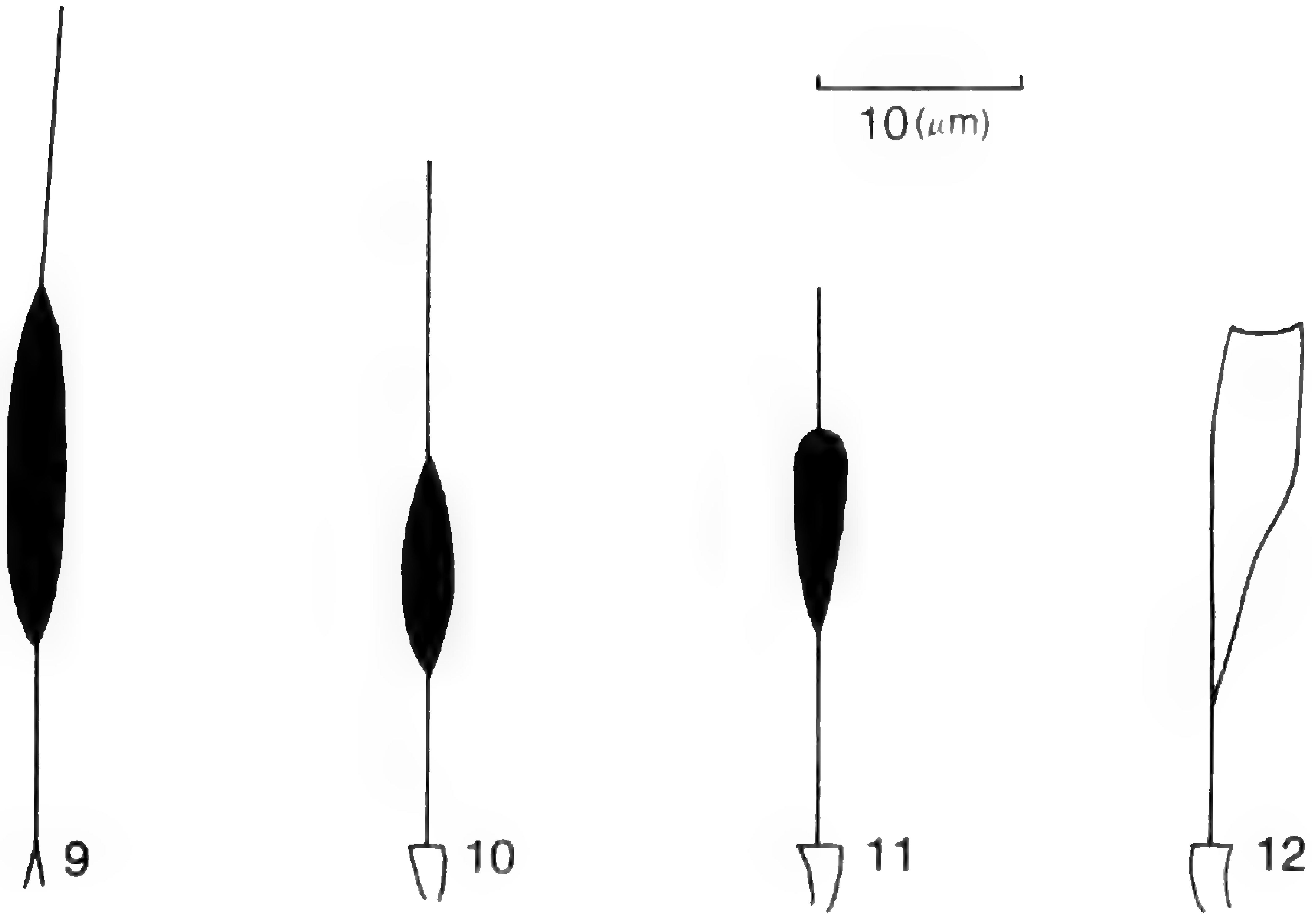


Figures 2-8. *Ankyra judayi.* **2-6, & 8,** Vegetative cells; 7, Anterior half of mother-cell-wall.

24% of the population also possesses cells in which the appendage is slightly robust, extending downward off a short lateral projection (Figures 10-11). These features are also evident in broken mother-cell-walls (Figures 7, 12).

DISCUSSION

The importance of the binate appendage in identifying species of *Ankyra* cannot be overemphasized, as it probably is the single most important morphological feature of the genus (Komárek & Fott, 1983). The robustness of the appendage and its perpendicular positioning to the main axis of the cell readily separates *Ankyra judayi* from most other Chlorococcalean algae in Lake Erie. Hopkins & Lea (1982) have previously recorded *A. ancora* from the Nanticoke region of Long Point Bay. The latter taxon is similar in morphology



Figures 9–12. *Ankyra lanceolata.* **9–11**, Vegetative cells; **12**, Anterior half of mother-cell-wall.

and could be confused with *A. judayi;* however, it is characterized by having a large H-shaped chloroplast and much larger cellular dimensions (Komárek & Fott, 1983).

Until the present investigation, *Ankyra lanceolata* has not been reported from the phytoplankton of Lake Erie. The filiform appearance of its forked appendage is extremely difficult to resolve using light microscopy. It is likely, therefore, that it has been misidentified in the past, perhaps as a species of *Ankistrodesmus* or *Schroederia.* Swale & Belcher (1971) have shown *Ankyra lanceolata* to be a highly variable taxon, especially when grown in culture. Even though the majority of their cells typically possessed filiform binate appendages, Komárek & Fott's illustrations (1983, p. 231, pl. 70, figs. 2a–g) suggest that the size and robustness of the appendage is highly variable in this species.

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STATUS OF ELM PRESERVATION IN NEW ENGLAND

George S. Ellmore and William E. Phair

ABSTRACT

Survival of *Ulmus americana* L. in New England has dramatically improved due to use of a shallow-pit injection technique which delivers systemic fungicide directly into the conducting elements of the outermost growth ring in the trunk. Previous injection methods drive fluids into older, non-functional wood, producing both inconsistent results and costly failures.

Key Words: Dutch elm disease, elm, *Ulmus americana*, New England

In 1941, Dutch elm disease was found in Massachusetts, making it the second New England state (behind Connecticut) to be visited by the fungal pathogen *Ceratocystis ulmi* (Buisman) C. Moreau. Vermont, Rhode Island, New Hampshire, and Maine were to follow within ten years (Sinclair and Campana, 1978). As it had in Europe, Dutch elm disease in New England killed millions of elms, both in native populations as well as in cultivated stands. The lethal disease continues to claim elms every year, but despite its forty-year presence in New England, valuable elms still remain.

Many communities are attempting to preserve valuable elms using control measures against Dutch elm disease but confusion over the effectiveness of various treatment plans has grown from the proliferation of recent advances in this area (Newbanks et al., 1982). In this paper, we discuss the treatment which has been most successful to date in preserving elms against Dutch elm disease in New England. As is typical in plant pathology, one cannot guarantee the survival of a given individual. However, new protocols have greatly enhanced elm survival rates against Dutch elm disease (Phair and Ellmore, 1984), and continued research in the area promises further success.

American elms were widely planted for shade, windbreak, and lumber (Richens, 1983), a practice which would continue were it not for Dutch elm disease. Rapid growth rate, ease of propagation, and tolerance of compact urban soil all contribute to the value of elms in landscaping and horticulture (Stipes and Campana, 1981). Less tangible, but compelling are the aesthetic virtues of the genus, particularly of *Ulmus americana* (American Elm), declared the State Tree of Massachusetts. When unencumbered by neighboring trees, the main axis of *U. americana* commonly divides low in the tree producing large flaring trunks which spread upward to form a handsome vase-shaped crown (Figure 1).

Many large American Elms are still alive, representing considerable aesthetic and property value. In New England, age (in years) of elms can be estimated by multiplying trunk diameter (in inches, measured 4 1/2 feet above ground level) by 2.8. Trees younger than 10 years are considered saplings, those between 25 and 90 years are in their prime, and centenarians are invariably in decline from stress, injury, and disease (Stipes and Campana, 1981). In their prime, elms are large and robust enough to achieve their greatest shade and windbreak value, but it is precisely this age group which suffers the greatest impact from Dutch elm disease. The disease blocks water flow in the wood, bringing on wilting, yellowing, and death of crown parts. Flying bark beetles (*Scolytus multistriatus* Marsham, and *Hylurgopinus rufipes* Eichhoff), no larger than fruitflies, spread the pathogen to new trees. As elms fall, landscapers are faced with the problem of replacing useful trees which are on the average 40–80 years old.

Treatment of elms must be made on an individual tree basis because the bark beetle vectors are too numerous and widespread to control by spraying. The most effective approach is to inject fungicide into selected trees. In theory this should prevent fungal growth in wood, but in practice results are so variable that elm preservation programs are often abandoned.

Recent studies of fluid flow in elm wood have revealed properties in elm which may account for defective injection procedures. Most water conduction occurs through wide-diameter vessels of the springwood (Ellmore and Ewers, 1985). In winter, these fluid-filled vessels freeze. As they thaw the following spring, bubbles (embolisms) remain suspended in the water column (Zimmermann, 1983; Ewers, 1985), blocking transport. The reactivated vascular cambium produces new springwood, and fluid transport up the trunk resumes through this tissue. Thus, winter freezing and subsequent embolisms restrict most axial conduction to the very youngest wood of the trunk. This finding has been recently confirmed by Ellmore and

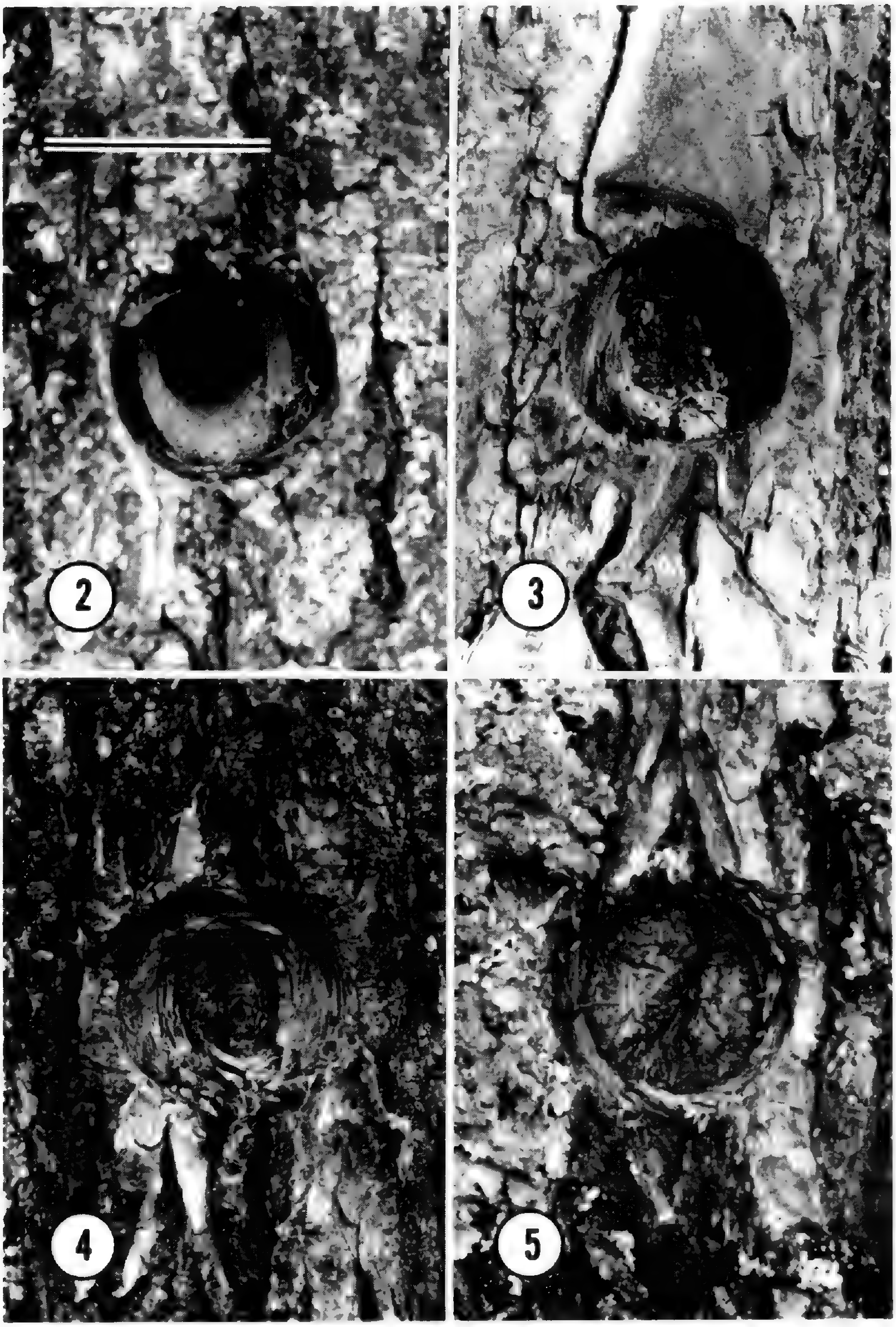
Figure 1. *Ulmus americana* on the South Village Green of Ipswich, MA. Over 120 years old, this tree finally succumbed in 1985 to the combined insults of decay, disease, and hurricane damage.

Ewers (1986) who found that the outermost growth ring of *Ulmus americana* is responsible for over 90% of xylem transport. These results are of considerable importance to the practice of tree injection, because they indicate that in order for an injected fluid, such as fungicide, to be placed throughout an elm tree, it must be injected into the outermost ring of wood. Conventional injections, commonly two inches deep, place much of their fluid into nonconducting xylem, wasting money and time, and leaving trees largely unprotected.

Paralleling the basic research of Ellmore and Ewers (1985; 1986) has been the development of "shallow-pit" injection (Phair and Ellmore, 1984). This procedure forces fungicide into the conducting vessels of the outermost growth ring. Evidence of its effectiveness ranges from a ten-fold increase in fluid acceptance rate by the trees, to unequaled survivorship in elms injected by shallow-pit (Phair and Ellmore, 1984). Briefly, shallow-pit injection involves drilling holes into target tissue just beneath the vascular cambium, inserting reusable injectors into the holes, and forcing several gallons of pressurized fungicide into the trunk using equipment routinely available to arborists. Elms usually take up the required dosage within 30 minutes, unlike several hours required for each tree to accept fluid delivered by conventional deep injectors.

Shallow-pit injectors are now marketed by Elm Medics Co. in Massachusetts, where both the principles and applications of the procedure originated. Two years after its appearance (Phair and Ellmore, 1984) the procedure is being widely used, representing a dramatic advance in arboriculture. Professional arborists in Massachusetts, New Hampshire, and Maine now employ shallow-pit injection against Dutch elm disease, as do some in Maryland, North Carolina, and New York. Universities, with a tradition of majestic campus elms, have also been testing the method. Those with significant populations of standing elms include Tufts University, Notre Dame, and Virginia Polytechnic Institute. Private estates in New England and the Midwest have adopted shallow-pit injection, and the US Forest Service is extending its application to treatment of oak and other woods in Louisiana and Mississippi. The method is so effective in propelling fungicide into trees that recommended dosages of commercial fungicides such as Arbotect and Lignasan must be re-evaluated and reduced.

To date, the most common objection to shallow-pit injection concerns the wounds left around elm trunks (Figures 2–5). Each year the treatment is given, a set of injection ports (Figure 2) is drilled



Figures 2–5. Healing of shallow-pit injection ports. **2.** Port 3 months after injection. **3.** Port 1 year after injection showing closure of deeper hole. **4.** Port 2 years after injection. **5.** Port 3 years after injection. Healing has filled in the shoulder between narrow and wide portions of the port. Scale bare = 1 inch for all figures.

around the trunk. Effects of such wounding are not yet completely documented. However, unpublished anatomical studies of old injection ports show that within 3 years after injection, tracheary initials in the vascular cambium over wounded areas become realigned to their normal configuration. Recently this finding has been confirmed in sections of wood taken from an elm downed by Hurricane Gloria in 1985.

Healing of injection ports is apparent in Figures 2–5. At first, an inner hole 1/2″ wide penetrates the cambium and reaches 1/4″ into young xylem (Figure 2). Within one year, cambial activity closes the inner hole (Figure 3). The shoulder between the 1/2″ inner hole and the 1″ outer hole becomes less apparent after two years (Figure 4). It usually disappears after 3 years, leaving only the outline of the 1″ hole in the bark. Even this mark vanishes in young trees, leaving no more than three sets of injection wounds visible at a time. Injecting underground parts avoids the problem of visible injection marks, but it produces slower and less complete crown coverage, is prohibitively expensive and damages ground landscaping such as lawns, curbing, and pavement.

Since there is as yet no cure for Dutch elm disease, preservation of American Elm depends on several preventive measures which must be applied on a yearly basis (Sinclair and Campana, 1978). At this time, shallow-pit injection figures strongly in this arsenal which includes newer and more effective fungicides, fertilizing, pruning, and insecticide sprays. Clearly such attention can only be paid to exceptional trees such as those with historical, aesthetic, or other values. For them, the prognosis has never been brighter.

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CYTOTAXONOMIC STUDIES OF *PIPTOCARPHA* SUBGENUS *HYPERICOIDES* (COMPOSITAE: VERNONIEAE)[1]

Gerald L. Smith[2] and Samuel B. Jones, Jr.

ABSTRACT

Chromosome numbers of $2n = 34$ and karyotypes of five species of *Piptocarpha* from southern Brazil are reported for the first time. The chromosome number of $2n = 34$ is the same as that for many of the species of *Vernonia* from the New World. The karyotypes are suggestive of an infrageneric classification of *Piptocarpha* based upon exomorphology and leaf flavonoids. These first reports are for *Piptocarpha quadrangularis, P. lundiana, P. sellowii, P. axillaris,* and *P. macropoda.*

Key Words: *Piptocarpha,* chromosome numbers, karyotypes, Brazil

The tribe Vernonieae is least known cytologically of any tribe in the Compositae (Turner, 1977). Although chromosome numbers have been reported for less than 25% of the genera, significant cytological information for *Vernonia* has been reported by Jones (1977, 1979). The Old World vernonias are dibasic with $x = 9$ or $x = 10$ and have polyploids of $n = 18$, 20, and 30. The New World vernonias have a base number of $x_a = 17$ and are assumed to represent ancient polyploids, derived from a base of $x = 9$ doubled to 18, followed by aneuploid reduction to 17. Polyploid series of $n = 34$, 51, and 68 have been reported in some Latin American species of *Vernonia.*

An alternative to Jones' hypothesis for the origin of the New World base number has been proposed by Turner (1981). His work on primitive vernonias in southern Mexico and Central America has shown that two of these species have $n = 19$ chromosomes. These observations suggested to Turner that $x = 17$ was derived from $x = 10$ doubled to 20, followed by aneuploid reduction to 17 or by amphiploid origin of $x = 9 + 10$, followed by reduction.

Turner considered his hypothesis to be more reasonable in light of

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[1] Based on a Ph.D. dissertation submitted by the senior author.

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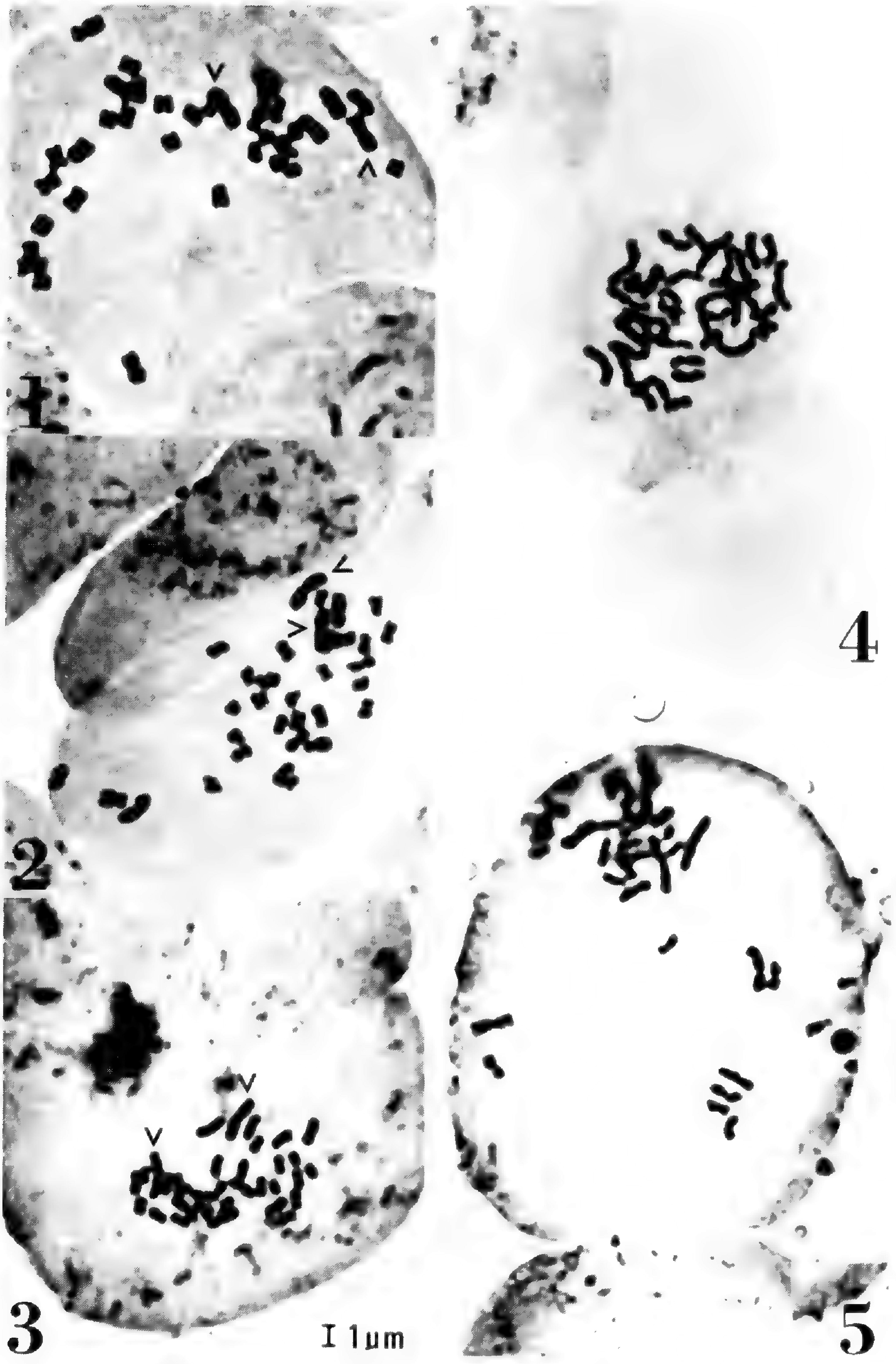
Table 1. Chromosome number determinations in *Piptocarpha* from Brazil.

Taxon	Count $2n =$	Location and Voucher Data
P. quadrangularis (Conc. Vell.) Baker	34 + 2B	Rio de Janeiro: Pocas das Antas Biological Reserve, Silva Jardim, *Araujo s.n.* (GA)
P. lundiana (Less.) Baker	34	Rio de Janeiro: Rio de Janeiro, near Jardim Botânico, *G. L. Smith 1112* (GA)
P. sellowii (Schultz-Bip.) Baker	34	Paraná: Porto Britania, Mun. Mal Candido Rondor, *Hatschbach 44000* (GA, MBM)
P. axillaris (Less.) Baker	34	Paraná: Serra São Luis, Mun. Balsa Nova, *G. L. Smith et al. 1105* (GA)
P. macropoda (DC.) Baker	34	Rio de Janeiro: Rio de Janeiro, Estrado Alto da Boa Vista, Tijuca National Forest, *G. L. Smith 768* (GA)

his new findings, but until cytological information is available for primitive *Vernonia* groups and other Vernonieae genera in South America, it may be premature to favor one hypothesis over another. In connection with a taxonomic revision of *Piptocarpha* and field work in southern Brazil, it became possible to obtain achenes to study the genus cytologically. There have been no previous chromosome reports for *Piptocarpha*.

MATERIALS AND METHODS

Greenhouse accessions of *Piptocarpha* were grown from achenes collected in southern Brazil. Methods of collecting, treating, fixing, and staining chromosomes were those followed by Flory and Smith (1980). Actively growing root tips were collected around noon on sunny days, placed directly in 0.2% colchicine for two hours, and fixed in Carnoy's solution (absolute ethanol: glacial acetic acid, chloroform, 3:1:1, v/v) overnight or longer. Following fixation the root tips were squashed after softening in 1 N HCl for ten minutes. Mitotic-metaphase divisions were photographed, and the chromosomes in at least two cells where they were reasonably spread were measured using a scale in camera lucida. Slides were made permanent by mounting in Euparal.



Figures 1–5. Somatic chromosomes of five southern Brazilian species of *Piptocarpha* with $2n = 34$. 1–3, Scandent species: **1.** *P. quadrangularis,* **2.** *P. lundiana,* **3.** *P. sellowii;* 4, 5, Tree species: **4.** *P. axillaris,* **5.** *P. macropoda.*

An index value indicating the relative position of the centromere was determined for each chromosome by dividing the length of the short arm by total length of both arms. An index value of 0.50 indicates an exactly median centromere. The lower the index value, the closer the centromere is to a chromosome end.

RESULTS AND DISCUSSION

Chromosome number determinations for five species of *Piptocarpha* are given in Table 1. Photomicrographs of the chromosomes of each species are shown in Figures 1–5. Efforts were made to obtain living material of all forty-four species of *Piptocarpha,* but because of difficulties in travel and inaccessibility of plants, our efforts were severely restricted. We were able to bring five species into cultivation. We realize the data are limited by the number of taxa sampled. However, we believe that information presented is representative of the major morphological types in the twenty species of subgenus *Hypericoides,* and therefore some general trends can be inferred.

Although the chromosomes are relatively small, differences in their size and morphology were detected. These differences are most striking between the scandent species, *Piptocarpha quadrangularis* (Conc. Vell.) Baker, *P. lundiana* (Less.) Baker and *P. sellowii* (Schultz-Bip.) Baker, (section *Macrolepideae)* (Figures 1–3), and the tree species, *P. axillaris* (Less.) Baker and *P. macropoda* (DC.) Baker, (section *Platycephalae*) (Figures 4, 5). The data support the classification of the scandent species and tree species in separate sections (Smith, 1984, Ph.D. dissertation, University of Georgia, Athens). The karotypes show that the chromosomes are generally uniform in each section.

Each of the scandent species has two metacentric chromosomes that are ca. 4 μm in length. They are indicated by arrows in the figures. This distinctive chromosome pair is the largest of the complement. The other chromosome pairs range from short metacentric, short submetacentric, and short acrocentric to extremely short metacentric and extremely short acrocentric.

The tree species, in contrast to the scandent species, have several comparatively large chromosome pairs which occur as medium metacentric and medium submetacentric. Further, they have some of the smaller chromosome types of the scandent species but lack the extremely short metacentric type.

Karyotypes of the five species of *Piptocarpha* in subgenus *Hypericoides* examined here are distinctly asymmetrical. Because the predominant trend in flowering plants is assumed to be toward increasing chromosome asymmetry (Stebbins, 1971), these karyotypes in *Piptocarpha* are believed to be derived. Supporting this idea is a number of morphological features in *Piptocarpha* (e.g., scandent growth habit for many of its species, axillary glomerules, stellate trichomes, small cream-colored corollas, caudate anther bases) which are considered specialized. This and other information now available for *Piptocarpha* suggest that subgenus *Hypericoides,* if not the entire genus, is advanced and derived from an ancestral *Vernonia*-like line (Smith, 1984, Ph.D. dissertation, University of Georgia, Athens).

Further cytological work is needed to obtain chromosome counts and karyotypes of representative species in subgenus *Piptocarpha* found predominately in northern South America. Karyotypes of species in subgenus *Piptocarpha* which are unknown cytologically and additional cytological information on subgenus *Hypericoides* should provide important information in understanding the systematics of *Piptocarpha.*

ACKNOWLEDGMENTS

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CYTOGEOGRAPHIC STUDIES ON NORTH AMERICAN ASTERS. III. ASTERS OF SOUTHERN ONTARIO

JERRY G. CHMIELEWSKI[1]

ABSTRACT

Chromosome numbers for individuals from 222 populations of *Aster* representing 8 species *(A. ciliolatus, A. cordifolius, A. laevis, A. macrophyllus, A. ontarionis, A. oolentagiensis, A. puniceus, A. urophyllus)* were determined. Sampling was concentrated in the area formerly occupied by Ontario Island. None of the taxa was represented by more than one cytotype for any of the Ontario populations.

Key Words: *Aster*, cytogeography, Ontario

INTRODUCTION

To date, the southern Ontario distribution of cytotypes in two aster taxa, *Aster lanceolatus* (Chmielewski & Semple, 1983) and *A. pilosus* (Semple, 1978) have been determined to be influenced by Ontario Island (Chapman & Putnam, 1966). Polyploids were not found in this area for the two common virguloid asters, *Virgulus ericoides* and *V. novae-angliae* (Chmielewski & Semple, 1985). The present study examines the distribution of cytotypes in eight asters which occur commonly in southern Ontario: *Aster ciliolatus, A. cordifolius, A. laevis, A. macrophyllus, A. ontarionis, A. oolentagiensis, A. puniceus* and *A. urophyllus*. Previously published chromosome counts and new reports were both used for this purpose.

MATERIALS AND METHODS

Chromosome counts were made from freshly prepared material following the procedures of Chmielewski and Semple (1983). Roottips were taken from transplanted rootstocks of plants collected in the wild. Mitotic metaphase-stage cells were examined to determine

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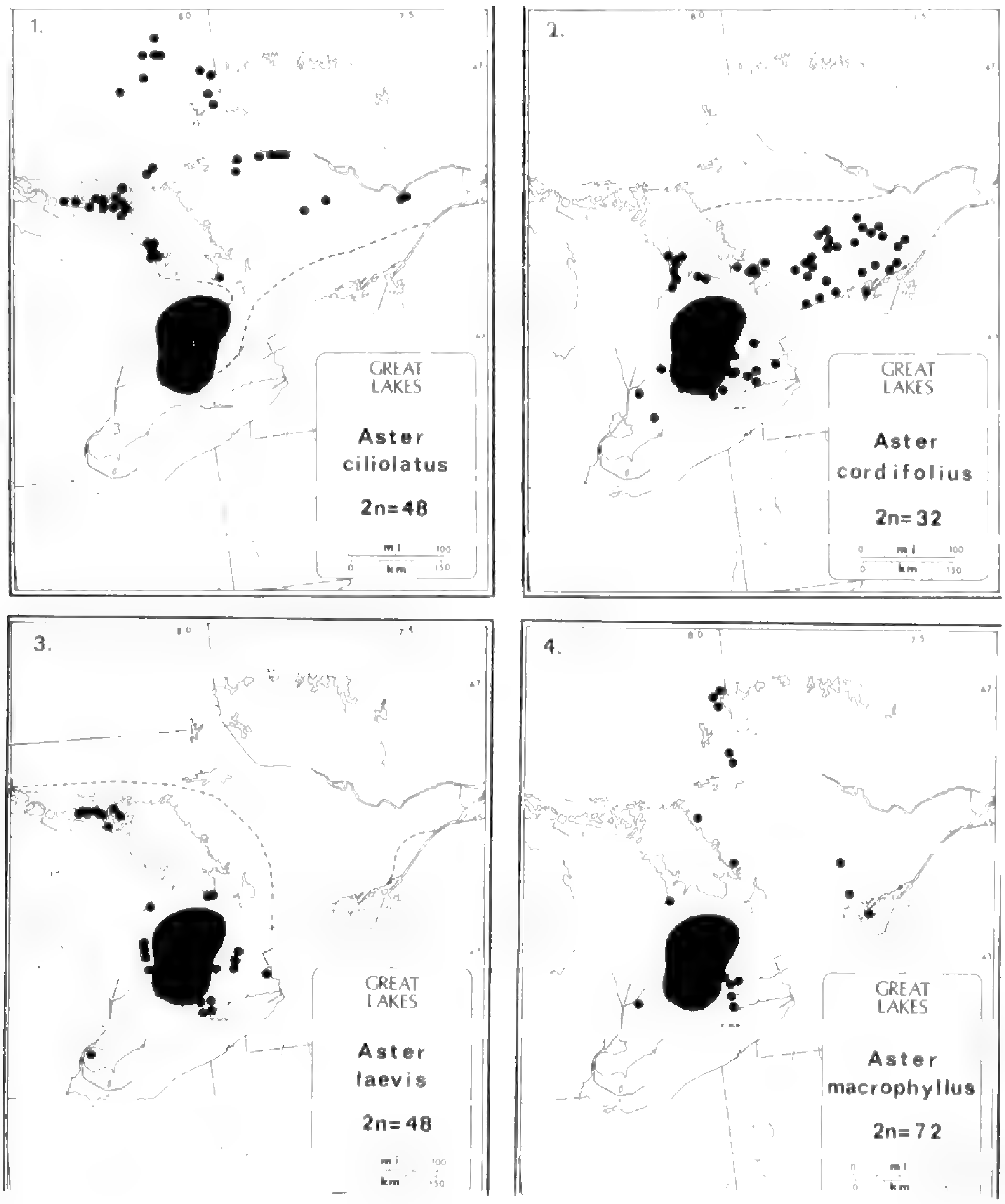
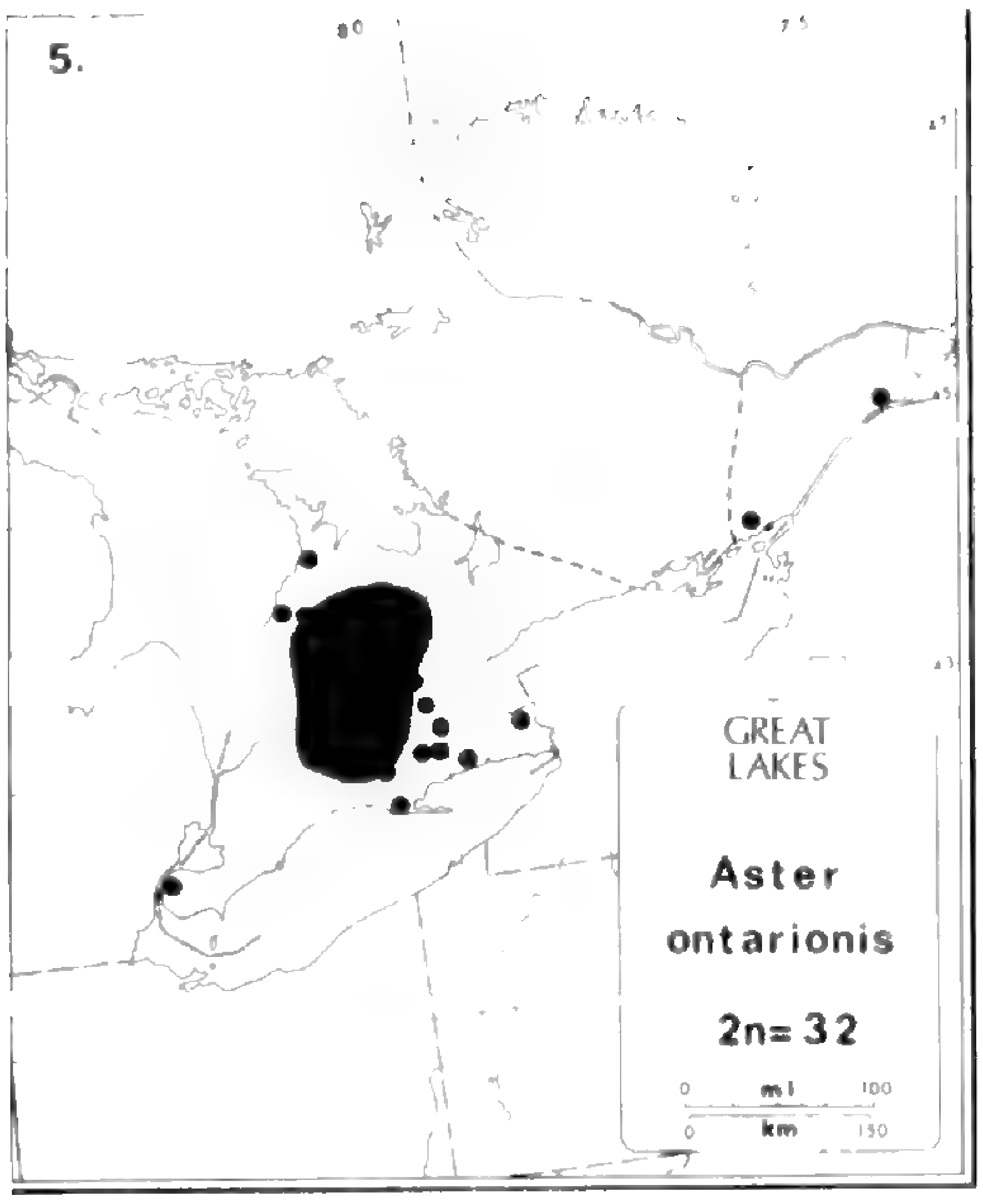


Figure 1–8. Cytogeography of asters in southern Ontario. **1.** *Aster ciliolatus* **2.** *A. cordifolius* **3.** *A. laevis* **4.** *A. macrophyllus* **5.** *A. ontarionis* **6.** *A. oolentagiensis* **7.** *A. puniceus* **8.** *A. urophyllus.* The shaded area in southern Ontario indicates the approximate limits of Ontario Island. The broken line indicates a taxon's northern or southern range in Ontario.

5.



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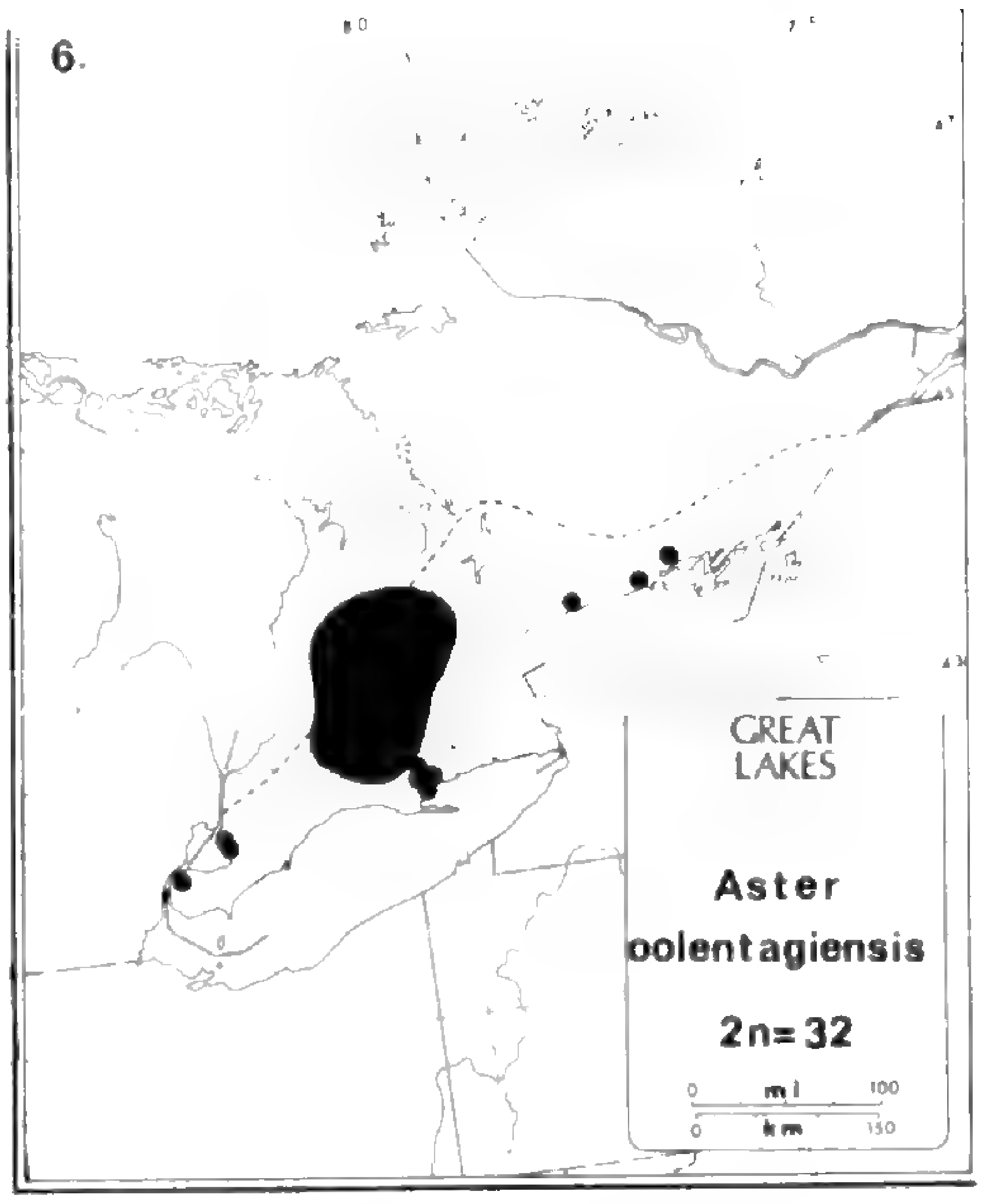

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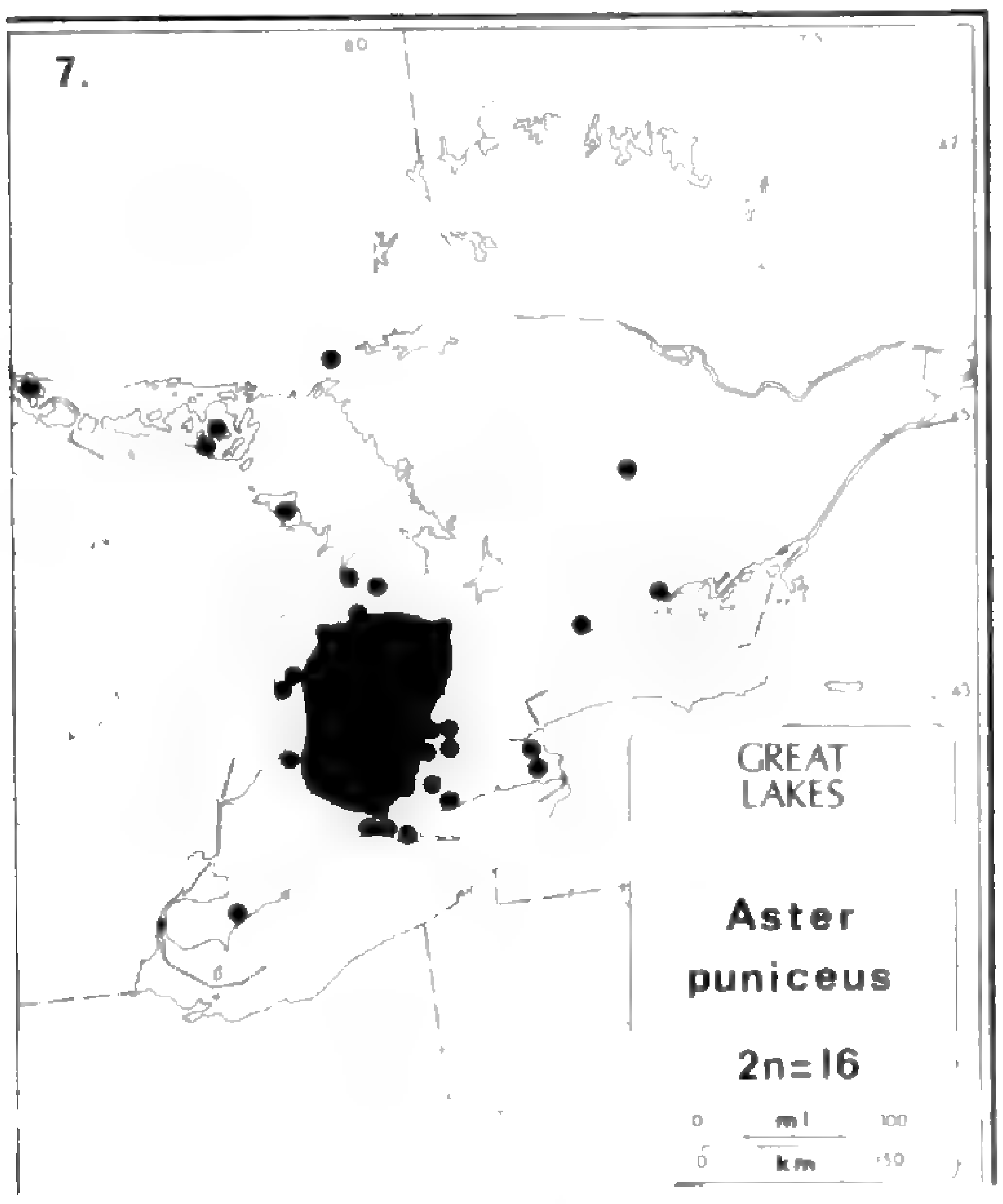

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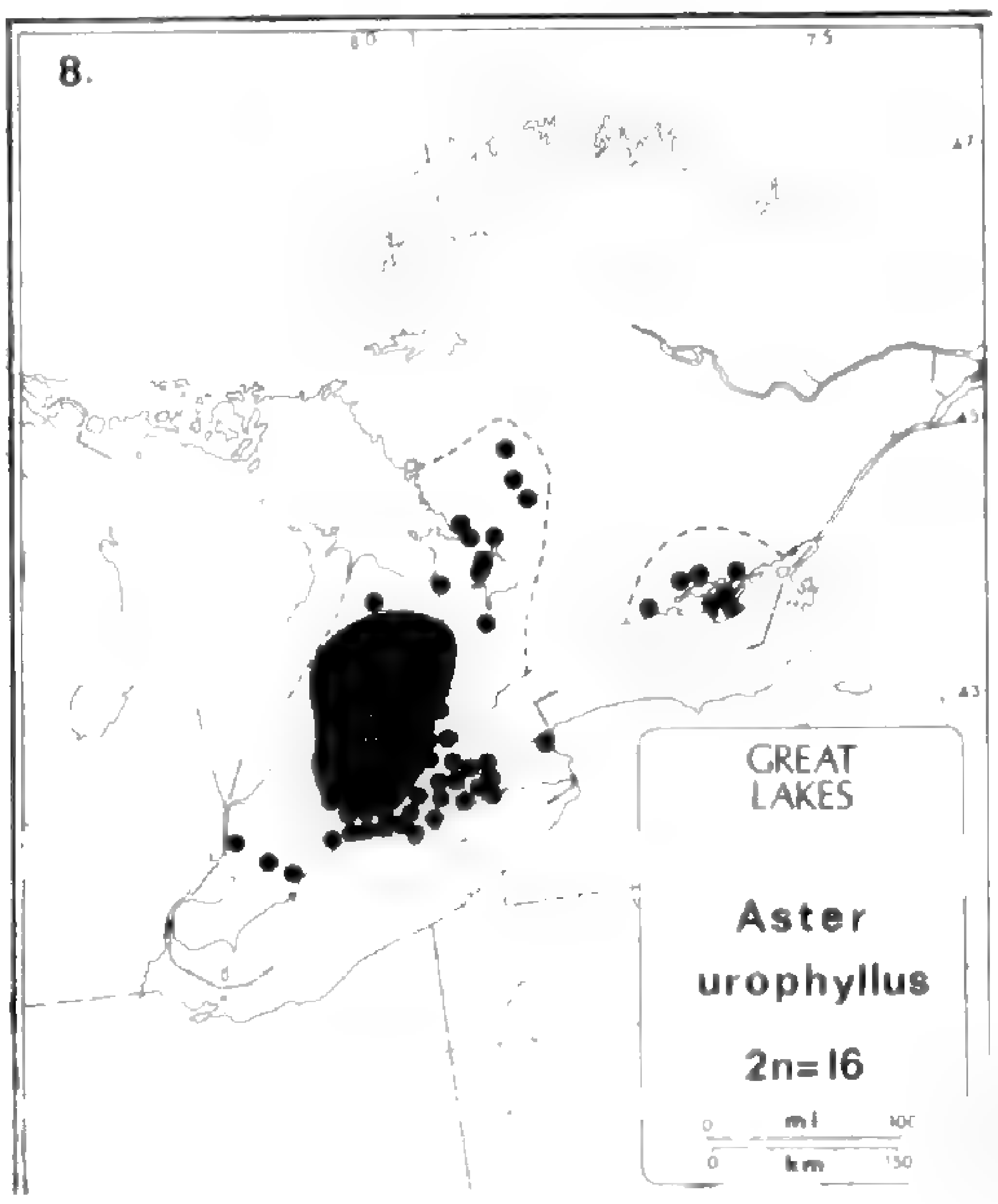

the chromosome number of each individual. Voucher specimens are deposited in WAT. Copies of detailed population locations have been submitted to the Depository of Unpublished Data[1], and are not listed in this paper.

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[1] Copies of the detailed population locations may be purchased from the Depository of Unpublished Data, CISTI, National Research Council of Canada, Ottawa, Ontario, Canada. K1A 0S2

RESULTS AND DISCUSSION

Chromosome number determinations for 222 individuals representing 8 species of *Aster* are reported. The distribution of cytotypes in southern Ontario for the respective taxa, are shown in Figures 1–8. The new reports are in agreement with previous determinations for all taxa from southern Ontario populations.

Although more than one cytotype has been previously reported for *Aster ciliolatus, A. cordifolius, A. laevis, A. puniceus* and *A. urophyllus* (= *A. sagittifolius*) (Semple & Brouillet, 1980), none of these taxa is represented by more than one cytotype in southern Ontario. However, Brouillet (1981, Ph.D. thesis, U. of Waterloo, Ontario, Canada) concluded that *Aster ciliolatus* and *A. laevis* are represented by only the hexaploid cytotype, other reports being in error. *Aster macrophyllus* has been consistently reported to be octoploid, whereas *A. ontarionis* and *A. oolentagiensis* (= *A. azureus*) have been consistently reported to be tetraploid (Semple & Brouillet, 1980). The present study confirms these previous findings. Apparently the factors that led to multiple cytotypes for some asters in the region of Ontario Island have not influenced the creation or distribution of polyploids in the above taxa as they occur in southern Ontario.

ACKNOWLEDGMENTS

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SYNOPSIS OF *DELPHINIUM* (RANUNCULACEAE) IN CONTINENTAL MÉXICO

MICHAEL J. WARNOCK

ABSTRACT

The Mexican species of *Delphinium* are examined; included are fifteen taxa of fourteen species (two subspecies of *D. bicornutum* Hemsley). One cultivated species (*D. ajacis* L.) native to Europe, and three species (*D. andesicola* Ewan, *D. scaposum* Greene and *D. wootonii* Rydberg) not yet found in México are included. Proximity of the present ranges of these latter three species on the north side of the United States—México border and presence of suitable habitat in adjacent México warrants their treatment here.

Key Words: *Delphinium*, larkspurs, Ranunculaceae, systematics, México

INTRODUCTION

Delphinium is well known as a genus with many morphologically similar species; complicating the similarity of species to one another, many of these taxa show wide ranges of variability within and between their natural populations. *Delphinium* species of México exemplify these problems, and their classification is further complicated by the fact that most of them occur in remote mountainous areas which have been only sparsely collected. Previous attempts to delimit the Mexican taxa of *Delphinium* were by Hemsley (1879), Huth (1895) and Ewan (1945). Hemsley described four new species from central and southern México but had precious little material (single collections for each taxon) to work with. Huth, also with little material, re-ordered Hemsley's classification, included several species described in the time between the two studies, and described one new species and one new variety. By the time Ewan (1945) monographed the North American species of *Delphinium*, more herbarium material was available (thanks mainly to the extensive collections of Pringle and Hinton), but Ewan formed his opinions based on as few as two or three collections of several taxa and not more than fifteen of any taxon from México. Ewan's classification generally followed that of Huth, except for making one change in rank, including three taxa recognized in the intervening years, and circumscribing three new species.

Now, with many of the preferred habitats of *Delphinium* in México becoming more accessible by motor vehicle (including dirt roads and relatively short hikes of ten km or less), the amount of material in various herbaria has grown considerably. This work is a re-evaluation of the systematics of Mexican *Delphinium* based on analysis of morphological structure by study of herbarium sheets and field populations, involving extensive analysis of morphology, population structure and ecology. Laboratory analyses of chromosome number and flavonoid chemistry were completed for most taxa.

As is evident by looking at the lists of specimens given for each taxon, several taxa still have not been extensively collected. Therefore, gaps exist in the ranges of some of these species. It remains to be seen whether these gaps are real or simply artifacts because of lack of collections from various regions of México. Many parts of the country remain inaccessible to those botanists without the considerable time and resources required to reach them. In a few cases, where I thought it appropriate, I have noted disjunctions and suggested areas where a taxon may be found in the future.

Many subgenera, sections, and series have been suggested for *Delphinium* in North America (Ewan, 1945; Huth, 1895; Nelson, 1925; Rydberg, 1917) but most have not been validly published. Ewan's (1945) epithets were not intended as formal names when he published them. Huth (1895) misapplied the term "Tribus" as a subgeneric category (although his sectional epithets are valid). Neither Nelson (1925) nor Rydberg (1917) provided circumscriptions or references for the sources of their infrageneric epithets. Valid infrageneric epithets (in addition to Huth's sections) have been published by Ewan (1936; 1942) and Warnock (1984). Comments as to the subgeneric status of each taxon treated here are found under the heading of salient taxonomic characters for each taxon. All Mexican species that were known to Huth [*D. bicornutum, D. carolinianum* (as *D. azureum*), *D. pediatisectum, D. scaposum, D. viride* and *D. wislizeni*] were included in section *Diedropetala*. The section is distinguished by presence of 3 carpels, separate petals, perennial plants, distinctly bifid lower petals, and upper petals and sepals of different colors. Section *Diedropetala* includes nearly all North American species known in 1895 and many

Eurasian species. At least provisionally, all native taxa treated here (only *D. ajacis* is excluded) are considered to be part of section *Diedropetala. Delphinium ajacis* remains in section *Consolida* (Huth, 1895).

TAXONOMY

Delphinium L. Sp. Pl. 530. 1753. TYPE: *Delphinium consolida* L. *Delphidium* Raf., Amer. Monthly Mag. & Crit. Rev. 3: 356. 1818. *Plectrornis* Raf., Med. Fl. II. 216. 1830. *Delphinastrum* Spach., Hist. Nat. Veg. 7: 336. 1839.

Annual or perennial herbs. Leaves alternate, more or less dissected; present or absent at anthesis, blades usually reduced upward. Inflorescences racemose. Flowers perfect, usually protandrous, calyx zygomorphic, of 5 separate sepals; uppermost sepal forming a more or less elongate spur, lateral and lower pairs of sepals more or less uniform in size and shape. Corolla zygomorphic, of 2 or 4 petals; pair of upper, nectariferous petals always present, sometimes partially fused, protruding into the spurred sepal; lower pair present in most perennial species, clawed. Stamens numerous, spirally arranged, maturing centripetally, filaments widened near the base, flattened against the carpels, anthers basifixed. Carpels 1 or 3 (–5), superior, free, uni-loculate and styles single. Fruits follicles. Chromosome numbers: $n = 8, 9, 16, 24, 32$.

ARTIFICIAL KEY TO TAXA

1. Carpels single; petals two, plants annual .... **1.** *D. ajacis.*
1. Carpels three (rarely four or five); petals four; plants perennial .... 2.
  2. Stems multiple from a single rootstock.................. 3.
  2. Stems solitary (or in twos or threes) .... 4.
    3. Stems glabrous below, densely puberulent in the inflorescence; sepals turning brown shortly after anthesis; restricted to high elevations of Nuevo León... **2.** *D. valens.*
    3. Stems glaucous to glabrous throughout; sepals purple during entire flowering period; possible at high elevations in northwestern Chihuahua and northeastern Sonora .... **3.** *D. andesicola.*
    4. Pedicels appressed-parallel with rachis of the inflorescence for most of their length; cells of seed coat aggregated into overlapping scales .... 5.

4. Pedicels immediately divergent from the rachis of the inflorescence (although often later parallel); cells of seed coat otherwise . . . . 7.
  5. Leaves distinctly tripartite; plants of sandy plains of lower Río Grande Valley . . . . **4.** *D. carolinianum* ssp. *vimineum.*
  5. Leaves typically with multiple, narrow segments; plants of rocky hills . . . . 6.
    6. Sepals blue; plants of limestone hills; Nuevo León and Coahuila . . . . **5.** *D. madrense.*
    6. Sepals white to lavender; plants of granite hills and nearby washes; northwestern Coahuila, northern Chihuahua and northern Sonora . . . **6.** *D. wootonii.*
  7. Spring flowering, anthesis March to July . . . . **7.** *D. scaposum.*
  7. Fall flowering, anthesis August to January . . . . 8.
    8. Sepals yellow . . . . **8.** *D. viride.*
    8. Sepals blue or purple . . . . 9.
      9. Leaves finely dissected into 15 or more segments. . . . . 10.
      9. Leaves less dissected, rarely more than 10 segments. . . . . 11.
        10. Racemes open, pedicels more than 1.5 cm long; usually fewer than 5 cauline leaves . . . . **9.** *D. wislizeni.*
        10. Racemes narrow, pedicels often less than 1.5 cm long; usually more than 5 cauline leaves . . . . **10.** *D. tenuisectum.*
        11. Upper petals less than 21 mm long . . . . 12.
        11. Upper petals more than 21 mm long . . . . 14.
          12. Leaves strictly with 7 or fewer segments; Oaxaca only . . . . 13.
          12. Leaves with 5–14 segments; widespread . . . . **11.** *D. pedatisectum.*
            13. Leaf blades glabrous or nearly so; petals never apically white . . . . **12.** *D. bicornutum* ssp. *bicornutum.*
            13. Leaf blades and petioles pubescent; petals often apically white . . . . **13.** *D. bicornutum* ssp. *oaxacanum.*

14. Inflorescence bracts foliaceous, at least those subtending the lower flowers; basal leaves often absent at anthesis .... **14.** *D. subscandens.*

14. Inflorescence bracts small, inconspicuous; basal leaves often present at anthesis .... **15.** *D. calcar-equitus.*

1. **Delphinium ajacis** L., Sp. Pl. 531. 1753. Type: A lectotype for *D. ajacis* has been designated by Molero and Blanché (Anales. Jard. Bot. Madrid 41: 217; 1984) in the Burser Herbarium (UPS). I have not seen the lectotype. Authentic material may also be present in the Linnaean and Clifford Herbaria. Inasmuch as a lectotype has been designated and I have not seen material in the Linnaean or Clifford Herbaria, I must accept the authenticity of the lectotype. Considerable disagreement exists as to the application of the name *D. ajacis.* However, since this is the epithet currently in common use for the taxon in México, and I do not have access to the type material, I will use *D. ajacis* for the species discussed below.

Annual herb, 3–10 dm tall, stem solitary, glabrous to very finely puberulent, from a branched or unbranched taproot. Basal and lower cauline leaves withered before anthesis; cauline leaves pinnately 3–5-fid, leaflets finely palmately divided, segments nearly filiform; blades rhomboid to sagittate, 2–5 cm long, 4–7 cm wide, petioles 0.0–4.5 cm long. Flowers 25–60, on a branched or unbranched narrow raceme, pedicels short (9–35 mm long); bracteoles subopposite to opposite, 3–4 mm long, 3–8 mm below receptacle. Sepals purple to pink or white; spur 15–18 mm long; lateral sepals 10–15 mm long, 7–12 mm wide, apically rounded; lower sepals 10–16 mm long, 4–7 mm wide, very narrow basally, acutish apically. Upper petals fused, clavate, 27–34 mm long, 6–10 mm wide, subapical cleft absent to very shallow; lower petals absent. Follicles single, 10–17 mm long, 3–6 mm wide, finely pubescent; $n = 8, 16$.

Salient taxonomic characters. Highly dissected, pinnately compound leaves, single carpel, annual habit and presence of only two petals (lower petals absent). *Delphinium ajacis* (and the other unicarpellate species) are often segregated into the genus *Consolida.*

Distribution and habitat. Cultivated. Native to Europe, grown commonly in North and Central America as an ornamental and frequently escaped. Waste areas, old homesites, etc. Flowering mostly in spring but in any time of the year in areas without frost.

Representative specimens. **México.** OAXACA: ruderales, cultivadas y silvestres del poblado Guelatao, 20 Dec 1972, *García et al. 426* (CHAPA). QUERÉTARO: 1850 m, 1910–1913, *Aguiel 10488* (ILL, NY, SS). SAN LUIS POTOSÍ: 1900 m, campo abandonada, San Luis Potosí, 1 May 1959, *Rzedowski 10361* (ENCB). TAMAULIPAS: 10 mi E International Hiway, by the Ribereña Road, sandy silt, 17 Apr 1962, *Escalante 50* (TEX).

2. **Delphinium valens** Standl., Publ. Field Mus. Nat. Hist., Bot. Ser. 17: 245. 1937. Type: México. Nuevo León, Galeana, peak of Cerro Potosí, upper pine woods, 21 Jul 1935, *Muller 2264*. (Holotype: F!; isotypes: MO!, TEX!).

Delphinium disjunctum Ewan, Nat. Hist. Misc. 61: 2. 1951. Type: México. Nuevo León, Zaragoza, 15 mi W Dulces Nombres, Cerro del Viejo, 2500 m, along small rivulet on limestone outcrops, 19 Aug 1948, *Meyer & Rogers 3019*. (Holotype: MO!; isotype: MO!).

Perennial herb, 6–15 dm tall, several glaucous, glabrous or rarely sparsely puberulent stems from a large, woody fibrous rootstock, stems becoming densely puberulent in the inflorescence. Basal and lower cauline leaves absent at anthesis, cauline leaves cordate to semicircular, palmatisect, 4–12 cm long, 5–14 cm wide, glabrous to finely puberulent; petioles 1.5–13.0 cm long. Flowers numerous (25–100+), more or less densely packed on a wide, elongated or stout, often branched raceme, pedicels spreading, 8–19 (–27) mm long; bracteoles linear-lanceolate, 4–12 mm long, opposite to subopposite. Calyx narrowly opened, sepals very dark purple, quickly fading to brown, spur 7–11 mm long; lateral sepals 8–11 mm long, 3.5–5.0 mm wide, apical one-third of sepals usually densely puberulent with yellow trichomes; lateral sepals similar. Upper petals 14–16 mm long, 2.5–4.0 mm wide, apex cleft 0–1 mm deep, upper petals purple; lower petals very dark purple, 8–11 mm long, 3.0–3.5 mm wide, cleft 1–2 mm deep, blade sparsely covered with straight yellow trichomes. Follicles 12–18 mm long, 4–5 mm wide, erect, glabrous, 10–19 seeded. Seeds lunate to narrow pyramidal, 2.2–4.2 mm long, 1.2–2.0 mm wide, dark brown to nearly black, seed coat more or less undulate. Chromosome number unknown.

Salient taxonomic characters. *Delphinium valens* is distinguished by multiple stems from a single root, fading of sepal color, inflorescence structure, sepal arrangement, dense pubescence in inflorescence on an otherwise glabrous stem and yellow puberulence at the edges of the sepal apices. *Delphinium valens* was included by Ewan (1945) in his provisional Racemibracteate Series (distinguished by brownish flowers, crowded raceme, and timberline habitat). Both species in that series (the other is from New Mexico and Colorado) are probably better treated as specialized members of his provisional Ceratophylloid Series (characterized by finely palmatisect leaves).

DISTRIBUTION AND HABITAT. Subalpine forests and krummholz areas of Cerro Potosí, Peña Nevada (Figure 1) and nearby high elevation ridges (above 3000 m). Recently found in the high mountains of southeastern Coahuila. *Pseudotsuga-Pinus* forest and above. Flowering June to August.

REPRESENTATIVE SPECIMENS. **México.** COAHUILA: Municipio de Arteaga, S el Coahuilon, 3290 m, pine forest, 23 Jun 1985, *Hinton et al. 18883* (TEX). NUEVO LEON: Cerro Potosi, 24°53′30″ N, 100°10′30″ W, subalpine meadow, 11,500 ft, 19 Jun 1966, *Gilbert 39* (TEX); Galeana, Cerro Potosí, pine forest, 3700 m, 25 May 1969, *Hinton 17043* (TEX); Galeana, Cerro Potosí, clearing in pine forest, 3650 m, 22 June 1969, *Hinton 17128* (TEX); above sharp bend in road, 2.6 mi above microwave station, Cerro Potosí, humusy soil on slope, 2 Aug 1975, *Lewis 114* (TEX 2); Cerro Potosí, near microwave tower, ca. 9000 ft, open forested area, shaded moist bank, 8 Jul 1963, *McGregor et al. 311* (TEX, US); ca. 20 mi NE Galeana, ascent of Cerro Potosí by N hogback, upper forest, 23 Jul 1934, *Mueller & Mueller 1233* (F, TEX); near microwave tower, Cerro Potosí, pine forest, Sep 1970, *Norris 17629* (MO); near Galeana, near summit of Cerro Potosí, 11,000 ft, 16 Jul 1945, *Sharp 45752* (GH, MEXU, TENN); ca. 18 mi W Dieciocho de Marzo, summit of Cerro Potosí, 20 Oct 1979, *Warnock 2005* (TEX). TAMAULIPAS: very summit of Peña Nevada, limestone outcrops, 5 Jul 1961, *Gillett 1242* (TEX).

3. **Delphinium andesicola** Ewan, J. Wash. Acad. Sci. 29: 476. 1939. TYPE: UNITED STATES. Arizona, Cochise Co., Chiricáhua Mts., Barfoot park, *Blumer 136.* (HOLOTYPE: ARIZ!; ISOTYPE: ARIZ!).

Perennial herb, 6–24 dm tall, several glaucous to glabrous stems from a large, woody, fibrous rootstock. Basal and lower cauline leaves absent in anthesis, cauline leaves cordate to semicircular, palmatisect, 5–8 cm long, 5–12 cm wide, glabrous to finely puberulent; petioles 1–15 cm long. Flowers numerous (20–80), on a seldom branched raceme; pedicels spreading-ascending, 7–35 mm long; bracteoles linear-lanceolate, somewhat scarious margined, 3–6 mm long, 1–3 mm below the receptable. Sepals dark purple, spur 10–13 mm long; lateral sepals 9–12 mm long, 5–7 mm wide, lower sepals somewhat narrower. Upper petals 16–21 mm long, 2.5–4.0 mm wide, the apical cleft 0.0–0.5 mm deep; upper petals white near the nectary, dark purple apically; lower petals 8–12 mm long, 2.0–3.5 mm wide, apical cleft 1.5–2.5 mm deep, blades hirsute with long white trichomes, lower petals dark purple. Follicles 12–15 mm long, 3–4 mm wide, erect, glabrous to sparsely puberulent, 8–14 seeded. Seeds black or dark brown, lunate, 2.5–3.5 mm long, 1.5–2.5 mm wide, appearing striate, cells of seed coat evenly covered with a waxy substance, this substance also forming knobby structures in addition to the waxy coating; $n = 8$.

SALIENT TAXONOMIC CHARACTERS. *Delphinium andesicola* is characterized by multiple, completely glabrous stems from a single root, dark purple flowers and elongate inflorescnece. This sepcies was included by Ewan in his provisional Ceratophylloid Series.

DISTRIBUTION AND HABITAT. Meadows of upper montane *Pinus-Pseudotsuga* forests (2500–3200 m). Locally common in Pinaleño, Huachuca and Chiricáhua Mountains of southeastern Arizona (Figure 1). To be expected in mountains on the Chihuahua-Sonora border, near Arizona. Flowering July to September.

REPRESENTATIVE SPECIMENS. **United States.** ARIZONA: Cochise Co.: Cochise National Forest, Rustler's Park, 8400 ft., subalpine meadow, 27 Sep 1944, *Barkley 14585* (TEX); Huachuca Mountains, Garden Canyon, *Harrison & Kearney 5770* (ARIZ); Coronado National Forest, Chiricáhua Mountains, Rustler Park Campground, upper slopes of meadow and woods edge, 14 Aug 1978, *Warnock 1644* (ILL, SHST, TEX); Coronado National Forest, Chiricáhua Mountains, S end of Long Park, NE facing slope, 28 Jul 1979, *Warnock 1938* (ILL); Graham Co.: Coronado National Forest, Pinaleño Mountains, 15.1 mi W Jct Rt 366 and US 666 on 366, steep E facing slope, 17 Sep 1981, *Warnock 2318* (ILL 2, TEX 2); Pima Co.: Stone Cabin Canyon, 15 Jul 1903, *Thornber s. n.* (ARIZ).

4. **Delphinium carolinianum** Walter ssp. **vimineum** (D. Don) Warnock, Syst. Bot. 6: 49. 1981. Basionym: *Delphinium vimineum* D. Don *ex* Sweet, Brit. Fl. Gard. ser. 2 p. 374. 1838. TYPE: UNITED STATES. Texas (probably Brazoria Co., near Freeport), *Drummond s.n.* (HOLOTYPE: K!). *Delphinium azureum* Michx. var. *vimineum* (D. Don) Gray *ex* Davis, Minnesota Bot. Stud. 2: 445. 1900. *Delphinastrum vimineum* (D. Don) Nieuwl., Amer. Midl. Naturalist 3: 173. 1914. *Delphinium virescens* Nutt. var. *vimineum* (D. Don) Martin, Bull. Torrey Bot. Club 65: 29. 1938. The type for the following may be an isotype of *D. vimineum*.

Delphinium azureum Michaux var. "α" T. & G., Fl. N. Amer. 1: 32. 1838. TYPE: UNITED STATES. Texas, Brazoria Co., Velasco, *Drummond s.n.* (HOLOTYPE: NY!).

Perennial herb, 2–10 dm tall, stem usually solitary, glabrous to puberulent, from a single rootstock of one to eight swollen parts. Basal and lower cauline leaves usually present at anthesis, blades distinctly tripartite, further divisions usually near apices of primary segments, blades 5–9 cm wide, 3–7 cm long, abruptly reduced upward; petioles 3–15 cm long. Flowers 5–40 (–65) on a usually branched, virgate raceme, pedicels close appressed to rachis for most of their length, 4–32 mm long; bracteoles opposite to subopposite, 0.0–1.5 mm long, 1–6 mm below receptacle. Sepals blue to white, spur 9–17 mm long, lateral sepals 8–25 mm long, 3–8 mm wide; lower sepals similar. Upper petals 15–24 mm long, 1.5–3.0 mm wide, apex cleft 0.0–1.5 mm deep, white to light blue; lower petals 9–12 mm long, 3–4 mm wide, apical cleft 1.5–4.0 mm deep, blade thickly covered with long, curled, white trichomes. Follicles 10–23 mm long, 2–4 mm wide, glabrous, 9–25 seeded. Seeds brown, lunate, 1.3–2.2 mm long, 0.8–1.9 mm wide, covered with cells aggregated into overlapping scales, these in turn possessing pustulate, waxy knobs; $n = 8, 16$.

SALIENT TAXONOMIC CHARACTERS. Virgate raceme, seeds scaly, tripartite leaves, rootstocks of swollen parts and presence of benzoylated flavonol glycosides. *Delphinium vimineum* was included by Ewan in his provisional Spiciform Series (includes species with a spiciform raceme and early withering leaves). *Delphinium vimineum* was included by Huth under *D. azureum* Michx. var. *virescens* (Nutt.) Huth in his "Tribus" Erectopedunculata (includes species with multi-parted palmatisect leaves; seeds smooth to rugulose; roots grumose, and strictly erect inflorescences with appressed pedicels).

DISTRIBUTION AND HABITAT. Coastal prairies, *Prosopis* or *Quercus* scrublands, in sandy or clay soils of the Gulf Coastal Plain. Common in southern Louisiana, southeastern and southern Texas, in Mexico in the Río Grande Valley from the Gulf of México to Ciudad Acuña, 0–300 m elevation (Figure 1). Flowering February to May. Hybridizes with *Delphinium madrense* in areas of sympatry, especially on the southern edge of the Edwards Plateau in Texas.

REPRESENTATIVE SPECIMENS. **México.** COAHUILA: 2–3 mi W Díaz along railroad, Río Grande Valley, 700 ft, Apr 1900, *Pringle 8325* (F, GH, MO, ND-G, NY, PH, POM, RM, UC). **United States.** TEXAS: Cameron Co.: Rudolph, 11 Apr 1905, *Lewton 138* (US); Fort Brown, Feb 1857, *Townsend s.n.* (NY); Hidalgo Co.: near San Manuel, roadside, 19 Mar 1942, *Lundell 10832* (LL).

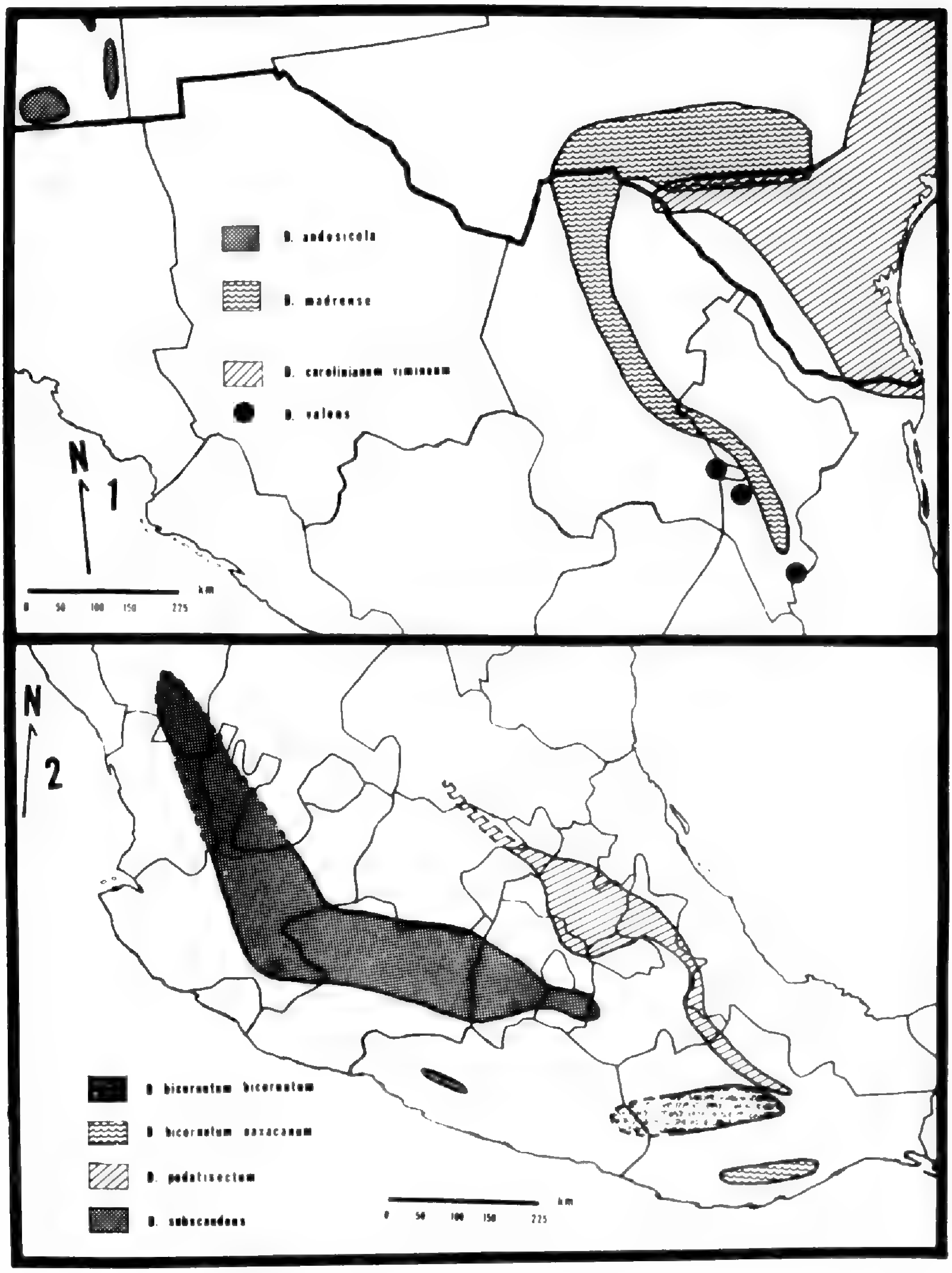
5. **Delphinium madrense** Wats., Proc. Amer. Acad. Arts 17: 141. 1890. TYPE: MÉXICO. Nuevo León, near Monterrey, Sierra Madre Oriental, *Pringle 3014*. (HOLOTYPE: GH!; ISOTYPES: F!, MEXU!).

Delphinium madrense forma *insigne* Ewan, Univ. Colorado Stud., Ser. D, Phys. Sci. 2: 165. 1945. TYPE: MÉXICO. Nuevo León, above Monterrey, Sierra Madre Oriental, 1800–3000 ft, 29 Mar and 27 Apr 1906, *Pringle 10178*. (HOLOTYPE: GH!; ISOTYPES: ARIZ!, CAS!, F!, LL!, MO!, TEX!, UC(2)!, US!).

Herbaceous perennial, 3–10 dm tall, stem usually solitary, subglabrous to puberulent, occasionally with glandular trichomes in the inflorescence, from a stout, 2–4-branched gradually tapered rootstock. Basal and lower cauline leaves usually present at anthesis, differing from other cauline leaves only in size of blade and length of petiole, blades semicircular to cordate, 2–8 cm long, 2–10 cm wide, palmatisect to 3–12 segments, segments 3–8 mm wide, blades glabrous to finely puberulent; petioles 1–26 cm long. Flowers 5–75 (–98), on a usually branched virgate raceme, pedicels strictly ascending, 7–25 (–49) mm long; bracteoles subopposite to opposite, 2–4 (–8) mm below the receptacle. Sepals dark blue to light blue, spur 10–15 (–19) mm long; lateral sepals 9–15 mm long, 5–7 mm wide, often with median stripe of lighter blue abaxially; lower sepals somewhat narrower. Upper petals 17–21 (–25) mm long, 2–4 mm wide, apex cleft 0.0–1.5 mm deep, upper petals white to white with a blue apex; lower petals blue-purple, 10–14 mm long, 3–4 mm wide, blade cleft 2–4 mm deep, blade covered with long, white, curled trichomes. Follicles 15–21 mm long, 3–4 mm wide, erect, glabrous to sparsely puberulent, 16–21 seeded. Seeds dark brown, lunate to trigonally pyramidal, 2.0–2.5 mm long, 1.2–2.0 mm wide, covered with cells aggregated into overlapping scales, these in turn possessing pustulate, waxy knobs. Chromosome number unknown.

SALIENT TAXONOMIC CHARACTERS. Virgate raceme, cells of seed coat aggregated into scales, presence of 4′-glycosylated flavonols in leaves and blue sepals. *Delphinium madrense* was treated by Huth as a species incertae sedis and by Ewan as part of his provisional Spiciform Series. This species appears closely allied with *D. carolinianum* and *D. wootonii* on the basis of morphological and chemical characters.

DISTRIBUTION AND HABITAT. Broken calcareous slopes of the northern Sierra Madre Oriental, mountains of northern Coahuila and southern Edwards Plateau in Texas (Figure 1). *Quercus* woodlands or desert scrub, 500–2000 m elevation. Flowering April to June (August). Hybridizes naturally with *Delphinium carolinianum* subspecies *vimineum* and possibly with *D. wootonii* in areas of sympatry with those taxa.



Figures 1 and 2. Maps showing geographic ranges of *Delphinium*. **1.** *D. andesicola, D. madrense, D. carolinianum* subspecies *vimineum* and *D. valens;* **2.** *D. bicornutum* subspecies *bicornutum, D. bicornutum* subspecies *oaxacanum, D. pedatisectum* and *D. subscandens.* Dashed lines represent areas where a taxon may occur but has not yet been collected.

REPRESENTATIVE SPECIMENS. **México.** COAHUILA: 25 mi NW Melchor Múzquiz, canyon of Sierra Hermosa de Santa Rosa, Jul 1963, *Latoire 16* (TEX); Múzquiz, Spring 1935, *Marsh 16* (F, TEX); Múzquiz, 12 Apr 1936, *Marsh 2157* (F, GH, TEX); 28°27′30″N 102°04″W, saddle at summit of Rincon de Maria, woodland-mattoral, 2100 m, 23 Aug 1975, *Wendt et al. 1288* (TEX); 28°28′15″N 102°02′30″W, Rincon de Maria, ca. 70 mi NW Múzquiz, 1200 m, N facing canyon, 27 Apr 1975, *Wendt & Riskind 958* (TEX). NUEVO LEÓN: Chipinque on Sierra Anáhuac, S of Monterrey, pine-oak forest, 1800 m, 14 Jun 1952, *Gould & Ortega 6350* (TEX); Villa de Santiago, near Horsetail Falls, 2500 ft, 3 Jul 1941, *Leavenworth 800* (F); ca. 15 mi SW Galeana, descent into Alamar, Sierra Madre Oriental, dense moist wood, 29 May 1934, *Mueller & Mueller 597* (F, GH, TEX); ca. 35 km SSE Monterrey, Horsetail Falls, open meadow, edge of dry woods, 600–700 m, 26 Apr 1976, *Sanders & Harborne 76080* (TEX); La Corona, Monterrey, 26 Feb 1960, *Smith M13* (TEX); near top of La Silla, Monterrey, 26 Apr 1960, *Smith M154* (TEX); just above gate to Chipinque, near La Corona, Monterrey, Apr 1961, *Smith M484* (TEX); Monterrey, 10–11 Mar 1923, *Tharp 1828* (TEX); 2.5 mi below Chipinque Lodge, S of Monterrey, steep WNW slope, oak forest, 5 Apr 1980, *Warnock et al. 2046* (ILL, MO, PAC, TEX).

6. **Delphinium wootonii** Rydb., Bull. Torrey Bot. Club 26: 587. 1900. TYPE: UNITED STATES. New Mexico, Doña Ana Co., Organ Mountains, 5000 ft, 20 Apr 1893, *Wooton s.n.* (HOLOTYPE: NY!; ISOTYPES: CAS!, GH!, ILL!, NMC!, UC!, US!). *Delphinium geyeri* Greene var. *Wootoni* (Rydb.) Davis, Minnesota Bot. Stud. 2: 446. 1900. *Delphinium virescens* Nutt. ssp. *Wootoni* (Rydb.) Ewan, Univ. Colorado Stud., Ser. D, Phys. Sci. 2: 169. 1945.

Herbaceous perennial, 15–40 (–60) cm high, stems stout, erect, often clumped, puberulent to pubescent, rootstock of several small, swollen parts. Leaves often primarily basal, finely divided, segments linear to sublinear, blades reniform or fan shaped, 2.5–4.0 cm wide, 1.5–3.0 cm long, puberulent to glabrous; petioles 4–7 cm long below, 1–3 cm long upwards on the stem. Flowers 15–49 on a rarely branched, virgate raceme, pedicels 8–36 mm long, closely appressed to the rachis for most of their length; bracteoles 0.0–1.5 mm long, 1–5 mm below the receptacle. Sepals white, slightly lavender, rarely light blue, spur 10–22 mm long, lateral sepals 8–13 mm long, 3–7 mm wide, basally cuneate, apically rounded, often reflexed; lower sepals similar, less often reflexed. Upper petals 15–25 mm long, 2.0–3.5 mm wide, apex cleft 0–1 mm deep, sometimes with a few long curled trichomes near the apex; lower petals 9–14 mm long, 3–5 mm wide, cleft 2.5–4.5 mm deep, blade covered with long, curled white trichomes. Follicles 10–24 mm long, 2.5–4.0 mm wide, erect, usually glabrous, 9–24 seeded. Seeds lunate, dark brown, 1.1–2.0 mm long, 0.8–1.8 mm wide, covered with cells aggregated into overlapping scales, these in turn possessing pustulate, waxy knobs. $n = 8$.

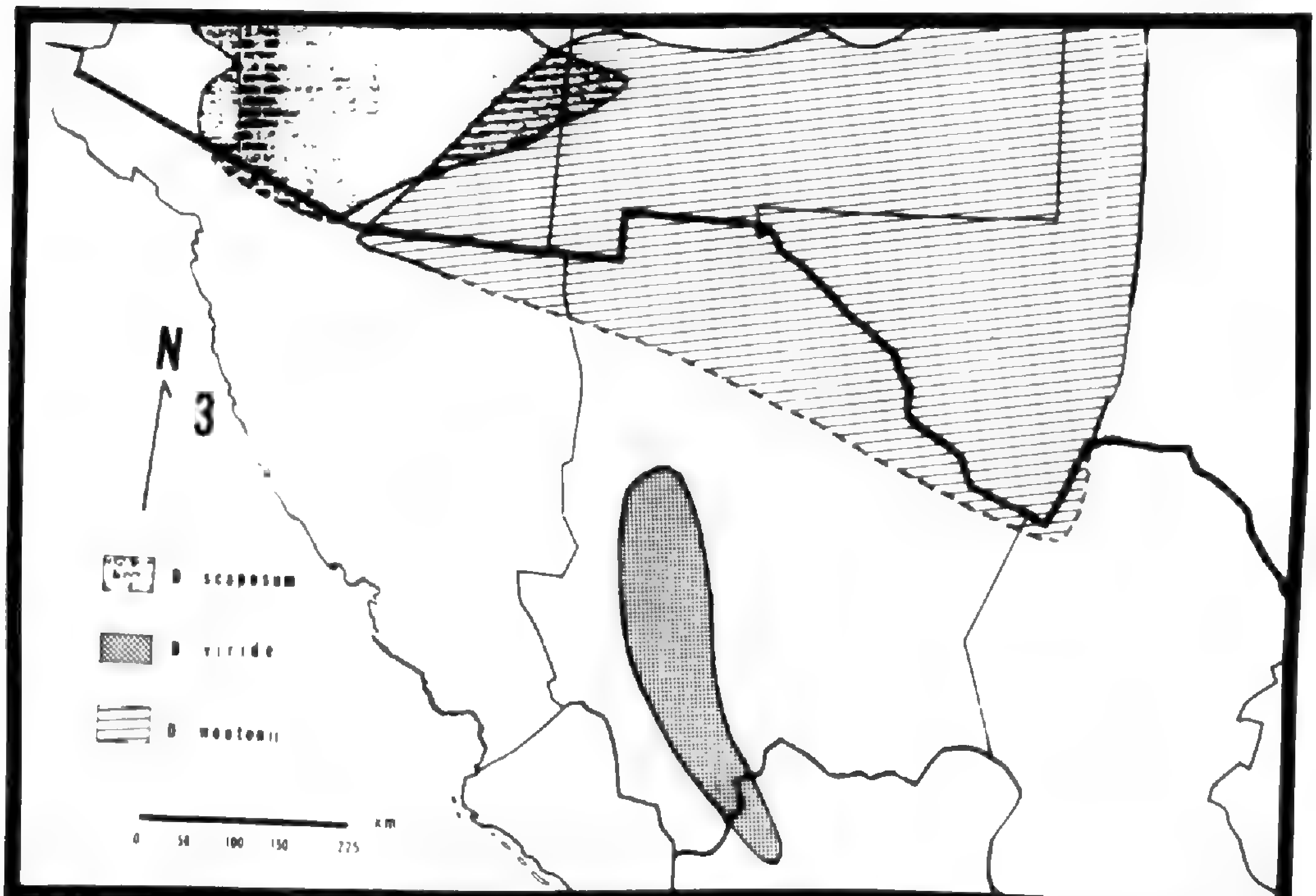
SALIENT TAXONOMIC CHARACTERS. Small size of the plant, virgate racemes, seeds with overlapping scales, arrangement of leaves, highly dissected leaves, presence of 4′ substituted flavonol glycosides, reflexed sepals and white to lavender sepal color. *Delphinium wootonii* was included as a subspecies of *D. virescens* Nutt. by Ewan in his provisional Spiciform Series.

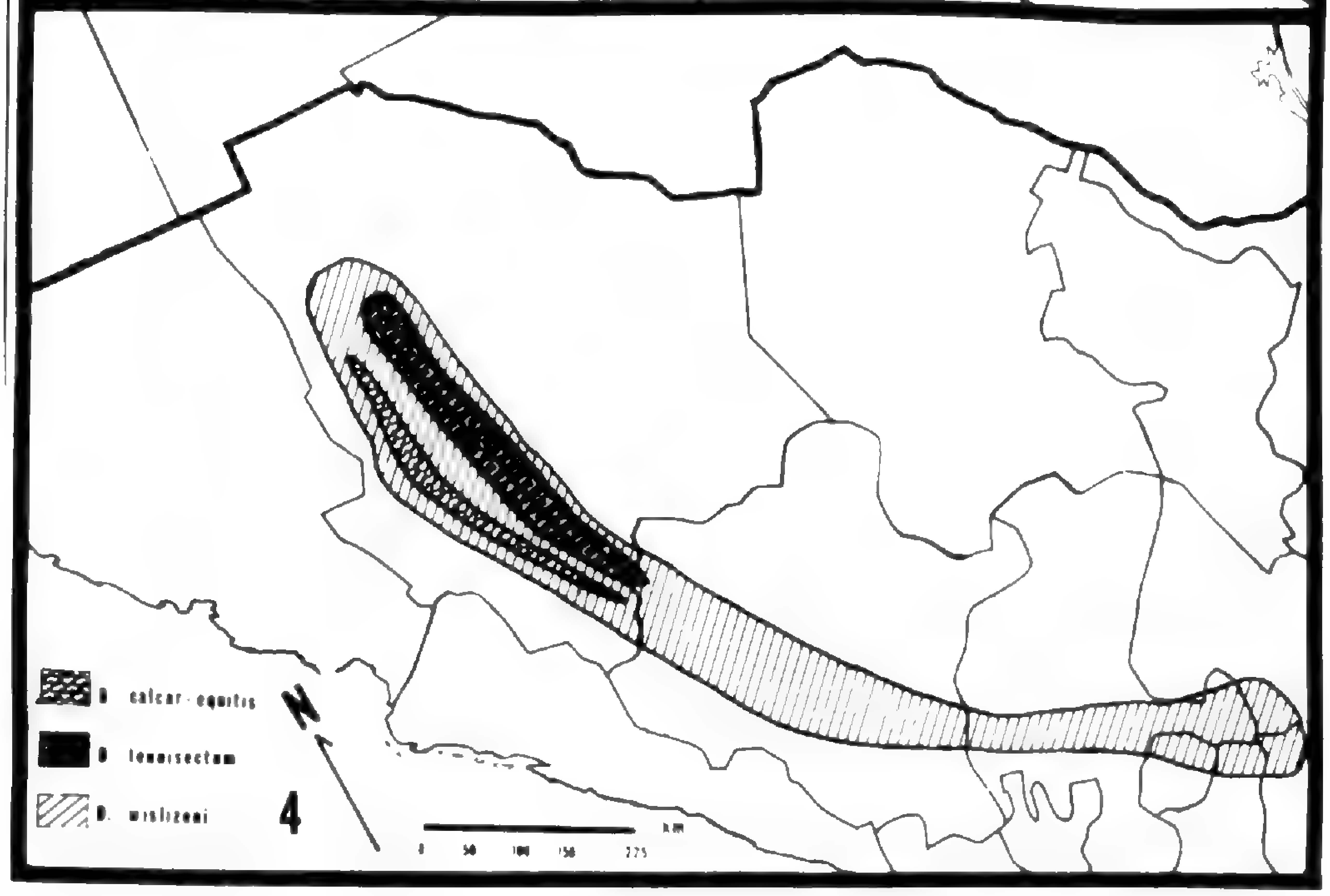
DISTRIBUTION AND HABITAT. Common at times in washes and canyons in deserts and lower slopes of mountains (700–1800 m) in southeastern Arizona, southern New Mexico, western Texas (Figure 3). Collected at least once in northern Sonora, to be expected also in northern Chihuahua and northwestern Coahuila. Often on igneous (granite) derived soils in open *Quercus* woods, or grasslands or desert scrub. Flowering April to May. May hybridize with *Delphinium madrense,* especially in the eastern Big Bend area of Texas.

REPRESENTATIVE SPECIMENS. **México.** SONORA: 23.5 mi NE Bacoáchic on road to Esqueda, gravelly slope, 10 May 1948, *Wiggins 11747* (DS, TEX, UC). **United States:** ARIZONA: Cochise Co.: Apache, 1300 m, 3 May 1924, *Eggleston 19863* (ARIZ, US); Chiricáhua Mountains, Jct of N and S forks of Pinery Canyon, 6000 ft, 3 Jun 1919, *Stone 228* (PH, RM); S end of Huachuca Game Reserve, rocky flats, 25 Apr 1950, *Wallamo & Gooding 132*-50 (ARIZ, CAS); Pima Co.: Arivaca, 5 May 1930, *Harrison & King 6946* (ARIZ); Santa Cruz Co.: 1 mi N Nogales, along railroad, 3800 ft, 9 May 1945, *Gould & Pultz 3083* (ARIZ). NEW MEXICO: Doña Ana Co.: Las Cruces, Jun 1898, *Herrick 215* (US); Hidalgo Co.: 19 mi S Animas, Eades Ranch, 29 Apr 1930, *Cory 2968* (GH); Guadlupe Canyon, 4600 ft, 22 Apr 1972, *Miller 19* (DS). TEXAS: Brewster Co.: 17.5 mi S Jct Rt 118 and US 90/67 on 118, upstream from rest area, open oak woods, 17 May 1981, *Warnock & McCormick 2255* (ILL, MO, PAC, SHST, TEX); El Paso Co.: El Paso, Mt. Franklin, lower limestone E slopes, 4000 ft, 19 Apr 1952, *Warnock 10420* (LL); Jeff Davis Co.: 4.33 mi W Davis Mts. Service Station on Rt. 90, 9 May 1946, *Cory 52266* (GH); 5.7 mi S Jct Rt 17 and Rt 118 on 17, grassy area, 17 May 1981, *Warnock & McCormick 2257* (ILL, MO, PAC, SHST, TEX).

7. **Delphinium scaposum** Greene, Bot. Gaz. (Crawfordsville) 6: 156. 1881. TYPE: UNITED STATES. New Mexico, Grant Co., Gila Bluffs, 25 Apr 1881, *Greene s.n.* (HOLOTYPE: CAS!). *Delphinium decorum* Fisch. & Mey. var. *scaposum* (Greene) Huth, Helios, 10: 33. 1893.

Perennial herb, 4–8 dm tall, stem glaucous or glabrous, solitary from a stout fibrous rootstock. Basal leaves present at anthesis, tripartite segments 5–15 mm wide, blades 2–4 cm long, 3–6 cm wide, cordate to semicircular, glabrous to very finely puberulent; petioles 9–12 cm long; cauline leaves 2–4 cm long, 2–6 cm wide, petioles 1–10 cm long. Flowers 15–40 (–56); pedicels ascending-spreading, 25–60 mm long; bracteoles lanceolate, opposite to subopposite, 3–8 mm long, 6–15 (–21) mm below the receptacle. Sepals dark blue, spur





Figures 3 and 4. Maps showing geographic ranges of *Delphinium*. **3.** *D. scaposum, D. viride* and *D. wootonii;* **4.** *D. calcar-equitis, D. tenuisectum* and *D. wislizeni.*

10–14 mm long; lateral sepals 10–15 mm long, 4.5–6.0 mm wide; lower sepals similar. Upper petals 19–23 mm long, 3.0–3.5 mm wide, apex cleft 0–1 mm deep, upper petals extremely dark blue near the nectary and apex, often with white near the protuberance on the lower edge of the petal; lower petals only slightly angled, 10–12 mm long, 3–4 mm wide, cleft 2–3 mm deep, blade more or less covered with white, curled trichomes. Filaments of stamens dark blue. Chromosome number unknown.

SALIENT TAXONOMIC CHARACTERS. Spreading pedicels, relatively undissected leaves, presence of basal leaves, blue filaments and desert scrub habitat distinguish this species. *Delphinium scaposum* was included by Ewan (1945) in his provisional Spiciform Series and by Huth in his "Tribus" Subscaposa (palmate leaves localized to the base of the stem, 2–3 lobed). Ewan (1936) placed *D. scaposum* in series *Pelligerae* (seeds enclosed in smooth papery pellicle) of subsection *Subscaposa*.

DISTRIBUTION AND HABITAT. Rocky slopes of desert hills in southwestern Colorado, Arizona, southern Utah, southeastern Nevada and western New Mexico (Figure 3). Collected in Organ Pipe Cactus National Monument, Arizona, within two miles of the Mexican border. To be expected in northern Sonora. Desert scrub (300–1000 m). Flowering March to June.

REPRESENTATIVE SPECIMENS. **United States.** ARIZONA: Pima Co.: 1 mi E Covered Wells, rocky slope, 1400 ft, 28 Apr 1941, *Cutler 4732* (ILL, MO); 10 mi NE Sells, foothills of Baboquivari Mts., rocky ravines at head of alluvial fans, 2 Apr 1932, *Fosberg 7463* (F, PAC); near Tucson, Tucson Mt., 2600 ft, 11 Apr 1913, *Greenman & Greenman 63* (MO); Organ Pipe Cactus National Monument, slope above marker #9 on Puerto Blanco Road, N facing sandstone, 20 Mar 1979, *Warnock 1786* (ILL, MO, PAC, SHST, TEX).

8. **Delphinium viride** Wats., Proc. Amer. Acad. Arts 23: 368. 1888. TYPE: MÉXICO. Chihuahua, Sierra Madre, gravelly banks of streams, 26 Sep 1887, *Pringle 1185*. (HOLOTYPE: GH!; ISOTYPES: DS!, F!, G(2)!, ND—G!, NY!, PH!, RSA!, US!(3)!, VT!).

Perennial herb, 3–11 dm tall, stem usually solitary, glabrous to puberulent, from a stout, fibrous rootstock. Basal and lower cauline leaves often present at anthesis; basal leaf blades 2–7 cm long, 4–15 cm wide, reniform-ellipsoid to circular, apex rounded, base cordate to very deeply cordate, 3–5 major divisions either undivided or sparingly parted to form 5–15 segments, leaf surfaces either glabrous or sparsely puberulent; petioles 8–19 cm long, glabrous to sparingly puberulent; cauline leaves semicircular to widely cuneate, 1–8 cm long, 1–11 cm wide, apex rounded, base truncate to wide cuneate, blades palmatisect, 3–12 segments, surfaces glabrous to minutely puberulent; petioles ascending, 0.5–9.0 cm long, gradually shorter upward. Flowers 2–20 (–36), on a usually branched, very wide raceme, branches arising from axils of upper leaves; pedicels spreading-ascending, 1.5–6.0 cm long; linear-lanceolate bracteoles opposite to subopposite, 2–13 mm below the receptacle, 2–5 mm long; yellow to yellow-green sepals, spur (14–) 17–25 (–28) mm long; lateral sepals 8–15 mm long, 4–7 mm wide; lower pair 9–16 mm long, 3–6 mm wide. Upper petals 25–33 (–35) mm long, 3–5 mm wide, apex shallowly (0.0–1.2 mm) cleft, upper petals yellow throughout or often purple or dark blue apically; lower petals purple, 9–12 mm long, clawed but often with the claw and blade on nearly the same plane, widest (1.5–3.0 mm) near midlength of the blade, blade cleft 0.5–2.0 mm in depth, blade glabrous or sparsely puberulent with white, simple trichomes. Follicles 13–19 mm long; 3.5–4.5 mm wide, glabrous to sparsely puberulent, 8–19 seeded. Seeds black, trigonally pyramidal to lunate, appearing irregularly striate, 2.1–3.5 mm long, 0.8–2.2 mm wide, cells of seed coat possessing many short, pustulate knobs appearing waxy. Chromosome number unknown.

Salient taxonomic characters. Distinctive here by its yellow or yellow-green sepals, *Delphinium viride* is allied with *D. wislizeni* on the basis of long spurs, lower petals with nearly coplanar parts, lack of pubescence on lower petals, absence of flavonol 7-rhamnosides in leaves, widely spreading pedicels and abruptly dissected, fibrous roots. *Delphinium viride* was included in "Tribus" Patentipedunculata (leafy stems, multi-palmatisect leaves, bifid lower petals, grumose roots, inflorescence patent to arcuate) by Huth and Ewan's provisional Longicalcarate Series (long slender spur). The species is now considered to be in series *Wislizenana* Warnock (long spurs, spreading pedicels, nearly coplanar blade and claw on lower petals, lack of pubescence on lower petals, absence of flavonol 7-rhamnosides) of subsection *Wislizenana* Warnock (abruptly dissected fibrous roots, usually branched racemes, divergent pedicels, pustulate seed coat cells and seed coat cells ± in scales).

Distribution and habitat. Slopes of *Pinus* or *Pinus-Quercus* forests of the Sierra Madre Occidental from central Chihuahua to northern Durango, occurring in heavy, fine-grained soil derived from tuffaceous rock, 2200–3000 m (Figure 3). Frequently found in areas of old landslides. Flowering late August to October.

REPRESENTATIVE SPECIMENS. **México.** CHIHUAHUA: along Río Oteros, W of Creel, pine-oak forest near stand of *Picea,* 2360 m, 31 Aug 1978, *Bye 9058* (COLO); Río Verde on road from El Vergel to Cienega Prieta, 8200 ft, *Correll & Gentry 22911* (ENCB, TEX); 35 km SW Minaca, barranca colorada, Sierra Gazáchic, moist ledges of igneous rock, 2200–2400 m, 16–17 Sep 1934, *Pennell 18878* (GH, MICH, NY, US); 15.6 mi W Tomochi on road to Basaseachi, E facing slope of ravine, oak-pine forest, 24 Sep 1981, *Warnock 2367* (ENCB, ILL, MEXU, MO, PAC, SHST, TEX); 1.2 mi N turnoff to La Bufa on Creel-Guachochi road, N facing slope, pink rock, oak-pine-aspen woods, 27 Sep 1981, *Warnock 2382* (ENCB, ILL, MEXU, PAC, SHST, TEX); 15.3 mi E spur to Guachochi on Guachochi-Balleza Road, pink-white rock, N facing slope, pine-oak-aspen woods, 27 Sep 1981, *Warnock 2384* (ILL, TEX). DURANGO: Sierra Madre, 30 mi N Guanacevi, 8000–9000 ft, 18 Aug 1898, *Nelson 4773* (GH, US).

9. **Delphinium wislizeni** Engelm., in Wisl., Memoirs of a Tour to Northern México, U.S. Senate Misc. Publ. 22: 106. 1848. TYPE: MÉXICO. Chihuahua, La Bufa Mt., above Cusihuiriachi, porphyritic rocks, 17 Sep 1846, *Wislizenus 159.* (HOLOTYPE: MO!).

Delphinium leptophyllum Hemsley, Diagnoses plantarum novarum Mexicanarum et Centrali-Americanarum 2: 18. 1879. TYPE: MÉXICO. San Luis Potosí, probably San Miguelito Mts., 1878, *Parry & Palmer 7.* (HOLOTYPE: K!; ISOTYPES: BM!, F!, G!, GH!, ISC, MO(3)!, P, US(2)!).

Perennial herb, 4–12 dm tall, stem usually solitary, glabrous to sparsely puberulent, from a stout, fibrous rootstock, this abruptly dissected into many narrow, string-like segments below. Leaves highly dissected, basal and lower cauline leaves present or absent at anthesis, blades reniform to subcircular, 2–7 cm long, 2–11 cm wide, apex rounded, base wide cuneate to very deep cordate, leaves glabrous or occasionally sparsely puberulent, petioles 0.5–25 cm long, spreading to ascending. Flowers 3–50 (–78), on a usually branched, wide raceme, branches arising from axils of upper leaves; pedicels spreading-ascending, 1.5–7.0 cm long; bracteoles subopposite, linear-lanceolate, 2–12 (–18) mm long, 2.5–25.0 (–36) mm below the receptacle. Sepals dark blue to very dark blue; spur sepal 15–25 mm long; lateral sepals 10–19 mm long, 3.5–10.0 mm wide; lower sepals somewhat narrower. Upper petals 22–37 mm long, 2.5–4.5 mm wide, cleft 0.0–1.5 mm deep, upper petals white to dark blue; lower petals purple to very dark blue, 9.5–17.0 mm long, 2–6 mm wide, clawed but nearly flat, cleft 1.5–5.0 mm deep, blade glabrous or only sparsely puberulent with white trichomes. Follicles 12–18 mm long, 2.5–5.0 mm wide, very sparsely puberulent to glabrous, 7–21 seeded. Seeds black to very dark brown, trigonally pyramidal to lunate, 2.0–3.8 mm long, 0.9–2.2 mm wide, appearing irregularly striate, cells of seed coat possessing many short, pustulate knobs, appearing waxy; $n = 8, 16$.

SALIENT TAXONOMIC CHARACTERS. *Delphinium wislizeni* is readily recognized by the presence of long spurs and upper petals combined with leaves having more than ten segments. It is allied with *D. viride* on the basis of floral morphology (long spurs, lower petals with nearly coplanar parts, lack of pubescence on lower petals), inflorescence structure (pedicels spreading from the rachis, paralleling it only apically), absence of flavonol 7-rhamnosides from leaves, seed coat morphology and fibrous, abruptly dissected roots. Huth included *D. wislizeni* in "Tribus" Patentipedunculata, Ewan placed the species in his provisional Longicalcarate Series. *Delphinium wislizeni* is the type species of series *Wislizenana* and subsection *Wislizenana.*

DISTRIBUTION AND HABITAT. *Quercus* and *Pinus-Quercus* woodlands of the Sierra Madre Occidental from Chihuahua southeast to San Luis Potosí. Usually in rhyolite-derived soils from 1500–2800 m (Figure 4). Typically found on N facing, moist slopes. Flowering August to October.

REPRESENTATIVE SPECIMENS: **México.** AGUASCALIENTES: La Congoja, cerca del poblado, orilla de arroyo, 2500 m, 17 Oct 1973, *Rzedowski & McVaugh 846* (ENCB). CHIHUAHUA: 15 mi E El Vergel on road to Parral, rocky, pine-oak slope, 7500 ft, 21 Oct 1959, *Correll & Gentry 23254* (ENCB, NY, TEX); mountains about Garabato, Madera, slopes, pine forest, 27 Sep 1939, *Muller 3525* (TEX); Calera, E of San Isidro, rocky, andesitic mountain, 2100–2300 m, 15 Sep 1934, *Pennell 18773* (F, GH, MICH, NY); ca. 16 mi SW Buenaventura on road to Ignácio Zaragoza, pinyon-juniper-oak woods, 7200 ft, 10 Sep 1972, *Reveal & Hess 2983* (MSC); ca. 38 mi W Colonia Juárez on road to Pacheco, N facing rhyolitic slope, oak-pine forest, 20 Sep 1981, *Warnock 2336* (ENCB, ILL, MEXU, MO, PAC, SHST, TEX); 16.3 mi W Rt 45 on road to Majalca Canyon, S of road, steep N facing slope, rhyolite, 22 Sep 1981, *Warnock 2347* (ENCB, ILL, MEXU, MO, PAC, SHST, TEX); 27.3 mi W La Junta on road to Tomochi, N facing slope near bottom of ravine, rhyolite, 24 Sep 1981, *Warnock 2365* (ENCB, ILL, MEXU, PAC, SHST, TEX); 15.6 mi SE Tomochi-Basaseachi road on road to San Juanito, E facing slope, thin rhyolitic soil, 26 Sep 1981, *Warnock 2375* (ILL, MEXU, TEX). DURANGO: 32 km W Durango on Rt 40, wet, savannah-like pastures with scattered pines, 2000–2500 m, 9 Sep 1966, *Anderson & Lagowski 3567* (ENCB, MICH); Cerro Blanco, Sierra de Míchis, 52 km SW Vicente Guerrero, pine-oak, 2350 m, 3 Oct 1975, *Hernández et al. 200* (MEXU); Sierra Madre Occidental, ca. 80 km W Durango, 3 mi N Coyotes RR station, moist slopng meadows, pine forest, 2400 m, 28 Sep 1962, *McVaugh 21679* (MICH); barranca below Sandia Station, 7000 ft, 19 Oct

1905, *Pringle 13502* (ARIZ, C, F, GH, MICH, MSC, S, SMU 2, US, VT). GUANAJUATO: 1880, *Duges s.n.* (GH). SAN LUIS POTOSÍ: San Miguelito Mts., Aug 1877, *Schaffner 27* (GH, NY). ZACATECAS: W of Chalchihuites, Sep 1945, *Martínez s.n.* (NY, US).

10. **Delphinium tenuisectum** Greene, Erythea, 2: 184. 1894. TYPE: MÉXICO. Chihuahua, vic. Guerrero, plains at base of Sierra Madre, 27 Sep 1887, *Pringle 1184*. (HOLOTYPE: ND-G!; ISOTYPES: F!, MEXU!, NY!, RSA!, UC!).

Dephinium tenuisectum forma *cucullatum* Ewan, Univ. Colorado Stud., Ser. D., Phys. Sci., 2: 149. 1945. TYPE: MÉXICO. Chihuahua, Colonia García, 7500 ft, Sierra Madre, 9 Aug 1899, *Townsend & Barber 138*. (HOLOTYPE: RM!; ISOTYPES: F!, ILL!, MEXU!, ND-G!, POM!, RM!, TEX!, UC!).

Perennial herb, 5–17 dm tall, stem solitary or in pairs, puberulent, from a stout, fibrous rootstock. Basal and lower cauline leaves generally absent at anthesis, cauline leaves 2–8 cm long, 2–13 cm wide, palmatisect into many narrow segments, segments linear to filiform, blades semicircular, cordate or widely cuneate; petioles 2–90 mm long, ascending-spreading, glabrous to puberulent. Flowers 5–60 (–94), on a branched or unbranched narrow raceme; pedicels spreading-ascending, 7–30 mm long; bracteoles linear-lanceolate, 1.5–5.0 mm long, 1–5 mm below the receptacle. Sepals dark blue, spur 12–19 mm long; lateral sepals 11–15 mm long, 5–8 mm wide; lower sepals similar. Upper petals 22–29 mm long, 3.5–4.5 mm wide, apex cleft 0.0–0.5 mm deep, upper petals dark blue to blue-purple, sometimes with white subapically; lower petals 12–17 mm long, 3–5 mm wide, cleft 1–3 mm deep, blade more or less hirsute with white curled trichomes. Follicles 10–20 mm long, 3.5–5.5 mm wide, glabrous to subglabrous, erect, 9–21 seeded. Seeds 2.1–2.9 mm long, 1.1–2.1 mm wide, cells of seed coat aggregated to form poorly defined, more or less overlapping scales, cells covered with many globose knobs, apparently waxy. Chromosome number unknown.

SALIENT TAXONOMIC CHARACTERS. Narrow, often dense inflorescence, highly dissected, numerous leaves and absence of flavonol 7-rhamnosides in leaves. Considered incertae sedis by Huth, *Delphinium tenuisectum* was included in Ewan's provisional Ceratophylloid Series. Although it has affinities with that group, the flavonoid chemistry of *D. tenuisectum* is nearly identical to that of *D. wislizeni.*

DISTRIBUTION AND HABITAT. *Quercus* and *Quercus-Pinus* woodlands of mountains of the Sierra Madre Occidental, south to the Chihuahua-Durango border (Figure 4). Usually in rocky soil derived from igneous rock (1600–2300 m). Ranges of this species and *Delphinium wislizeni* considerably overlap and habitats are similar but no mixed populations were discovered. Flowering August to October.

REPRESENTATIVE SPECIMENS. **México.** CHIHUAHUA: Guadlupe y Calvo, tuffaceous rocky slope, 6000–6500 ft, 11 Oct 1959, *Correll et al. 17974* (TEX); Sep 1934, *Dobie 28* (TEX 2); Madera, 3 mi E Chuhuichupa, open pine forest, 29 Sep 1939, *Muller 3568* (TEX); near Colonia García in Sierra Madre, 1–20 Aug 1899, *Nelson 6178* (GH); base of Sierra Madre, cool banks and ravines, plains, 26 Sep 1888, *Pringle 1565* (S 2); 4 mi N Chuhuichupa, open meadows, rocky clay soil, 2000 m, 17 Jul 1959, *Straw & Forman 1651* (RSA, GH); 30° 07′N 108° 13′W, 14 km ENE Colonia Pacheco on road to Colonia Juárez, gentle slopes of extrusive rock, 2150 m, 31 Jul 1972, *Wilson et al. 8498* (TEX); ca. 25 mi W Colonia Juárez on road to Pacheco, base of rhyolite cliff, 20 Sep 1981, *Warnock 2330* (ILL, MEXU, MO, PAC, SHST, TEX); 4.0 mi N Chuhuichupa on road to El Norte, semi-porous rhyolite, 21 Sep 1981, *Warnock 2340* (ENCB, ILL, MEXU, MO, PAC, SHST, TEX). DURANGO: San Julian to Cerro Prieto, Sep 1898, *Nelson 4958* (GH).

11. **Delphinium pedatisectum** Hemsl., Diagnoses plantarum novarum Mexicanarum et Centrali Americanarum 2: 18. 1879. TYPE: MÉXICO. *Parkinson s.n.* (HOLOTYPE: K!).

Delphinium ehrenbergii Huth, Bull. Herb. Boissier 1:336 t. 17, fig. 2. 1893. TYPE: MÉXICO. Hidalgo, Atotonilco El Grande, El Cerro de los Nabajos, *Ehrenberg 574*. (HOLOTYPE: B). The type was apparently destroyed during World War II, since it could not be located (fide, pers. comm. Prof. P. Hiepko, Curator, Berlin Herbarium, 1981). However, the figure published with Huth's description adequately serves as a lectotype (here designated). *Delphinium pedatisectum* ssp. *ehrenbergii* (Huth) Ewan, Univ. Colorado Stud., Ser. D, Phys. Sci. 2: 159. 1945.

Delphinium latisepalum Hemsl., Diagnoses plantarum novarum Mexicanarum et Centrali-Americanarum 2: 17. 1879. TYPE: MÉXICO. Oaxaca, Mt. Tanga, Cordillera de Oaxaca, 8000–8500 ft, *Galeotti 4547*. (HOLOTYPE: K!; ISOTYPES: G!, P).

Perennial herb, 2–11 dm tall, stem solitary or occasionally in twos or threes, puberulent to glabrous, from a stout, fibrous rootstock. Basal and lower cauline leaves usually present at anthesis, basal leaf blades 2–6 cm long, 3–11 cm wide, deeply cordate to semi-circular, apex rounded, base cordate to truncate, blades palmatisect, the 3–5 major divisions sometimes with little additional dissection and sometimes with up to 14 total segments, blades puberulent to glabrous; petioles 6–30 cm long, spreading, rarely ascending, glabrous to sparsely puberulent; cauline leaves semicircular to wide cuneate, apices rounded, bases truncate to cuneate, blades 1–7 cm long, 1–11 cm wide, palmatisect, 3–8 segments, puberulent to glabrous; petioles 0.5–9.0 cm long, ascending, sparsely puberulent to glabrous. Flowers 2–20 (–35), on an often branched raceme, branches arising from axils of upper leaves; pedicels ascending, 1–6 cm long; bracteoles subopposite, lanceolate, 3–11 mm long, 2–30 mm below the receptacle. Sepals purple to purple-blue, spur 9–16 mm long; lateral sepals 9–21 mm long, 4–10 mm wide; lower sepals slightly longer. Upper petals 14–21 mm long, 2.5–4.0 mm wide, apical cleft 0–1 (–1.8) mm deep, upper petals mostly white, frequently blue-purple, 9–16 mm long, 2–4 mm wide, cleft 2.0–2.5 mm deep, blade hirsute with long yellow or white trichomes. Follicles 10–15 mm long, 2–4 mm wide, very sparsely puberulent, 7–13 seeded. Seeds black, trigonally pyramidal to lunate, 1.5–2.8 mm long, 0.8–1.8 mm wide, appearing irregularly striate, rugose, cells of seed coat possessing many short, pustulate knobs appearing waxy; $n = 8$.

Salient taxonomic characters. *Delphinium pedatisectum* is characterized by very short spurs in combination with lateral sepals as long or longer than spurs and variably dissected lower leaves. Its seed morphology, presence of flavonol 7-rhamnosides in leaves, root morphology, hirsute lower petals, nearly perpendicular parts of lower petals and inflorescence structure (pedicels paralleling the rachis for most of their length) ally it with *D. bicornutum, D. calcar-equitis* and *D. subscandens* in series *Bicornuta* Warnock (short spurs, ascending pedicels, presence of flavonol 7-rhamnosides, presence of pubescence on lower petal blades and strongly clawed lower petals) of subsection *Wislizenana*. Huth placed *D. pedatisectum* in "Tribus" Patentipedunculata. Ewan included *D. pedatisectum* in his provisional Longicalcarate Series.

Distribution and habitat. *Quercus* or *Quercus-Pinus* woodlands and *Abies-Juniperus* forests on seaward slopes of the Sierra Madre Oriental from Querétaro to Oaxaca, 1800–3000 m (Figure 2). To be sought in southern San Luis Potosí. Often seen growing up through dense shrubbery. Flowering August to January.

Representative specimens. **México.** HIDALGO: cerca de la presa Jamarillo, cañada, 2850 m, 12 Sep 1975, *Barrios s.n.* (ENCB); Sierra de Pachuca, 10,000 ft, 8 Sep 1899, *Pringle 8230* (BM, C, F 2, G 3, GH, K, MEXU, MICH 2, MO, MSC, ND-G, NY, POM, S, TEX, US 2, VT). MÉXICO: Cerro Santa Rita, Sierra del Alcaparrosa, oak forest, andesite, 2950 m, 21 Sep 1973, *Rzedowski 31318* (ARIZ, ENCB, UMO). OAXACA: 0.5 mi NE turnoff to Llano de Flores on Rt 175, SW facing slope, pine-oak woods, 19 Oct 1981, *Warnock 2537* (ENCB, ILL, MEXU, MO, PAC, SHST, TEX). PUEBLA: Noria, 1900 m, 16 Aug 1909, *Nocolas s.n.* (G). QUERÉTARO: Caseta de Incendios, near Pinal de Amoles, 2600 m, 15 Nov 1975, *Arguelles 303* (MEXU).

Delphinium bicornutum Hemsl., Diagnoses Plantarum novarum Mexicanarum et Centrali-Americanarum 2: 17. 1879. TYPE: MÉXICO. Oaxaca, 1842, *Ghiesbreght, s.n.* (HOLOTYPE: K!; ISOTYPES: F!, K!, US!).

Perennial herb, 4–16 dm tall, stem usually solitary, from a stout fibrous rootstock. Basal and lower cauline leaves present or absent at anthesis, if present, basal leaf blades 3–12 cm long, 5–14 cm wide, deeply cordate to circular, apex rounded, base deeply cordate, blades palmatisect, 3–7 divisions; petioles 7–38 cm long, spreading-ascending; cauline leaves cordate to semi-circular, apex rounded, base cordate to truncate, blades 2–8 cm long, 3–13 cm wide, palmatisect, 3–7 segments; petioles 0.5–8.0 cm long, ascending. Flowers 2–43, on a usually branched raceme, branches arising from axils of upper leaves; pedicels ascending, 1–8 cm long; bracteoles opposite to subopposite, lanceolate, 2.5–12.0 mm long, 2–23 mm below the receptacle. Sepals purple to blue-purple, spur 10–18 mm long; lateral sepals 10–17 mm long, 5–10 mm wide; lower sepals 11–19 mm long, 3–10 mm wide. Upper petals 15–25 mm long, 2–4 mm wide, apex shallowly (0.0–1.3 mm) cleft; lower petals 9–14 mm long, widest (2.5–5.0 mm) near midlength of the blade, blade cleft 2–4 mm deep, blade hirsute-villous with long, yellow trichomes. Follicles 9–17 mm long, 2.5–4.0 mm wide, sparsely puberulent, 7–15 seeded. Seeds black, trigonally pyramidal to lunate, 1.5–2.7 mm long, 0.8–1.8 mm wide, appearing irregularly striate, rugose, cells of seed coat possessing many short, pustulate knobs appearing waxy; $n = 8$.

12. **Delphinium bicornutum** Hemsl. ssp. **bicornutum** based on *Delphinium bicornutum* Hemsl.

Delphinium bicornutum Hemsl., var. *hemsleyi* Huth, Bot. Jahrb. Syst. 20: 453. 1895. TYPE: MÉXICO. Oaxaca, 1842, *Ghiesbreght s.n.* (HOLOTYPE: K!; ISOTYPES: F!, K!, US!).

Stem glabrous to sparsely puberulent. When present, basal leaf blades slightly puberulent to glabrous; petioles glabrous to sparsely puberulent; cauline leaves pubescent to glabrous; petioles sparsely puberulent to glabrous. Upper petals white near the nectary, becoming blue-purple apically; lower petals blue-purple.

SALIENT TAXONOMIC CHARACTERS. *Delphinium bicornutum* ssp. *bicornutum* is recognized by short spurs, relatively large size of the plants (compared to most *D. pedatisectum*), leaves always with fewer than 8 segments, lack of white on apices of petals and relatively less pubescence on the plants than *D. bicornutum* ssp. *oaxacanum.* Root structure, seed morphology, hirsute lower petals, parts of lower petals nearly perpendicular, sigmoid pedicels paralleling the inflorescence rachis for most of their length and presence of flavonol 7-rhamnosides in leaves ally *D. bicornutum* ssp. *bicornutum* with *D. calcar-equitis, D. subscandens* and *D. pedatisectum* in series *Bicornuta* of subsection *Wislizenana.* Huth included *D. bicornutum* in "Tribus" Patentipedunculata. Ewan placed the species in his provisional Longicalcarate Series.

DISTRIBUTION AND HABITAT. Often fog-shrouded slopes of *Pinus* or *Pinus-Quercus* woods in the Cordillera of Oaxaca, north and west of the city of Oaxaca, 2000–2800 m (Figure 2). At the crest of the mountains north of Ciudad Oaxaca, the ranges of *Delphinium bicornutum* ssp. *bicornutum* and *D. pedatisectum* overlap. No mixed populations were observed. To be looked for in eastern Guerrero where it may contact the range of *D. subscandens.* Flowering September to January. Once collected in April.

REPRESENTATIVE SPECIMENS. **México.** OAXACA: Cerro de San Felipe, 7000 ft, 29 Nov 1895, *Conzatti 29* (GH); 1 km N Cuajimaloya on logging road, wet pine woods, 10,100 ft, 2 Oct 1973, *Hill 1848* (VT); abundant along river between Rancho Teja and Tamazulápam, 23 Sep 1970, *Leonard & Mickel 3925* (NCU); near Reyes, 6500–8500 ft, 20 Oct 1894, *Nelson 1805* (NY); Sierra de San Felipe, 9500–10,000 ft, 19 Sep 1894, *Pringle 4894* (BM, F, G 3, GH, K, LA, MEXU, MICH, MO, MSC, ND-G, POM, S, TEX, VT); 16.5 mi NE Jct Rt 175 and Rt 190 on 175, ca. 1 mi W El Puerto, NW of road, SE facing slope, along stream, pine-oak forest, 20 Oct 1981, *Warnock 2542* (ENCB, ILL, MEXU, MO, PAC, SHST, TEX); km 140, ca. 12 mi NW Jct Rt 190 and Rt 131 on 190, S of road, steep sides of gully, pine-oak woods, 20 Oct 1981, *Warnock 2544* (ILL, MEXU, TEX).

13. **Delphinium bicornutum** Hemsl. ssp. **oaxacanum** Warnock. Madroño 31: 247. 1984. TYPE: MÉXICO. Oaxaca, Municipio de Miahuatlan, 11.5 mi S of Miahuatlan Pemex on Rt 175, S of road, steep N facing slope in oak-pine woods, 19 Oct 1981, *Warnock 2536.* (HOLOTYPE: TEX!; ISOTYPES: ENCB!, ILL! MEXU!, MO!, PAC!, SHST!).

Stems sparsely puberulent to puberulent. When present, basal leaf blades variably canescent; petioles puberulent; cauline leaf blades sparsely canescent; petioles sparsely puberulent. Upper petals white near the nectary, becoming blue to dark blue or remaining white apically; lower petals blue-purple to white.

SALIENT TAXONOMIC CHARACTERS. *Delphinium bicornutum* ssp. *oaxacanum* is characterized by large size of the plants (relative to most *D. pedatisectum*), 7 or fewer leaf segments, often completely white petals and puberulent to canescent pubescence on stems and leaves. Root structure, seed morphology, pedicels paralleling rachis of the inflorescence for most of their length and presence of flavonol 7-rhamnosides in leaves ally *D. bicornutum* ssp. *oaxacanum* with *D. calcar-equitis, D. pedatisectum* and *D. subscandens* in series *Bicornuta* of subsection *Wislizenana.*

DISTRIBUTION AND HABITAT. Crest and upper Pacific slopes of the Sierra Madre del Sur, south of the city of Oaxaca, north facing slopes of *Quercus-Pinus* woodlands, 2500–2800 m (Figure 2). Probably once more common but now in danger of extirpation due to logging and agriculture. Flowering September to January.

REPRESENTATIVE SPECIMENS. **México.** OAXACA: Meratlau(?), S. Andres, Oct 1842, *Liebmann 1035* (BM, C 5, US); Santa Catalina Quieri, Sierra de Quieri, 17 Jan 1964, *MacDougall s.n.* (MEXU); Municipio de Pochutla, Pluma Hidalgo, 10 Jan 1967, *MacDougall s.n.* (MEXU).

14. **Delphinium subscandens** Ewan, Univ. Colorado Stud., Ser D, Phys. Sci. 2: 159, 1945. TYPE: MÉXICO. México, Municipio de Temascaltepec, cliffs, rocky hill, 1750 m, 25 Sep 1934, *Hinton 6579.* (HOLOTYPE: LA!; ISOTYPES: ARIZ!, ASC!, BM!, DES!, ENCB!, G!, GH!, LAM!, MEXU!, MO!, NY 2!, S!, TEX 2!, WTU!, US!).

Delphinium barrancae Ewan, Univ. Colorado Stud., Ser. D, Phys. Sci. 2: 160, 1945. TYPE: MÉXICO. Jalisco, barranca of Guadalajara, 5000 ft, 29 Sep 1903, *Pringle 11368.* (HOLOTYPE: F!; ISOTYPES: ARIZ!, CAS!, F!, GH!, LA!, MICH!, MEXU!, MO!, NMC!, SMU!, US!, VT!).

Perennial herb, 4–20 dm tall, stem usually solitary, glabrous to sparsely puberulent, from a stout fibrous rootstock. Basal and lower cauline leaves present or absent at anthesis; if present, basal leaf blades 3–8 cm long, 6–12 cm wide, cordate to nearly circular to elliptical, apex rounded, base cordate to very deeply cordate, blades palmatisect, the 3–5 major divisions usually not further divided, then only to form 7 or fewer total segments, blades glabrous to puberulent, especially below; petioles 11–33 cm long, spreading to slightly ascending, glabrous to sparsely puberulent; cauline leaves cordate to semicircular, apices rounded, bases cordate to truncate, blades 2–7 cm long, 2–9 cm wide, dissected into 3–7 segments, puberulent to glabrous; petioles 0.5–20.0 cm long, ascending, sparingly puberulent, much shorter upward on the stem. Flowers 3–30 (–66), on a usually branched raceme, branches arising from axils of cauline leaves as much as half way down the stem; pedicels ascending, 1–8 cm long; bracteoles usually subopposite, lanceolate, 2–10 mm long, 3–25 (–36) mm below the receptacle; bracts often foliaceous (at least the lower ones); sepals purple to blue-purple, spur (10–) 12–20 (–22) mm long; lateral sepals 9–17 mm long, 4.5–10.0 mm wide; lower sepals 10–18 mm long, 3–9 mm wide, apex narrowly rounded, base cuneate. Upper petals 19–30 (–35) mm long, 2.5–4.5 mm wide, apex shallowly (0–1; rarely 1.5 mm) cleft, upper petals white near the nectary, becoming blue to purple-blue apically; lower petals blue-purple, 10–16 mm long, 2.5–4.5 mm wide; blade cleft 0.4–3.5 mm in depth, blade hirsute with long yellow (occasionally white) trichomes. Follicles 11–19 mm long, 3.0–4.5 mm wide, sparsely puberulent, 8–14 seeded. Seeds black to very dark brown, trigonally pyramidal to lunate, 1.7–2.2 mm long, 1.0–1.3 mm wide, appearing irregularly striate, rugose, cells of seed coat possessing many short, pustulate knobs, appearing waxy; $n = 8$.

SALIENT TAXONOMIC CHARACTERS. *Delphinium subscandens* is distinguished by relatively long spurs (compared to *D. bicornutum* and *D. pedatisectum*), foliaceous nature of lower floral bracts and usual absence of basal and lower cauline leaves at anthesis. It is allied with *D. bicornutum, D. pedatisectum,* and *D. calcar-equitus* in series *Bicornuta* of subsection *Wislizenana* by seed morphology, hirsute lower petals, nearly perpendicular parts of lower petals, leaf structure (less than 7 segments), inflorescence structure (pedicels parallel with the rachis for most of their length) and presence of flavonol 7-rhamnosides in the leaves. *Delphinium subscandens* is further allied with *D. calcar-equitis* on the basis of relatively long spurs and nearly identical flavonoid chemistry. Ewan included *D. subscandens* in his provisional Longicalcarate Series.

DISTRIBUTION AND HABITAT. *Quercus* or *Quercus-Pinus* woodlands of the Pacific slopes of the Sierra Madre Occidental and Sierra Madre del Sur from Chihuahua to Guerrero, 1300–2400 m (Figure 2). Widespread but extremely local, most often in mountainous ravines. Flowering August to December.

REPRESENTATIVE SPECIMENS. **México.**CHIHUAHUA: headwaters of Río Loera just SE of Nabogame, along small river, rocky wooded ravine, N facing slope, 6000 ft, 11 Oct 1959, *Correll & Gentry 23019* (TEX); Cerro Mohinora, 10 mi S Guadlupe y Calvo, openings in rich, deep, pine-oak-fir forest, NE facing slope, 2500–3000 m, 12 Aug 1960, *Straw & Forman 1990* (MICH). GUERRERO: Aguazarca, Espinaso del Diablo, 22 Sep 1936, *Hinton 9564* (F, GH, LAM, MEXU, MICH, MO, NY, US); Mina, Chiriágua, pine forest, 13 Sep 1937, *Hinton 10659* (ARIZ 2, BM, ENCB, G, GH, LAM, MO, NY, S, TEX 2, US). JALISCO: 12 km NW Los Volcánes, grassy slopes with *Pinus* and *Quercus,* 1990 m, 30 Oct 1973, *Breedlove 35790* (CAS); headwaters of Rio Mascota, ca. 20 km by air SE Talpa de Allende, steep mountain valley near stream, 28 Nov 1960, *McVaugh 21477* (MICH); 3–5 km NE San Juan Cozala, precipitous mountainsides, 2000–2300 m, 11 Sep 1967, *McVaugh 23825* (MICH 2); barrancas W of La Quemada, steep rocky slope, 1400 m, 21 Aug 1935, *Pennell 19898* (US); between Mesquite and Monte Escobedo, Aug 1897, *Rose 2615* (F, GH, NY, US); ca. 9 mi S Rt 15 on road up Cerro Tequila, N facing slope, oak woods, 30 Oct 1981, *Warnock 2600*

(ENCB, ILL, MEXU, MO, PAC, SHST, TEX). MICHOACÁN: rincon near Morélia, 1950 m, 9 Sep 1909, *Arsène* 2546 (BM, GH, ILL, MO, NY, S, US); 8–10 km SW Jiquilpan, Cerro Santa Maria, 2000 m, 5–7 Aug 1959, *Feddema 147* (MICH); Zitácuaro, La Campaña, steep slopes in oak forest, 2125 m, 9 Dec 1938, *Hinton 13518* (F, K, LAM, MEXU, MICH 3, MO, NY, US); entre Tlalpuyhahua y Contepec, 4 Nov 1959, *Paray 2980* (ENCB). MORELOS: Tepoztlán, 22 Nov 1953, *Paray 1312* (ENCB, MEXU); above Cuernavaca, bluffs of mountain canyon, 6500 ft, 30 Sep 1899, *Pringle 8259* (BM, F, GH, K, MICH, MO, ND-G, NY, PH, POM, US).

15. **Delphinium calcar-equitis** Standl., Publ. Field Mus. Nat. Hist., Bot. Ser. 17: 244. 1937. TYPE: MÉXICO. Chihuahua, Memelichi, headwaters of Río Mayo, pine slope, 2250 m, 13 Sep 1936, *Gentry 2700*. (HOLOTYPE: F!; ISOTYPES: ARIZ!, F 2!, MEXU!, MO!, S!, UC!, US 2!).

Perennial herb, 3–12 dm tall, stem usually solitary, mostly glabrous, from a stout fibrous rootstock. Basal and lower cauline leaves usually present but sometimes lacking at anthesis; basal leaves reniform to cordate, 2–6 cm long, 4.0–9.5 cm wide, apex acutely rounded, base cordate to deeply cordate, blades palmatisect, nearly always with 5 segments, each segment 1–3 cm wide, blades puberulent or glabrous, petioles 5–20 cm long, spreading to slightly ascending, sparsely puberulent or glabrous; cauline leaves cordate to semicircular, apices rounded, bases cordate to truncate, blades 1–5 cm long, 1–6 cm wide, dissected into 3–5 segments, usually glabrous, sometimes slightly puberulent marginally; petioles 0.5–6.0 cm long, ascending, glabrous to sparingly puberulent. Flowers 3–18 (–30), on an often branched, open raceme, branches arising from axils of upper leaves; pedicels ascending, 1.0–5.5 cm long; bracteoles usually subopposite, linear-lanceolate, 3–6 mm long, 3–18 mm below receptacle. Sepals very dark blue to purple, sometimes tinged with red-purple, especially after drying, spur 16–25 mm long, apex rounded; lateral pair of sepals 10–16 mm long, 5–12 mm wide, lower pair 10–15 mm long, 3–8 mm wide. Upper petals 25–34 mm long, 3.0–4.5 mm wide, apex shallowly (0.0–1.1 mm) cleft, upper petals white near the nectary, becoming blue to blue-purple apically; lower petals blue-purple, 9–14 mm long, 2–4 mm wide; blade cleft 1.0–3.5 mm in depth, blade variously hirsute with long white (occasionally yellow) trichomes. Follicles 11–18 mm long, 3–4 mm wide, glabrous to very sparsely puberulent, 7–12 seeded. Seeds black to very dark brown, trigonally pyramidal to lunate, 2.0–2.6 mm long, 1.3–2.1 mm wide, appearing irregularly striate with a rough surface, cells of seed coat possessing many short, pustulate knobs appearing waxy; $n = 8$.

Salient taxonomic characters. Long spurs, lack of foliaceous bracts and usual presence of basal and lower cauline leaves at anthesis separate *Delphinium calcar-equitis* from other taxa of series *Bicornuta*. This species is placed in series *Bicornuta* because of seed morphology, hirsute lower petals, nearly perpendicular parts of lower petals, leaves with 7 or fewer dissections, presence of flavonol 7-rhamnosides in leaves and inflorescence structure (pedicels paralleling rachis for most of their length). *Delphinium calcar-equitis* is very similar to *D. subscandens;* both appear relatively recently derived from a common ancestor. Ewan included *D. calcar-equitis* in his provisional Longicalcarate Series.

Distribution and habitat. Local on steep slopes in *Pinus-Quercus* or *Picea-Quercus* forests on the western slopes of the Sierra Madre Occidental in west-central Chihuahua, 2200–2800 m (Figure 4). Usually seen in shade of mature forests. In danger of extermination if present rate of logging continues or increases in the area. Flowering September and October.

Representative specimens. **México.** CHIHUAHUA: Santa Brígida, ca. 28° 21′23″N, 108° 26′35″W, open forest, steep slopes, rich soil, 7500 ft, 30 Oct 1945, *Hewitt 85* (GH); Barrancas del Divisadero, pine-oak forest, 2290 m, 27 Sep 1978, *Hernández 3237* (MEXU); 12.5 mi S turnoff to Cusarare on road between Guachochi and Creel, W of road, N facing slope, 26 Sep 1981, *Warnock 2379* (ENCB, ILL, MEXU, PAC, TEX); 7 mi N turnoff to La Bufa on Guachochi-Creel road, E of road, NNE facing slope of ravine, 27 Sep 1981, *Warnock 2381* (ILL, PAC, TEX).

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Lists of exsiccatae may be obtained from the author.

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A STUDY OF SELECTED TAXA OF *VITIS* (VITACEAE) IN THE SOUTHEASTERN UNITED STATES

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ABSTRACT

Principal components analysis (PCA) of morphological data and foliar flavonoid content were used to delimit five frequently confused southeastern *Vitis* taxa and to infer phylogenetic relationships. The PCA revealed four morphological groupings corresponding to *V. aestivalis, V. cinerea* var. *cinerea, V. cinerea* var. *floridana* and, in the fourth group, *V. vulpina* and *V. riparia.* The flavonoid survey of the taxa confirmed interspecific distinctions and indicated three distinct chemical groups: one producing only flavonol 3-0-glycosides (*V. vulpina, V. riparia*), one producing a flavone 7-0-glycoside in addition to the flavonols (*V. cinerea* var. *floridana*), and one producing C-glycosylflavones in addition to the flavonols and flavones (*V. aestivalis, V. cinerea* var. *cinerea*). These flavonoid data also suggest putative relationships between taxa. Combined use of these two techniques is likely to be useful in future studies addressing taxonomic problems within *Vitis.*

Key Words: *Vitis, Vitaceae,* phenetics, morphology, flavonoids, chemostystematics, southeastern U.S.

INTRODUCTION

Current classifications of North American *Vitis* are based largely on the treatments of Planchon (1887), Munson (1909) and Bailey (1934). These treatments, however, are discordant in species and subgeneric definitions. The few recent revisionary studies have depended only on morphological characters and have not employed phenetic and/or cladistic techniques in data analysis (Duncan, 1975; Rogers and Mortensen, 1979). Comeaux (1984, unpubl. Ph.D. thesis, N.C. State, Raleigh) attempted to determine the most natural classification of *Vitis* and concluded that Munson's (1909) treatment more closely reflected phylogenetic relationships within the genus. These studies, however, based determinations of phylogeny within *Vitis* solely on morphological evidence and, in view of the discrepancies among them, it is apparent that new sources of data are necessary to determine which, if any, represents the most natural treatment of *Vitis*. Several authors (Brizicky, 1965; Radford et al., 1968) have stated the need for a thorough taxonomic and nomenclatural revision of North American *Vitis*.

One problem encountered in delimination of *Vitis* taxa is the disparity present in characters used to circumscribe these taxa. Species of North American *Vitis* are morphologically variable, with a large number of morphological characters being employed by various authors to define the taxa. General leaf shape, leaf-blade length, types of lower leaf surface vestiture, lower leaf surface color, degree of leaf lobing, types of leaf margin serration, petiole length, types of petiole pubescence, branchlet shape in cross section, types of branchlet vestiture, nodal diaphragm width, fruit diameter, fruit glaucescence, and seed size are some of the characters used by various authors to delimit the taxa (Radford et al., 1968; Duncan, 1975; Gleason and Cronquist, 1963; Godfrey and Wooten, 1979; Correll and Johnston, 1970). However, no studies have employed quantitative analyses (principal components analysis) of these characters to determine which are the most consistent and therefore most reliable for delimiting the species.

The major objective of this study was to apply quantitative methods of data analysis to the morphological characters attributed to selected *Vitis* taxa in an effort to determine which are least variable and most diagnostic of the taxa. For this pilot study, five southeastern taxa were chosen for investigation. Duncan (1967, 1975) stated that intergradation among *V. cinerea* Engelm. ex Millardet, *V. aestivalis* Michx. and *V. vulpina* L. is probably more common than among any other species combination. These three species, along with *V. riparia* Michx., which is frequently confused with *V. vulpina*, and *V. cinerea* var. *floridana* Munson, a taxon placed in partial synonymy with *V. cinerea*, *V. aestivalis* and *V. vulpina* by Duncan (1975), were therefore selected for study. This latter taxon was originally named *V. simpsonii* by Munson (1887), but was changed to *V. cinerea* var. *floridana* three years later, also by Munson (1890). Bailey (1934), however, disagreed with Munson's latter interpretation and treated this taxon as *V. simpsonii* Munson. Nevertheless, current treatments classify this taxon as *V. cinerea* var. *floridana*.

The five taxa considered in this study represent nearly half of the species recognized as occurring in the southeast, with only two excluded species (*Vitis palmata* and *V. rupestris*) thought to be closely related to the considered taxa. Three other species (*V. labrusca*, *V. shuttleworthii* and *V. mustangensis*) are quite distinct

Table 1. Morphological characters of *Vitis* taxa examined and character states used in principal components analyses.

Character	Value
1. Leaf blade length	Actual measurement
2. Leaf blade width	Actual measurement
3. Length/Width ratio	Actual ratio
4. Petiole length	Actual measurement
5. Teeth margin curvature	0 = convex, 1 = concave
6. Number of teeth per cm	Actual measurement
7. Teeth shape	0 = wider than long, 1 = longer than wide
8. Teeth shape	0 = obtuse, 1 = acute, 2 = short acuminate
9. Arachnoid leaf pubescence	0 = present, 1 = absent
10. Hirtellous leaf pubescence	0 = present, 1 = absent
11. Arachnoid branchlet pubescence	0 = present, 1 = absent
12. Hirtellous branchlet pubescence	0 = present, 1 = absent
13. Inflorescence length	Actual measurement
14. Leaf lobing	0 = unlobed, 1 = slightly three lobed, 2 = three lobed, 3 = five lobed
15. Leaf margin vestiture	0 = cilia present, 1 = absent
16. Fruit diameter	Actual measurement
17. Fruit glaucescence	0 = none, 1 = slightly, 2 = heavily
18. Branchlet character	0 = terete, 1 = slightly angled, 2 = angled
19. Leaf glaucesence	0 = present, 1 = absent
20. Lower leaf surface color	0 = green, 1 = tan, 2 = whitish

from and not thought to be closely related to the considered taxa. All aforementioned taxa are placed phylogenetically in subgenus *Vitis*. Two other southeastern species (*V. rotundifolia* and *V. munsoniana*) are classified in a different subgenus (*Muscadinia*) than are all other *Vitis* species.

A second objective of this study was to determine if the flavonoid complements of these taxa could provide a second independent line of evidence to help resolve infra- and interspecific relationships within this group of taxa. Previous attempts at applying molecular approaches such as protein analysis, isozyme analysis, and nuclear DNA distribution via cesium chloride density centrifugation to taxonomic problems within North American *Vitis* have all failed to aid materially in delimitation of the taxa (Schaeffer, 1982; Berdize et al., 1973). However, several studies have determined that differences are present in the flavonoid complements of several *Vitis* species (Yap and Reichardt, 1964; Bachmann, 1978) but results of these studies were not applied to overall taxonomic problems within *Vitis*.

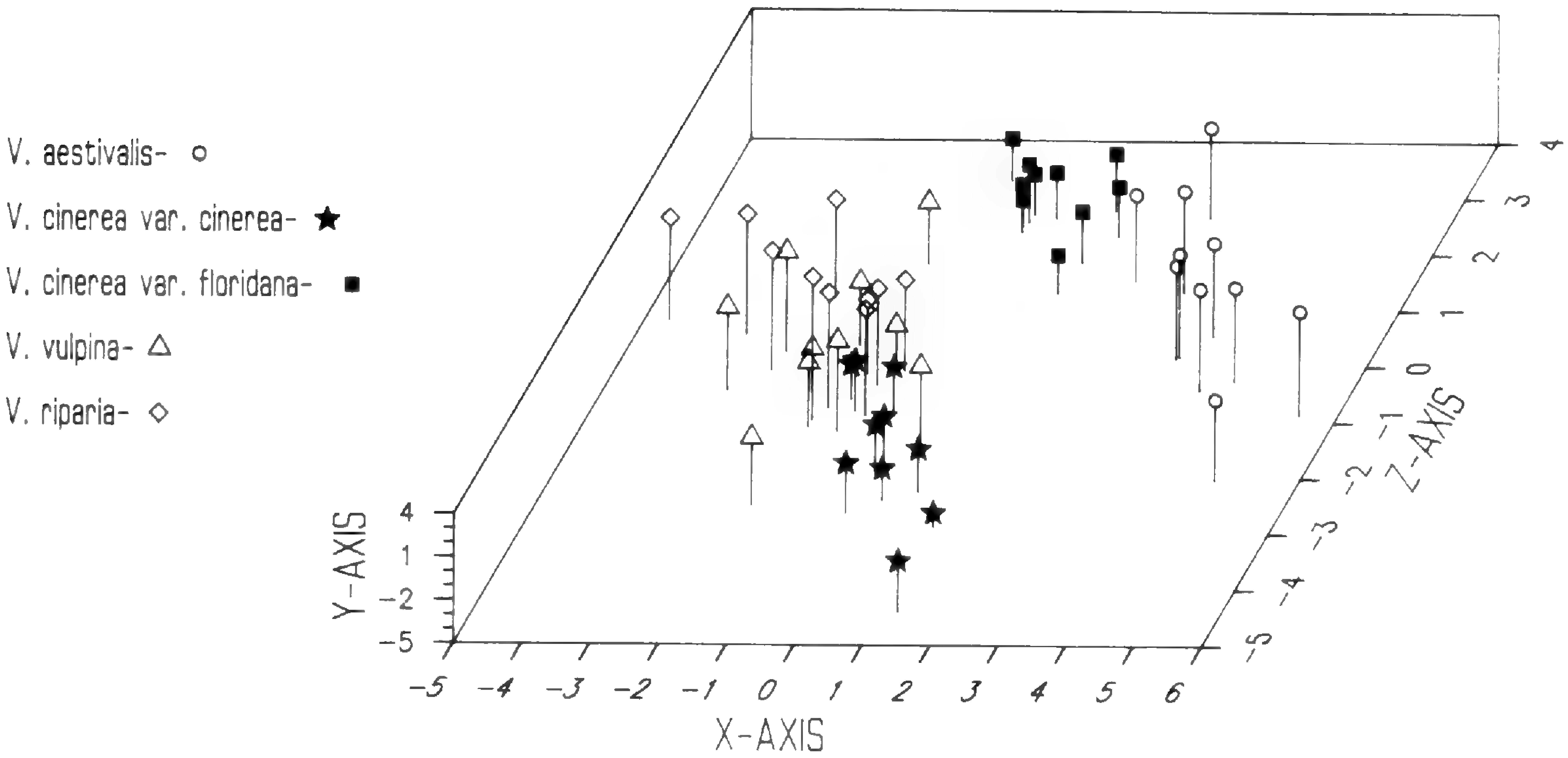

Figure 1. Three-dimensional ordinate plot of new variables generated by principal components analysis of morphological data, first analysis; x-axis, first principal component; y-axis, second principal component; z-axis, third principal component.

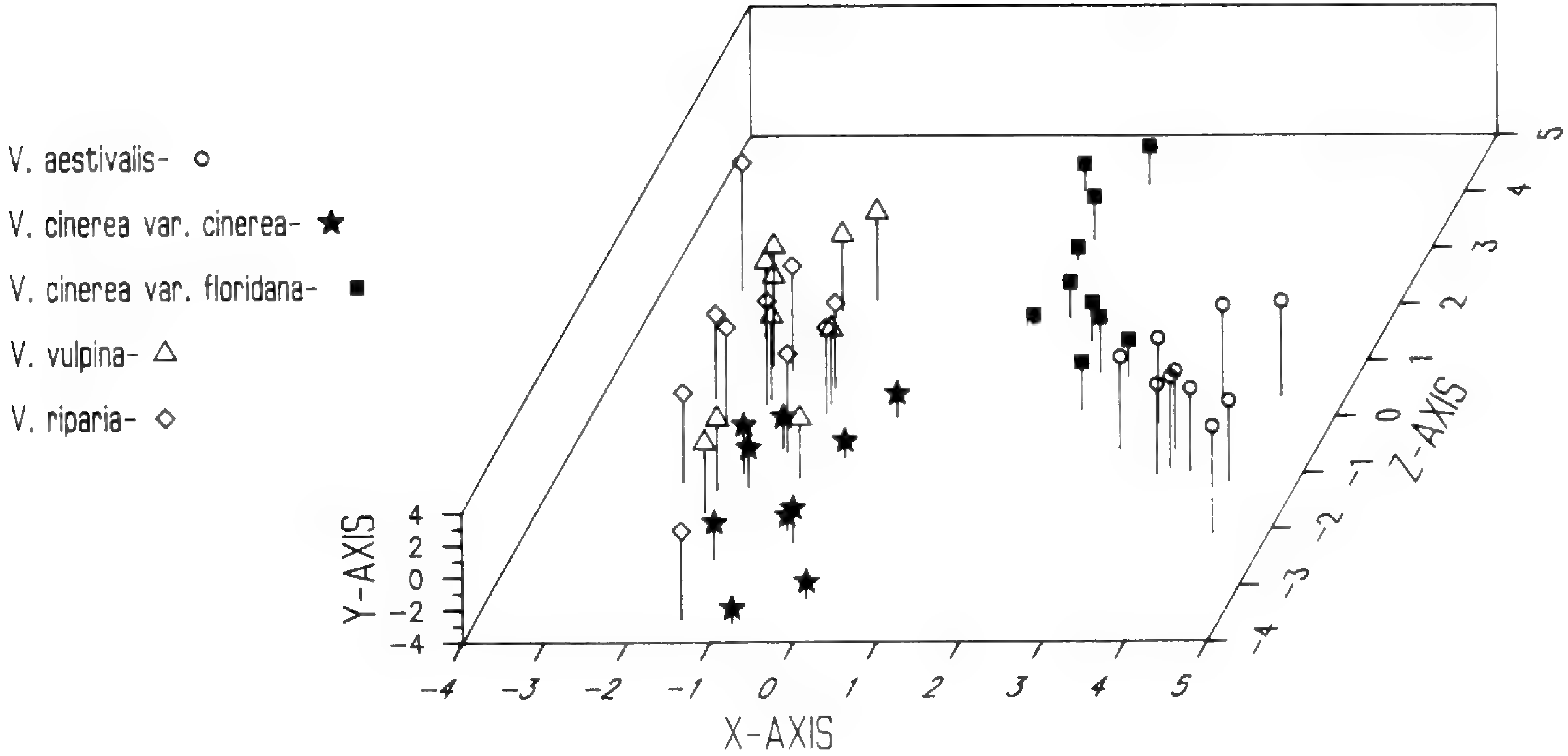

Figure 2. Three-dimensional ordinate plot of new variables generated by principal components analysis of morphological data, second analysis; x-axis, first principal component; y-axis, second principal component; z-axis, third principal component.

MATERIALS AND METHODS

Specimen loans were received from six major herbaria: BH, CU, FSU, MO, NY and US. These specimens, along with those housed at GA, provided the basis for morphological measurements and characterizations. Additionally, field work was conducted throughout the southeast by the author; a minimum of 30 field collections of each presumed taxon provided additional specimens for morphological investigations and flavonoid analysis.

Twenty morphological characters based on those characters used for taxon delimitation in previous studies were chosen for examination (Table 1). The resulting data set was then analyzed using principal components analysis (PCA; *see* Radford et al., 1974) by choosing 10 individuals with no missing characters (e.g., including inflorescences) from each taxon. The new variables generated were used in construction of three-dimensional ordinate plots (Figures 1 and 2).

To ensure that the phenetic results were repeatable, a second PCA using a second set of individuals was performed. The data and resulting new variables were handled and presented in the same way to ensure consistency.

For flavonoid analysis, extraction of foliar flavonoids followed techniques of Mabry et al. (1970) and Giannasi (1975). The general survey employed two-dimensional descending-paper chromatography using Whatman 3MM paper. Compounds were isolated and purified using polyclar (polyamide) column chromatography (Ulubelen et al., 1980) and paper chromatography. Structural identification was accomplished using UV spectroscopy (Mabry et al., 1970; Giannasi, 1975; Markham, 1982) and co-chromatography with commercially available standards along with comparisons to published data (Giannasi, 1975; Mabry et al., 1970). Glycosides were analyzed by acid hydrolysis using HCl and TFA and/or enzymatic hydrolysis coupled with sugar recovery and comparison with known standards (Wilkins and Bohm, 1976). The flavonoid data were also analyzed using similarity clustering to examine phenetically flavonoid similarities and differences among the taxa.

RESULTS AND DISCUSSION

Morphological/Phenetic Studies

Figures 1 and 2 represent three-dimensional ordinate plots of new variables generated by the two principal components analyses of morphological data. A voucher listing of those specimens from all taxa used in the PCA is given in Appendix 1.

The PCA for the first set of morphological data partitioned the variability as follows: 23.3% for the x-axis, 18.2% for the y-axis and 15.2% for the z-axis. Variability was partitioned similarly of the second analysis: 23.5% for the x-axis, 17.6% for the y-axis and 15.2% for the z-axis.

Analysis of three-dimensional ordinate plots of the two morphological analyses revealed four main groupings (Figures 1 and 2). In both plots, *Vitis aestivalis* and *V. cinerea* var. *floridana* clustered distinctly from the other three taxa under consideration. These two taxa, however, are not as morphometrically close as implied in the two three-dimensional ordinate plots. Close examination of these plots shows that in both the first (x-axis) and second (y-axis) principal components, the two varieties of *V. cinerea* completely overlap. It is in the third principal component where the separation of the two varieties of *V. cinerea* occurs. In all three principal components, *V. cinerea* var. *floridana* and *V. aestivalis* are distinct entities, indicating that *V. cinerea* var. *floridana* is morphologically similar to *V. cinerea* var. *cinerea* and not to *V. aestivalis.* The third grouping, corresponding to *V. cinerea* var. *cinerea,* overlapped slightly with the fourth grouping, which corresponded to *V. vulpina* and *V. riparia.* In this fourth grouping, no distinction could be made between *V. vulpina* and *V. riparia,* inferring that only four distinct taxa are present.

Analysis of the loadings of new variables generated by the PCA can be used to determine which characters are most useful in separating taxa; those characters weighted heavily in each principal component are most useful for delimiting the taxa. For the first principal component in both analyses, the most heavily weighted characters were as follows: presence or absence of glaucous leaf undersurfaces, presence or absence of hirtellous leaf pubescence, and presence or absence of arachnoid leaf pubescence. Those characters weighted heavily in the second principal component were branchlet shape in cross section and the presence or absence of hirtellous branchlet pubescence. For the third principal component, leaf blade length and the presence or absence of arachnoid branchlet pubescence were most heavily weighted. Morphological attributes of the taxa which can best be used in distinguishing each taxon are summarized in Table 2.

Results from this study indicate that within the immediate southeast (NC, SC, GA, FL, AL, MS), and based on these morphological characters, *Vitis vulpina* and *V. riparia* are indistinct. Based on nomenclatural priority, they should be considerd as a single taxon, *V. vulpina.* Consideration of two previously distinct species as one

Table 2. Morphological characters most distinctive of the *Vitis* taxa based on principal components analysis.

Morphological Character	Taxon			
	V. aestivalis	*V. cinerea* var. *cinerea*	*V. cinerea* var. *floridana*	*V. vulpina*
Glaucous leaf undersurfaces	present	absent	absent	absent
Hirtellous abaxial leaf pubescence	sparse to absent	generally present along veins, varying to absent	generally absent	present along veins and in vein axils
Arachnoid abaxial leaf pubescence	present in varying degrees	present	present, often dense	absent, varying to very thinly arachnoid
Branchlet shape in cross section	terete	distinctly angled	slightly angled	terete
Hirtellous branchlet pubescence	absent	present, often dense	generally absent	generally absent
Arachnoid branchlet pubescence	sparse to absent	sparse to absent	present, often dense	absent
Leaf blade length	longer than 10 cm	longer than 10 cm	longer than 10 cm	generally shorter than 10 cm

within the immediate southeast should not be taken to mean that *V. riparia* and *V. vulpina* are indistinct throughout their ranges. *Vitis riparia* may be a taxon of more northern and western distribution, while those individuals passing as *V. riparia* within the immediate southeast are in reality ecotypical variants of *V. vulpina.*

Several of the morphological characters analyzed here (petiole length and pubescence, tooth margin curvature, number of teeth per centimeter, general tooth shape, inflorescence length, leaf lobing, leaf margin vestiture, and nodal diaphragm width) proved to be of little use in delimiting the taxa. Young sprouts of taxa that normally have unlobed leaves were frequently deeply lobed, and lobed and unlobed leaves were often encountered on the same vine. Inflorescence lengths tended to be relatively long (ca. >10 cm) in all taxa considered, but individuals in all taxa occasionally had shorter inflorescences. Leaf-tooth shape varied from obtuse to short-acuminate in all taxa, whereas leaf-margin vestiture varied from abundantly ciliate in *Vitis vulpina* to sparsely ciliate to generally absent in the remaining three taxa. Nodal diaphragm width ranged from thin in *V. vulpina* to relatively thick in all others. These characters were therefore considered either intraspecifically too variable or interspecifically too consistent to be of use in delimiting taxa.

In summary, the PCA of morphological data differentiated those characters which were least variable and most diagnostic of the taxa. The PCA further provided a means for determining those taxa which were or were not morphologically distinct.

Flavonoid Chemistry

Eighteen flavonoid glycosides and one unidentified phenolic compound were isolated from leaves of the taxa considered. Identities of these compounds and their distributions among taxa are shown in Table 3 and are reported in detail elsewhere (Moore, 1985, unpubl. M.S. thesis, Univ. of Ga., Athens). The flavonoid patterns of the individual taxa in Table 3 are each a composite of a survey of individuals from throughout the southeastern U.S.

Three general classes of flavonoids were identified: flavonols, flavones and C-glycosylflavones. The flavonols detected were kempferol, quercetin, isorhamnetin, and myricetin compounds, all as 3-0-glycosides. Flavones present were apigenin 7-0-glucoside and luteolin 7-0-glucoside. Three C-glycosyl forms of apigenin and one C-glycosyl form of luteolin were also identified. Three of these C-glycosylflavones are tentatively identified as vitexin (21), isovitexin (22) and orientin (24), all found previously in *Vitis cinerea* by Wagner et al. (1967). Flavonoid aglycones were sporadic in their

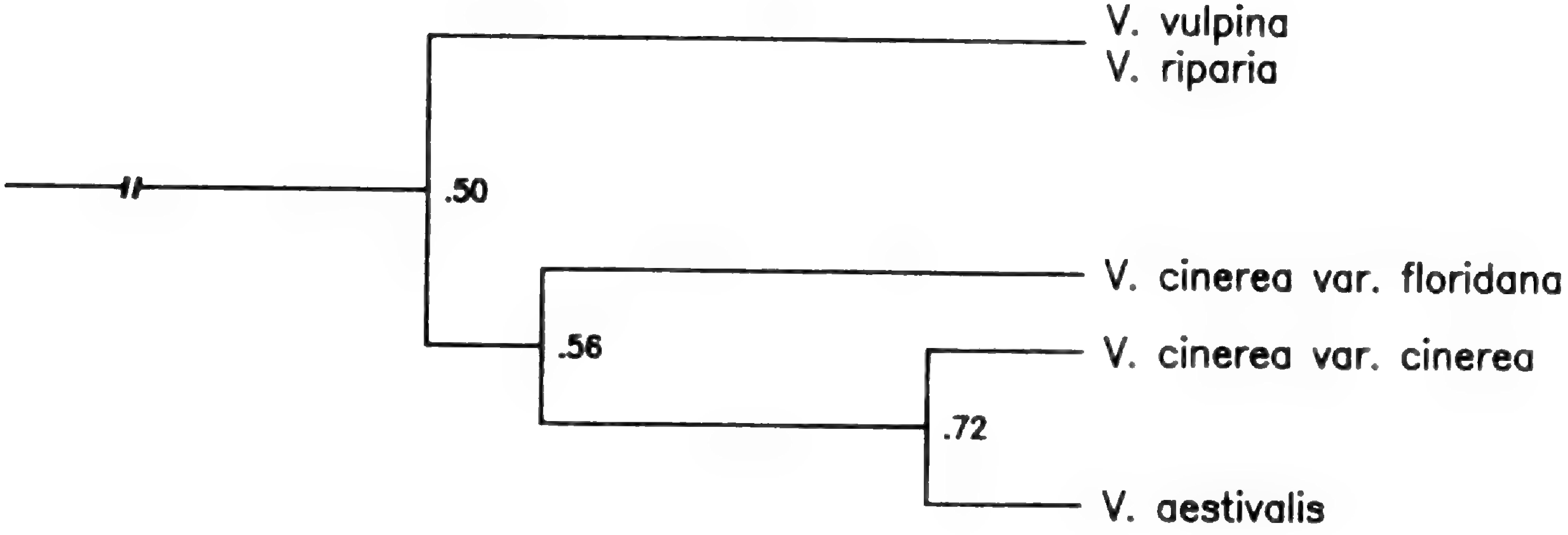

Figure 3. Cluster diagram of *Vitis* taxa herein considered, based on similarity clustering (SIMIL) of flavonoid data.

Table 3. Flavonoid distribution in *Vitis* taxa considered.

	Flavonols																Flavones				C. Glycosylflavones				UP*
Taxon	**1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
V. aestivalis	+	+			+	+		+	(+)	(+)	***		(+)	(+)				+		(+)	+	+	+	+	
V. cinerea var. *cinerea*					+	+		+						(+)			+	+	(+)	(+)	+	+	+	+	
V. cinerea var. *floridana*	+	+	(+)		+	+		+			+		(+)	(+)	(+)			+		(+)					
V. vulpina	+	+		+			+	+				+	(+)	(+)		(+)									+
V. riparia	+	+		+			+	+				+	(+)	(+)		(+)									+

* UP = Unidentified phenolic.

** 1. kaempferol 3-0-glucoside, 2. kaempferol 3 0 rutinoside, 3. kaempferol 3 0-glycoside, 4. quercetin 3 0 glucoside, 5. quercetin 3 0 glucoside, 6. quercetin 3-0-galactoside, 7. quercetin 3 0 rhamnoside, 8. quercetin 3 0 rutinoside, 9. quercetin 3 0 glycoside, 10. quercetin 3-0-glycoside, 11. isorhamnetin 3 0 glucoside, 12. myricetin 3 0 rhamnoside, 13. kaempferol, 14. quercetin, 15. isorhamnetin, 16. myricetin, 17. apigenin 7 0-glucoside, 18. luteolin 7-0-glucoside, 19. apigenin, 20. luteolin, 21. 8-C glycosylapigenin, 22. 6 C glycosylapigenin, 23. 6-C-glycosylapigenin, 24. 8 C glycosylluteolin, 25. unidentified phenolic.

*** (+) = Compound detected in trace quantities only and of sporadic occurrence.

occurrence within all taxa and were therefore more easily identified via hydrolysis of glycosides. Little infraspecific qualitative flavonoid variation was found within each taxon.

The taxa considered fall into three major groups based on flavonoid content (Table 3). The first group consists of *Vitis vulpina* and those individuals passing as *V. riparia* within the immediate southeast. In this group, flavonol 3-0-glycosides are the only compounds present. Two unique compounds of this group are quercetin 3-0-rhamnoside (7) and myricetin 3-0-rhamnoside (12), the latter compound being the only myricetin compound detected in this study. The taxa in this group were also found to contain a different form of quercetin 3-0-glucoside (4) from that identified in the remaining taxa (5). The significant differences in the R_f values for this compound are suspected to be due to a different form of the same sugar (pyranose vs. furanose; Harborne et al., 1970). A final unique chemical characteristic of this group is the presence of an unidentified phenolic compound (25). Within this first chemical group (*V. vulpina* and *V. riparia*), uniformity of flavonoid complements supports the results obtained from the PCA of morphological data; i.e., at least within the immediate southeastern U.S., *V. vulpina* and *V. riparia* are indistinct.

The second chemical group (*Vitis cinerea* var. *floridana*) was found to contain luteolin 7-0-glucoside (18) in addition to flavonol 3-0-glycosides. This taxon is distinguished from the remainder of the taxa by its production of isorhamnetin 3-0-glucoside, the only methylated compound encountered. In addition, a kaempferol 3-0-glycoside (3) was unique to this taxon. It is perhaps a di- or triglycoside since it has a high R_f value in pure water solvent. However, insufficient quantities were isolated to allow for analysis of its glycosylation pattern.

The third chemical group, consisting of *Vitis aestivalis* and *V. cinerea* var. *cinerea*, is characterized by the presence of C-glycosylflavones in addition to flavone 7-0-glycosides and flavonol 3-0-glycosides (Table 3). However, within this chemical group, the two taxa can be distinguished on the basis of several other chemical characters. Two kaempferol 3-0-glycosides (1, 2) were present in *V. aestivalis*, whereas no kaempferol compounds were detected in *V. cinerea* var. *cinerea*. Also, *V. aestivalis* contained two unique quercetin 3-0-glycosides (9, 10), but these compounds were sporadic in their occurrence within this taxon, limiting their chemosystematic value. In contrast, apigenin 7-0-glucoside (17) was found to be a unique chemical constituent of *V. cinerea* var. *cinerea*.

Distribution of flavonoid compounds (Table 3) among the taxa was subjected to a common phenetic similarity clustering routine (SIMIL) to examine flavonoid similarities and differences among the *Vitis* taxa. The hierarchial clustering technique begins by assuming that each taxon within the set is a single cluster. The two most similar taxa are combined into one, then the two most similar entities among the new sets are combined using single linkage, and so on, until a single cluster is produced. The measure of similarity is the simple distance between respective taxa or clusters of taxa. The resulting cluster diagram (Figure 3) reflects degrees of flavonoid relatedness among the taxa.

Table 4 shows the similarity ratios among the taxa derived by the SIMIL program based on flavonoid data. It was expected that the similarity ratios between *Vitis vulpina* and those individuals passing as *V. riparia* would be 1.0 (identical), as these two species had identical flavonoid complements. From these data, the two taxa which contain the next most similar flavonoid complements are *V. cinerea* var. *cinerea* and *V. aestivalis* (0.72) followed by *V. cinerea* var. *floridana* and *V. aestivalis* (0.56). Three pairs of taxa had similarity ratios of 0.50 (*V. cinerea* var. *cinerea* and *V. cinerea* var. *floridana; V. vulpina* and *V. cinerea* var. *floridana; V. riparia* and *V. cinerea* var. *floridana*). It is interesting to note that, of those pairs of taxa with similarity ratios of about 0.5, all contain *V. cinerea* var. *floridana* as one member of the pair. This finding indicates that this taxon is chemically intermediate between *V. vulpina* and *V. riparia* on one hand and *V. cinerea* var. *cinerea* and *V. aestivalis* on the other. Those pairs of taxa with the least similar flavonoid complements are *V. vulpina* and *V. aestivalis* (0.28), *V. riparia* and *V. aestivalis* (0.28), *V. vulpina* and *V. cinerea* var. *cinerea* (0.22), and *V. riparia* and *V. cinerea* var. *cinerea* (0.22).

Considering the flavonoid results, it appears that *Vitis cinerea* var. *cinerea* and *V. cinerea* var. *floridana* are not as closely related as their classification as varieties of the same species implies. The production of C-glycosylflavones in *V. cinerea* var. *cinerea*, a primitive character according to Harborne (1977), and the presence of a methylated compound coupled with the absence of C-glycosylflavones in *V. cinerea* var. *floridana*, both advanced characters according to Harborne (1977), indicate that these two taxa should best be treated as distinct species. This statement is supported by the flavonoid similarity clustering results, where a similarity ratio of only 0.50 occurred between the two varieties of *V. cinerea*. The

Table 4. Similarity ratios among *Vitis* taxa considered derived from similarity clustering (SIMIL) of flavonoid data.

Taxon	Similarity Ratios				
AE*	1.00				
CI	0.72	1.00			
FL	0.56	0.50	1.00		
VU	0.28	0.22	0.50	1.00	
RI	0.28	0.22	0.50	1.00	1.00
	AE	CI	FL	VU	RI

*AE = *V. aestivalis*, CI = *V. cinerea* var. *cinerea*, FL = *V. cinerea* var. *floridana*, VU = *V. vulpina*, RI = *V. riparia*.

results from the two PCA's of morphological data are also in complete agreement with the flavonoid data and Bailey's (1934) interpretation of this taxon (Figures 1 and 2). Here, *V. cinerea* var. *floridana* clustered separately and distinctly from *V. cinerea* var. *cinerea*. Flavonoid analysis of the remainder of North American *Vitis* should confirm whether *V. cinerea* var. *floridana* might best be treated as a distinct species, *V. simpsonii*, as originally named by Munson (1887) and subsequently treated by Bailey (1934), or if it is more closely related to a taxon not considered here.

In conclusion, the use of phenetic and flavonoid techniques has proven to be a most valuable tool in *Vitis* for delimiting taxa and circumscribing morphological variation within the taxa. Completion of a flavonoid survey of all North American *Vitis* taxa should result in a workable subgeneric classification that better reflects evolutionary relationships and overcomes the incongruences present among the treatments of Planchon (1887), Munson (1909) and Bailey (1934).

ACKNOWLEDGMENTS

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APPENDIX 1

Origin and accession number of collections of *Vitis* used for principal components analyses of morphological data.

FIRST ANALYSIS

Vitis aestivalis: VIRGINIA: Floyd Co., *Duncan 22860* (GA); Surry Co., *Fernald & Long 12728* (GA); Patrick Co., *Moore 232* (GA); Carroll Co., *Moore 233* (GA); TENNESSEE: Benton Co., *Moore 276* (GA); Weakly Co., *Moore 271* (GA); NORTH CAROLINA: Watauga Co., *Moore 253* (GA); Wautauga Co., *Moore 255* (GA); GEORGIA: Walker Co., *Coile 4216* (GA); Stewart Co., *Moore 262* (GA).

Vitis cinerea var. **cinerea:** TEXAS: Fannin Co., *Shinners 13328* (GA); TENNESSEE: Lake Co., *Moore 278* (GA); Obion Co., *Moore 287* (GA); MISSOURI: Cape Girardeau Co., *Moore 288* (GA): Green Co., *Standley 8910* (US); Lowndes Co., *Moore 344* (GA); MISSISSIPPI: Coahoma Co., *Moore 291* (GA); Washington Co., *Ray 4955* (GA); LOUISIANA: Bossier Par., *Moore 335* (GA); Franklin Par., *Thieret 23992* (GA).

Vitis cinerea var. **floridana:** FLORIDA: Wakulla Co., *Godfrey 77986* (FSU); Calhoun Co., *Godfrey 57732* (FSU); Taylor Co., *Godfrey 81564* (FSU); Jackson Co., *Godfrey 71442* (FSU); Clay Co., *Godfrey 70938* (FSU); Levy Co., *Moore 318* (GA); Okeechobee Co., *Moore 311* (GA); Hardee Co., *Moore 323* (GA); DeSoto Co., *Moore 320* (GA); GEORGIA: Coffee Co., *Moore 310* (GA).

Vitis vulpina: VIRGINIA: Amelia Co., *Lewis 683* (GA); Pittsylvania Co., *Massey 4260* (GA); TENNESSEE: Carter Co., *Moore 251* (GA); Williamson Co., *Moore 275* (GA); SOUTH CAROLINA: Anderson Co., *Duncan 9965* (GA); NORTH CAROLINA: Stokes Co., *Moore 238* (GA); GEORGIA: Floyd Co., *Coile 4058* (GA); Clarke Co., *Bell 62* (GA); Jones Co., *Moore 259* (GA); FLORIDA: Dixie Co., *Moore 317* (GA).

Vitis riparia: VIRGINIA: Montgomery Co., *Massey 4180* (US); SOUTH CAROLINA: Charleston Co., *Hunt 3197* (BH); NORTH CAROLINA: Church's Island, *McAfee s.n.,* (US); MISSISSIPPI: LeFlore Co., *Moore 347* (GA); KANSAS: Scott Co., *Harms 1133* (US); Leavenworth Co., *Bush 14089* (BH); GEORGIA: Morgan Co., *Hill 931* (GA); Oglethorpe Co., *Montgomery 954* (GA); Morgan Co., *Hill 688* (GA); ILLINOIS: LeSalle Co., *Bailey 624* (GA).

SECOND ANALYSIS

Vitis aestivalis: WEST VIRGINIA: Monongalia Co., *Stewart & Bartholemew 2019* (GA); VIRGINIA: Dinwiddie Co., *Massey 4455* (GA); Madison Co., *Fosberg 45872* (US); NORTH CAROLINA: Watauga Co., *Moore 252* (GA); Avery Co., *Moore 255* (GA); Davison Co., *Moore 230* (GA); MISSOURI: Wright Co., *Steyermark 76999* (GA); MISSISSIPPI: Montgomery Co., *Moore 346* (GA); Pontotoc Co., *Moore 304* (GA); ALABAMA: Cullman Co., *Moore 303* (GA).

Vitis cinerea var. **cinerea:** MISSISSIPPI: LeFlore Co., *Temple 3455* (GA); LOUISIANA: Caldwell Par., *Thieret 24022* (GA); Catahoula Par., *Thieret 23093* (GA); Franklin Par., *Thieret 23992* (GA); Iberville Par., *Thieret 18289* (GA); Lincoln Par., *Thieret 24612* (GA); Rapides Par., *Thieret 26751* (GA); Claibourne Par., *Vincent 1783* (GA); ARKANSAS: Marion Co., *Moore 300* (GA); Ashly Co., *Moore 349* (GA).

Vitis cinerea var. **floridana:** FLORIDA: Clay Co., *Godfrey 70938* (FSU); Manatee Co., *Munson s.n.,* (MO); Nassau Co., *Wright 618* (CU); Highlands Co., *Small et al. 11489* (GA); Hillsborough Co., *Moore 319* (GA); Hardee Co., *Moore 323* (GA); Levy Co., *Moore 318* (GA); Jackson Co., *Godfrey 71442* (FSU); Okeechobee Co., *Moore 311* (GA); Calhoun Co., *Godfrey 57732* (FSU).

Vitis vulpina: VIRGINIA: Franklin Co., *Duncan 22838* (GA); James City Co., *Massey 4537* (GA); TENNESSEE: Rutherford Co., *Moore 273* (GA); SOUTH CAROLINA: McCormick Co., *Duncan 9817* (GA); Anderson Co., *Radford 18008* (GA); NORTH CAROLINA: Yadkin Co., *Moore 241* (GA); Stokes Co., *Moore 235* (GA); MISSOURI: Wayne Co., *Moore 290* (GA); GEORGIA: Clarke Co., *Hunt GA803* (GA); Morgan Co., *Moore 186* (GA).

Vitis riparia: VIRGINIA: Floyd Co., *Duncan 22857* (GA); Roanoke Co., *Massey s.n.,* (GA); TENNESSEE: Williamson Co., *Kral 32195* (GA); Shelby Co., *Demaree 21371* (GH); GEORGIA: Ben Hill Co., *Faircloth 4646* (GA); LOUISIANA: Concordia Par., *Thieret 23870* (GA); Concordia Par., *Thieret 23876* (GA); TEXAS: Randall Co., *Eggart s.n.,* (MO); MARYLAND: Baltimore Co., *O'Neill 7572* (GH); ILLINOIS: Woodford Co., *Chase 11388* (GA).

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NEW ENGLAND NOTE

THE FIRST RECORD OF *ALLIUM VINEALE* L. (LILIACEAE) FOR VERMONT[1]

PETER F. ZIKA

A small colony of *Allium vineale* L. was first observed on the campus of the University of Vermont in 1983, growing under *Berberis thunbergii* DC. and *Crataegus phaenopyrum* (L.f.) Medic. thickets at the south end of Votey Hall. This pesty European adventive resisted the annual weeding and mulching efforts of the university groundskeepers, and by 1985 had increased tenfold and spread throughout the thornbushes that encircle Votey. At this point it seems appropriate to record the species as a new weed in the flora of Vermont. A voucher has been deposited at the Pringle Herbarium of the University of Vermont.

Apparently this is a new northeastern extension of the range of *Allium vineale* in North America. Fernald (1950) and Seymour (1969) indicated its range extends north and east as far as New York and Massachusetts. Although the species has been recorded in Canada from southern Ontario, it is not known from adjacent southwestern Quebec or the Maritime Provinces (Scoggan, 1978).

This marks the establishment of yet another potentially noxious weed on University property (*see* Zika, 1986). How *Allium vineale* arrived in a cultivated hedgerow at the north end of campus is a mystery. The thorn thickets at Votey were planted many years before the appearance of the *Allium*, but it is remotely possible some bulbs were introduced in the soil of the nursery stock, and only recently started to spread. Vagrant frugivorous birds (e.g., *Bombycilla* spp.) are frequently attracted to the *Crataegus* fruits and may have deposited the onion while feeding or roosting. Another potential source of propagules is mud on the earth-moving equipment or building supplies in the vicinity. If campus construction is

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[1] Present address: Cascade Head Exp. Forest, Rte. 2, Box 2, Otis, Oregon 97368.

playing a role in the introduction of weeds in northwestern Vermont, the University will undoubtably continue to yield new pest species, such as *Allium vineale*.

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HISTORICAL NOTE

EARLY YEARS OF CHARLES SCHWEINFURTH ORCHIDOLOGIST

Harold St. John

At the fiesta in honor of Prof. Merrit L. Fernald, held by the New England Botanical Club in May 1984, I was asked if I knew anything about the early years of Charles Schweinfurth. Yes, we grew up together. Wouldn't I please write my recollections of him?

There are two biographies of C. Schweinfurth, one by Schultes (1971), and the other by Garay (1972). These relate principally to his later career and to his scientific accomplishments.

Charles Schweinfurth was born on April 13, 1890 in Brookline, Mass. His father was a successful architect; some of his notable designs are the Town Hall of Brookline and several buildings in the early campus of Wellesley College. He was a big, burly, gruff business man. His wife was slender, delicate, shy, and seldom left the house, which was on a side street near the center of the village in Brookline. The son Charles was an only child. He was bright, slender, shy and timid.

My family moved to Brookline in the summer of 1900, and I, being eight years old, was entered in the third grade of Pierce School, the nearest public school. Charles, who was nearly two years older, was one grade ahead of me. Just when we met and became friends, I do not now recall, but it was not long after my entry into this elementary school.

Soon after my arrival, I became friendly with Ralf (Alfred Dupont Chandler, Jr.), one of my classmates. This early contact ripened into an enduring friendship, and together we studied in the Brookline Pierce School, in the High School, and in Harvard College, where we were roommates, and I later married his younger sister, Elizabeth. Ralf invited me to come after school and play in his yard, which was of some two acres, with flowers, fruit trees, vines, a pond, gravel paths, and an imposing house, a barn and a work shop. Ralf was an organizer and a natural leader. For playmates he had his brother Bill (William Sumner Chandler), and his sister Elizabeth. To these he attracted and added four other boys regularly and several others for shorter periods during the school years. My parents allowed me to play there regularly, indoors in inclement weather, but usually outdoors. We practiced various sports: football, baseball, tennis, skating, running games, and particularly track athletics. The garden paths furnished a quarter mile track. The driveway near the barn was used for sprinting events. We had jumping and pole vaulting stands, shot put, hammer, and discus. We all practiced and competed in every event and took them seriously. Ralf excelled in the high jump; I did in the pole vault, and others in the runs. Charles Schweinfurth joined in occasionally, and he could sprint like a scared rabbit. He was fascinated by our gang and our activities, but was somewhat timorous of it all, and could not be persuaded to come regularly.

Charles helped to get me started as a bird student. He and I joined the Norfolk Bird Club, the only one in the town of Brookline. It was an organization of a dozen boys, and it lasted for some eight years, had meetings, trips and published a little magazine. Prominent members were Joseph Kittredge, who became a forester and eventually was professor of forestry at the University of California, Berkeley; James Peters, who became ornithologist at the Museum of Comparative Zoölogy, Harvard University; Richard Marble, who became a gentleman farmer in Vermont; Charlesworth Levy, a cripple, who died while still a member. Several of us became students at Harvard College, where they had ornithologists in the Museum of Comparative Zoölogy but offered no courses on the subject. We composed and sent a petition to the president of Harvard, asking to have courses in ornithology offered, but it had no effect.

Charles and I early became botanical friends—just when I cannot remember. He was older and had learned more of the local flora than I had. By the age of six I was already a young botanist and a plant collector. My mother knew many of the local plants and helped me with an excellent flower book: F. Schuyler Mattews' *Field Book of American Wild Flowers*. Until his third year at Harvard College, my father took the training to be a naturalist, so he knew much botany.

Charles and I made one-day collecting trips in and near Brookline. We brought back choice specimens, but at first we did not preserve them. The first specimen that I preserved and saved to start my herbarium was a *Habenaria*, collected in Dover, Massachusetts in July 1906. My family regularly spent one month of the summer with mother's parents, the George Draper Everett family at their farm in Dover. On several summers I invited Charles to visit us there for a week, and we botanized actively. My first research project was to learn and then publish a flora of Dover. That is one project which I have never finished.

The month of July 1909 we spent in the White Mountains of New Hampshire at a hotel in Jackson, a charming place near the Carter Range. We invited Charles to join us for several weeks. We botanized actively, and I collected for my herbarium mostly the wild orchids. After exploring the Jackson vicinity, we were eager to climb and collect on Mt. Washington. My father was already semi-invalid, and did not feel strong enough for such a trip, so he asked mother to accompany us. She was capable and active, and went with us on August 12, 1909. We drove from Jackson in a carriage to the foot of Mt. Washington, climbed via Tuckerman's Ravine and the Lake of the Clouds to the summit and descended by the alpine garden and the carriage road, returning to our carriage in full darkness. I collected mosly orchids.

In 1909 Charles had already entered Harvard College, and while studying under Prof. M. L. Fernald had learned of the botanical rarities to be found in northern Vermont. Hence, we planned a trip there, and in late June 1911 we took off alone to Stowe, Vermont. There we found lodging in a farm house, well up towards the mountains. For several days we botanized the lowlands, then on July 2nd we climbed Mt. Mansfield, by the road to the hut near the summit. Pushing north, we crossed over the top and I proposed that we follow the ridge till above Smuggler's Notch, and descend the cliffs there to the road below. The idea was a good one, but there was no trail, and the ridge cover was of dwarfed spruce only a few feet tall, and interlaced so that one could not walk either under or through the evergreen trees. We progressed at about half a mile an hour, and the afternoon waned. It was almost dusk when we arrived at the ridge top above Smuggler's Notch. There it was open, but the descent was down steep, calcareous gulches and cliffs. Eagerly we started down, but soon Charles collapsed. He was suffering from altiphobia, and nothing could persuade him to stand up and continue. I gave him a drink and a piece of a sandwich, with no benefit. It was late twilight. We could not descend or spend the night there so I lifted him up, got him on my back, and struggled up the hundred or so feet to the summit. The ground was mossy and soft, so, with a cover of a gather of ferns, we spent the night. We rested, but were pestered by biting bugs that easily entered through our blanket of ferns. The next day Charles counted the bites on the back of one hand—140! At first dawn we heard the chirps of the white throated sparrow and of the thrushes. Soon we continued along the ridge to the north. The ridge sloped down, and the trees became tall enough so that we could walk beneath them. Then in the outskirts of Jeffersonville we came to pastures, fields and a farm house where we found hospitality. In a hired carriage, we drove south over Smuggler's Notch, where we gazed again at the famous cliffs.

Next, after days of rest, we headed for the White Mountains in New Hampshire. At Randolf on July 5, 1911, we met Nelson Smith who had a cabin on Mt. Madison, in the woods just below tree line, at about 5,000 feet altitude. We bought food supplies, and separated them into three packs. We started trudging up the mountain, but after going half a mile it was obvious that Charles was too weak to backpack a load. So we divided his pack and added it to Smith's and mine. By early afternoon we were three-quarters of the way up. The weather had been fine but then a big, dark cloud loomed over the mountain; lightning and loud thunder came from it. Till then Charles had been dragging behind us, but at the first crack of thunder he dashed by us and disappeared up the trail. The storm overcame us two and we were drenched, but when we reached the cabin, there was Charles, dry and content. Smith was not a botanist, but a mountaineer and a good companion. For a week we botanized the granite mountains, Madison, Adams, and Jefferson.

When a sophomore in college, Charles had to withdraw due to an attack of poliomyelitis. He was bedridden for months. Since I was his close friend, his father came to me and asked me to call on Charles, keep him in touch with events and stimulate him. For months I visited him once a week in his sick room. He slowly got better, and by exercises he recovered the use of his right arm. The next year he reentered Harvard College, but changed his major from chemistry to botany.

Charles and I got on well together in botany, natural history, the outdoors and travel notwithstanding his being a confirmed pessimist. I offer these details to complete the life picture of Charles; I do so as his friend, and for many years his only friend.

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RHODORA
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Vol. 89 **January 1987** **No. 857**

STILL ANOTHER UNPUBLISHED LETTER FROM SPRUCE ON EVOLUTION

RICHARD EVANS SCHULTES, FLS

In 1978, I published an unknown letter from Richard Spruce on the theory of evolution (Schultes, 1978). During the course of my research on the work of this remarkable and unsung hero of tropical American botanical field studies, I have found still another letter showing that Spruce was an early thinker along evolutionary lines.

This letter was written from Welburn, Yorkshire, on May 28, 1870, when Spruce had retired to his cottage in Coneysthorpe following 14 years of intensive plant collecting and floristic studies in the Amazon Valley and in the northern Andes. It is my opinion that few scientists—including modern investigators—have ever had such an inclusive and personal knowledge of the Amazon flora as did Richard Spruce. It was the result of his own intimacy with the flora of first the Malton district, then the Pyrenees and finally of the Amazon and Andes that led him to speculate on plant classification, phylogeny and evolution. This letter is preserved in the British Museum (Natural History) to the authorities of which I express my deepest appreciation for permission to publish it.

"My dear friend—

"I have not been well enough lately to write to you as I could wish, or to make a few notes on your drawings—as I hope to do in a few days and then return them to you. I shall try to send the two memoirs on *Orthotrichum* by this post. Dr. Wood has certainly succeeded in involving the poor *O. anomalum* in a degree of 'obscenity and mysticism' (to use his own words) which I have rarely seen paralleled.

"Your vindication of the character of *Dicranium strumiferum* is curious. My recollections of the moss are very dim. I suppose Mitten would place *D. polycarpum* in his genus *Anisothecium* (see Musia Austro-Am.). I note a slight laxity at the basal angle of one of

Figure 1. *Hypnum/Plagiothecium denticulatum.* Bruch, Ph., W. Ph. Schimper and Th. Gümbel: *Bryologia Europaea* 5 (1851 1855) t. viii (501).

Figure 2. *Hypnum*/*Plagiothecium sylvaticum*. Bruch, Ph., W. Ph. Schimper and Th. Gümbel: Bryologia Europaea 5 (1851 1855) t. xi (503).

the leaves of the latter in your preparation. If I may make to you an auricular confession: I w$^{\underline{d}}$ say that the auricular character seems to me quite insufficient to separate *Dicranella,* etc., except as subgenera, from the great genus *Diacrinum.*

"If you come here you shall see Bentham and Hooker's great work, the *Genera Plantarum,* wherein they have taken great pains to make their genera *large* natural groups. I tried to get Mitten to follow the same plan. He has done so in some measure, but he is crotchety, and he does not know how to contrast characters—sometimes indeed the essential distinction has altogether escaped him, and he is often very vague and untrustworthy about sexes and peristomes.

"When travelling in South America and long before, I knew aught of Mr. Darwin and his speculations, I had convinced myself that the same Forces and the same Laws are in existence now as have been from all eternity and will be *per secula seculorum.* That the Evolution of Organic Form is continuous and without any break. Also that the unceasing variations of living beings are progressive—and mere oscillations around first points which we call types of species or genera; consequently, that if we could have before our eyes all the individuals now existing and that have ever existed of any (so-called) species or genus, we should find it impossible to draw any line of separation, or to indicate any central point, for our species or genus, and especially to distinguish one species from another of the same genus.

"Darwin's doctrine that a Natural Classification is based on community of descent seems to me irrefragable. To take an example: *Hypnum denticulatum* and *sylvaticum* may be several states of the same existing species—I think they are. But you and others may think them so completely severed that they do not interbreed and that no exactly intermediate forms now exist so that they truly merit to be called 'species'. But, even so, it is clear to me that at a period immediately preceding our own the two had a common progenitor. At a period more remote there was but a single species of *Plagiothecium,* from which all of that ilk have descended, the forms having gradually multiplied by the accumulation and inheritance of minute changes induced by varied external conditions, and having been segregated into species by Nature's selection of those forms only best fitted to survive. At a period still more remote every *Hypnum* (as we used of old to understand that name) must have had but a single progenitor. It is this genealogy we attempt to trace in our Species, Genera, Tribes and Orders; and the more closely we can do so, the more natural will be all our groups. So, with regard to species, it matters not (were it not for this awful question of "names") whether we give a doubtful species a distinct name, or regard it as a variety of the species to which it stands most nearly related. We are unfortunately often called on to make up our minds as to the degree of consanguinity of individuals and forms when our materials are quite insufficient. A tyro will make no difficulty at considering three mosses (whose differences seem to his slender experience constant) distinct species; while a veteran like yourself will find it quite impossible to come to a definite decision; for 'fools rush in where angels fear to tread.'

"Whenever we are able to rigidly define, or assign limits, to genera and species, surely it is because either we do not possess those intermediate forms that actually exist, or else those intermediate forms have already ceased to be, through the action of the inevitable law of the 'Survival of the Fittest.'

"The Misteltoe may be very widely separated in structure from the tree whereon it grows. (I have gathered above 60 species of Misteltoe, growing on trees of many different families). Still the difference is only one of degree, and it is sometimes not needful to go very far back (down the genealogical tree) to arrive at the type of plant which may have been their common ancestor. With the whole of the existing vegetable kingdom before us, we see in space somethng very like what must have taken place in time.

"If you have thought out this and collateral questions as anxiously as I have done, and have come to different conclusions, I do not wish to force mine upon you. The one thing certain (for me) is that this universe is regulated by immutable laws; that to find out these laws, physical, moral, etc. is to bring ourselves into closer relation with the Supreme Intelligence from whom they emanate and who must be infinitely superior to all the gods that mythologists (or theologists, for there is no difference) have ever invented.

"Nearly all our most eminent naturalists are converts to Darwinism. Bentham hung off a long time but is now one of its most strenuous advocates. A few German idealists refuse to be convinced, and it is they who are just now causing the greatest confusion among species. Two of them have been writing on the geographical botany of India. Hooker and Thomson have written on the same subject. But in several cases a single species of H. and T. stands for about 25 species of the Germans:—There is no end to it, if you will substitute ideas for facts.

"Most faithfully yours,
R. Spruce

"W. Wilson Esq."

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BOOK REVIEW

Beeftink, W. G., J. Rozema and A. H. L. Huiskes, Eds. *Ecology of Coastal Vegetation.* Pp. xx + 598. Charts, maps and illustrations. Dr. W. Junk Publ., Kluwer Academic Group, Spuiboulevard 50, Box 989/3300 AZ Dordrecht, Holland. (1985). Cloth. Dfl. 400; US. $139.50; £110.95.

The proceedings of a symposium held at Haamstede in March, 1983, in celebration of the 25th anniversary of the Delta Institute for Hydrobiological Research in Yerseke, Holland, this extensive volume emphasizes the integration of numerous aspects of geobotanical and environmental research of European sand dunes and salt marshes. The contributions focus on studies of the vegetation, ecophysiological investigations, research of biogeochemical and physical processes, conservation, management and populations.

The list of contributors to the proceedings number 67 experts from 12 countries; 94 specialists participated in the symposium.

The volume is divided into seven parts: 1) Vegetation studies 2) Population studies 3) Ecophysical studies 4) Biogeochemical and physical processes in coastal ecosystems 5) Conservation and management studies 6) Concluding papers. The seventh section consists of abstracts of 11 poster papers.

While the contents of the book are based on studies of European coastal regions, there is much information that can be of great interest to specialists working in coastal areas of North America.

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IN MEMORIAM

ROBERT C. FOSTER

1904 – 1986

Robert Crichton Foster was born in Springfield, Massachusetts and died in the same city on March 10, 1986. Although Foster was associated with the Gray Herbarium of Harvard University throughout most of his professional career, his early training was not in systematic botany. His undergraduate degree, A.B. cum laude (1926), was from Harvard in history. After an A.M. degree in the same field, he served as an instructor at Connecticut College for Women in New London from 1927–32. Returning to Harvard, Foster studied biology, specializing in plant cytology and cytogenetics under Professor Karl Sax. His doctoral thesis dealt largely with the cytogenetics of the genus *Iris* but by the time it was published it not only had a strong cytotaxonomic flavor, but became more monographic in nature. This shift of emphasis signaled Foster's entry into the field of plant taxonomy. His early encouragement in this direction came from M. L. Fernald and C. A. Weatherby at Harvard, H. A. Gleason at the New York Botanical Garden, and P. A. Munz at Pomona College. Field work for his studies of *Iris,* as a Parker Fellow in Biology at Harvard, was centered in California where he was associated with Pomona College. After a year (1937–38) as instructor of botany at the University of Arizona, Foster returned to Springfield, Massachusetts because of serious illness in his immediate family.

Early correspondence of Professor Fernald shows that Dr. Foster began as a part-time assistant in the Gray Herbarium in 1940; he became a full-time assistant the following year. In 1947 he was given the title of Acting Curator, a position he held until 1954 when he was appointed Botanist and Bibliographer. One of his responsibilities was the compiling and publishing of the Gray Herbarium Card Index, which he did from 1954 until his retirement in 1970. Foster's botanical research was centered on the family Iridaceae and the Flora of Bolivia. He published considerably in both areas, his papers appearing in Contributions from the Gray Herbarium, beginning in 1936. [Reed C. Rollins]

NEBC 1987 AWARD
FOR THE SUPPORT OF BOTANICAL RESEARCH IN NEW ENGLAND, U.S.A.

The New England Botanical Club will again offer an award of $1000 in support of botanical research to be conducted in the New England region during 1987. This award is made to stimulate and encourage botanical research on the New England flora and to make possible visits to the New England region by those who would not otherwise be able to do so. The award will be given to the graduate student submitting the best research proposal dealing with field studies in systematic botany and plant ecology, but proposals for research in other areas of botany will also be considered. This award is not limited to graduate students at New England institutions, nor to members of the New England Botanical Club. Papers based on this research must acknowledge the NEBC's support, and it is encouraged that they be submitted to *Rhodora,* the Club's journal, for possible publication—subject to standard review processes.

Applicants should submit a proposal of no more than three double spaced pages, a budget (the budget will not affect the amount of the award), and a curriculum vitae. Two letters, one from the student's major professor, in support of the proposed research are also required. Proposals and supporting letters should be sent before 28 February 1987 to:

Awards Committee
The New England Botanical Club
22 Divinity Avenue
Cambridge, MA 02138

The recipient of the award will be notified by 30 April 1987.

THE 1987 JESSE M. GREENMAN AWARD

The Greenman Award is named for Jesse More Greenman (1867–1951), who was Curator of the Missouri Botanical Garden Herbarium from 1919 until 1943. A cash prize of $250 is presented each year by the Garden, recognizing the paper judged best in vascular plant or bryophyte systematics based on a doctoral dissertation that was published during the *previous* year. Papers published during *1986* are now being considered for the 19th annual award, which will be presented in the summer of 1987. Reprints of such papers should be sent to:

Greenman Award Committee
Department of Botany
Missouri Botanical Garden
P.O. Box 299
St. Louis, MO 63166-0299, U.S.A.

In order to be considered for the 1987 award, reprints must be received by 1 July, 1987.

MEETING ANNOUNCEMENT AND CALL FOR ABSTRACTS

NEW ENGLAND BOTANY GRADUATE STUDENT MEETING

The second New England Botany Graduate Student Meeting will be hosted by the Department of Botany and Plant Pathology at the University of New Hampshire, Durham, NH on Saturday 14 March 1987. Attendance is open to all. Paper presentations will be largely restricted to graduate student research (completed or in progress) representing all areas of botany (systematics, ecology, reproductive biology, anatomy, physiology, etc.). Time slots for paper presentations are limited and prior registration is required. Abstracts are due by 15 February 1987.

For information and abstract forms, contact Debra A. Dunlop or Julie A. Hambrook.

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JOINT FIELD MEETING: JUNE 21–25, 1987

The Annual Joint Field Field Meeting of
The Northeastern Section of the Botanical Society of America
The Torrey Botanical Club, and
The Philadelphia Botanical Club
will be held June 21 through 25 in Southern Maine. Accomodations will be at the University of Southern Maine, in Gorham. The cost will be about $145.00; this includes eleven meals, and four nights' housing (double occupancy), plus trips and programs. Field trips, on Monday through Wednesday, are planned to saltmarshes, rocky shores, coniferous and deciduous woods, and wetlands. Space is limited and prior registration is required. For full details and registration information, contact:

Karl Anderson
Rancocas Nature Center
Mount Holly, NJ 08060
Tel.: (609) 261-2495
(609) 267-2195

Vol 88, No. 856, including pages 427–539, was issued October 31, 1986

INSTRUCTIONS TO CONTRIBUTORS TO RHODORA

Submission of a manuscript implies it is not being considered for publication simultaneously elsewhere, either in whole or in part.

Manuscripts should be submitted in **triplicate** (an original and two xerographic copies) and *must be double-spaced* (at least 3/8″) **throughout** including tables, figure legends, and literature citations. Please do not use corrasable bond. The list of legends for figures and maps should be provided on a separate page. Footnotes should be used sparingly. Do not indicate the style of type through the use of capitals or underscoring, particularly in the citation of specimens. Names of genera and species may be underlined to indicate italics in discussions. Specimen citations should be selected critically, especially for common species of broad distribution. Systematic revisions and similar papers should be prepared in the format of "A Monograph of the Genus Malvastrum", S. R. Hill, Rhodora 84: 1–83, 159–264, 317–409, 1982, particularly with reference to indentation of keys and synonyms. Designation of a new taxon should carry a **Latin diagnosis** (rather than a full Latin description), which sets forth succinctly just how the new taxon is distinguished from its congeners. Papers of a floristic nature should follow, as far as possible, the format of "Annotated list of the ferns and fern allies of Arkansas", W. Carl Taylor and Delzie Demaree, Rhodora 81: 503–548, 1979. For bibliographic citations, refer to the Botanico-Periodicum-Huntianum (B-P-H, 1968), which provides standardized abbreviations for journals originating before 1966. All abbreviations in the text should be followed by a period, except those for standard units of measure and direction (compass points). For standard abbreviations and for guidance in other matters of biological writing style, consult the *CBE Style Manual,* 5th ed. (original title: *Style Manual for Biological Journals*). In preparing figures (maps, charts, drawings, photos, etc.) please remember that the printed plate will be 4 × 6 inches; be sure that your illustrations are proportioned to reduce correctly, and indicate by blue pencil the intended limits of the figures. (Some "turn-page" figures with brief legends will be 3 1/2 × 6 in.) Magnification/reduction values given in text or figure legends should be calculated to reflect the actual printed size. An Abstract and a list of Key Words should be supplied at the beginning of each paper submitted, except for a very short article or note.

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Rhodora

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Scientific papers and notes relating to the plants of North America and floristically related areas, and articles concerned with systematic botany and cytotaxonomy in their broader implications will be considered. Brevity is urged; please conform to the style of recent issues of the journal. See "Instructions to Contributors to RHODORA" at the end of each issue. Fifty reprints of each article are supplied free of charge. Authors may arrange with Lexington Press for additional copies. RHODORA assesses page charges.

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Cover illustration

The American elm (*Ulmus americana* L.), official state tree of Massachusetts, has been a familiar sight for decades throughout the Northeast. The largest known living specimen in Mass. is located in Stockbridge. In 1982, it was 119′ high, had a crown spread of 118′, and was 232″ in circumference. In recent years, many of these stately trees have succumbed to Dutch Elm disease, a fungus accidentally introduced from Europe. The article by Ellmore and Phair (Rhodora Vol. 89, No. 857) contains the latest information of the status of this once dominating tree in our flora. Photo courtesy of Rhoda Vanderwall.

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NOTES ON THE RARE FLORA OF MASSACHUSETTS

Bruce A. Sorrie

ABSTRACT

Since 1978 the Massachusetts Natural Heritage Program has conducted an inventory of rare species throughout the state of Massachusetts. For 286 rare vascular plant taxa information is provided on current nomenclature, number of stations, endangerment status, range extensions, habitat preference, and identification.

Key Words: endangered, threatened, special concern, historical, extirpated, Massachusetts.

INTRODUCTION

Several years have now passed since publication of "Rare and Endangered Vascular Plant Species in Massachusetts" by Coddington & Field in 1978. That valuable work was the first complete and annotated list of the state's rare or declining flora. In it the authors indicated geographical range by county for 243 rare taxa and provided comments on current status, based on herbarium vouchers and personal communications.

The year 1978 also marked the beginning of the Massachusetts Natural Heritage Program (MNHP), an ongoing inventory of the state's rare fauna, flora, and plant communities. The Program operated within the Department of Environmental Management until September of 1983 when it transferred to the Division of Fisheries and Wildlife. As Program Botanist since the fall of 1979, I have been compiling information on the current and historical distribution of the state's rare plant taxa, particularly those species which are rare over most or all of their entire range. Ten herbaria not visited (or incompletely inventoried) by Coddington & Field have been scoured for pertinent specimen data. A complete literature search through RHODORA for Massachusetts rare species has provided much additional material. Dozens of people have shared their knowledge of current or historical plant stations. Many of these people are amateur botanists who have given freely of their time and whose contributions to the botany of Massachusetts, whether through discovery of a rare plant site, rediscovery of a "lost" station, or locating a valuable specimen or literature report, has been inestimable.

For five field seasons (1980–1984) I have searched the Commonwealth from Nantucket to Williamstown, collecting specimens and recording information on exact locations, population sizes, threats, and quality of habitat. One of the major products of the MNHP inventory is the very large computerized database on the state's rare flora. Not only is there a vast quantity of historical specimens, local floras, and literature reports, but current field work and the continuing discovery of new stations for plants clearly indicate that the inventory is far from over. Indeed, it is remarkable in a small, industrialized state with a long history of botanical exploration that my assessment today is that much of Massachusetts remains under-collected. Nonetheless, as of this writing over 75% (184 taxa) of the original 243 taxa on the Coddington & Field list are known from at least one current station, compared with about 37% (90 taxa) in 1978. Based on information in the MNHP data base, 21 taxa included in Coddington & Field have been determined to be relatively common or secure in the state and consequently have been dropped from the state rare list. Also, 7 others have been delisted due to taxonomic revisions, 7 due to misidentifications of the original specimens, and 6 because they are not believed to be native to Massachusetts. Conversely, 43 taxa not listed by Coddington & Field have been added, based on current assessment of rarity. Of these, 32 are known from current stations, 5 are new discoveries to the state's flora, and 11 have not been recently verified in the field. Due to the number of current populations and lack of obvious threats, 3 of the additions have already been delisted. Thus, 286 taxa are treated in this paper. As of the end of 1984, the number of taxa on the state's rare plant list stood at 242 (Sorrie, 1985).

This paper revises and updates Coddington & Field's annotated list. My intent is not to replace Coddington & Field's publication, but to make necessary additions and corrections to provide readers with a current and more complete understanding of the rare flora of Massachusetts. Specifically, this paper covers the following topics in this order for each taxon:

1) Nomenclatural changes. Taxonomy and nomenclature will follow Kartesz & Kartesz (1980) except where noted.
2) Numbers of current (1978–1984) stations / total number of historical and current stations in Massachusetts. Note that these numbers have been derived differently than those used by Coddington & Field, who indicated numbers of vouchered *towns*. Literature records are not accepted unless information contained therein renders identification certain.
3) Current state rank. E = endangered; T = threatened; SC = special concern (rare or declining, may become threatened if trend continues); H = historical records only, no current stations; X = apparently extirpated.
4) Deletion of species (or specimen records) for reasons such as current abundance, incorrect identification, or taxonomic revision.
5) New county range extensions.
6) Notes on preferred habitat.
7) Notes on identification.

The sequence of plant families follows that of Gray's Manual (Fernald, 1950); genera and species are arranged alphabetically within each family. Additional species listed since Coddington & Field are indicated by *; those which are also new additions to the state's flora are indicated by +. Specimen citations are given for taxa known from only 1 or 2 current stations and for new county range extensions. Specimens collected by the author are indicated by BAS. Many cited specimens are in the herbarium of the Maria Mitchell Association on Nantucket Island; for convenience I have assigned them the temporary acronym MMS. With very few exceptions, records and information in this paper are included through the end of 1984.

ANNOTATED LIST OF RARE PLANTS

EQUISETACEAE -Horsetails

Equisetum palustre L. 0/2. H.

Range extension to "bogs" in Melrose, Middlesex Co. (*Morong s.n.*, NY). The Hadley specimens are correctly determined (*Manning* *s.n.*, SCHN, NEBC), but field checks along the Connecticut River in 1983 1984 turned up abundant *E. fluviatile* and *E. arvense*, but no *E. palustre*.

E. scirpoides Michx. 7/23. SC.

All current stations are west of the Connecticut River, usually under hemlock and birch on cool, steep, north-facing slopes of streams. This species is widespread, but usually occurs as small colonies and will likely be found in many more sites if searched for systematically. Jackson (1909) reports a range extension to Southbridge, Worcester Co., but the specimen collected by Ammidown cannot be located.

E. variegatum Schleich. 15/20. Recently delisted.

A remarkable range extension to Norwood, Norfolk Co., was made by S. Higginbotham in 1981 (*Higginbotham s.n.*, NEBC). It prefers open seepage slopes, abandoned marble quarries, and wet roadside outcrops. Many of the current populations are large and vigorous, the plants numbering in the thousands. A report from Salisbury, Essex Co. (Committee on the Flora of Massachusetts, 1933), is as yet unsubstantiated by a specimen.

LYCOPODIACEAE—Clubmosses

Lycopodium alopecuroides L. 0/2. X.

Known only from two locations on southeastern Nantucket Island. The Plymouth Co. collections (*Oakes s.n.*, NEBC) are *L. inundatum* var. *robustum* R.J. Eaton (R.J. Hickey, pers. comm.). As suggested by Hickey (1980) and Bietel (1979), there is much work yet to be done in determining the relationships among the various members of the *L. inundatum* complex. Characters such as arching stems and ciliate strobilar leaves are found in var. robustum as well as in *L. alopecuroides*. In southeastern Massachusetts the former is usually found with *L. appressum* (Chapm.) Lloyd & Underwood and with apparent intermediates, suggesting genetic mixing of these taxa. Strobili of *L. alopecuroides* are relatively short compared to overall branch length and are convex-sided, whereas strobili of var. *robustum* are quite variable (up to 50% of branch length) and tend to be straight-sided.

L. carolinianum L. 0/1. X.

The single station in Hatfield, Hampshire Co., discovered by the late H.E. Ahles in 1975, was bulldozed in 1980 and the species has not been seen again despite searches of nearby suitable habitat. It represents the only New England record.

L. selago L. 1/3+. E.

The Hampshire Co. station was rediscovered in 1981 (*BAS & R. Harlow 1234,* NEBC), where it grows on the exposed north face of a vertical traprock ridge. The material collected suggests hybridization with *L. lucidulum* Michx. (J. Bietel, pers. comm.) and more inventory is needed to determine whether the rare parent is still present in "pure" form. Historical reports from Worcester Co. (Dodge, 1896) and Franklin Co. (Livingston, 1964) are not yet supported by specimens, nor is a report from the Bellows Pipe area of Mt. Greylock, Berkshire Co. (Andrews, 1901). However, there is a voucher from elsewhere on Mt. Greylock (*Burnham s.n.*, S; J. Bietel, pers. comm.).

SELAGINELLACEAE—Spikemosses

Selaginella rupestris (L.) Spring 15/75+. Recently delisted.

Although current stations are mostly small and subject to overshading, this species is not difficult to find in western Massachusetts, where it shows a decided preference for calcareous to circumneutral rocks. It has not been found at many historical (and apparently still suitable) sites in eastern counties for reasons as yet unclear.

ISOETACEAE—Quillworts

+***Isoetes acadiensis*** Kott 0/1. H.

A newly described species; see Kott (1981) for description and differences from *I. hieroglyphica* A. A. Eaton. The sole Massachusetts station is at the southern limit of the species' range: "sandy shore of Fearing Pond, Plymouth," Plymouth Co., 5–6 Aug. 1937 (*Seymour 4905*, NEBC, MO). The pond is heavily used for recreation and the species was not found there in 1982.

I. eatonii Dodge 1/5. E.

Range extension to Middlesex Co.: "Arlington Brook" (*Boott s.n.*, GH); Cambridge, Fresh Pond (*Boott s.n.*, NY), both annotated by Kott in 1980. Despite searches at historical stations and elsewhere, we have been able to locate only the one population in Easton, Bristol Co. (*Hickey 530*, pers. herb.).

I. foveolata A. A. Eaton var. **plenospora** A. A. Eaton 0/1. Recently delisted.

Synonymized under *I. engelmannii* A. Braun by Hickey (1980), but placed under *I. tuckermanii* A. Braun by Kott & Britton (1983). The type station of var. *plenospora* is "Long Pond, North Easton," Bristol Co. (*A. A. Eaton s.n.*, MO, NEBC).

I. macrospora Dur. 0/4. H.

Range extension to Uxbridge, Worcester Co., as reported by Pfeiffer (1922). The Plymouth Co. collection (*Seymour s.n.*, NEBC) actually is *I. tuckermanii* A. Braun, as is a specimen collected by Hinds in Wellfleet, Barnstable Co. (*Hinds s.n.*, Cape Cod Natl. Seashore herb.), both annotated by Hickey in 1984.

I. saccharata Engelm. var. **amesii** A. A. Eaton 0/2. Recently delisted.

Synonymized under *I. riparia* Engelm. ex A. Braun by Hickey (1980) and by Kott & Britton (1983). In Massachusetts it is known only from the type station in Easton, Bristol Co. (*A. A. Eaton s.n.*, NEBC, VT), and from Belmont, Middlesex Co. (*Blankinship s.n.*, GH).

OPHIOGLOSSACEAE—Adder's-tongue Ferns

Ophioglossum vulgatum L. 3/88. T.

Despite former abundance, only three current stations are known and the species remains difficult to find. It is no doubt a victim of habitat succession, development, etc., but much apparently suitable habitat exists and the paucity of current sites is somewhat baffling.

SCHIZAEACEAE—Climbing Ferns

Lygodium palmatum (Bernh.) Sw. 14/46. SC.

Range extension to Lynn or Saugus, Essex Co. (*Emery s.n.* and *Sears s.n.*, both PMS); to Sharon and Dover, Norfolk Co. (*Fisher* *s.n.*, CUW), (Fuller, 1899); and to Monterey, Berkshire Co. (*Townsend & Weatherby s.n.*, GH). It is usually associated with young, relatively shrub-free moist woods of red maple and pine, as well as in lightly shaded thickets and in clearings such as utility rights-of-way. One large colony has persisted for over 110 years, presumably experiencing occasional disturbance.

HYMENOPHYLLACEAE—Filmy Ferns

+***Trichomanes* sp.** 3/3. SC.

Gametophytes of an unidentified species of filmy fern were first found in Massachusetts at Mt. Toby, Franklin Co., in 1976 (McAlpin & Farrar,1978), (*McAlpin 2573,* GH, NY; *Hickey 637,* GH). Subsequently it has been found at a site W of Mt. Toby (Farrar et al., 1983) and at Bartholomew's Cobble in Sheffield, Berkshire Co. (*BAS 1810,* ISC). Plants were also found at Campbell Falls gorge just over the state line in Connecticut (Farrar et al., 1983). Prefers moist, deeply shaded crevices in ledges and gorges.

POLYPODIACEAE—Cliff Ferns, Wood Ferns, etc.

Asplenium montanum Willd. 3/6. E.

With the recent discovery of a station in southern Vermont, Massachusetts is no longer the northern limit of the species' range (*Jenkins s.n.*, VT). The Sturbridge, Worcester Co., station still could not be relocated in 1983. Current stations are all in southern Berkshire Co. and appear to have stable populations.

A. ruta-muraria L. 5/8. T.

Extension of range to Mt. Tom, Hampden Co. (*BAS 2074*, NEBC). A large population was found well north of previous Berkshire Co. stations by P. Weatherbee on a high ledge in Lanesborough (*BAS & Weatherbee 2561,* NEBC).

Cryptogramma stelleri (Gmel.) Prantl 4/10. T.

This species is difficult to census because of imprecise historical data; nonetheless, many apparently suitable sites lack the plant. It usually requires moist or dripping rock crevices and shelves, but a huge population in West Stockbridge, Berkshire Co., occurs in thin, moss-covered soil of a shaded ledge.

Diplazium pycnocarpon (Spreng.) Broun 16 28. Recently delisted.

The number and distribution of current stations indicate that this species is more common than previously believed. Historical stations from Concord, Middlesex Co., and Norwood, Norfolk Co., were introduced and believed no longer extant.

***Dryopteris goldiana** (Hook.) Gray 19/31. Recently delisted.

Known from Middlesex, Bristol, Worcester, Franklin, Hampshire, Hampden, and Berkshire Cos., often occurring with *Diplazium pycnocarpon*. Although listed in 1980 due to the paucity of recent reports, subsequent field work indicates that stations are relatively easy to find in rich, mesic forests, especially along bases of talus slopes. Rediscovered in 1984 on Wachusett Mtn., Worcester Co., by E. Bullock (*Bullock s.n.*, NEBC), the only current site E of the Connecticut River Valley. I am skeptical of the Easton, Bristol Co., record, due to lack of suitable habitat in that part of the state. It likely was taken from plants grown at the Oakes Ames estate (see comments under *Solidago ptarmicoides*).

Pellaea atropurpurea (L.) Link 11/26. SC.

Range extension to Hampshire Co. (reported by Stone,1913), (*BAS 1368*, NEBC). The Worcester Co. station at Mt. Pisgah in Berlin could not be found in 1981 and 1984. Most current populations are relatively vigorous, although adversely affected by overshading in some cases.

Polystichum braunii (Spenner) Fee 1/5. E.

Range extension southward in Berkshire Co. to Becket (*Jones s.n.*, NY). A collection made in "Berlin" (no state named) may actually refer to Berlin, NY, or Berlin, NH, rather than Worcester Co., MA (*Blodgett s.n.*, CUW). See *Aplectrum hyemale* for comments regarding Blodgett specimens. The sole current station consists of a single plant discovered on Mt. Greylock by P. Weatherbee in 1982 (*Weatherbee s.n.*, NEBC). Extensive searches at historical sites have proven fruitless.

+***Woodsia glabella** R. Br. 1/1. E.

Discovered for the first time in the Commonwealth in 1984 in crevices of a wet calcareous ledge on Mt. Greylock (*BAS & Weatherbee 2415*, NEBC, GH). The population and the individual plants are very small but apparently healthy and not under any obvious threats, unless it be from additional collecting. In New England this species was previously not known S of Manchester, Vermont. The southernmost locality for the species is in the Catskill Mountains of New York.

SPARGANIACEAE—Bur-reeds

Sparganium minimum (Hartman) Fries 2/8. E.

A range extension to Lake Quinsigamond, Worcester Co., was reported by Jackson (1909), but the specimen collected by Stone has not been found. Current status poorly known; needs more field work. In Stockbridge, Berkshire Co., *S. minimum* occurs in small pools of a basin fen, accompanied by *Carex limosa, C. prairea, Scirpus hudsonianus, Potentilla palustris, Utricularia intermedia,* and *Galium labradoricum* (*BAS, Gilbert, & King 2456,* pers. herb.).

POTAMOGETONACEAE—Pondweeds

***Potamogeton alpinus** Balbis 0/1. H.

Southern limit of range. The sole collection was made in 1864 by J. W. Robbins in Richmond, Berkshire Co. (*Robbins s.n.,* GH). The cold, alkaline wetlands of the Richmond-Pittsfield area are known to harbor many boreal species, so it is not unlikely that *P. alpinus* will be rediscovered. A collection of *P. alpinus* var. *subellipticus* (Fern.) Ogden from Dighton, Bristol Co., and cited by Seymour (1969), has been annotated by Hellquist as *P. gramineus* L. × *perfoliatus* L. var. *bupleuroides* (Fern.) Farw. (*Seymour 17182,* NEBC).

P. friesii Rupr. 2/5. E.

This pondweed remains a very rare species despite much recent field work in Berkshire Co. by C. B. Hellquist.

P. hillii Morong 29/30. Recently delisted.

The many current stations vouchered by Hellquist indicate that this species is locally abundant in western Berkshire Co. and under no obvious threats (Hellquist, 1984; Hellquist & Crow, 1980).

P. lateralis Morong 0/1. Recently delisted.

Research by Hellquist indicates that this may not be a valid taxon (a manuscript is in progress). Type station is "Charles River, Dedham," Norfolk Co. (*Faxon s.n.,* GH,NEBC).

P. strictifolius Benn. 1/5. E.

Its status is similar to that of *P. friesii.*

NAJADACEAE—Naiads

Najas guadalupensis (Spreng.) Magnus 3/7. Recently delisted.

Reported from Dukes Co. (Committee on the Flora of Massachusetts, 1942), but no specimens have been seen. Limited field work indicates that this species is locally abundant at coastal salt-ponds and inland alkaline ponds. Very weedy southward, its native status here is questionable. It appears to be spreading in New England and is now known from all six states (Hellquist & Crow, 1980; Hellquist, pers. comm.). Wentz and Stuckey (1971) have amply documented this species' rapid increase in Ohio.

ALISMATACEAE—Arrowheads

Echinodorus parvulus Engelm. 0/3. X.

This disjunct species was last seen in the state in 1920 at Winter Pond near Boston. Although abundant suitable habitat remains, most of the rarities once found at the pond have disappeared. Herbicide application is a possible cause of disappearance at all historical sites.

Sagittaria calycina Engelm. var. **spongiosa** Engelm. (=*Lophotocarpus spongiosus* [Engelm.] J. G. Smith) 1/7. E.

Range extension to Middlesex Co. (*Boott s.n.,* GH), where now extirpated due to damming of the Mystic River. Rediscovered at Rowley/Newbury in 1981, where a large population flourishes on brackish tidal mud with *Zizania aquatica, Polygonum punctatum, Lilaeopsis chinensis, Samolus parviflorus,* and *Bidens hyperborea* (*BAS 1214,* NEBC). The northern limit of its range is eastern Quebec and eastern New Brunswick. Type station is "mud-covered sand, banks of the Merrimack River, Newburyport," Essex Co. (*A. A. Eaton s.n.,* NEBC, NY).

S. cuneata Sheldon 3/8 T.

Wapato remains a rare species despite field work in what appears to be suitable habitat. In Lenox, Berkshire Co., it occurs in shallow floodplain lagoons by the Housatonic River, with *Alisma* sp., *Calla palustris, Peltandra virginica, Proserpinaca palustris* (*BAS 2494,* NEBC). At the Connecticut River H. E. Ahles found it on the protected shore of an island in Sunderland, Franklin Co., and in a richly vegetated former river channel just off the main stream in Holyoke, Hampden Co. (*Ahles 86341, 86205,* MASS, NEBC).

***S. subulata** (L.) Buch. var. **subulata** 2/4. T.

The nominate variety is currently known from vigorous colonies at East Wareham, Plymouth Co. (*Hellquist 1495,* NASC; *BAS 693,* pers. herb.), and Rehoboth, Bristol Co. (*BAS 2827,* NEBC). The var. *gracillima* (S. Wats.) J. G. Smith is known from at least ten current stations and ten other historical sites. It is perhaps referable to *S. stagnorum* Small (see Godfrey & Wooten, 1979, and Hellquist & Crow, 1981). The relationship between var. *subulata* and var. *gracillima* is unclear. Both varieties were collected in 1928 from "tidal water" of the North River and tributaries, Plymouth Co., and a mixed population was found in 1984 at the inland limit of tides, Palmer River, Rehoboth. Here there was evident gradation from greatly elongate plants of sandy substrates in fast flowing water to short phyllodial plants of oozy mud in quiet backwaters (*BAS 2827, 2828, 2829,* NEBC). Plants at the inland and non-tidal Sudbury River in Concord, Middlesex Co., showed similar gradation (*Hellquist 264, 2784, 2786, 2789,* NASC).

S. teres S. Wats. 27/43. SC.

Common within its very limited state range, where it prefers shallow water and exposed bottoms of acid freshwater ponds. It still inhabits a few ponds in Hampden Co., but apparently rarely flowers there. Because it is known from only 18 current sites outside of Massachusetts and due to widespread threats to its habitat, we will retain *S. teres* as a listed species. Type station is "shore of Lewis Pond, Hyannis," where now extirpated (*Deane s.n.,* GH, AC, NY, NHA).

POACEAE—Grasses

Aristida purpurascens Poir. 4/38. T.

Range extension to Boston, Suffolk Co., and Westfield, Hampden Co. (*Faxon s.n.,* GH; *Shurtleff s.n.,* NY). Also reported by Stone (1913) from Mt. Holyoke, Hampshire Co., and West Springfield, Hampden Co., but the specimens have not been found. Extant populations occur only on the islands of Nantucket, Martha's Vineyard, and Naushon. The latter population is large and vigorous, probably due to sheep grazing; landowners there inform me that sheep avoid eating this grass. Elsewhere in Massachusetts it is severely declining due to reforestation of open habitats.

A. tuberculosa Nutt. 8/12. SC.

Most populations are vigorous and on protected land. It prefers stabilized maritime dunes with *Hudsonia tomentosa,* but also is found on a sandy roadside and in an unused sandpit in Plymouth Co. Curiously absent from the extensive dune systems of Cape Cod and the islands.

Calamagrostis pickeringii Gray 0/4. X.

Subspecific taxa have been synonymized with the species (Greene, 1980). Searches in 1984 were unsuccessful due to alterations of the habitats at the Andover, Essex Co., sites.

Dichanthelium acuminatum (Sw.) Gould & Clark var. **implicatum** (Scribn.) Gould & Clark (in part = *Panicum auburne* Ashe) 6/10+. Recently delisted.

Placed in synonymy with several taxa of dry, open sandplains and sandy pondshores; see Gould & Clark (1978) for a revision of this genus. In the field these taxa present an overlapping series of morphological entities, and studies are needed to determine whether observed differences are due to genetic makeup or to ecological variation. Plants assignable to "*P. auburne*" are frequent on sandplains and disturbed sandy ground on Nantucket and Martha's Vineyard; occasional on Cape Cod.

D. boscii (Poir.) Gould & Clark (=*Panicum b.* Poir.) 0/0. Recently delisted.

All specimens seen are referable to *D. latifolium* (L.) Gould & Clark (=*P. l.* L.): *Pease 11364* (NEBC), *St. John 771* (NEBC), *collector unknown* (NHA), *BAS 1297* (NEBC). Visits to historical collection sites yielded abundant *D. latifolium,* most plants with "bearded" nodes. However, this character is much more variable in *D. latifolium* than most keys allow: up to 1 mm long on the lower nodes, whereas the denser beards of *D. boscii* are 2–3 mm long. Spikelet length also clearly separates these two species: spikelets of the purported "*boscii*" from Massachusetts are no longer than 3.5

mm, whereas those of true *D. boscii* from Connecticut and southward are 4.0–4.5 mm. A record from Medfield, Norfolk Co. (Knowlton, 1950), is not supported by specimens and a visit to the site in 1981 yielded only *D. latifolium* with pubescent nodes.

D. ovale (Ell.) Gould & Clark var. **addisonii** (Nash) Gould & Clark (=*Panicum commonsianum* Ashe) 7/19. SC.

Nominate *P. commonsianum* and its var. *addisonii* are synonymized in the recent revision by Gould & Clark (1978). "*Panicum owenae*" Bickn. of Nantucket appears to be merely a depauperate, narrow-leaved form of *D. ovale* and I have not encountered it (*Bicknell 10910, 10912, 10913,* NY). *Dichanthelium ovale* is most often found on roadsides, railroad embankments, and in disturbed sandy grasslands and heathlands.

D. scoparium (Lam.) Gould (=*Panicum s.* Lam.) 0/7. H.

Several searches at historical sites have failed, but lack of specific locality and habitat information hinders efforts.

D. sphaerocarpon (Ell.) Gould var. **isophyllum** (Scribn.) Gould & Clark (=*Panicum polyanthes* Schultes) 0/0. Recently delisted.

All Massachusetts specimens are referable to nominate *D. sphaerocarpon (=Panicum s.* Ell.): *Griscom & Svenson 6360* (NEBC, SCHN, CUW), *Fernald 16158* (NEBC), *R. J. Eaton s.n.* (NEBC), *Svenson s.n.* (NEBC), *Svenson 3015* (Cape Cod Museum of Natural History), *Coddington IX.7.1978.1* and *IX.6.1978.4* (pers. herb. BAS). There is no question that *D. sphaerocarpon* is variable in Massachusetts, given its ecological tolerance, but no specimens that I have seen clearly match the larger leaves and longer inflorescences of var. *isophyllum,* even though a few collections have essentially glabrous nodes. In their recent revision, Gould & Clark (1978) give the following measurements to separate var. *sphaerocarpon* from var. *isophyllum,* respectively: width of median blades 6–11 (–14) mm vs 15–30 mm; length of uppermost blade 3–9 cm vs 10–15 cm. In addition, measurements of material at GH indicate that panicle length of the former is 3–10 cm vs 12–18 cm for the latter. The habitats of these taxa appear to overlap, but var. *isophyllum* seems to prefer dry, shady woods and alluvial forests, while var. *sphaerocarpon* prefers dry to damp sandplains, roadsides, and clearings.

D. wrightianum (Scribn.) Freckmann (=*Panicum w.* Scribn.) 13/22. SC.

Frequent on sandy-peaty shores of Coastal Plain ponds, often in company with *Eleocharis melanocarpa, Fuirena pumila, Drosera filiformis,* and *Sabatia kennedyana.* Despite habitat overlap with "*Panicum meridionale*" Ashe, "*P. spretum*" Schultes, and other taxa included by Gould & Clark (1978) under *D. acuminatum,* I find no evidence of intergradation and favor retention of *D. wrightianum* as a full species. Spikelets of *D. wrightianum* (0.6–0.9 mm) do not overlap with those of *D. meridionale* (1.2–1.5 mm), at least in New England, and *D. wrightianum* is a much less hairy plant. See Freckmann (1981) for a reconsideration of the *D. acuminatum* complex.

***Diplachne maritima** Bickn. (=*Leptochloa fasciculata* [Lam.] Beauv. var. *maritima* [Bickn.] Gleason) 3/6. T.

Native to brackish pools and borders of saltponds on Nantucket, Martha's Vineyard, and the Elizabeth Islands. The Boston, Suffolk Co., and Worcester, Worcester Co., collections are clearly adventive (*Swann s.n.*, NEBC; *Ahles 81937,* MASS). Current stations are on Nantucket and Naushon Islands, where populations are relatively large and stable (*BAS 2233,* GH, NEBC; *BAS 2258,* NEBC).

Elymus mollis Trin. (=*E. arenarius* L. var. *villosus* Meyer) 2/4. E.

Range extension to Tisbury, Dukes Co. (*MacKeever MV651,* NEBC, NY). Both current stations are in Gloucester, Essex Co., where rediscovered after a lapse of 101 years (*BAS 1838, 1839,* NEBC). Collections from Provincetown and especially Tisbury may have been from human-caused introductions, although the specimens clearly belong to the North American taxon. Murdoch (1913) considered the Provincetown plants native, despite an extensive program at the turn of the century to stabilize dunes with various planted grasses and woody plants. In a search of available documents, R. LeBlond (pers. comm.) has not been able to verify that *E. mollis* was used in those plantings.

***Eragrostis frankii** C. A. Meyer 5/7. SC.

Vouchered from Franklin, Hampshire, Hampden, and Berkshire Cos. Collections made in the late 1970's by H. E. Ahles could not be located in the field in 1983, but this annual species of exposed river shores and sandbars may not persist at a specific site beyond a few years. It is known to be native along the Connecticut and Housatonic Rivers, where associated with *Digitaria sanguinalis, Eragrostis pectinacea, E. hypnoides, Leersia oryzoides, Panicum capillare, Cyperus aristatus, C. rivularis, Salix exigua,* and seedlings of *Populus deltoides* and *Salix nigra.* Occasionally adventive to city sidewalks, flower boxes, and disturbed sandy ground in Essex, Middlesex, and Suffolk Cos. A specimen from Lancaster, Worcester Co., is without locality data; it may be native on the Nashua River.

Milium effusum L. 5/8. T.

An extremely large population occurs in West Stockbridge, Berkshire Co., discovered by J. Jenkins in 1980; another small population occurs not far away in the same town (C. Caljouw, MNHP files). Plants are scattered in three localities on the middle and upper slopes of Mt. Greylock and Ragged Mtn. in Adams, Berkshire Co. Jackson (1909) lists it for Brookfield, Worcester Co., based on a specimen collected by R. M. Harper, but I have not found the specimen. Similarly, a report from Mt. Toby, Franklin Co., is without a voucher (Committee on the Flora of Massachusetts, 1947).

Muhlenbergia capillaris (Lam.) Trin. 0/3. X.

Range extension to Mt. Sugarloaf, Franklin Co. (*Cooley s.n.,* NY). All three historical stations have been searched without success, although habitat appears suitable on the Holyoke Range and Mt. Sugarloaf. Other traprock ridges have been searched to no avail.

Panicum gattingeri Nash 4/7. SC.

Range extension to Greenfield and Heath, Franklin Co. (*Ahles 86354, 84412,* MASS). It apparently prefers disturbed calcareous or clayey soil; present stations are on open roadsides or cliff tops. Very likely overlooked due to its similarity to other species. Usually separable from *P. philadelphicum/tuckermanii* by *P. gattingeri's* straw-colored vs nigrescent spikelets, longer spikelets, and narrower, vase-shaped inflorescences.

P. longifolium Torr. 1/5. E.

Synonymized under *P. rigidulum* Bosc ex Nees in Kartesz & Kartesz (1980), but most herbaria that I searched maintain it as specifically distinct due to its narrower leaves, narrowly ascending panicles, fewer spikelets, and ciliate (not erose) ligules. In 1984 a vigorous population was found on the moist sphagnous border of a marsh in Dartmouth, Bristol Co. (*BAS, J. Pingeon, K. Langthorne 2717,* NEBC, MASS). It grows with *Lycopodium appressum, Panicum spretum, Muhlenbergia uniflora, Platanthera blephariglottis, Spiranthes cernua, Drosera intermedia, Linum striatum,* and *Kalmia angustifolia.*

P. philadelphicum Bernh. (includes *P. tuckermanii* Fern.) 3/22. SC.

Both taxa are part of a difficult taxonomic complex, the resolution of which is far beyond the scope of this paper. Nonetheless, work by Steyermark & Schmoll (1939) indicated that *P. philadelphicum* and *P. tuckermanii* are only varietally distinct at best. An examination of specimens at GH and NEBC supports this concept—several collections supposedly of each "species" were made at the same locality on the same date. Current stations are on receding peaty pondshores in Bristol and Hampden Cos. Probably overlooked.

Paspalum laeve Michx. var. **circulare** (Nash) Fern. 0/1. X.

Several collections by Bicknell apparently were all from the same Edgartown locality (*Bicknell 11115–11118,* NEBC, GH, NY). Reported by Jackson (1909) in Worcester Co., but the specimen collected by Stone cannot be found.

Puccinellia langeana (Berlin) Sorensen ssp. **alaskana** (Scribn. & Merrill) Sorensen (=*P. paupercula* [Holm] Fern. & Weatherby var. *alaskana* [Scribn. & Merrill] Fern. & Weatherby) 0/5. H.

The Nantucket record listed by Seymour (1969) is misidentified and actually is *P. fasciculata* Bickn., due to the short lemmas (2.0 mm) and the disposition of spikelets nearly to the bases of inflorescence branches (*Flynn s.n.,* VT). Two historical stations have been searched on Martha's Vineyard and in Wellfleet, but without success. Inconspicuous and probably overlooked.

Setaria geniculata (Lam.) Beauv. 5/18. SC.

Range extension to Nantucket, Nantucket Co. (*Gardner s.n.,* MMS; *Zika & Jenkins 7848,* VT), and to Dartmouth, Bristol Co. (*BAS 2644,* NEBC). Despite weedy tendencies southward, this species in Massachusetts is confined to moist, sandy, grassy to shrubby borders of saltmarshes and brackish pools. Current populations are large and vigorous.

Spartina cynosuroides (L.) Roth 5/12. SC.

Current taxonomy does not distinguish varieties. Range extension to Nantucket, Nantucket Co. (*Flynn s.n.,* VT). Although the number of current stations is small, all populations are large and most are on conservation land. It forms large patches, sometimes dominant over a few acres, along landward borders of saltmarshes and brackish creeks.

Sporobolus heterolepis Gray 0/1. X.

Field work has not been successful in locating suitable habitat for this rarity in Webster, Worcester Co., where the only Massachusetts collection was made. In the Northeast it is known from traprock in Connecticut, calcareous pavement barrens in New York, and serpentine in Pennsylvania.

***S. neglectus** Nash 1/3. E.

Considered native only in Berkshire Co., where currently known from open, seepy gravels by an artificial pond adjacent to a calcareous fen in Stockbridge (*Rawinski, Caljouw, & BAS s.n.,* pers. herb.). An associate at this site and also at Monroe, NH, is *Lobelia kalmii* (T. Rawinski, pers. comm.). Five other historical collections are adventive in Essex, Plymouth, Dukes, Worcester, and Hampden Cos.

Tripsacum dactyloides L. 2/4. E.

Range extension to Nantucket, Nantucket Co. (*Sheldon s.n.,* MMS), but it could not be found there in 1983–84. Current stations are in Fall River and Westport, Bristol Co. (*Castro s.n.,* NEBC; *BAS 2125*, NEBC, GH), the former on the shore of a pond near the coast and the latter on the shore of a tidal river.

***Trisetum spicatum** (L.) Richter var. **molle** (Michx.) Beal 1/11. T.

Vouchered from Essex, Middlesex, Norfolk, Worcester, Franklin, Hampshire, Hampden, and Berkshire Cos. The current station is at the summit of Mt. Nonotuck, Hampden Co., on lightly wooded traprock slopes exposed to northerly winds (*BAS 2537,* NEBC). This species was not found at three historical stations in 1984 and is believed to be declining due to forest succession. A northern plant of ledges and rocky shores, it reaches its southern limit in the East in Connecticut and Pennsylvania, with disjunct stations in North Carolina and Tennessee.

CYPERACEAE—Sedges

Carex alopecoidea Tuckerman 2/5. E.

The Holden, Worcester Co., specimen is misidentified; the perigynia are clearly veined on each face and the sheaths are not purple-dotted (*Seymour 6819,* CUW). One current station in Cheshire, Berkshire Co., occupies an open swale dominated by grasses and sedges near an extensive complex of seepage swamps, rich alder thickets, and open, fen-like wetlands which support *Carex schweinitzii* and *C. trichocarpa* (*BAS, Jenkins, & Weatherbee 2021,* NEBC). No doubt overlooked due to its superficial resemblance to *C. stipata* Muhl. and *C. laevivaginata* (Kükenth.) Mack.

C. baileyi Britton 0/2. H.

Historical collections are from New Marlborough and Cheshire, Berkshire Co. It is of some questionable taxonomic standing; an alternative name is *C. lurida* Wahlenb. var. *gracilis* (Boott) Bailey. It resembles a small, slender *C. lurida,* but a high percentage of specimens at NEBC and GH are readily distinguishable from *C. lurida* by the slender foliage, narrow spikes, and smaller-bodied perigynia with proportionately longer beaks. The New Marlborough specimen is transitional to *C. lurida* in having spikes 14–15 mm wide and fairly large-bodied perigynia, but it has long beaks and narrow leaves as in *C. baileyi (Hoffmann s.n.,* NEBC).

C. bushii Mack. 1/2. E.

Range extension to Sherborn, Middlesex Co. (*Loomis 1244,* NY). The sole current site was discovered by the late H. E. Ahles in a clayey, streamside meadow with *Scirpus pendulus* in Northampton, Hampshire Co. (*Ahles 81791,* MASS; *BAS 2080,* NEBC).

+***C. castanea** Wahlenb. 1/1. E.

Discovered for the first time in Massachusetts by T. Rawinski and C. Caljouw in 1984 in seepy ground near a calcareous wetland in Pittsfield, Berkshire Co. (*Rawinski & Caljouw 84–186,* pers. herb.). This station fills a distribution gap between southern Vermont and northwestern Connecticut; the latter is the southern limit of the species' range.

+***C. chordorrhiza** L. 1/1. E.

Discovered for the first time in Massachusetts by C. Caljouw and T. Rawinski in a calcareous, marshy fen in Richmond, Berkshire

Co. (*Caljouw & Rawinski 84-180*, pers. herb.). Associated species include *Carex diandra, Salix pedicellaris, Potentilla palustris,* and *Andromeda glaucophylla.* This station extends the New England range of this boreal sedge from southern Vermont; elsewhere it is found S to northern Indiana.

C. davisii Schw. & Torr. 1/2. E.

Reported by Stone (1913) from North Hadley, Hampshire Co., but no specimen has been seen. It was rediscovered in the state in 1984 in debris-strewn floodplain forest of *Fraxinus pennsylvanica* and *Populus deltoides* by the Housatonic River, Sheffield, Berkshire Co., in the company of *Carex grayi, Menispermum canadense,* and *Ribes americanum* (*BAS 2470,* NEBC, GH). Hoffmann (1922, p. 179) states that Dewey's type collection came from Sheffield, but the type specimen merely reads "Dewey. Mas." (*Dewey s.n.,* PH).

C. flaccosperma Dewey var. **glaucodea** (Tuckerman) Kükenth. 2/5. E.

Rediscovered at the type station on Bare Mtn., Holyoke Range, Hampshire Co., in 1983, where it is very local but common (*BAS 2136,* NEBC; *BAS 2530,* MASS, GH, NEBC). Rare on Mt. Tom, Hampden Co. (*BAS 2075,* NEBC). Both colonies occupy south-facing traprock slopes under oak-hickory canopy. The type collection is "moist trap rocks of the Mt. Holyoke Range" (*Tuckerman s.n.,* GH).

C. formosa Dewey 2/4. E.

Current stations are in rich, mesic forests dominated by sugar maple, basswood, white ash, and hemlock at the borders of calcareous seepage swamps in Egremont and Stockbridge, Berkshire Co. (*BAS, Rawinski, & Caljouw 2424,* NEBC, MASS; *BAS 2462,* NEBC). Reported from Amherst, Hampshire Co., by Stone (1913), but I have seen no specimen. Type station is "wet upland meadows, in great abundance with *Carex flava,* Stockbridge," Berkshire Co. (*Dewey s.n.,* GH).

C. grayi Carey 4/6. T.

Range extension to South Hadley, Hampshire Co., and to Gill, Franklin Co. (*BAS 2677,* MASS,NEBC; *BAS & Poland 1072,* NEBC). Characteristically, it is found in floodplain forests of *Fraxinus pennsylvanica, Acer saccharinum, Quercus palustris,* and *Populus deltoides* by the Connecticut and Housatonic Rivers.

C. hitchcockiana Dewey 5/9. SC.

Undoubtedly more common than the number of records indicates, particularly as forests are now older and more widespread than when the bulk of historical collecting was done. Current colonies contain small numbers of plants, often in association with *Diplazium pycnocarpon, Dryopteris goldiana, Uvularia grandiflora,* etc. Type station is "borders of mountain woods, west foot of Saddle Mtn., Williamstown," Berkshire Co. (*Davis s.n.,* GH). Saddle Mtn. was renamed Mt. Greylock around the turn of the twentieth century.

C. lenticularis Michx. 4/9. T.

As L. Standley has suggested (pers. comm.), recognition of infraspecific taxa is unwarranted in eastern North America. Range extension to Montgomery, Hampden Co. (*Manning s.n.,* SCHN), and on exposed gravel and cobble by islands in the Connecticut River, Franklin Co. (*BAS 2650, 2622, 2779,* NEBC). A further range extension to Gloucester, Essex Co., is doubtful and I suggest a check of the specimen (*Hoffmann s.n.,* MO).

C. livida (Wahlenb.) Willd. var. **grayana** (Dewey) Fern. 1/2. E.

A range extension to Templeton, Worcester Co. (*Blodgett s.n.,* CUW), is highly questionable; see comments under *Aplectrum hyemale.* Reported from the Connecticut River Valley by Stone (1913), but no specimen has been seen. Rediscovered at a calcareous meadow in Lynnfield with *Carex exilis, C. interior, C. lasiocarpa, C. stricta, Potentilla fruticosa,* and *Utricularia intermedia* (*BAS, Standley, & Leahy 1988,* NEBC). Voss (1966) suggests that our taxon is properly named *C. livida* var. *radicaulis* Paine.

C. michauxiana Boeck. 1/3. E.

Locally abundant along seepy inlets on boggy shores of a pond near Tannery Falls, Savoy, Berkshire Co., where discovered by H. E. Ahles in 1972 (*Ahles 69050,* MASS; *BAS 2169,* NEBC).

C. molesta Mack. 0/2. Recently delisted.

Further research is needed regarding its taxonomic standing. Gleason (1952, p. 325) suggests that it may represent a hybrid between *C. brevior* (Dewey) Mack. and *C. normalis* Mack. Voss (1972) maintains *C. molesta* as a species but notes that some authors unite it under *C. brevior* as var. *molesta* (Mack.) Gates. Both Massachusetts specimens are from non-specialized, disturbed habitats and the taxon may be adventive here.

C. oligocarpa Schkuhr 0/4. H.

A range extension to Colrain, Franklin Co. (*Knowlton s.n.*, MO), needs a check of the specimen, for Knowlton collected the morphologically similar *C. hitchcockiana* there on the same date. It needs field work and likely is more common than records indicate for reasons stated under *C. hitchcockiana.*

***C. oligosperma** Michx. 2/10. T.

Vouchered from Middlesex, Norfolk, and Barnstable Cos., nearly all from within 35 km of Boston. Current sites were found in 1984 in openings in shrubby peat bogs and on boggy margins of ponds in Provincetown, Barnstable Co. (*R. LeBlond s.n.,* NEBC).

C. pauciflora Lightf. 1/6. E.

Abundant at Cranberry Swamp, Hawley, Franklin Co., where known at least since the mid 1800's (*BAS 2090,* NEBC). Beaver have temporarily raised the water level at Wolf Swamp, New Marlborough/Sandisfield, Berkshire Co., and plants could not be found in 1983.

C. polymorpha Muhl. 0/4. H.

Range extension to Myricks, Bristol Co. (*Bicknell 2017,* NY), and to Westfield, Hampden Co. (*Dewey s.n.,* GH, NY). This is a plant of dry, sandy glacial deposits or decomposing granite of rocky hilltops and bluffs, now listed as rare in every state within its range (Maine–Virginia). None of the Massachusetts collections provides any specific locality data.

C. salina Wahlenb. var. **kattegatensis** (Fries) Almquist 0/6. H.

A recent report by Mathieson & Fralick (1973) from Salisbury, Essex Co., is not substantiated by specimens (pers. comm. F. Brackley), nor by a thorough search of the area in 1982. In 1984 a population was found that keys to *C. salina* but appears to represent hybrids involving *C. paleacea* Schreb. ex Wahlenb. and *C. salina* or another taxon. Conclusions will await further work on these plants in laboratory and field by L. Standley and J. Cayouette.

C. schweinitzii Dewey 2/6. E.

Current stations are in West Stockbridge and Cheshire, Berkshire Co., both in open, seepy, calcareous wetlands near streams (Jenkins, pers. comm.; *BAS, Jenkins, & Weatherbee 2022,* NEBC). Type station is "wet sandy soil at the foot of the descent to the alluvial of the Hoosick, Williamstown," Berkshire Co. (*Dewey s.n.,* GH, AC).

C. sterilis Willd. 0/1. X.

This New England rarity was not found at the sole historical station in 1981 and 1984, due to flooding of the wetland by beaver. Old specimens from Ipswich, Essex Co. (*Oakes s.n.,* BSN), and Amherst, Hampshire Co. (*Jesup s.n.,* NHA), need checking; both are very likely referable to other species under current taxonomy. A modern treatment of this species group is provided by Reznicek & Ball (1980).

C. striatula Michx. 0/0. Recently delisted.

The historical specimens are misidentified and actually represent narrow-leaved examples of *C. laxiflora* Lam. Their perigynia beaks are straight and the bracts and sheaths are smooth on the angles. A specimen from New Haven, Connecticut, appears to be correctly determined, thus marking the species' northern limit (*Allen 42,* NEBC).

C. tetanica Schkuhr 4/8. T.

Recent taxonomists maintain *C. tetanica* var. *woodii* (Dewey) Bailey as a full species, *C. woodii* Dewey; see Voss (1972) for a key. It is a moot point, for all New England "*woodii*" at NEBC and GH are referable to nominate *C. tetanica.* The current Massachusetts stations are relatively small and occupy calcareous fens in Berkshire Co. The bog where it formerly occurred in Sudbury, Middlesex Co., could not be found in 1983. Reported from Amherst, Hampshire Co., by Stone (1913) and from Worcester Co. by Jackson (1909), but no specimens have been seen.

C. trichocarpa Muhl. 2/6. E.

Much habitat has been destroyed along the Hoosic River, where most records have been documented. The current Berkshire Co. stations are nearby at Eph Pond, Williamstown (*BAS & Jenkins 1515,* NEBC, BEDF) and at Cheshire, where it associates with *C. schweinitzii* (*Ahles 84362,* MASS). The Ashland, Middlesex Co., specimens are correctly determined, but the species is curiously disjunct there, as is *Blephilia ciliata* (*Morong s.n.,* AC, VT). Reported from Amherst, Hampshire Co., by Stone (1913), but no specimen has been seen. A specimen from Worcester, Worcester Co., is actually *C. lanuginosa* Michx. (*T. Eaton s.n.,* Worcester Science Museum).

C. typhina Michx. 3/6. T.

Range extension to North Andover, Essex Co. (*J. Robinson s.n.*, PM), and to Bristol and Franklin Cos. (see below). Current stations are from *Acer saccharinum-Fraxinus pennsylvanica* floodplain forests: Threemile River in Taunton, Bristol Co. (*BAS & C. Hedge 2034,* NEBC); a large population at Bachelor Brook in South Hadley, Hampshire Co. (*BAS 2082,* NEBC, MASS); Sawmill River in Montague, Franklin Co. (*BAS 2675,* NEBC).

C. walteriana Bailey var. **brevis** Bailey 2/5. E.

Two large populations are extant on boggy margins of small Coastal Plain ponds in Plymouth County: Harlow Brook area, Wareham (*Ahles & BAS 80767,* MASS; *BAS 1569,* NEBC), and S of Whites Pond, Plymouth (*BAS & Caljouw 3059,* NEBC). A collection from Plympton, Plymouth Co., is actually immature *C. bullata* Schkuhr (*Sanford 771,* NEBC). This species is curiously restricted in its Massachusetts distribution, despite much seemingly suitable habitat. All historical sites have been searched; two have been destroyed by commercial cranberry operations, another by habitat succession.

***C. wiegandii** Mack. 0/1. H.

Found in "wet open ground" in South Ashburnham, Worcester Co. (*Forbes s.n.,* GH, NEBC, NY, MICH, QK). According to Reznicek & Ball (1980), it is a species of cold peat bogs, at the southern limit of its boreal range in Massachusetts and Pennsylvania.

C. willdenowii Schkuhr 0/2. H.

Little known in New England; needs field work to determine habitat preference and current status. Both historical sites were searched without success in 1984. Jackson (1909) reports it from Worcester Co., but the specimen collected by T. Eaton has not been found.

Cyperus engelmannii Steud. 6/6. SC.

Range extension to West Newbury and Newburyport, Essex Co. (*BAS 1343, 1345,* NEBC). All historical stations are extant, despite extensive development surrounding the sites. It prefers sandy-peaty or clayey shores of circumneutral ponds, but also fresh to brackish tidal shores of the Merrimack River.

C. ferruginescens Boeck. 0/2. Recently delisted.

Now placed in synonymy with *C. odoratus* L. and probably best treated as a freshwater form of it. There is a tendency for *C. ferruginescens* to produce shorter scales than *C. odoratus,* but otherwise I see no differences.

Eleocharis equisetoides (Ell.) Torr. 0/1. X.

Although the historical site (Lake Waban, Norfolk Co.) has been repeatedly searched, no plants can be found, perhaps as a result of mechanical weed control there. Also occurring at this same site was *E. quadrangulata* var. *crassior.* On Long Island, New York, *E. equisetoides* occurs in shallow, acid, Coastal Plain ponds with *Juncus militaris, Cladium mariscoides,* and *Rhynchospora inundata* (R. Zaremba, pers. comm.). In Rhode Island, it occurs in similar situations, the ponds often supporting stands of *Chamaecyparis thyoides* on their borders and exhibiting little water level fluctuation (R. Enser, pers. comm.). In Massachusetts, therefore, it is to be expected in southern Worcester, Norfolk, and Bristol Cos.

E. erythropoda Steud. (=*E. calva* Torr.) 9/11. Recently delisted.

Range extension to Franklin Co. (*BAS 2149, 2780,* NEBC and pers. herb.). Apparently overlooked in the past, it is now relatively easy to find in peaty to gravelly, alkaline wetlands and streamsides in Berkshire Co. and on exposed muddy-cobbly shores of the Connecticut River, where the species forms extensive colonies.

E. fallax Weatherby (includes *E. ambigens* Fern.) 1/4. E.

This species is probably not as rare in New England as previously thought. In addition to the Massachusetts collections from Cuttyhunk (Dukes Co.) and Yarmouth (Barnstable Co.), there are vouchers in GH from Block Island, Rhode Island and East Haven, Connecticut. Since publication of Coddington & Field (1978), two other Massachusetts collections have been found: "springy border of salt marsh, Red River, Chatham," Barnstable Co. (*Fernald &*

Long 18027, GH, originally det. *E. halophila* Fern. & Brackett), and from Nantucket, Nantucket Co. (*Bicknell s.n.,* NY). Weatherby's type station, "border of Dinah's Pond, Yarmouth," Barnstable Co., was rediscovered in 1980, a small population now on the edge of a lawn (*BAS 785,* pers. herb.). *Eleocharis fallax* is distinguished from its close relatives by the combination of: 1) single sterile scale at base of spikelet; 2) conspicuously and sharply pitted achene surface; 3) maroon bases of the culms. See Svenson (1947, 1932), Weatherby (1922), and Fernald (1935) for a discussion of this species and its taxonomic standing.

E. intermedia (Muhl.) Schultes 2/8. T.

Range extension to Connecticut River shores in Hadley and Hatfield, Hampshire Co. (*Ahles 84622,* MASS; *BAS 2846,* NEBC). This species may not appear annually; Ahles' 1977 stations on the Connecticut River could not be found in 1983. In Great Barrington, Berkshire Co., the species is common on exposed mud of a recently drawn-down pond, in which the pH is highly alkaline.

E. melanocarpa Torr. 15/33. SC.

This species is gone from several historical stations due to development of pondshores, but many healthy populations persist. One population in Plymouth, Plymouth Co., has been known at least since 1863. The Salisbury, Essex Co., collection proves to be *E. rostellata* Torr.; thus *E. melanocarpa* does not occur anywhere N of Plymouth Co. (*collector unknown,* MASS #10067).

E. obtusa (Willd.) Schultes var. **ovata** (Roth) Drapal. & Mohlenb. (=*E. ovata* [Roth] R. & S.) 1/4. E.

Eleocharis diandra C. Wright is included here for convenience; see Svenson (1953) for a discussion of identification and taxonomy within this species complex. Only nominate *E. obtusa* could be found at Lake Wyola, Shutesbury, Franklin Co., in 1984; much of the pondshore has been altered by recreation and development. A small population of "*E. diandra*" was discovered on the exposed sandy shore of the Connecticut River in Northfield, Franklin Co., in 1984 (*BAS 2722,* NEBC). It represents the second voucher of this taxon in Massachusetts, previously known from the river at Northampton, Hampshire Co., in 1899 (*Brainerd s.n.,* GH).

E. quadrangulata (Michx.) R. & S. (includes var. *crassior* Fern.) 0/2. X.

Lake Waban, Wellesley, Norfolk Co., is the type station for var. *crassior,* but several recent searches have failed to relocate it (*Fernald & Wiegand Pl. Exs. Gr. 133,* GH, NY, etc.). See notes under *E. equisetoides.*

E. tricostata Torr. 1/2. E.

The sole current station occurs at a small, peaty kettlehole pond on Nantucket, Nantucket Co. (J. Jenkins, MNHP files). The historical station at Almanac Pond on Nantucket remains unconfirmed despite searches spanning five years. The collection from Barnstable, Barnstable Co., proves to be *E. melanocarpa* Torr. (*Sargent s.n.,* NHA).

Fuirena pumila (Torr.) Spreng. 19/32. Recently delisted.

Range extension to Nantucket, Nantucket Co. (*Owen s.n.,* GH). This species has proven to be more common than previously thought. It has already benefited from efforts to protect other, rarer, pondshore species.

Psilocarya nitens (Vahl) Wood 4/9. T.

Range extension to Falmouth, Barnstable Co., (*BAS 700,* NEBC). Like the next species, *P. nitens* requires extremely low water levels in its Coastal Plain ponds to trigger seed germination (Sorrie, 1977).

P. scirpoides Torr. 17/25. SC.

Most current stations are in the town of Plymouth, Plymouth Co. However, most of these sites, and especially those in Barnstable and Hampden Cos., are increasingly threatened by housing development and intense recreation.

+***Rhynchospora capillacea** Torr. 1/1. E.

Discovered for the first time in Massachusetts in 1983 at a calcareous bog in Pittsfield, Berkshire Co. (*BAS & Weatherbee 2184,* NEBC). The population is very restricted in area, but appears healthy. Plants inhabit small muddy openings surrounded by *Larix laricina, Muhlenbergia glomerata, Carex lasiocarpa, C. flava, Eriophorum viridicarinatum, Andromeda glaucophylla, Ledum groenlandicum, Lobelia kalmii,* and *Solidago purshii.*

R. inundata (Oakes) Fern. 5/8. E.

Rare and local, despite the presence of much apparently suitable habitat. The type station is "West Pond, Plymouth," Plymouth Co. (*Tuckerman s.n.*, NEBC). It still occurs at this pond complex, growing on an exposed peaty-boggy shore with *Psilocarya scirpoides* and *Eleocharis tuberculosa*. Records from north and northwest of Plymouth are all *R. macrostachya* Torr.

R. torreyana Gray 3/6. E.

Massachusetts stations are all at sandy to gravelly upper borders of freshwater Coastal Plain ponds, except on Nantucket, where this species is abundant in a flat sandy scrape which just intercepts the water table. There it occurs with *Lycopodium inundatum* var. *robustum, Andropogon glomeratus, Rhynchospora alba, R. capitellata, Xyris difformis, X. torta, Juncus dichotomus, Aletris farinosa, Platanthera blephariglottis, Drosera filiformis, Polygala cruciata, and Utricularia subulata.*

Scirpus ancistrochaetus Schuyler 0/1. H.

Apparently extirpated from its only known Massachusetts station; searches in 1978 and 1982 found apparently suitable habitat but no plants. It seems to prefer river-flooded swales and beaver meadows, so other Massachusetts sites are likely. See Crow (1982) for description, illustrations, and New England status.

S. fluviatilis (Torr.) Gray 3/6. SC.

Very locally distributed, but colonies may be enormous, such as along the Sudbury River in Wayland, Middlesex Co., where it is a dominant over several hectares. Prefers nutrient-rich muck of meandering rivers and fresh-to-brackish tidal river shores.

S. hallii Gray 0/2. X.

This disjunct is apparently extirpated from the Winter Pond, Winchester (Middlesex Co.), station, although *S. purshianus* Fern. is still abundant there. As with other rarities no longer found at Winter Pond, *S. hallii* may be a victim of herbicides applied in the 1960's and '70's. A collection was made by C. N. S. Horner in Georgetown, Essex Co., in the last century; recent efforts to find suitable habitat have failed.

S. longii Fern. 0/8. X.

Nearly all historical sites have been highly modified by ditching, diking, or other development, so that hectares of *Lythrum salicaria* now reign supreme. Schuyler (1962, 1964) found a hybrid *S. longii* × *S. cyperinus* in Dedham, Norfolk Co., so perhaps *S. longii* will turn up again when conditions are favorable. Recently *S. longii* was found to be abundant in the New Jersey pine barrens following an extensive fire (D. Snyder, pers. comm.), and Schuyler (1962), and Schuyler & Stasz (1985) have discussed *S. longii's* apparent relationship with fire.

S. pendulus Muhl. (formerly included in *S. lineatus* Michx.) 10/11. SC.

Frequent in moist calcareous fields, meadows, and seepage slopes in Berkshire Co., where more common than historical records indicate. Eastward, only the Northampton, Hampshire Co., and Whately, Franklin Co., stations are known, both discovered by H. E. Ahles in meadows with clayey soil.

***Scleria pauciflora** Muhl. var. **caroliniana** (Willd.) Wood 1/2. E.

The current station occupies an open fire lane in the Martha's Vineyard State Forest, Dukes Co., the habitat closely resembling a sandplain grassland (*BAS et al. 1705,* NEBC, GH). Associated species include *Andropogon scoparius, Festuca* sp., *Panicum meridionale, Sorghastrum nutans, Linum intercursum, Polygala nuttallii, Viola pedata,* and *Aster paternus.* After this discovery in 1983, an 1846 collection from Uxbridge, Worcester Co., was found (*J. Watson s.n.,* NEBC).

S. reticularis Michx. 25/35. Recently delisted.

Range extension to Nantucket, Nantucket Co. (*BAS 619,* NEBC). Although pondshores in general are threatened by overuse, many populations of *S. reticularis* are large and vigorous and some of these will be preserved through efforts to protect other, rarer, species. It is still extant far inland in the Connecticut River Valley at Ludlow, Hampden Co., but very rare.

S. triglomerata Michx. 0/11. X.

Range extension to Dartmouth, Bristol Co.: "Nonquitt, brackish marsh" (*E. L. Sturtevant s.n.,* MO). Range extension to Hadley and Mt. Holyoke, Hampshire Co. (*Robbins s.n.,* NEBC; *Hitchcock s.n.,* NY). It is very likely a victim of forest succession in its preferred habitats of moist or dry, open sandplains and prairie-like openings on dry, wooded slopes.

ARACEAE—Arums

Arisaema dracontium (L.) Schott 5/11. T.

Middlesex Co. records are specimens of cultivated plants from the old Harvard Botanic Garden and therefore are deleted. This species has been adversely affected by the widespread conversion of floodplain forests and alluvial meadows to croplands. Recent field work indicates that it may be frequent in southern Berkshire Co. in remnant floodplain forests along the Housatonic River.

Orontium aquaticum L. 11/26. T.

Range extension to Hampden Co., where vouchered historically from Springfield and Ludlow, and currently from Monson (*Coddington VII.31.78.1,* NEBC). Current stations are large and protected; however, all but two are concentrated in a small area of shallow, muddy ponds in Provincetown, Barnstable Co. (LeBlond, report in MNHP files). Many historical stations, including all six from the Connecticut River Valley, are no longer extant.

ERIOCAULACEAE—Pipeworts

Eriocaulon parkeri Robinson 3/7. T.

All current sites support vigorous populations. Fassett (1928) reports it from the Taunton River estuary, but no specimens have been seen and searches have so far turned up no populations. In Massachusetts, field work indicates that *E. parkeri* is truly rare, not merely overlooked.

Juncus biflorus Ell. 2/5. E.

Synonymized in Kartesz & Kartesz (1980) and in Godfrey & Wooten (1979) with *J. marginatus* Rostk., but I believe that this is too drastic a treatment, at least for New England plants. Here *J. biflorus* is a species of peaty pondshores, whereas *J. marginatus* prefers meadows, open boggy swales and swamps, and is only rarely on pondshores. I have not encountered the two together. Morphological differences include rootstock character, height, leaf width, number of heads in inflorescence, relative size of heads (larger in *J.*

marginatus due to greater number of flowers), seed shape and size, and stamen size. These differences are all noted by the standard manuals, plus Seymour (1969) and Bicknell (1904). Current stations are at Salls and Keeler Ponds, Brewster, Barnstable Co. (Coddington, MNHP files; *BAS 1790*, NEBC). Several other historical stations have been searched without success and are presumed extirpated.

J. pervetus Fern. 0/1. X.

Despite some apparent discrepancies on herbarium labels, this taxon was known only from the type locality: "forming a dense colony for a few rods only at the peaty upper border of a brackish swale, eastern side of Lewis Bay, Yarmouth," Barnstable Co. (*Fernald & Butters 15064*, GH, VT, NEBC). Although there has been intense development in this area, some apparently suitable habitat remains but no one has been able to relocate the plants. The specimens suggest a hybrid between *J. militaris* Big. and *J. articulatus* L., but this has not been proven.

Luzula parviflora (Ehrh.) Desv. ssp. **melanocarpa** (Michx.) Hamet-Ahti 1/1. E.

Known only from the summit of Mt. Greylock, at least since 1906. This population has probably benefited by the maintenance of open roadsides and trails, due to reduced competition from woody plants. Jackson (1909) lists a station from Wachusett Mtn., Worcester Co., but no specimen has been seen and efforts to find plants have failed on that excessively trampled summit.

LILIACEAE—Lilies

Chamaelirium luteum (L.) Gray 1/5. E.

Known only from a few towns at the SW corner of the state, and always very rare. The current station in Sheffield, Berkshire Co., consists of about 30 plants, only 1 2 of which flower in a given year, if at all (*BAS & H. Woolsey 981*, NEBC). The plants occupy tiny depressions in dryish woods of oak, chestnut, white pine and mountain laurel.

Streptopus amplexifolius (L.) DC. var. **americanus** Schultes 15/27. Recently delisted.

Rare and local in Hampshire Co., widespread in Franklin Co. (C. Markle, pers. comm.) and Berkshire Co., but numerically rare at most stations. It prefers cool, rocky ravines along brooks, where it may occur with *Ribes lacustre;* also in swampy, northern hardwoods with balsam fir or hemlock. Probably undercollected. Reported from Worcester Co. (Jackson, 1909), but no specimen has been seen.

Uvularia grandiflora Sm. 17/24. Recently delisted.

Although certainly rare at the turn of the century, it now is frequently encountered in mesic woodlands of sugar maple-basswood-beech-hop hornbeam, especially on calcareous slopes and lime cobbles. Nothing is known of the Lancaster, Worcester Co., collection; undoubtedly it was adventive or an escape from cultivation (*Marvin s.n.,* CUW). Vegetative and fruiting plants may be difficult to separate from *U. perfoliata* L. due to variation in leaf pubescence; see Braun (1967) and Wilbur (1963) for identification aids.

SMILACACEAE—Catbriers

Smilax bona-nox L. var. **hederaefolia** (Bey.) Fern. 0/0. Recently delisted.

This species is not definitely known north of Maryland. All five specimen sheets at NEBC and GH are referable to *S. rotundifolia* L. Because the specimens are vegetative only, they resisted correct identification due to the tamnate leaf shape (on some leaves) and spinulose margins. However, these characters can be matched by fruiting specimens collected by McKelvey and by Nelson & Nelson on Martha's Vineyard (both at GH), which clearly show the short peduncles of *S. rotundifolia.* Furthermore, these and the five Nantucket specimens possess thin leaf margins, not the obviously thickened margins characteristic of *S. bona-nox.* I am indebted to W. H. Duncan (1967) for critical aids to identification.

HAEMODORACEAE—Bloodworts

Lachnanthes caroliana (Lam.) Dandy (=*L. tinctoria* [Walt.] Ell.) 8/25. SC.

Current populations are apparently stable, but threatened by widespread pondshore development. Not known in Massachusetts N of Big Sandy Pond, Plymouth, Plymouth Co.

IRIDACEAE—Irises

Sisyrinchium arenicola Bickn. 26/35. SC.

See note on nomenclature by Voss (1966). The Braintree, Norfolk Co., collection (*Eaton & Channell s.n.,* NEBC) is almost certainly *S. atlanticum* Bickn.; the old fibrous leaf bases are barely developed, the dried specimen is green and not blackened, and the habitat is moist. The single Barnstable Co. collection (*Collins 1397,* NEBC), although blackened and from a dry habitat, shows relatively few fibrous leaf bases. Otherwise this species is not known in New England off of Martha's Vineyard and Nantucket Islands, where frequent on dry, open, grassy sandplains (historically often called "moors") with *Linum intercursum, Helianthemum dumosum,* and *Aster concolor.*

ORCHIDACEAE—Orchids

Aplectrum hyemale (Muhl.) Torr. 2/10. E.

Available habitat dictates that putty-root should be more numerous than records indicate, yet it remains among the most elusive Massachusetts species. Current stations consist of only a few plants which seldom flower and occur near *Cypripedium calceolus* var. *pubescens;* both stations were discovered by R. Poland (photos on file, MNHP). A specimen exists allegedly from Templeton, Worcester Co. (*P. Blodgett s.n.,* CUW), but like other out-of-range plants collected by him in that county (*Thuja occidentalis, Juniperus horizontalis, Polystichum braunii, Carex livida, Vaccinium vitis-idaea, Lonicera hirsuta*), it probably is a labeling error.

Arethusa bulbosa L. 9/93. T.

Arethusa is decidedly more frequent in coastal locations, where found in old interdune peat bogs, cranberry swales, and peaty meadows; now very rare at inland sphagnum bogs. The reasons for this precipitous decline are as yet unclear, but the gradual succession of many inland bogs, coupled with this species' prevalence at coastal sites, suggests a preference for occasional habitat disturbance. It is also likely that most of the historical records were of short-lived populations in early successional habitats following abandonment of meadows and cut-over swamps.

***Corallorhiza odontorhiza** (Willd.) Nutt. 6/20. SC.

Vouchered from Middlesex, Suffolk, Franklin, Hampshire, Hampden, and Berkshire Cos. Reported in Southbridge, Worcester Co. (Jackson, 1909), but the specimen by Ammidown cannot be found. However, in 1984, R. Angelo, L. Mehrhoff, and members of the NEBC discovered a small colony in Sturbridge, Worcester Co., just N of the Connecticut line (*Angelo s.n.*, NEBC). Available habitat suggests that this species is more numerous than records indicate, but its small size, dull coloration, and late flowering period render it inconspicuous. It prefers dryish to moist, rocky, deciduous woods, especially where vernally wet.

Cypripedium arietinum R. Br. 0/4. X.

The reference to Worcester Co. in Coddington & Field (1978) actually is to Wilbraham, Hampden Co. The well-known Mt. Toby, Franklin Co., station appears to have been extirpated by overshading from hemlocks and perhaps also by overpicking.

***C. calceolus** L. var. **parviflorum** (Salisb.) Fern. 1/15+. E.

Historically reported from Essex, Middlesex, Norfolk, Worcester, Franklin, Hampshire, Hampden, and Berkshire Cos., but collaborators have not seen this plant in many years. The sole current station is in a calcareous, forested fen in Sheffield, Berkshire Co., where it associates with *Conioselinum chinense* and *Petasites frigidus* var. *palmatus* (C. Caljouw, MNHP files). See Luer (1975) and Case (1964) for species concepts, identification, and habitat preference. *Cypripedium calceolus* var. *pubescens* (Willd.) Correll tolerates a wide variety of habitats, so that many of the records of small-flowered plants from seepage slopes and swampy woods probably refer to that taxon rather than var. *parviflorum*. Indeed, of the 34 collections of var. *parviflorum* at NEBC and AMES, fully 9 appear to me to represent var. *pubescens* and another 8 are equivocal.

C. reginae Walt. 11/29. SC.

Frequent in forested fens and calcareous swamps in Berkshire Co., rare elsewhere. There are no current stations E of the Connecticut River, although few searches have been made in those vast swamps where once found. Several stations are threatened by overshading and/or overbrowsing by deer.

Isotria medeoloides (Pursh) Raf. 2/3. E. Federally listed as endangered by the U.S. Fish & Wildlife Service.

Range extension to Essex Co., where a large colony was found by E. Hatfield (*BAS 2052,* pers. herb.). There the species occurs in birch-beech-oak-hemlock woods, particularly in vernally moist areas between rock outcrops. In 1984 a second current station was found by J. Cavanaugh in Hampden Co. in a vernally moist depression on the slope of an extensive traprock ridge (photos on file, MNHP). This species is to be expected elsewhere in similar habitats across the state.

I. verticillata (Willd.) Raf. 23/65. Recently delisted.

Range extension to Barnstable, Barnstable Co. (P.M. Brown & R. Angelo, pers. comm.), and to Berkshire Co., where now known from Sheffield, Great Barrington, Williamstown, and Clarksburg. This species is probably more common now than 50–100 years ago due to reforestation and is not difficult to find in proper habitat, with many colonies numbering in the hundreds of plants.

Listera cordata (L.) R. Br. 1/9. E.

One healthy colony is extant in an Atlantic coast white cedar swamp in Yarmouth, Barnstable Co. (*BAS 1990,* NEBC), where most plants had already finished flowering by 16 June. Other historical sites need checking.

Malaxis brachypoda (Gray) Fern. 5/13. T.

Still considered very rare in Massachusetts, but recent field work by C. Caljouw, T. Rawinski, P. Weatherbee, R. Poland, and BAS suggests that this species may be frequent in Berkshire Co. It shows a decided preference for herb-free sphagnum patches and mossy knolls in calcareous seepage swamps, usually near the bases of steep slopes. Reported in Spencer, Worcester Co. (Jackson, 1909), but the specimen by Kingsbury cannot be found.

Platanthera ciliaris (L.) Lindl. 0/9. X.

Range extension to Middlesex and Worcester Cos.: Lexington, *Boott s.n.* (AMES); Uxbridge, *Sharpe & Dodge s.n.* (CUW). Only *P. blephariglottis* could be found at the 1970's Plymouth Co. station; *P. ciliaris* is presumed extirpated there. Several historical sites have been altered by development.

P. cristata (Michx.) Lindl. 0/2. X.

Searches of the historical collecting area have failed to turn up suitable habitat. On Long Island, NY, the species is currently known from moist sand beneath pitch pines in an old, stabilized dune system, not unlike that at Horseneck Beach State Park in Westport, a few miles SW of the old Massachusetts stations. At Westport only *Cypripedium acaule* and *Spiranthes ochroleuca* could be found in 1984.

P. dilatata (Pursh) Lindl. 4/19. T.

Range extension to South Hadley, Hampshire Co. (*M. P. Dole s.n.,* Mt. Holyoke College herb.). It needs additional field work, particularly in Franklin and Berkshire Cos. In Massachusetts this orchid shows a definite preference for circumneutral to calcareous seepage slopes.

P. flava (L.) Lindl. var. **herbiola** (R. Br.) Luer 5/64. T.

Range extension to Essex Co. (7 towns cited by Harris, 1975); Chesterfield, Hampshire Co. (*BAS & J. Lundgren 2587,* NEBC); and Springfield, Hampden Co. (*Andrews s.n.,* NEBC, SPR). Although it is generally believed that this species has declined due to forest succession of peaty meadows and streamside thickets, two of the current stations are in forest environments. One inhabits rocky-swampy terrain of the hemlock-red maple-white ash-beech border of an Atlantic coast white cedar swamp, while the other occupies a vernal creek bed under hop hornbeam, musclewood, red oak, white ash, birch, and American elm.

P. obtusata (Banks ex Pursh) Lindl. 0/2. H.

Preliminary searches have failed to locate this species, here at the southern limit of its range, but suitable habitat exists in spruce-fir bogs high up on the Berkshire Plateau. Reported from Wachusett Mtn., Worcester Co. (Jackson, 1909), but the specimen by Pratt cannot be found.

***Spiranthes tuberosa** Raf. (includes var. *grayi* [Ames] Fern.) 21/33. Recently delisted.

Added to the list in 1980, but removed due to the relative ease of finding current stations. Currently known from Nantucket, Dukes, Barnstable, and Plymouth Cos.; formerly also from Bristol Co. and

Holbrook, Norfolk Co. The latter is the northern limit of the species' range, since the Cumberland, ME, record cited by Seymour (1969) has been annotated by P. Catling in 1980 as *S. lacera* var. *lacera* (Raf.) Raf. Although flower size of *S. lacera* var. *gracilis,* a frequent associate of *S. tuberosa* in dry fields, occasionally approaches that of *S. tuberosa,* the green throat of the former will always distinguish it from the pure white throat of the latter. Type station of *S. tuberosa* var. *grayi* (originally named *S. simplex* Gray) is "in summo sepulchreto novo, Nantucket," Nantucket Co. (*Robbins s.n.,* AMES).

S. vernalis Engelm. & Gray 10/18. SC.

Range extension to Edgartown and West Tisbury on Martha's Vineyard, Dukes Co. (*BAS 1770,* NEBC; *J. Bruno s.n.,* NEBC), and Lincoln, Middlesex Co. (*R. J. Eaton s.n.,* AMES). It prefers mown fields, pastures, grassy clearings, etc., probably not long remaining at a given site unless repeatedly disturbed; e.g., hundreds of plants occur in dryish *Andropogon scoparius* fields in Uxbridge, Worcester Co. In 1980 P. Catling annotated an NEBC specimen collected at Strafford, NH, thus marking the species' northern limit. In Massachusetts it is unknown N of Lincoln, Middlesex Co.

Tipularia discolor (Pursh) Nutt. 3/5. E.

Given the excellent account by Fogg (1930a) in Rhodora, it is puzzling that Seymour (1969) chose to doubt the existence of *Tipularia* in New England. Current stations are from oak-hickory-holly-hop hornbeam-dogwood forest in Barnstable, Barnstable Co. (*Svenson & Lucas s.n.,* NEBC), and oak-beech-tupelo-holly forest in Chilmark and West Tisbury, Dukes Co. (*BAS et al. 290, 292,* NEBC, MASS; J. Bruno, pers. comm.). The latter may be the same station that W. Oakes discovered in 1828 (*Oakes s.n.,* NY; *Robbins s.n.,* NEBC; Boston Soc. Nat. Hist. current repository unknown). The Barnstable station consists of only a few plants and is under imminent threat of development.

Triphora trianthophora (Sw.) Rydberg 1/3. E.

No doubt this species is much more numerous than records indicate; the small size, late flowering period, and narrow habitat tolerance make this a most elusive orchid. The current station in

Greenfield, Franklin Co., occupies small, leaf-lined pockets on a forested, sandstone knoll with *Corallorhiza maculata* and *Conopholis americana (Zika 4855,* VT).

SALICACEAE—Willows

Salix candida Flügge 23/29. Recently delisted.

Range extension to Ashfield, Franklin Co. (*BAS & J. Lundgren 2590,* NEBC). Fairly common in open, calcareous seepage wetlands and fens in Berkshire Co.; rare elsewhere. Most populations are healthy and of large size. Hoary Willow is very useful as an indicator of the presence of *Salix serissima, Carex tetanica,* and other fen-loving rarities.

S. exigua Nutt. (=*S. interior* Rowlee) 8/11. SC.

Confined to the Connecticut River, where it occurs on islands, sandbars, and gravel shores, frequently with *Prunus pumila* var. *depressa* and *Eragrostis frankii.*

S. serissima (Bailey) Fern. 11/16. SC.

Infrequent in the same habitats as *S. candida.* Populations usually are composed of less than 25 plants. This species is distinguished by its persistent catkins; yellowish twigs; leaves finely toothed, bright green above, glaucescent below, and without the strongly attenuate leaf tips of *S. lucida.*

BETULACEAE—Birches, Alders

Alnus viridis (Chaix.) DC. ssp. **crispa** (Ait.) Turrill (=*A. crispa* [Ait.] Pursh var. *mollis* Fern.) 8/20. SC.

Range extension to South Hadley, Hampshire Co., on ledges along the Connecticut River shore (*Ahles 86000,* NEBC). Also reported from Still River, Harvard, Worcester Co., but the specimen cannot be found (*Lowe s.n.,* CUW) as cited by Potter & Woodward (1935, p. 85). Probably more common than the available records indicate, since there is considerable habitat yet to check. It is unknown away from the Deerfield and Connecticut Rivers, where usually found on riverside rock ledges and cobbly shores, but occasionally well up on adjacent open ridges such as at 518 m on Negus Mtn. in Rowe, Franklin Co.

Betula pumila L. 3/4. T.

This calciphile is abundant at the interface between open sedgy fen and mixed forest, Kampoosa Fen, Stockbridge; common at Juniper Pond, New Marlborough; and a single plant occurs at Schenob Brook Fen, Sheffield, all in Berkshire Co.

FAGACEAE—Oaks

Quercus macrocarpa Michx. 10/13. SC.

Widespread and locally common in the Schenob Brook area of Sheffield; locally rare to uncommon elsewhere in Berkshire Co. At Schenob Brook, bur oak is a dominant in calcareous seepage swamps with *Q. bicolor, Q. rubra, Acer rubrum, Fraxinus nigra, Betula* spp., *Carpinus caroliniana, Ulmus americana, Tsuga canadensis,* and *Liriodendron tulipifera.* Specimens from Newbury, Essex Co., are *Q. bicolor* Willd. or perhaps *Q.* × *jackiana* Schneid. (*Q. bicolor* Willd. × *alba* L.) as annotated by Ahles (*Harris 8226,* NEBC; *Harris & Bean 8398,* NEBC). Harris (1975) suggested that the trees were "probably introduced." Individual variation in leaf shape (and probable limited hybridization in southern Berkshire Co.) accounts for some difficulties in separating *Q. macrocarpa* from *Q. bicolor.* In addition to the much more pronounced fringing on the acorn cup, well-developed leaves of *Q. macrocarpa* show two kinds of lobing: deeply and broadly lobed (nearly to midrib) along the basal 2/3 of the leaf, and sinuate-dentate along the outer 1/3 and tip. Leaves of *Q. bicolor* are merely sinuate-dentate to sinuate throughout, some trees with tendencies toward deeper indentations basally.

Q. muhlenbergii Engelm. 11/12. SC.

Despite extreme rarity historically, yellow oak is now frequent on dry limestone cobbles in Sheffield, and very local in similar situations elsewhere in Berkshire Co., where Great Barrington marks the northern limit in the state. The Worcester Co. specimen is *Q. prinoides* Willd., as later annotated by the collector (*Ahles 79182, -3, -4,* MASS). I cannot find a voucher for the Bernardston, Franklin Co., record cited by Seymour (1969). *Quercus muhlenbergii* is readily distinguished by having pale, ashy, flaking bark like *Q. alba* L., but leaves like *Q. prinus* L.

Q. stellata Wang. 25/30. Recently delisted.

A common and conspicuous member of the oak-pine forests on dry outwash plains on Martha's Vineyard, Dukes Co.; rare and local on Nantucket, Nantucket Co.; locally uncommon in middle Cape Cod, Barnstable Co. Despite historical records from New Bedford, Bristol Co. (*Hervey s.n.,* NEBC), and from Plymouth Co. (Emerson, 1894), there are no vouchers this century from these counties and I doubt the accuracy of the records. Specimens purportedly of *Q. stellata* var. *margaretta* (Ashe) Sarg. were collected in Yarmouth, Barnstable Co. (*Fernald & Long 9356,* NEBC, GH). The NEBC sheet has been annotated as *Q.* × *stelloides* Palm. (*Q. stellata* × *prinoides* Willd.). I am inclined to agree, as the leaves are densely stellate-pubescent beneath with non-stipitate hairs and possess at least seven lobes per leaf. The var. *margaretta* ordinarily ranges N only to southeastern Virginia.

LORANTHACEAE—Mistletoes

Arceuthobium pusillum Peck 6/20. SC.

Locally common in peat bogs and cold, black spruce-balsam fir swamps. A few historical stations have been destroyed by development.

POLYGONACEAE—Knotweeds, Docks

Polygonum glaucum Nutt. 14/33. Recently delisted.

Range extension to Revere, Suffolk Co., a doubtfully natural occurrence (*Faxon s.n.,* GH). The Plymouth Co. report in Coddington & Field (1978) is erroneous, based on my own misidentification. This species is suffering severe pressure from ORV's and concentrations of beach-goers and it is now absent along many miles of once suitable habitat. However, it is an aggressive colonizer and appears to be maintaining adequate population levels. It prefers washover areas near saltponds, beaches with active sand deposition, and sandspits.

P. puritanorum Fern. 11/29. SC.

Placed in synonymy under *P. persicaria* L. by Kartesz & Kartesz (1980) and Mitchell & Dean (1978). Dalci (1972) renamed it *P.*

persicaria ssp. *puritanorum* (Fern.) Dalci, but he did not do field studies in the geographical area where *P. puritanorum* has been historically known. I believe that more cytotaxonomic and genetic studies need to be performed in order to define more clearly this taxon's rank. Although affinities to *P. persicaria* are obvious, *P. puritanorum* occupies a habitat where not a single alien species has managed to make more than a token presence. *Hypochoeris radicata* and a few others are occasionally found at the uppermost margin of pondshores, but *P. puritanorum* and most of its distinctive cohorts occupy the middle and lower sections of the beach, areas which are not exposed annually and which remain inundated until a cycle of dry years. Following the receding waters, *P. puritanorum* often forms well-defined concentric bands along the shores with *Panicum* spp., *Hemicarpha micrantha, Psilocarya* spp., *Eleocharis* spp., *Fuirena pumila, Fimbristylis autumnalis, Juncus* spp., *Hypericum* spp., *Lysimachia terrestris, Sabatia kennedyana, Lycopus* spp., *Stachys hyssopifolia, Gratiola aurea, Coreopsis rosea,* and *Solidago tenuifolia.* A specimen from Nantucket, Nantucket Co., is actually *P. lapathifolium* L. var. *salicifolium* Sibth. (*Johnson s.n.,* MMS). Type station is "bare sandy beach at east end of Long Pond, Harwich," Barnstable Co. (*Fernald & Long 16756,* GH, NEBC).

P. setaceum Baldw. ex Ell. var. **interjectum** Fern. 5/10. SC.

Range extension to Nantucket, Nantucket Co. (*Gardner s.n,* MMS), and to Duxbury, Plymouth Co. (*BAS 2302,* NEBC). So far this species is known from marshy and thickety borders of acid but nutrient-rich streams and ponds. In the latter habitat it can be a dominant plant at the interface between open water and shrubby border. It probably is overlooked despite its large size and bold white inflorescences. Type station is "moist thickets along Doane Creek, Harwichport," Barnstable Co. (*Fernald & Long 16749,* GH).

Rumex pallidus Bigelow 6/13. T.

Range extension to Weymouth, Norfolk Co. (Merzer, pers. comm.), and Boston, Suffolk Co. (Perkins, pers. comm.). I can find no voucher for Dukes Co. as reported in Coddington & Field (1978). Current populations are small in size, usually occupying spits and beaches with stable physiognomy. It is absent from large expanses of ocean beach in southeastern Massachusetts. One remarkable population occupies the stony, exposed tidal shore of the Merrimack River in West Newbury, Essex Co., 12 km upstream from the mouth.

Suaeda americana (Pers.) Fern. 4/? SC.

Range extension to Essex, Suffolk, Middlesex, Plymouth, Bristol, and Dukes Cos. according to annotations made at GH by Hopkins & Blackwell in 1975. Despite a recent synopsis of the genus by Hopkins & Blackwell (1977), the characteristics and specific limits of *S. americana* remain somewhat unclear to me. I strongly disagree with many of their determinations of Massachusetts *S. americana* (most are *S. linearis* [Ell.] Moq. by the authors' own criteria) and from personal observation I find that *S. linearis* is anything but rare, even N of Boston. I believe that a major obstacle in taxonomic revisions of this genus is the reliance on dried material for determinations. Shrinkage and distortion of leaves and sepals render them almost useless for discriminatory work. Furthermore, growth habit (erect, prostrate, ascending) may be entirely obscured on herbarium sheets. However, in defense of the aforementioned authors, I believe in the existence of four taxa in New England. Their distinctiveness needs to be worked out in a study of living plants. See comments under *S. richii.* Current stations believed to represent *S. americana* occupy sandy, saline flats on the leeward side of sandspits on Monomoy Island, Barnstable Co.; Great Point and Tuckernuck Island, Nantucket Co.; and probably also Castle Neck, Essex Co.

S. richii Fern. 10/11. Recently delisted.

Due to the relative ease of finding historical and new stations, this species has been removed from the list after only a few field seasons. Range extension to Hingham and Marshfield, Plymouth Co. (*BAS 1873, 2263,* NEBC). It prefers saline flats on the protected side of barrier beaches and islands, thus often associated with tidal estuarine systems. As typically developed, it is entirely green, prostrate, and with all major branches diverging from the base of the plant. Many branches are at least half the length of the plant. Leaves are fat-looking, subcylindric (not much flattened on the upper surface), blunt, and disposed singly, never (?) in fascicles or whorls. All sepals are rounded on the sides, without any obvious keel. Seeds are 1.2–1.6 mm across. Other prostrate plants which are mostly purplish in color (even early in the season) and which have ascending branches, slender leaves flattened on the upper surface, and a tendency toward keeled sepals, represent *S. americana.*

AMARANTHACEAE—Pigweeds

***Amaranthus pumilus** Raf. 0/3–4. H.

There are four historical records, two of which may have been from the same station: Martha's Vineyard, Dukes Co., no date (*J. W. Robbins s.n.,* NEBC); Gay Head, Martha's Vineyard, Dukes Co., 1829 (Oakes, 1847); Nashawena Island, Dukes Co., no date, found by T.A. Greene (Dewey, 1840); Nantucket, Nantucket Co., "on the beach, S. T. Olney, 1849" (Owen, 1888). Miles of ocean beach and wrack-line flora have been searched on Martha's Vineyard and Nantucket without a trace of *A. pumilus,* a species now rare throughout its range (Massachusetts—South Carolina).

PORTULACACEAE—Purslanes

Claytonia virginica L. 3/10. T.

Range extension to Sandwich, Barnstable Co., where it occurred with *Erythronium americanum,* a species still abundant at the Town Neck thickets (*Roos s.n.,* GH). It is very local in the Connecticut and lower Housatonic River valleys, but current populations appear to be relatively large and stable. A large population in Wellesley, Norfolk Co., was introduced by previous landowners (*Hellquist 14881,* NASC; *BAS & Strawn 889,* NEBC).

CARYOPHYLLACEAE—Sandworts, Pinks

Minuartia stricta (Sw.) Hiern. (=*Arenaria s.* Michx.) 7/12. T.

Surprisingly, no current Berkshire Co. stations have been found, despite much field work in apparently suitable habitat. Many limestone ledges and cobbles are experiencing overshading from forest succession and this species' populations consist of relatively few, sparsely distributed individuals in most cases.

Moehringia macrophylla (Hook.) Fenzl (=*Arenaria m.* Hook.) 2/3. E.

Current stations in Florida, Berkshire Co. (*Hellquist 14551,* NASC; *BAS et al. 892,* NEBC), and on the Middlefield/Chester line (*BAS 1908,* NEBC) are large and healthy, the latter numbering over

2500 plants. Fernald made collections at what appear to be three separate sites in these same towns; if so, then the third station is likely on the extensive serpentine deposits on Gobble Mtn. in Chester, but I was unable to relocate the species there in 1983.

Paronychia argyrocoma (Michx.) Nutt. 1/1. E.

Recent taxonomic work by A. Robinson for the Office of Endangered Species, U.S. Fish & Wildlife Service, places the var. *albimontana* Fern. in synonymy with the species. It is thus removed from the list of candidate species for federal listing (see Federal Register 48 [229], Nov. 1983: 53667). The current station appears healthy; apparent variations in population estimates may be due to differences in census methodology (Coddington, pers. comm.; *Hellquist 14643,* NASC; *BAS 1970,* NEBC). The sole Massachusetts site is in Salisbury, not Newburyport, contra virtually all previous literature and label data.

Sagina nodosa (L.) Fenzl ssp. **nodosa** 3/3. T.

Rediscovered by Hellquist & Crow at Rockport, Essex Co., in 1980 after a lapse of many years. Since then two other historical sites in Rockport and Gloucester have been reverified and I believe that further search may turn up other stations of this inconspicuous species on rocky offshore islands and coastal ledges from Massachusetts Bay northward.

NYMPHAEACEAE—Water Lilies

Nymphaea tuberosa Paine 4/5. Recently delisted.

The Middlesex Co. stations are introductions (Hellquist, 1972). Despite extensive collecting of aquatic plants by C.B. Hellquist, this species remains rare and local in Berkshire Co. However, Hellquist and I believe that even these stations result from introductions. In 1984 it was learned that two of the four current populations are directly traceable to material transplanted from Michigan and it is very likely that this species has been spreading in the county from this source in Great Barrington.

RANUNCULACEAE—Buttercups, etc.

Cimicifuga racemosa (L.) Nutt. 2/7. E.

Range extension to Holyoke, Hampden Co. (*Ahles 85943,* MASS), and Williamsburg, Hampshire Co. (*Ahles 77720,* MASS);

neither could be found in 1983. In Sheffield, Berkshire Co., J.R. Churchill's 1920 station was finally rediscovered in 1983 (*BAS & Caljouw 2116,* NEBC, GH). Forest succession is obvious at the latter site and although the population is very large, only 10% of the plants were flowering or fruiting. Adventive in Boston, Suffolk Co., and Shrewsbury, Worcester Co. (*collector unknown,* NHA; *Darling s.n.,* CUW).

Clematis occidentalis (Hornem.) DC. (=*C. verticillaris* DC.) 11/35. SC.

This species is no doubt overlooked due to the small size of populations at most sites; overshading may be a factor in reducing numbers. Large populations are found at relatively open sites at Mt. Tom, Hampden Co., and Bash Bish Falls gorge, Berkshire Co.

+***Hydrastis canadensis** L. 1/2. E.

Golden seal was not known as a member of the Massachusetts flora until 1980, when a colony was found in Hingham, Plymouth Co., in a rich morainal hollow under *Betula lenta, Acer saccharum, Fraxinus americana, Carya ovata,* and *Quercus rubra,* growing with *Botrychium virginianum, Actaea pachypoda, Hepatica americana, Viola conspersa,* and *Cornus alternifolia.* Subsequently a specimen from "rich ground, Lynn," Essex Co., was found (*Comstock s.n.,* SCHN). The sheet bears the word "planted" annotated in pencil by someone other than the collector. Given the rich character of some of the deciduous forests of the Boston Basin, I see no reason to dismiss the record completely, even though golden seal is known to be cultivated as a medicinal. See Charette (1964) for a discussion of the other New England stations.

Ranunculus circinatus Sibth. var. **subrigida** (W. Drew) L. Benson (=*R. subrigidus* W. Drew) 0/1. H.

As interpreted by Benson (1948) this taxon is the North American representative of the Old World *R. circinatus,* whereas *R. longirostris* Godr. is a distinct species restricted to the New World. Differences between the two are slight and are most pronounced in the length of the beak of the fruit, a character best developed when plants are relatively difficult to detect except by boat.

R. longirostris Godr. 10/13. Recently delisted.

Frequent in the southern half of Berkshire Co. and usually abundant where found. Additional stations will certainly be found. It prefers alkaline ponds, oxbows, and slow moving rivers.

***R. micranthus** Nutt. 2/13. T.

Vouchered from Essex, Middlesex, Suffolk, Norfolk, Bristol, Worcester, and Hampden Cos. Reported from Hingham, Plymouth Co., by Bouvé, but no specimen has been found. Despite this rather wide range in Massachusetts, stations are rare and local due to the species' narrow ecological tolerance. Current sites are in Woburn, Middlesex Co. (BAS & H. Woolsey, pers. obs.; P. M. Brown, pers. comm.), and in North Attleborough, Bristol Co. (*BAS 1533,* NEBC), both on low, shelving ledges in dryish, rich, rocky deciduous woods. Associates include *Woodsia obtusa, Asplenium trichomanes, Aquilegia canadensis, Paronychia canadensis,* and *Cornus rugosa.*

MAGNOLIACEAE—Magnolias

Magnolia virginiana L. 1/2. E.

The history and status of the only current New England site has been reviewed by P. Del Tredici (1981). Subsequently, he and others have begun the task of augmenting the population. To date, 48% of the seedlings (out of 500 planted) have survived (Primack et al., 1986). A second station elsewhere in Gloucester was known to S. K. Harris (1959), but of its status I know nothing.

FUMARIACEAE—Poppies, Fumitories

Adlumia fungosa (Ait.) Greene 3/20. T.

This species is biennial (Gleason, 1952). Much more field work needs to be done before definitive statements can be made regarding its status and habitat. I have not seen it, despite visits to suitable habitats.

BRASSICACEAE—Mustards

***Arabis lyrata** L. 2/5. T.

Range extension to Mt. Tom, Hampden Co. (*Stebbins s.n.,* SPR). Current stations are large and vigorous at West Stockbridge Mtn. and Bash Bish Gorge, Berkshire Co. (J. Jenkins, MNHP files; *Hellquist 14095,* NEBC; *BAS 1944,* NEBC). In Massachusetts it is considered native only at Mt. Tom and in Berkshire Co., where it prefers more-or-less open, calcareous ledges. Collections from Worcester Co. are believed to be adventive: Northborough, roadside (*Flynn s.n.,* CUW); Westborough, no data, (*Whitman s.n.,* CUW).

Cardamine douglassii (Torr.) Britton 1/2. E.

The current site was discovered in a calcareous seepage swamp in Sheffield in 1984 (*BAS & Rawinski 2351,* NEBC). The plants were in full flower on 9 May, whereas those of *C. bulbosa* (Muhl.) BSP. in nearby swamps were just producing buds. See Hart & Eshbaugh (1976) for a discussion of the taxonomy of these closely related species.

***C. longii** Fern. 0/2. H.

Two collections are known: "Muddy Brook, Chicopee," Hampden Co. (*Seymour 476,* MASS, AC, SCHN), annotated by T.J. Crovello from *Nasturtium officinale* R. Br. in 1975; "inlet and outlet of Greenwich Pond, Greenwich," Hampshire Co. (*Seymour 2242,* AC, GH). The GH sheet was originally determined as *Nasturtium officinale* and annotated as that species by Fernald in 1947, but reannotated as *C. longii* by P. S. Green in 1961. The AC sheet was annotated as *C. longii* by Crovello in 1975. Despite the presence of an additional pair of leaflets on many leaves in all these collections, the siliques and pedicels are too short for *C. pensylvanica* Muhl., and the single row of seeds eliminates *Nasturtium.* I therefore agree with Green and Crovello, but these collections are both from freshwater habitats far inland and never under the influence of tides nor of saline water. In 1985 T. Wieboldt of Virginia Polytechnic Institute examined the AC and MASS specimens and agreed with the determination as *C. longii.* His recent work with this species suggests that *C. longii* inhabits freshwater swamps as well as tidal river shores, so the Massachusetts stations are apparently not unusual. A third collection by Seymour was in 1919 by the Charles River, Newton, Middlesex Co. (*Seymour s.n.,* GH). These plants were grown from seeds originally obtained by F.F. Forbes from Bowdoinham, ME; nothing further is known of the experiment.

***Draba reptans** (Lam.) Fern. 0/2. H.

Two presumably native stations are known, one at least since 1824: Salem Neck, Salem (several collections by Pickering, Robinson, Sears at GH), and Danvers (*Sears s.n.,* GH), both in Essex Co. Currently known from Dutchess Co., NY (Rawinski pers. comm.), and to be expected in southern Berkshire Co. on open calcareous ledges.

DROSERACEAE—Sundews

Drosera filiformis Raf. 34/45. Recently delisted.

Within its limited state range thread-leaved sundew is frequently encountered, with some populations numbering in the thousands. Threats are real and obvious (development around ponds, increased recreational use of pondshores) but some populations of this species will be protected by efforts to preserve other, much rarer, species. A small, disjunct colony was discovered in Nova Scotia in 1977 (*Dowhan s.n.,* GH), thus marking the northern range limit.

PODOSTEMACEAE—Riverweeds

Podostemum ceratophyllum Michx. 5/11. SC.

Range extension to Deerfield, Franklin Co. (*Poland 838,* pers. herb.), and North Attleborough, Bristol Co. (*BAS 2819,* NEBC). It is certainly more common than records indicate, as suggested by recent work in northern New England by Philbrick and Crow (1983). Reported in Worcester Co. by Jackson (1909), but no specimen has been seen.

CRASSULACEAE—Stonecrops

***Crassula aquatica** (L.) Schoenl. (=*Tillaea a.* L.) 3/8. T.

Vouchered from Essex, Bristol, Plymouth, Dukes, Nantucket, and Hampshire Cos. In Wareham, Plymouth Co., the species grows with *Eriocaulon parkeri* along the margin of a tidal river laced with cold springy seeps. On Nantucket, Nantucket Co., P. Dunwiddie rediscovered the famous historical site at Hummock Pond (see Owen, 1912) on a moist exposed sandbar with *Panicum dichotomiflorum, Polygonum pensylvanicum, Hydrocotyle verticillata, Lysimachia terrestris, Limosella subulata,* and *Gnaphalium uliginosum* (*Dunwiddie 1233,* MMS; *BAS & Dunwiddie 2695,* NEBC).

SAXIFRAGACEAE—Currants, Saxifrages

Ribes americanum P. Mill. 12/61. Recently delisted.

Range extension to Essex Co. (several collections at NEBC, GH, AC). It favors seepage swamps and rich floodplain thickets by streams, the soil circumneutral to calcareous. It is found frequently along the Housatonic River, Berkshire Co., sporadically elsewhere. The number of sites already documented without much effort indicates that this species is recovering from near decimation.

R. lacustre (Pers.) Poir. 12/16. SC.

Frequent about Mt. Greylock, Berkshire Co., sporadic elsewhere, preferring ledges and brooksides in steep rocky ravines. Several populations are small and not vigorous, as evidenced by lack of flowers and fruits. It is certainly under-collected, especially on the Berkshire Plateau. A collection from Newbury, Essex Co., proves to be *R. hirtellum* Michx. (*Palmer 46281*, A).

R. triste Pallas 8/14. SC.

Collections from Essex Co. (*Harris 17750, 31885*, NEBC), Middlesex Co. (*Moore 740*, GH), and Norfolk Co. (*Moore 1638*, GH) all are referable to *R. sativum* Syme, as annotated by R. Angelo, H. Ahles, and myself. The Worcester Co. specimens need rechecking (*Gates 13598, 14028*, CUW; *Blodgett s.n.*, CUW). Currently the species is not known E of Berkshire Co., where frequent on mossy knolls in cold calcareous swamps under hemlock, black ash, red maple, larch, or balsam fir; occasional in rocky mountain ravines. Differences between *R. triste* and *R. sativum* are subtle and most keys oversimplify them. Pedicels and petioles of both species can be glandular-hairy, those of *R. triste* usually distinctly so, those of *R. sativum* usually sparsely so if at all. Leaf lobes and leaf teeth are narrower and sharper in *R. triste*, but these characters are best appreciated in direct comparison. A useful "gestalt" character is leaf shape: *R. sativum* nearly always shows some development of basal lobes; *R. triste*, in my experience, almost never does, which gives its leaves a less cut, more blocky outline. Symonds (1963) shows these leaf characters rather well. Furthermore, leaves of *R. triste* are usually a darker green.

ROSACEAE—Roses, Shadbushes, etc.

***Agrimonia pubescens** Wallr. (=*A. mollis* [Torr. & Gray] Britton) 3/12. T.

Vouchered from Middlesex, Suffolk, Nantucket, Hampden, and Berkshire Cos. All three current stations are along moist paths: near bases of lime cobbles in Sheffield, Berkshire Co., and at the foot of a traprock ridge in Holyoke, Hampden Co. The Oak Island, Revere, Suffolk Co., station has been destroyed by development and I could not find the Horn Pond Mtn. station in Middlesex Co. in 1981–1983.

Amelanchier bartramiana (Tausch) Roemer 7/12. T.

Uncommon to rare in thickets, open woods, and krummholz on the summits of Mt. Greylock, Ragged Mtn., Spruce Hill, and Wachusett Mtn.; rare and local on the northern Worcester Co. plateau. Probably occurs elsewhere along the northern border of the state, but difficult to inventory due to its tendency to occur as very small populations.

A. nantucketensis Bickn. 36/47. T.

Widespread and fairly common on Nantucket, uncommon and local along the southern outwash plains of Martha's Vineyard. This species is given threatened status due to its extremely small global range. It prefers open sandplain grasslands and ericaceous, morainal heathlands or "moors", especially where locally dominated by low wind-pruned shrubs –*Myrica pensylvanica, Gaylussacia baccata, Prunus maritima, Rosa virginiana, Aronia arbutifolia, Viburnum dentatum.* It is susceptible to overshading by *Quercus ilicifolia* and taller woody vegetation; hence its prevalence on roadsides. Nantucket Shadbush is generally a taller plant than *A. stolonifera* Wieg., usually .7–1.2 m, and instantly recognizable when flowering (May 10–30, lingering to June 7) by its short, narrow, spatulate, white to cream-colored petals. The hypanthium is glabrous or sparsely tomentose, contra Seymour (1969). *Amelanchier stolonifera* forma *micropetala* (Robins.) Rehd. also has short petals (3–6 mm) which may be spatulate, but the hypanthium is densely tomentose. Type station is "bank at Reed Pond, Nantucket," where still extant (*Bicknell 4850,* NEBC, NY). This species is no longer considered endemic, as a few historical sites are known from Long Island, NY (R. Zaremba, pers. comm.; specimens at BKL). A small population discovered on Long Island in 1984 was bulldozed in 1985 (*Zaremba s.n.,* GH).

A. sanguinea (Pursh) DC. 9/23. SC.

Range extension to Pelham, Hampshire Co. (*McCune 28,* AC). This shadbush is uncommon and spottily distributed, although easily overlooked and thus likely to be found at many more stations. It prefers riverside ledges, cliff tops, and other outcrops that are at least partially open to sunlight, shunning acid sites.

Prunus pumila L. var. **depressa** (Pursh) Gleason (=*P. d.* Pursh) 8/10. SC.

Known only from sandbars, cobbles, and ledges by the Connecticut and Deerfield Rivers, where current populations appear to be stable and fairly large. Frequently occurs with *Salix exigua, Amelanchier sanguinea,* and *Aster tradescantii.*

Rosa acicularis Lindl. 1/2. E.

This northern species was not found at the summit area of Mt. Greylock in 1983–1984, the sole historical site. The current station, discovered by P. Weatherbee, occupies the open top and wooded border of a high limestone ledge in Lanesborough, Berkshire Co. (*BAS, Weatherbee, Tribble, & Carrolan 2562,* NEBC).

Sorbus decora (Sarg.) Schneider (=*Pyrus d.* [Sarg.] Hyland) 2/4. E.

Current stations are on the summit of Mt. Greylock, Adams (*BAS et al. 2039,* NEBC), and Spruce Hill, North Adams, Berkshire Co. (*C. Quinlan s.n.,* NEBC). Although not large, both populations appear to be healthy. Prefers thickets, borders of woods, and openings in the company of *Sorbus americana, Betula alleghaniensis, Abies balsamea, Acer spicatum. Sorbus decora* flowers 1–2 weeks earlier than *S. americana* and the leaflets are much darker green, the tips merely acute rather than acuminate. Nothing is known of the Worcester Co. records cited by Seymour (1969); specimens cannot be found.

Waldsteinia fragarioides (Michx.) Tratt. 9/17. SC.

Range extension to Northampton, Huntington, and Cummington, Hampshire Co. ("*E.T.E.*" *s.n.,* Mt. Holyoke College herb.; *Parsons s.n.,* SPR; *BAS & J. Lundgren 2588,* NEBC). It occurs frequently along the Green River, Franklin Co., on rich, wooded to semi-open banks and in rich, mesic forest on old floodplains. Several colonies there number over 100 plants each. It is local in Berkshire and Hampshire Cos., sporadically adventive or escaped eastward. Reported from Winchendon, Worcester Co., by Jackson (1909), but the specimen by Hathaway cannot be found.

FABACEAE—Peas, Vetches, etc.

Desmodium sessilifolium (Torr.) Torr. & Gray 0/6. X.

Range extension to Holyoke and West Springfield, Hampden Co. (*Sargent s.n.,* GH, SCHN). This species is definitely gone from the

Plymouth Co. sites and apparently from Nantucket as well. The precise habitat is unknown, but probably along borders and openings in pitch pine-oak barrens; occasionally on open sandplains.

***Lespedeza violacea** (L.) Pers. 8/24. Recently delisted.

Vouchered from Middlesex, Norfolk, Worcester, Franklin, Hampshire, Hampden, and Berkshire Cos. Given the relative ease of locating populations, this species has been dropped from the list after only two field seasons. It prefers open, dry, rocky, wooded slopes and talus, the soil circumneutral to calcareous. Most of the current stations showed limited or no flowering except through cleistogamy. When the elongate, chasmogamous flowering branches are absent, *L. violacea* can be told from *L. intermedia* (S. Wats.) Britton by the much less hairy stem and leaves, the broader leaflet shape, the relatively shorter sepals of the cleistogamous flowers, and the habitat (usually open, sandy woods and clearings for *L. intermedia*).

OXALIDACEAE—Wood-sorrels

***Oxalis violacea** L. 3/12. T.

Vouchered from Essex, Middlesex, Bristol, Franklin, Hampden, and Hampshire Cos. Reported from Southbridge, Worcester Co., by Ammidown (1882), but no specimen has been seen. Currently rare in Concord, Middlesex Co., where it flowers sparsely (R. Angelo, MNHP files), but a very large and vigorous population inhabits a patch of dry, rocky, semi-open oak-hickory woods on the Holyoke Range in South Hadley, Hampshire Co. (*BAS & M. Rohman 1945,* NEBC).

LINACEAE—Flaxes

Linum intercursum Bickn. 15/34. SC.

This southern species is most numerous on Nantucket, where characteristic of open grassy sandplains near the south shore with *Sisyrinchium arenicola, Helianthemum dumosum,* and *Aster concolor.* It is less common on Martha's Vineyard and Cape Cod, where forest succession restricts it to mown fire lanes, power lines, and a few remnant sandplains. Several historical records are from sandy pondshores, but I have not yet seen *L. intercursum* in that habitat. Type station is "Nantucket," Nantucket Co., without further data (*Bicknell 5455,* NY).

L. sulcatum Riddell 0/3. X.

Its native habitat is probably dry, calcareous ridges and rocky outcrops. The Suffolk Co. specimen is referable to *L. medium* (Planch.) Britton var. *texanum* (Planch.) Fern.: West Boston (*C. Swan s.n.,* NEBC).

POLYGALACEAE Milkworts

Polygala nuttallii Torr. & Gray 20/30. Recently delisted.

Range extension to Berkley, Bristol Co. (*Hunnewell 16292,* NEBC). Many current stations number in the hundreds of plants and it is a vigorous colonizer of power lines and fire lanes. It is curiously absent from Nantucket and outer Cape Cod, where not a single record exists.

P. senega L. 0/1. X.

Searches so far have failed to locate the historical station, but this species is to be expected in the calcareous districts of Berkshire Co., most likely on gravelly river shores or on upland rock outcrops.

CALLITRICHACEAE—Water-starworts

***Callitriche anceps** Fern. 1/1. E.

Callitriche anceps is currently known from a tiny pond atop Wachusett Mtn., where known since 1894 (*BAS & W. Brumback 2161,* NEBC). The colony is threatened by extensive development and large-scale recreation. Other supposed records from Massachusetts are actually *C. heterophylla* Pursh (*Seymour & Gates 17029,* CUW; *Gates s.n.,* CUW).

C. terrestris Raf. (=*C. deflexa* A. Braun var. *austinii* [Engelm.] Hegelm.) 0/4. H.

Range extension to Essex, Essex Co. (*Harris 13339,* NEBC); Rutland, Worcester Co. (*Gates s.n.,* CUW); and Sunderland, Franklin Co. (*Seymour 3757,* AC, MASS; *Seymour 3385,* AC, MASS, GH). It was last found in the state in 1957.

EMPETRACEAE—Crowberries

Corema conradii Torr. 40/54. SC.

Declining over most of its state range, yet still dominant over many acres on Nantucket and outer Cape Cod, where it colonizes sandy barrens, roadsides, scrapes, and burns. Forest succession and fire suppression are clear threats.

LIMNANTHACEAE—Meadowfoams, False Mermaids

Floerkea proserpinacoides Willd. 0/1. X.

Recent searches along the Green River, Franklin Co., the only known state locality, have failed to locate this spring ephemeral despite the existence of suitable habitat.

AQUIFOLIACEAE—Hollies

Ilex montana Torr. & Gray 3/3. T.

Restricted to the schist and quartzite uplift in the town of Mt. Washington, Berkshire Co., where two of the current stations occupy shaded rocky slopes near ponds, under *Quercus rubra, Fagus grandifolia, Acer rubrum,* and *Tsuga canadensis* (*Coddington VIII.23.78.1,* MASS; *Coddington VIII.23.78.2,* MASS; *BAS 2289,* NEBC, GH; *BAS et al. 1193,* NEBC).

ACERACEAE—Maples

***Acer nigrum** Michx. 5/18. SC.

Vouchered from Worcester, Franklin, Hampshire, Hampden, and Berkshire Cos. Currently known from all but Worcester and Hampshire Cos., but most populations contain few plants. Prefers calcareous woods, often on steep, dryish slopes with a mull soil, but also in alluvial situations. Characters separating it from *A. saccharum* Marshall are not always reliable, as leaf shape and pubescence are variable in both species, but most trees encountered can be satisfactorily assigned. When well developed, these characters give *A. nigrum* a very different "gestalt": darker bark, darker upper leaf surface, olive-colored lower leaf surface, lower leaf surface densely pubescent, drooping margins to leaf blades, leafstalk oriented downwards rather than outward.

HYPERICACEAE—St. John's-worts

Hypericum adpressum Barton 7/8. T.

The Worcester Co. (CUW) and Plymouth Co. (NEBC) collections are misidentified and both are referable to *H. ellipticum* Hook.

On Nantucket *H. adpressum* is a vigorous plant of sandy-peaty pondshores, numbering in the hundreds of plants at most stations. Atypical habitats include a sandy-peaty, seasonally wet roadbed and the margin of a cranberry bog. The only mainland population is also quite healthy, although threatened by recreational use of the pond. This species' absence at other mainland sites, where abundant habitat is present, is inexplicable.

H. hypericoides (L.) Crantz ssp. **multicaule** (Michx. ex Willd.) Robson (=*Ascyrum h.* L. var. *m.* [Michx.] Fern.) 1/6. E.

The current station, the only one in New England, consists of a single vigorous low shrub in an open, rolling, grassy sandplain on Nantucket, Nantucket Co. The habitat is dominated by *Agrostis stolonifera, Andropogon scoparius, Danthonia spicata, Carex pensylvanica, Hudsonia ericoides, Helianthemum dumosum, H. propinquum, Vaccinium angustifolium,* and lichens, with scattered *Quercus ilicifolia* and *Q. prinoides* (*BAS & G. Flatebo 1717,* NEBC). Most of the area where this species formerly occurred on Nantucket has succeeded to *Q. ilicifolia* thickets or oak-pine scrub. In 1962 MacKeever found it in a roadside sandy scrape (*MacKeever N654,* NY) and mentions its occurrence in mown areas; I therefore suspect that this inconspicuous species will be found elsewhere on the island as a colonizer of open or disturbed sites, but intensive searches have failed so far.

H. prolificum L. (=*H. spathulatum* [Spach] Steud.) 3/7. Recently delisted.

Of all the New England specimens that I have seen, none suggests native status. Plants occur in sandy thickets, clearings, roadsides, and other disturbed areas. In 1984 a large population was found in an abandoned nursery in Falmouth, Barnstable Co., and is the probable source of the Cape Cod records. Fernald (1950) states "cult. and locally esc. in Mass."—I agree.

ELATINACEAE—Waterworts

Elatine americana (Pursh) Arnott 0/0. Recently delisted.

Although true *E. americana* occurs in other New England states, usually in tidal river mudflats, all Massachusetts specimens examined at NEBC, MASS, AC, VT, and NHA prove to be *E. minima* (Nutt.) Fischer & Meyer. Magnification of at least 20X is necessary for positive identification. In *E. americana* the seeds are quite straight, relatively long, and possess more aureoles; the aureoles are not obviously elliptical in shape and the walls between them are thin. In *E. minima,* seeds are curved or banana-shaped, relatively short, and possess fewer aureoles; the aureoles are elliptical and divided by thick walls. A specimen from Great Barrington was annotated by Hellquist as *E. triandra* Schkuhr, introduced or adventive from the Old World (*Hellquist 11822,* NASC).

CISTACEAE—Rockroses

Helianthemum dumosum (Bickn.) Fern. 49/75. SC.

Range extension to Plymouth, Plymouth Co. (*BAS 2261.5,* NEBC); the only other specimen from that county proves to be *H. canadense* (L.) Michx. (Scituate, sandy ground, *Churchill s.n.,* AC). Common on Nantucket and Martha's Vineyard, where found in open sandplains, heathlands, dry sandy pastures, and openings in oak-pine scrub; uncommon on the Elizabeth Islands, where some plants are transitional to *H. canadense;* rare on the mainland, where forest succession and development have eliminated most historical stations. Bushy Rockrose is characteristic of dry, grassy outwash sandplains in company with lichens, *Sisyrinchium arenicola, Linum intercursum, Aster concolor,* and often *Amelanchier nantucketensis.* It largely replaces *H. canadense* on Nantucket and Martha's Vineyard and is distinguished from that species by its depressed to ascending, very widely-branching, bushy habit; tendency to branch from near the base of the plant; much more densely pubescent herbage; paler green and dull (not lustrous) upper leaf surface; relatively broader and more elliptical leaf shape; and tendency to produce very few cleistogamous flowers. *Helianthemum dumosum* is retained on the rare species list because of its scarcity outside of Massachusetts—only 15 current stations. Type station is "Nantucket," Nantucket Co., without further data (*Bicknell s.n.,* NY, NEBC).

VIOLACEAE—Violets

Viola adunca Sm. 1/5. E.

The current station occupies a now-abandoned borrow pit in the bog country of Ashburnham, Worcester Co. (*BAS 1902,* NEBC).

More field work is needed to determine its natural habitat and current status. I cannot locate a specimen to support the Millers Falls, Franklin Co., range given by Seymour (1969).

***V. brittoniana** Pollard (includes var. *pectinata* [Bickn.] Anderson) 3/21. T.

Vouchered records are from Middlesex, Suffolk, Norfolk, Plymouth, and Bristol Cos., primarily from riverside open woods and meadows. The Essex Co. record in Seymour (1969) is actually *V. palmata* L. Current stations are from the Great Meadows area of the Concord River, Middlesex Co., and from the Fowl Meadow section of the Neponset River, Norfolk Co. Several historical stations have been lost due to habitat destruction for agriculture, water level manipulation, diking, and ditching.

V. nephrophylla Greene 3/11. T.

Vouchers for Berkshire Co. exist at NEBC, AC. Field inventories for this species have been limited but indicate that *V. nephrophylla* is infrequent in Franklin and northern Berkshire Cos. In the field it is not always separable from *V. septentrionalis* Greene due to variation in leaf pubescence and shape, but notes on identification by Russell (1965) are helpful.

CACTACEAE—Cacti

Opuntia humifusa (Raf.) Raf. (=*O. compressa* [Salisb.] Macbride) 14/18. SC.

Frequent on the Coskata-Coatue sandspit on Nantucket, where certainly native and known for over 150 years. At least 10 colonies are currently known from outer Cape Cod, Barnstable Co., in dry sterile fields, lawns, and cemeteries, but their native status is open to question (see Collins, 1914, for a discussion). A range extension to Southwick, Hampden Co. (*Gillette s.n.,* US), is also questionable, the species being very rare in New England away from the coast (Graves et al., 1910; Mehrhoff, pers. comm.).

LYTHRACEAE—Loosestrifes

Cuphea viscosissima Jacq. (=*C. petiolata* [L.] Koehne) 0/3. H.

Range extension to Pittsfield, Berkshire Co., as reported by Dewey (1840). Its native status is questionable, but there are no compelling reasons to remove this species from the rare list.

Rotala ramosior (L.) Koehne 0/9. H.

Range extension to Springfield, Hampden Co. (*Owen s.n.*, NEBC, SPR; *Chapin s.n.*, SPR). I have unsuccessfully searched for it at several historical sites. Although reasons for its disappearance are unclear, most ponds visited have been degraded by heavy recreational use or by manipulated water levels. *Rotala* is curiously absent from the acid Coastal Plain ponds of Plymouth Co., Cape Cod, and the islands; no record exists despite abundant habitat.

MELASTOMATACEAE—Meadow Beauties

Rhexia mariana L. 5/9. T.

This southern species has been extirpated from several historical sites due to pondshore development and the situation at a few current stations is precarious. Population levels vary greatly from year to year. Its paler pink petals and narrow leaves give it a more delicate appearance than its sometime associate, *R. virginica* L.

ONAGRACEAE—Evening Primroses

Ludwigia polycarpa Short & Peter 4/8. T.

Range extension to Northampton, Hampshire Co. (*M. H. Sackett 766, 119,* SCHN), where extant on conservation land. A second extant Northampton station was discovered by H. E. Ahles (*Ahles 84825,* MASS). It prefers oxbows and old river channels of the Connecticut and lower Deerfield Rivers, where it inhabits wet, exposed mud with *Leersia oryzoides, Alisma* sp., *Polygonum punctatum, Penthorum sedoides, Ludwigia palustris, Lycopus virginicus, Gratiola neglecta,* and *Cephalanthus occidentalis.*

L. sphaerocarpa Ell. (includes var. *macrocarpa* Fern. & Griscom) 2/9. T.

There is far too much overlap in fruit dimensions to warrant separating var. *macrocarpa* from nominate *L. sphaerocarpa.* Current stations are in Rochester and Bridgewater, Plymouth Co. (*BAS 670, 680,* NEBC), the latter very large and on protected land. Old stations from along the Concord River in Bedford and Billerica, Middlesex Co., need field checking.

HALORAGACEAE—Water-milfoils

Myriophyllum alterniflorum DC. 1/6. T.

Range extension to Boston, Suffolk Co. (*Faxon s.n.*, GH), and Quincy, Norfolk Co. (*Deane s.n.*, GH). The current station is in Boxford, Essex Co., growing with *M. humile, M. heterophyllum,* and several *Utricularia* spp. (*BAS 1346,* pers. herb.). At this pond it was most numerous where the substrate was sandy and clear of other competing species. The plant shows a strong reddish cast, especially the stem and terminal leafy tips.

M. pinnatum (Walt.) BSP. 4/13. SC.

No specimen supports the Hampshire Co. report given in Coddington & Field (1978). At this locality, the Hampton Ponds, I found *M. heterophyllum* Michx., *M. exalbescens* Fern., and *M. humile* (Raf.) Morong; perhaps one of these species was mistaken for *M. pinnatum.* See the note on p.11 of Crow & Hellquist (1983) about discriminating among these species. I am skeptical of the Northbridge, Worcester Co., specimen (*Gates s.n.,* CUW). Although annotated as *M. pinnatum* by C. B. Hellquist, it lacks flowers and fruit and to me resembles vegetative *M. heterophyllum.* A specimen from Brookfield, Worcester Co. (*Medoff s.n.,* CUW), is correctly annotated by Hellquist as *M. heterophyllum,* as is a collection from Canton, Norfolk Co. (*Hellquist 2656,* NEBC). In Massachusetts *M. pinnatum* inhabits small, shallow, muddy, brackish ponds adjacent to the ocean, where it occurs with *Typha latifolia, Diplachne maritima* (occasionally), *Phragmites communis, Eleocharis smallii, Scirpus validus, Hibiscus palustris, Ludwigia palustris,* and *Proserpinaca palustris. Phragmites* seems to be threatening the *M. pinnatum* populations at a few sites, where it is so abundant as to severely reduce open water and exposed mud. Most historical stations are on the Elizabeth Islands and are very likely still extant.

ARALIACEAE—Ginsengs

Panax quinquefolius L. 21/39. SC.

The effects, if any, of root hunters on the Massachusetts ginseng populations are unknown; I am unaware of any active collecting or exporting. Most populations consist of less than ten plants, rarely fifty or more. Ginseng often grows in association with *Diplazium pycnocarpon* and *Dryopteris goldiana* on shaded talus slopes. It is listed in Appendix II by CITES, which regulates export. Because of the lack of documentation on the taking and artificial propagation of ginseng in Massachusetts, the U.S. Fish & Wildlife Service does not authorize export at this time.

APIACEAE—Carrots, Angelicas, etc.

Angelica villosa (Walt.) BSP. (=*A. venenosa* [Greenway] Fern.) 0/3. X.

One of the least known of all Massachusetts plants. All three collections are from southwestern Berkshire Co. and only one of them gives relatively specific site information. To date, attempts to find this species have been unsuccessful, perhaps due to ignorance of its microhabitat.

Conioselinum chinense (L.) BSP. 8/14. SC.

Range extension to Auburn, Worcester Co. (*Woodward s.n.,* GH). The Nantucket Co. collection listed by Seymour (1969) is an error in transcription and refers to a specimen of *Conium maculatum* L. (fide P. Zika). *Conioselinum* is frequent in Berkshire Co. (all current stations occur here) but rare elsewhere.

Hydrocotyle verticillata Thunb. 5/11. SC.

Range extension to New Bedford, Bristol Co. (*Greene s.n.,* NY), and Nantucket, Nantucket Co. (*Dunwiddie 1232,* MMS; *BAS & Jenkins 600,* NEBC; *BAS & Dunwiddie 2696,* NEBC). Known in Massachusetts only from brackish to nearly fresh ponds adjacent to the ocean, growing among grasses, sedges, coarse herbs, and shrubs on peaty or sandy margins. It is apparently not coexistent with *Myriophyllum pinnatum,* but like that species it is most numerous on the Elizabeth Islands (Fogg, 1930b). Most collections represent *H. verticillata* var. *triradiata* (A. Richard) Fern.; specimens of this variety at GH were recently annotated as *H. prolifera* Kellogg by G. P. Frank. *Hydrocotyle verticillata* and *H. prolifera* are not known to share the same ponds in Massachusetts.

PYROLACEAE—Pyrolas, Pinesaps

+***Pterospora andromedea** Nutt. 0/1. X.

Admitted to the state's flora on the basis of a collection by E. Hitchcock from Easthampton, Hampshire Co., as cited by Stone

(1913). As yet I have been unable to find said specimen and searches of the Mt. Tom region have failed to locate plants.

Pyrola asarifolia Michx. var. **purpurea** (Bunge) Fern. 2/2. E.

Current stations are in Stockbridge and Pittsfield, Berkshire Co. (*BAS, Rawinski, & Caljouw 2310,* NEBC; *BAS & Weatherbee 2185,* NEBC). Both populations occur in cold calcareous swamps with larch, black ash, red maple, and spicebush, adjacent to open fens.

ERICACEAE—Heaths

Rhododendron maximum L. 3/16. T.

Range extension to Berkshire Co.: Pittsfield (*Rawinski 83-242,* pers. herb.); Otis (*Otis s.n.,* NEBC, SPR); and reported by Hoffmann (1922) from three other towns, although I have seen no specimens. Several collections, especially from Worcester Co., suggest small adventive colonies; field work is needed to clarify their status. Current stations are in Medfield, Norfolk Co., where large, vigorous, and protected; Pittsfield, where a tiny population exists; and Princeton, Worcester Co., where a small population exists (E. Bullock, MNHP files).

Vaccinium vitis-idaea L. ssp. **minus** (Loddiges) Hulten 1/3. E.

Range extension to Mt. Greylock, Berkshire Co., where a few plants were found near the summit in 1982 by C. Quinlan (*Quinlan s.n.,* NEBC). Range extension to Wachusett Mtn., Worcester Co. (*Peck s.n.,* GH), but there have been no reports there this century and efforts to find plants have failed. Reported from Templeton, Worcester Co., by Jackson (1909), but the specimen by Blodgett cannot be found. Granby, Connecticut, marks the species' southern limit in North America.

EBENACEAE Persimmons

Diospyros virginiana L. 2/2. Recently delisted.

I see no compelling reason to consider these two roadside colonies as native. In 1965 R. J. Eaton considered them "thoroughly naturalized" (*Eaton 5885,* NEBC) and notes accompanying the NEBC specimens indicate that horticultural items carried by the ship Franklin, wrecked nearby in the mid-1800's, were salvaged and planted. These occurrences are too far disjunct, with abundant suitable habitat intervening, to seriously consider as native.

GENTIANACEAE—Gentians

Gentianopsis crinita (Froel.) Ma (=*Gentiana c.* Froel.) 20/65. Recently delisted.

Although certainly much diminished due to forest succession, this species is too common in central and western Massachusetts to warrant listing. It shows a definite preference for circumneutral to calcareous soils.

Halenia deflexa (Sm.) Griseb. 1/2. E.

Two historical records are documented for this species, disjunct from northern New England: "banks of the Manhan River, Southampton," Hampshire Co., 1830 and 1892 (*Chapman s.n.,* NY; *collector unknown,* MO), and "near East Cummington," Hampshire Co., 1868 (*Jesup s.n.,* AC). In August 1984, J. Lundgren and I rediscovered the latter station on mossy, semi-shaded, exposed shores of the Westfield River in Cummington and Chesterfield (*BAS & Lundgren 2580,* NEBC, MASS, GH). Plants are vigorous and numerous, but found locally where conditions of moisture, shading, and lessened competition from other herbs and shrubs are favorable. Associates at this site are *Platanthera psycodes, Rosa blanda, Sanguisorba canadensis, Hypericum ellipticum, Gentiana clausa.*

Sabatia campanulata (L.) Torr. 3/8. E.

Range extension to Pembroke, Plymouth Co. (*Foster s.n.,* GH). A vigorous population in Barnstable, Barnstable Co., is threatened by development and recreational use. A small population on Nantucket, Nantucket Co., was rediscovered by R. Zaremba (MNHP files) after a lapse of 55 years. This species is gone from several historical sites due to ecological succession of its pondshore habitat.

S. kennedyana Fern. 45/88+. SC.

Range extension to Newburyport, Essex Co., but its occurrence there and its flowering in June are very curious (*Chamberlain s.n.,* NY). It has been extirpated from many historical sites by development, recreation, alteration of water levels, etc. MNHP maintains it as a listed species because of its extreme scarcity elsewhere in its disjunct range (16 current stations outside of Massachusetts) and because of the obvious and ongoing threats to its ecologically important habitat. Hybrids with *S. campanulata* have been collected in Barnstable, Barnstable Co. (*BAS 560,* NEBC; *BAS 2153,* pers. herb.). Type station is "shore of Wequonoket Pond" (now named Lake Wequaquet), Barnstable (*Williams s.n.*, GH).

S. stellaris Pursh 1/2. E.

The current station is in Dartmouth, Bristol Co., where I rediscovered a large colony in 1975 (*BAS 70,* MASS). There it occurs at the dryish upper border of a saltmarsh with *Spartina patens, Agalinis maritima, Plantago maritima, Aster subulatus,* and *Iva frutescens.* It is apparently extirpated from Tisbury, Dukes Co., due to the permanent alteration of water level in a saltpond.

ASCLEPIADACEAE—Milkweeds

Asclepias tuberosa L. 32/50+. Recently delisted.

Although seriously reduced in numbers and range within the state, Butterfly-weed is still frequently encountered in southern Bristol, southern Plymouth, and Barnstable Cos. It is rare on Nantucket, but common on Martha's Vineyard, where it adorns roadsides, yards, and dry grassy fields. Only two current stations exist northwest of Bristol Co.: grassy border of airport in Agawam, Hampden Co., discovered by J. Cavanaugh (*BAS 2534,* NEBC) and dry, open trap ledge along the Connecticut River, Greenfield, Franklin Co., where it occurs with such unlikely companions as *Minuartia stricta* and *Solidago ptarmicoides* (*BAS 2664,* NEBC).

***A. verticillata** L. 5/25. T.

Vouchered in all counties except Nantucket and Berkshire. Historically this species was most numerous on the rocky hills of the Boston Basin, but some of these stations cannot now be found. Current stations usually have few plants per site and are subject to overshading by encroaching forest.

HYDROPHYLLACEAE Waterleafs

Hydrophyllum canadense L. 1/2. E.

The current station is in North Adams, Berkshire Co., largely within the Mt. Greylock State Reservation (*BAS & Jenkins 1517,* NEBC, BEDF; *BAS & Weatherbee 2300,* GH, MASS). A very large and vigorous colony, it occurs in rich northern hardwood-hemlock forest along a mountain stream. The Boylston, Worcester Co., specimen (*Young s.n.,* CUW) was collected in 1943 but is without habitat data; presumably it is adventive there, as is another Worcester

Co. station: Worcester, "spontaneous in a fern bed," 1933 and 1934 (*Woodward s.n.,* Worcester Science Museum).

BORAGINACEAE—Borages, Lungworts

Cynoglossum boreale Fern. 0/5. X.

Practically nothing is known about this species' habitat preferences in Massachusetts and imprecise location data on specimen labels render field searches at historical sites a matter of guesswork. It apparently prefers clearings or young, open woods on or near ledges, so may be declining due to forest succession. In 1985 plants were found in thin soil with *Thuja occidentalis* and *Carex eburnea* on a limestone island in Lake Champlain, New York (T. Rawinski, pers. comm.).

Mertensia maritima (L.) S.F. Gray 1/10. E.

Range extension to Plymouth, Plymouth Co. (*Russell s.n.,* NEBC). The current station on Nantucket is on protected land, but is very small and in peril from recreational use of the beach. It grows on the lee side of a barrier beach, at the upper tide level with *Ammophila breviligulata, Polygonum glaucum,* and *Glaucium flavum. Mertensia* has also been reported extant within the past five years at Provincetown, Barnstable Co. (R. Zaremba, pers. comm.), but the population has not been relocated.

Onosmodium virginianum (L.) A. DC. 0/12. X.

Range extension to Monson and Springfield, Hampden Co. (Stone,1913), (*Burnham s.n.,* SPR). This is another species which has simply disappeared from the Commonwealth despite the presence of much apparently suitable habitat. Most specimens were collected in the eastern third of Nantucket, where succession to scrub oak is rapidly closing open habitats. Virtually no habitat information is given on herbarium labels, but this species seems to prefer dry, open fields, sandplains, and clearings in pine barrens.

VERBENACEAE—Vervains

***Verbena simplex** Lehm. (=*V. angustifolia* Michx.) 1/9. E.

Vouchered from Hampshire, Hampden, and Berkshire Cos. The current station is on the dry, upper wall of an abandoned marble quarry in Sheffield, Berkshire Co. (*BAS 1814,* NEBC). Other habitats indicated by specimen data are traprock ledges, dry, rocky openings on south-facing slopes, and occasionally sandplains. The Springfield, Hampden Co., station has been destroyed by development (Andrews, 1924).

LAMIACEAE—Mints

Agastache scrophulariifolia (Willd.) Kuntze 0/6. X.

The Worcester Co. stations are adventive: "extremely weedy field, in a great variety" (*Gates s.n.,* CUW) and "War garden, N Worcester" (Jackson,1927). The Suffolk Co. station, the famous Oak Island in Revere, has been extirpated due to the near total development of the habitat, despite having been collected by botanists from 1864-1917. The preferred habitat is not known with certainty; most Massachusetts collections are from roadside thickets or woods near rivers.

Blephilia ciliata (L.) Benth. 1/11. E.

Range extension to Ashland, Middlesex Co., where perhaps adventive on "dry open ground and hillsides" (*Morong s.n.,* NY). This is an early successional species, but most plants at the current station persist in young, open woods and dryish thickets near an abandoned marble quarry in West Stockbridge, Berkshire Co. (*BAS & Weatherbee 2055,* NEBC).

B. hirsuta (Pursh) Benth. 1/4. E.

Range extension to Cummington, Hampshire Co., according to Stone (1913). The current station is in rich, mesic forest on Mt. Greylock, Berkshire Co., growing with *Milium effusum, Uvularia grandiflora, Panax quinquefolius,* and an abundance of calciphilic herbs (*P. Weatherbee s.n.,* NEBC). A collection from Becket, Berkshire Co. (*Jones 17205,* NY), is actually *Satureja vulgaris* (L.) Fritsch, often mistaken for species of *Blephilia* because of the ciliate-hirsute calyx and head-like flower clusters. However, it lacks the large, broad, often colorful bracts which subtend the flowering heads of *Blephilia,* having only small, narrow bracts mingled with the flowers. Flowers of *Satureja* are much less clearly bilabiate.

Pycnanthemum clinopodioides Torr. & Gray 1/2. E.

The Norfolk Co. station was rediscovered in Canton in 1983, where it occurs on a dry, rocky, lightly wooded south slope under oak-hickory canopy with *Panicum commutatum, P. latifolium, Thalictrum revolutum, Eupatorium sessilifolium,* and *Helianthus* *divaricatus (BAS 2157,* NEBC). I could find only one clump of seven flowering stalks, growing with *Pycnanthemum tenuifolium* Schrad. and near to *P. incanum* (L.) Michx. Due to the intermediate nature and variability of several morphological features, I strongly suspect hybrid origin for these plants. The stems are densely short-downy, even to the base. Leaf width and pubescence are variable; the lateral veins number 5–7. Calyx lobes are more-or-less equal, but teeth vary from 0.8–1.5 mm long. Oddly, *P. clinopodioides* was in full flower, whereas *P. incanum* was just past anthesis and *P. tenuifolium* had finished flowering altogether. See discussion in Gleason (1952, vol. 3: 178) regarding hybridization. Grant & Epling (1943) maintain *P. clinopodioides* as a full species, but comment on the intermediate nature of this taxon, stating that the two major phylads within the genus "appear to be connected by *P. clinopodioides*" and that "this species is rather variable in habit and suggests strongly a hybrid origin between a member of the *P. incanum* group and one of the narrow-leaved species, such as *P. verticillatum*."

Scutellaria integrifolia L. 0/2. X.

Range extension to Bridgewater, Plymouth Co. (*A. Gray s.n.,* GH). No habitat data accompany the specimen labels; elsewhere in the Northeast it is a plant of fields, meadows, thickets, and open woods. No specimen record can be found to support the Worcester Co. distribution listed by Coddington & Field (1978). This species was last verified extant in Massachusetts before 1900. It is presumed native here due to its pattern of distribution in southern New England.

Stachys hyssopifolia Michx. 36/41. Recently delisted.

The Plymouth Co. range was inadvertently omitted in Coddington & Field (1978). It is locally common on dry to moist, sandy to cobbly shores of freshwater ponds; uncommon in seasonally moist, sandy power lines; and rare on sandy-peaty roadsides. MNHP records indicate that it is certainly declining due to development pressures, but many populations are large and vigorous.

Trichostema brachiatum L. (=*Isanthus brachiatus* [L.] BSP.) 3/5. T.

Current stations are in: Holyoke, Hampden Co. (*Ahles 85823,* MASS), where it occurs on exposed beds of Triassic sandstone and on nearby railroad gravel; open shelves of an abandoned marble quarry in Sheffield, Berkshire Co. (*BAS 2293,* NEBC); and on dry, calcareous outcrops in a pasture in Williamstown, Berkshire Co. (Weatherbee, MNHP files).

SCROPHULARIACEAE—Figworts, Gerardias, etc.

Agalinis acuta Pennell 2/20. E.

Range extension to Middlesex and Worcester Cos. (NEBC,GH). Both current stations are in Barnstable Co. in old cemeteries with many other associates of dry, open sandplains. One population has numbered up to 500 plants and has responded well to an altered mowing regime; the other has less than 40 plants and has shown no sign of increase under similar management. Most historical stations are from Nantucket and Martha's Vineyard islands, occasional on Cape Cod, and sporadic northwestward. A victim of forest succession, it has withdrawn to a very small portion of its former range, despite the fact that two associates, *Helianthemum dumosum* and *Spiranthes tuberosa,* are not difficult to find today. The known world population currently numbers less than 2500 plants in six stations in Massachusetts and Long Island, NY. An understanding of its reproductive biology and ecology will be essential to its preservation. Type station is "dry sandy downs, Edgartown," Dukes Co. (*Fernald pl. exs. Gr. 45,* US, NY, GH).

***Castilleja coccinea** (L.) Spreng. 0/37. X.

Vouchered from Essex, Middlesex, Norfolk, Plymouth, Bristol, Worcester, Hampshire, and Hampden Cos. The most recent specimen is from Dudley, Worcester Co., in 1939 (*Pride s.n.,* CUW). There exists a current station at the border of a fen-like wetland in Salisbury, CT, only a few miles from the Berkshire Co. line (C. Caljouw, pers. comm.). Its disappearance from peaty meadows and open swampy woods is certainly in part due to succession.

Mimulus alatus Ait. 1/3. E.

The Stoughton, Norfolk Co., record is actually *M. ringens* L. (*Hellquist 4287,* NASC). I have not yet found a specimen to support the Springfield, Hampden Co., record listed by Seymour (1969). Stone (1913) remarks that a station from Amherst, Hampshire Co., was "not observed in recent years," but I cannot find the specimen by Hitchcock. The current station was discovered by H. E. Ahles and occurs in a floodplain forest under *Acer saccharinum, Fraxinus* *pennsylvanica, Quercus palustris,* and *Platanus occidentalis,* along with *Carex typhina* (*Ahles 84602,* MASS; *BAS 2135,* NEBC). This small population is in jeopardy due to grazing by cows. In Massachusetts this species is restricted to the Connecticut River floodplain.

M. moschatus Douglas 3/7. T.

This western species is undoubtedly adventive in Lexington, Middlesex Co. (specimens in GH, NEBC), but native in Franklin and Hampshire Cos., where current stations inhabit cold, springy seepage areas at the base of steep riverside slopes, associated with *Glyceria canadensis, Carex scabrata* and others, *Spiranthes lucida, Polygonum sagittatum, Stellaria alsine, Epilobium* sp., *Myosotis laxa,* and *Veronica americana* (*S. Garanin 7214,* MASS; *BAS 1688,* NEBC; *BAS & Lundgren 2584,* NEBC, MASS).

Pedicularis lanceolata Michx. 1/14. E.

Range extension to Leicester, Worcester Co., as cited by Jackson (1927) and Potter et al. (1940). Potter et al. also list Uxbridge in Worcester Co., but the specimen is *P. canadensis* L. (T. Rawinski, pers. comm.). Several historical records are from the Broad Brook drainage, Hampshire and Hampden Cos.; the current population inhabits a wet streamside meadow and thicket there with *Carex stricta, Alnus rugosa, Impatiens capensis, Verbena hastata, Aster puniceus,* and *Eupatorium* spp. (*BAS 2206,* NEBC). The existence close by of *Laportea canadensis, Rumex orbiculatus, Geum rivale, Penthorum sedoides, Gentiana clausa, Cirsium muticum,* and *Solidago patula* indicates the presence of circumneutral to calcareous seepage water. The Revere, Suffolk Co., station is almost certainly extirpated, although its precise locality is not indicated on the specimen; development there renders field searches futile.

Schwalbea americana L. 0/10. X.

Range extension to Hubbardston, Worcester Co. (*Alexander s.n.,* GH, NEBC), and Montague, Franklin Co., as cited by Stone (1913). Reported from Plymouth, Plymouth Co., by Dewey (1840), but the specimen by Greene has not been found. Reported from Southbridge, Worcester Co., by Jackson (1909), but the specimen by Ammidown has not been found. Of the Hubbardston station, Russell (1841) stated that it was "abundant on sandy fields." I could not relocate the species there in 1984, nor at the extensive Montague pine barrens where much apparently suitable habitat remains. Despite having been seen on Nantucket as recently as 1963, *Schwalbea* can no longer be found there. It is feared extirpated over most of its range due to forest succession and/or fire suppression and is now known only from New Jersey in the northeastern U.S. *Schwalbea* is an obligate root-parasite (Musselman and Mann, 1977), a crucial area of study in this species' conservation biology.

Veronica catenata Pennell (=*V. comosa* Richter, *V. connata* Raf., *V. salina* Schur.) 0/3-4. X.

Range extension to Ipswich, Essex Co. (*Oakes s.n.,* GH), but the specimen is very similar to the introduced Old World species *V. anagallis-aquatica* L. The relationship between these two species is certainly very close and, indeed, they are synonymized by Godfrey & Wooten (1981). In 1984 I found a few plants of what appear to be *V. anagallis-aquatica* on a moist, exposed bank of the Housatonic River in Sheffield, Berkshire Co. The plants were glabrous, sepals acute, corollas pale blue, leaves nearly devoid of marginal teeth and not strictly sessile (*BAS & Byrne 2720,* NEBC). See Heckard & Rubtzoff (1977) for a discussion of hybridization between these two taxa. Both are known in Massachusetts from only a few specimens each; *V. catenata* is considered native in Berkshire Co. in springy, alkaline stream borders.

***Veronicastrum virginicum** (L.) Farw. 7/15. SC.

Vouchered from Worcester, Hampshire, Hampden, and Berkshire Cos., where it prefers meadows, stream borders, and open borders of swamps, always in calcareous soil. It is declining due to succession of its habitat. Current stations are of relatively large populations in southern Berkshire Co. and a small population in Amherst, Hampshire Co., where rediscovered by M. Rohman after a lapse of 39 years (*Rohman 2535,* MASS). Culver's-root has been used as a medicinal and it is a popular garden plant, so that some historical stations may have been the result of garden escapes or discarded material.

LENTIBULARIACEAE—Bladderworts

Utricularia biflora Lam. 6/9. T.

The status of this species and the next reflects data gathered through 1985. The Franklin Co. record listed by Coddington &Field (1978) actually is *U. minor* L., as annotated by C. B. Hellquist

(*Ahles 68545,* MASS). Extant stations are all from muddy-peaty to muddy-sandy shores of freshwater ponds, in very shallow water or later in the season becoming fully stranded. At Big West Pond in Plymouth, Plymouth Co., I have seen it growing with *U. resupinata, U. cornuta,* and *U. gibba;* up to four other species of *Utricularia* float nearby in deeper water. See comments under *U. fibrosa* for identification and distribution of it and *U. biflora.*

U. fibrosa Walt. 5/8. T.

Although similar to *U. biflora* in its preference for muddy-peaty substrates in very shallow water of Coastal Plain ponds, *U. fibrosa* appears to inhabit more nutrient-rich situations. Some of the species associated with *U. fibrosa* such as *Sagittaria latifolia, Scirpus americanus, Pontederia cordata,* and *Hydrocotyle umbellata,* are seldom found with *U. biflora,* at least in Massachusetts. No pond supports both of these Utricularias.

Because *Utricularia fibrosa* and *U. biflora* are very sensitive to water levels, they seldom flower, making identification difficult. The presence of "specialized vegetative branches" is diagnostic for *U. fibrosa* and they do not occur on *U. biflora.* However, as noted by Uttal (1956) and supported by my own observations, many specimens of *U. fibrosa* lack such branches, as a result of incomplete collecting or, more importantly, due to the fact that when growing in very shallow water or when stranded ashore *U. fibrosa* seldom produces such branches. In Massachusetts these two species overlap in most dimensions (i.e., scape length, scape thickness, flower size), so that most keys are inadequate. Recent work by R. LeBlond and myself indicates that spur length, spur shape, and lower lip width are very useful distinguishing characters in Massachusetts. In *U. fibrosa* the spur is almost always distinctly shorter than the lower lip, the spur is thick and tapers to a blunt tip, and the lower floral lip measures ca. 11 mm wide. Spur tips are not only blunt, but often truncate, as noted by Godfrey & Wooten (1981). In *U. biflora,* the spur is equal to or distinctly longer than the lower floral lip, the spur is slender-tapered to an elongate, acute tip, and the lower floral lip width measures ca. 7.5 mm. These points of difference are quite obvious in Massachusetts plants, but may not be applicable elsewhere, since our *U. fibrosa* plants appear to be much shorter in stature than individuals from Long Island, NY, and southward.

A review of current stations and historical specimens of these two species at GH, NEBC, and MASS yields the following distributional pattern: *U. fibrosa* is known only from Barnstable Co.; all records from Plymouth Co. that I have seen are *U. biflora.* The specimen of *U. fibrosa* cited by Seymour (1969) from Bradford, Essex Co., is very fragmentary but clearly is *U. purpurea* L. by shape of scape bract. *Utricularia biflora* is practically confined to Plymouth Co., but is known from a single station in Barnstable Co. as vouchered by R. LeBlond in 1985 (*LeBlond 222,* Cape Cod Mus. Nat. Hist.).

***U. subulata** L. 6/26. SC.

Vouchered from Plymouth, Barnstable, Dukes, and Nantucket Cos. Despite relative abundance historically, the species is seldom encountered today due to ecological succession and to overuse and development of pondshores. It prefers open sphagnous borders of shallow ponds and boggy quagmires, and rarely occurs in seepy disturbed ground such as near commercial cranberry bogs. Most plants seen are forma *cleistogama* (Gray) Fern.

RUBIACEAE Bedstraws

Galium labradoricum (Wieg.) Wieg. 5/10. SC.

Early in the season this species can be confused with immature *G. obtusum* Bigelow, which also has a smoothish stem, but is distinguished from *G. obtusum* by its erect, unbranched or few-branched habit, smaller size, shorter leaves, and darker green coloration. *Galium labradoricum* prefers open to semi-open sphagnous knolls in wet portions of calcareous fens, where it no doubt is an overlooked species.

Hedyotis purpurea (L.) Torr. & Gray var. **calycosa** (Gray) Fosberg (=*Houstonia lanceolata* Poir.) 0/4. Recently delisted.

Range extension to Springfield, Hampden Co. (*collector unknown,* GH, SPR). The Salisbury station listed in Seymour (1969) refers to Salisbury in Litchfield Co., Connecticut, not Essex Co., Massachusetts. The distribution of this species in New England suggests that of a waif; indeed, E. Terrell annotated all New England specimens at GH with "introduced?". I agree, and pending more substantive information on its status I will place it on the Natural Heritage Program's "watch list." See Terrell (1959) for taxonomy and nomenclature.

CAPRIFOLIACEAE—Honeysuckles, Viburnums, etc.

Lonicera hirsuta Eaton 2/2. E.

After several failed attempts by J. Coddington, J. Jenkins, and myself, the type station in Williamstown, Berkshire Co., was finally rediscovered after persistent efforts by P. B. Weatherbee in 1983 (*Weatherbee s.n.,* NEBC). There it occurs at the summit of a very steep, calcareous rocky slope with *Cystopteris bulbifera, Clematis occidentalis, Acer nigrum, Cornus rugosa,* and *Diervilla lonicera;* the population, however, is threatened by abundant *Lonicera morrowi, Berberis vulgaris,* and *B. japonica.* The Berlin record listed in Seymour (1969) is not accepted, since no state is given on the label and it is one of many out-of-range species collected by Blodgett (see comments under *Aplectrum hyemale*). It likely was collected in Berlin, NY, just west of Williamstown, MA. The late H.E. Ahles discovered the state's only other station in 1967 in Lee, Berkshire Co. (*Ahles 66103,* MASS; *BAS, King, & Gilbert 2453,* NEBC). It occurs atop a dry, limy knoll with *Pinus strobus, Carex eburnea, Rhamnus cathartica, Cornus rugosa, Fraxinus americana,* and *Lonicera morrowi.*

***Symphoricarpos albus** var. **albus** (L.) Blake 1/2. E.

The single historical Berkshire Co. collection is from Sheffield "in a groove on low limestone hill" (*Hoffmann s.n.,* NEBC). The current station came as a complete surprise, as it occurs on Mt. Sugarloaf in Deerfield, Franklin Co., a locality scoured by eminent botanists for over 175 years. Low shrubs of it are abundant there in a small section of an exceedingly steep, dry, grassy, sandstone slope with *Andropogon scoparius, Danthonia spicata, Deschampsia flexuosa, Hystrix patula, Muhlenbergia sobolifera, Asplenium platyneuron, Cerastium arvense* (native), *Rosa carolina, Asclepias verticillata, Solidago arguta,* and scattered small *Carya glabra, Ostrya virginiana,* and *Acer saccharum (BAS 2790,* NEBC, MASS, GH).

Viburnum rafinesquianum Schultes 2/4. T.

Range extension to Greenfield, Franklin Co. (*Ahles 86701,* MASS), on dry traprock slopes by the Connecticut River. Current stations in Berkshire Co. are on non-calcareous to circumneutral mountain ridges in oak-hickory-red maple-shadbush woods (Jenkins, pers. comm.; *BAS 1937,* NEBC), similar to situations found by McVaugh (1958) in adjacent Columbia County, NY. Young leaves of *V. recognitum* Fern. are often quite hairy underneath with short, erect, deciduous hairs; it may be found considerable distances up mountain slopes. By contrast, those of *V. rafinesquianum* are very densely hairy with felt-like, appressed, permanent hairs.

CAMPANULACEAE—Bluebells, Lobelias

***Lobelia siphilitica** L. 3/4. T.

Vouchered from southern Berkshire Co., where localized in wet meadows, brooksides, moist woodland borders and roadsides. Hoffmann (1922) considered it native but rare in three localities in southern Sheffield, Berkshire Co. Specimens seen from east of Berkshire Co. are considered adventive.

ASTERACEAE—Asters, Goldenrods, etc.

***Artemisia campestris** L. ssp. **borealis** (Pall.) Hall & Clements (=*A. canadensis* Michx.) 1/2. E.

Curious about a report of this northern plant on Mt. Sugarloaf in Deerfield, Franklin Co. (Stone, 1913), I visited the near-vertical sandstone ledges in 1983. There the *Artemisia* was common on bare exposed flanks with *Selaginella rupestris, Juniperus virginianus, Deschampsia flexuosa, Cerastium arvense* (native), *Amelanchier sanguinea,* and *Antennaria plantaginifolia (BAS 2244,* NEBC, GH). A specimen also exists for Mt. Tom, Hampshire/Hampden Cos., but living plants have not yet been relocated (*Thies s.n.,* MASS). These plants seem to represent the more robust, southern form (see Gleason, 1952, for discussion), although I am not fully confident of the relationship between our plants and *A. campestris,* nor of the relationship between *A. campestris* and *A. caudata* Michx.

Aster concolor L. 6/13. E.

In New England this species is extant only on Nantucket, where much reduced from its former abundance. It prefers open sandplain grasslands and heaths, usually in association with *Sisyrinchium arenicola, Linum intercursum,* and *Helianthemum dumosum.* Most current stations were discovered by R. Zaremba and J. Jenkins and contain relatively few plants per site. All sites are threatened by succession of the heathlands to scrub oak thickets.

A. infirmus Michx. 1/10. E.

Range extension to Holyoke, Hampden Co. (*Sargent s.n.,* GH, SCHN), and to Paxton, Worcester Co., as reported by Harper

(1899). The current station occupies the dry, forested upper slope and top of a low talus ridge in Lincoln, Middlesex Co. The habitat is dominated by *Quercus* spp., *Carya* spp., *Betula lenta, Pinus strobus,* and *Fraxinus americana,* with *Polygonum tenue, Desmodium* spp., *Pycnanthemum incanum, Galium circaezans, Aster patens,* and *Solidago* spp. (*BAS 1316,* NEBC). It is very likely overlooked in western Norfolk, southern Worcester, and Hampden Cos.

A. prenanthoides Muhl. 3/9. T.

Range extension to Hadley, Hampshire Co. (*Manning s.n.,* SCHN). Currently restricted to the two Green Rivers in northern and southern Berkshire Co., where frequent locally on exposed gravelly shores, banks, and in open thickets.

A. ptarmicoides—see *Solidago p.*

A. tardiflorus L. (=*A. novi-belgii* L. ssp. *t.* [L.] A. G. Jones) 0/? Recently delisted.

Pending further study of specimens, MNHP will keep this species off the rare plant list. Of the twelve specimens purported to be *A. tardiflorus,* two have been annotated as "*Aster puniceus* hybrid" by Ahles, one as *A.* × *herveyi* Gray by me, and several others appear to be of hybrid origin as well, for they do not match specimens in GH annotated as *A. tardiflorus* by A. G. Jones. As Jones (1980) indicates, many collectors misapplied the name *A. tardiflorus* L. to their hybrid plants. In giving *A. tardiflorus* subspecific rank, Jones (1984) admits that "there is complete interfertility and a high degree of intergradation in areas of sympatry between populations of this subspecies and the other subspecies of *A. novi-belgii.*"

A. tradescantii L. 6/7. SC.

Listed by Stone (1913) as occurring in Hampshire Co., but no specimens have been seen. All current stations are from flood-prone ledges and riverbed cobbles along the Deerfield and Connecticut Rivers. Along both rivers, plants are subject to irregular flooding throughout the growing season due to release of water by power companies and from severe rainstorms. Most populations exceed 100 plants and appear to be healthy. This species resembles other small white-flowered asters, but is distinguished by the combination of short stature (often less than 0.3 m high), relatively few cauline and bracteal leaves, elongate and loose inflorescences, relatively tall involucres, involucral bracts with gradually widened midribs, and its distinctive habitat. See Fernald (1933) and Wiegand (1933) for discussions of taxonomy, typification, and identification.

Bidens eatonii Fern. 3/7. T.

At this time no attempt will be made to distinguish the several named varieties. Current populations vary from a few plants to hundreds, all from rich, tidal river mudflats near the inland limit of salt influence. As noted by Fernald (1903), this species often grows near *B. connata* Muhl. ex Willd. and superficially resembles it. In addition to identification characters given by Fernald, *B. eatonii* has striate, etuberculate achenes (contra *B. connata*) and thus can be identified correctly regardless of achene shape or length. The two taxa do hybridize, producing *B.* × *multiceps* Fassett (Fassett, 1925a, 1928). Plants with intermediate head and achene characters are still found with both parents along the Threemile River in Bristol Co. (*BAS 1801,* pers. herb.), where Fassett first described them. The type station of *B. eatonii* is "brackish muddy bank of the Merrimac River, Newburyport," Essex Co. (*A. A. Eaton & Fernald s.n.,* GH).

B. hyperborea Greene 2/3. E.

Range extension to Essex Co., where a small population survives at the Mill River (*BAS 1215,* NEBC); see also Fassett (1925b, 1928). The other current station is in the North River system of Plymouth Co. (*BAS 2227, 2228,* NEBC). *Bidens hyperborea* occurs in similar habitats as *B. eatonii*, but usually grows down nearer to the soft, bare mud and becomes fully inundated at high tides. Although *B. hyperborea* and *B. eatonii* are not syntopic in Massachusetts, they share many interesting associates: *Sagittaria calycina* ssp. *spongiosa, S. rigida, Zizania aquatica, Scirpus smithii, Eriocaulon parkeri, Crassula aquatica, Lilaeopsis chinensis, Lindernia dubia* var. *inundata.* Occasionally plants of *B. hyperborea* are found which produce yellow rays. They resemble short-rayed forms of *B. laevis* (L.) BSP., but differ in their smaller heads, included anthers, erect leafy bracts, and clear tendency towards basal branching. The type station of our taxon, which may be called var. *colpophila* (Fern. & St. John) Fern., is "brackish muddy shore of the Merrimac, Newburyport," Essex Co. (*A. A. Eaton & Fernald s.n.,* GH).

***Eupatorium aromaticum** L. 0/15. H.

Vouchered from Middlesex, Suffolk, Norfolk, Bristol, Plymouth, Barnstable, Dukes, and Nantucket Cos. Inhabits dry, semi-open to open, rocky slopes and pine barrens. In ten years of intense botanizing in southeastern Massachusetts, I have never encountered it. Historical stations in Suffolk, Norfolk, and Nantucket Cos. could not be located in 1983–1984.

E. leucolepis (DC.) Torr. & Gray var. **novaeangliae** Fern. 8/13. T.

A few current sites are being given protection through efforts of The Nature Conservancy, the Massachusetts Natural Heritage Program, and the Massachusetts Department of Environmental Management. Among these sites is the largest known population anywhere, numbering over 2000 shoots. This distinctive variety prefers the uppermost margin of freshwater pondshores, adjacent to the shrub border of *Clethra alnifolia, Leucothoe racemosa, Lyonia ligustrina, Rhododendron viscosum,* and *Vaccinium* spp. Three historical stations have been extirpated (Sorrie, 1981). The type station is "damp sandy shore of Loon Pond, Lakeville," Plymouth Co., where the population has been reduced to two plants (*Fernald & Long 10492,* NEBC).

E. rotundifolium L. 0/0. Recently delisted.

No Massachusetts specimens are unequivocally nominate *E. rotundifolium.* The collection from Georgetown, Essex Co., comes nearest, but is too fragmentary to allow positive identification (*Horner s.n.,* NEBC). All specimens seen, and recent stations cited by Coddington & Field (1978), are referable to *E. r.* var. *ovatum* (Bigelow) Torr. (=*E. pubescens* Muhl.) or to *E. r.* var. *saundersii* (Porter) Cronq. (=*E. pilosum* Walt.). Both varieties are frequently encountered in eastern Massachusetts in sandy, peaty, or clayey soils of open, seasonally wet places; rare in the Connecticut River Valley.

Gnaphalium purpureum L. 2/13. E.

Range extension to New Bedford and Dartmouth, Bristol Co.(*Greene s.n.,* NY; *Prince s.n.,* MO). Reported from Worcester Co. by Jackson (1909), but specimens have not been found. The Lowell, Middlesex Co., collection is certainly adventive (probably on wool waste), for this species is otherwise unknown N of Cape Cod (*Swan s.n.,* NEBC). This species has been extirpated from several historical stations, presumably due to ecological succession of fields and sheep pastures. The current populations were discovered in 1984 by P. Dunwiddie at the ecotone between grassy heathlands and ice channel ponds on Nantucket, where small numbers of plants were hidden among thick herbaceous vegetation (*Dunwiddie 1234,* MMS).

Helianthus giganteus L. 0/1. Recently delisted.

This midwestern species is adventive here; no known collections are from native populations. Stone (1913) listed it as a native species in the Connecticut River Valley, but no specimens have been seen to corroborate his report.

Petasites frigidus (L.) Fries var. **palmatus** (Ait.) Cronq. (=*P. palmatus* [Ait.] Gray) 2/13. T.

One current station inhabits the margins of a cold, calcareous seepage swamp in Sheffield, Berkshire Co., associated with *Tsuga canadensis, Betula* spp., *Quercus macrocarpa, Acer rubrum, Conioselinum chinense,* and *Mitella nuda (Caljouw 84-32,* pers. herb.; *BAS & Rawinski 2319,* NEBC). The second station inhabits a fairly steep slope laced with cold, springy seeps in Williamstown, Berkshire Co. Plants are abundant there, associated with *Equisetum scirpoides, Hystrix patula, Carex flava, C. scabrata, Parnassia glauca, Conioselinum chinense,* and *Solidago patula.* The Norfolk Co. stations are apparently extirpated, since little suitable habitat remains due to ditching, filling, and development. Connecticut is the southern limit of the species' range in eastern North America.

Sclerolepis uniflora (Walt.) BSP. 1/1. E.

This disjunct species is still extant at its only known Massachusetts station (*BAS 1329,* NEBC) (Mehrhoff, 1983), where plants are found in scattered colonies on exposed sandy to peaty shores, usually among boulders with *Gratiola aurea.* Mehrhoff (1983) stated that plants may be abundant and easily overlooked when in the submersed, aquatic form. *Sclerolepis uniflora* is inexplicably absent from the hundreds of ponds in southeastern Massachusetts, where conditions for Coastal Plain species are far more favorable than at the current site.

Solidago erecta Pursh 0/0. Recently delisted.

After re-examining all New England specimens at NEBC and GH, including one from Rhode Island that in 1982 I had annotated from *S. hispida* Muhl. ex Willd. to *S. erecta,* I now conclude that none are *S. erecta.* I base this conclusion on two important factors:

1) examination of freshly collected plants from New Jersey along with other material at GH; 2) rediscovery of Fernald's station in Brewster, Barnstable Co. At my request Mr. Sibley Higginbotham, a knowledgeable amateur botanist, collected fresh specimens of *S. erecta* from Batsto, NJ, in 1982. Comparing these, plus dried specimens of *S. erecta* from elsewhere in its range, with the New England "*erecta*" reveals the following points of difference. True *S. erecta* has long (ca. 2.5 mm), slender, glabrous achenes. The involucral bracts show an ill-defined green midrib. The New England "*erecta*" has short (1.5–2.0 mm), plump (liked cooked rice), upwardly hispidulous achenes. The involucral bracts are distinctly marked with a dark green midrib which is expanded near the tip. In these characters the New England specimens match *S. bicolor* L.

Fernald collected what he thought was *Solidago erecta* from "dry woods at north end of Cliff Pond" in Brewster, 26 Oct. 1919 (*Fernald 19179,* NEBC, GH). He also collected *Dichanthelium ovale* var. *addisonii* there on the same date. On 17 Sept. 1982, G. Flatebo, L. Meier and I found the *Dichanthelium* scattered in small numbers in disturbed spots under the pine-oak-sassafras canopy. Near the bottom of this south-facing bank we found a *Solidago* with pale yellow flowers in the midst of some *S. bicolor.* In gross morphological features these plants all resembled *S. erecta* in being less hispid-hairy on the lower stem and leaves than normal *S. bicolor,* but differed by clearly showing bold midribs on involucral bracts and having short, plump, hispidulous achenes. We later found two other plants with pale yellow rays near Higgins Pond, again with *S. bicolor* (*BAS, Flatebo, & Meier 1785,* pers. herb.). Herbarium work reveals that length and density of hairs are quite variable in *S. bicolor;* our yellow-flowered Brewster plants are matched by several specimens of white-flowered *S. bicolor* collected elsewhere in New England. The other Massachusetts specimens of "*erecta*" also show a tendency towards reduced hairiness. Thus I believe that previous botanists failed to recognize the plasticity of *S. bicolor.*

S. hispida Muhl. ex Willd. 0/6. H.

Given the complexity of the *S. bicolor* problem (see discussion under *S. erecta*), I feel inclined to follow Seymour's (1969) suggestion to treat *S. hispida* as *S. bicolor* var. *concolor* Torr. & Gray. Regardless, no yellow-flowered hispid plants have been found recently in Massachusetts, despite searches of open limestone ridges, cobbles, and riverside ledges. No doubt it is a victim of increased forest cover.

S. macrophylla Pursh 2/3. SC.

Very common above 750 m on Mt. Greylock, Berkshire Co., where it inhabits relatively open spruce-fir-birch-maple woods, roadsides, and clearings. In 1981 C. Quinlan found a population at Spruce Hill, E of Mt. Greylock up on the Berkshire Plateau, so this species is to be looked for on other high summits (*Quinlan s.n.,* NEBC).

S. ptarmicoides (Nees) Boivin (=*Aster p.* [Nees] Torr. & Gray) 4/6. T.

Range extension to South Hadley, Hampshire Co. (*collector unknown,* GH; *Ahles 86001,* MASS), and at South Hadley Falls as reported by Stone (1913). A further range extension was made in 1984 to Greenfield, Franklin Co. (*BAS 2666, 2782,* NEBC, GH, MASS). There is in NEBC a sheet of small plants collected in Easton, Bristol Co., without habitat data (*Blomberg s.n.,* NEBC). I suspect that these plants, like other out-of-range species collected at Easton, were taken from one of the Ames estates, where they were either under cultivation or locally escaped. The first collection made this century was by H. E. Ahles in cracks of gently sloping Triassic sandstone by the Connecticut River in Holyoke, Hampden Co. (*Ahles 85822,* MASS). There it grows with *Aster tradescantii* in a large, vigorous colony spread out over 200 m within the flood zone. A second extant station is located on an open, grassy, riverside traprock slope on the Connecticut River, Greenfield. Plants are numerous and occur with *Andropogon gerardii, Elymus canadensis, Cerastium arvense* (native), *Minuartia stricta, Lespedeza virginica,* and *Asclepias tuberosa.* Nearby, many plants also inhabit exposed ledges in the riverbed with *Amelanchier sanguinea, Prunus pumila* var. *depressa, Aster linariifolius,* and *A. tradescantii.*

S. rigida L. 0/4. X.

Range extension to Nantucket, Nantucket Co. (*Stewart & Manning s.n.,* MMS) and to Hampshire Co. (*M. Dole s.n.,* Mt. Holyoke College herb.), (Stone,1913). Reported from Middlesex Co. (Smith, 1899), but I have not found the specimens. Despite searches on dry, calcareous ridges and fields in southern Berkshire Co. and in the

Connecticut River Valley, no plants have been found. Similarly, a search of the very specific Nantucket station proved futile; I suspect that *S. rigida* was adventive there, even though most collections from nearby Connecticut are from coastal towns (Graves, 1910).

***S. spathulata** DC. ssp. **randii** (Porter) Cronq. (=*S. randii* [Porter] Britton) 1/3. E.

Hoffmann (1922) reported it from ledges about Guilder and Plantain Ponds, Mt. Washington, Berkshire Co., but I have been unable to locate voucher specimens and Seymour (1969) did not list this taxon for Massachusetts. Nonetheless, I have found Hoffmann to be a careful and reliable observer and I was thus able to locate *S. randii* along the edge of the high escarpment E of Plantain Pond (*BAS 2290,* NEBC). Plants were vigorous, although not numerous, and occurred with *Deschampsia flexuosa, Poa compressa, Carex pensylvanica, Aronia melanocarpa, Spiraea latifolia, Potentilla tridentata,* and *Vaccinium angustifolium.*

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DAHLIA CONGESTIFOLIA, SECTION *ENTEMOPHYLLON* (ASTERACEAE: HELIANTHEAE, COREOPSIDINAE), NEW FROM HIDALGO, MEXICO

PAUL D. SØRENSEN

ABSTRACT

Dahlia congestifolia, new from Cerro Chulco near Apan, Hidalgo, belongs to Section *Entemophyllon* within which its herbaceous and solitary shoot habit, purple disc florets, and non-leafy stems combine to enlarge morphic diversity and, perhaps, draw the section closer to Section *Dahlia*.

Key Words: *Dahlia*, Sect. *Entemophyllon*, Asteraceae, Heliantheae, Coreopsidinae, México

In the taxonomic revision of the genus *Dahlia* Cavanilles (Sørensen, 1969a, b), I established the new Section *Entemophyllon* ("dissected leaves") to include an interesting assemblage of species comprising a clearly separate evolutionary line within the genus. With some modification of the intrageneric position, Giannasi (1975b), using biochemical evidence, has corroborated my view of a separate evolutionary status for this section. Originally, however, the impetus for my recognition of this new section derived from morphological and cytological data, and to a lesser extent, from indirect biochemical observations. Of the six taxa on which I based my sectional circumscription, I had on hand for detailed analysis ample collections and living greenhouse plants of the following three: *Dahlia rupicola* Sørensen, *D. linearis* Sherff, and *D. dissecta* S. Wats. var *dissecta*. These, with others known solely from herbarium materials, possessed: 1) highly dissected leaves reminiscent of the commonly cultivated *Cosmos bipinnatus* Cav., the weedy *Cosmos* of cane and corn fields in the Central Plateau of México, more than of any *Dahlia* familiar to the nonspecialist; 2) secondary and tertiary leaflets alternate on their rachillae; 3) unusually large, almost leafy, outer involucral bracts that remain erect rather than reflexed at anthesis; 4) elongate roots, less tuber-like than generally found among other dahlias; 5) stems slightly woody at or above the base, giving the plants a suffrutescent habit; 6) pith chambered in older stems especially in those from the previous season that remained living; 7) a crystalline white precipitate developing in methanolic extracts of dried and fresh foliage and identified by Giannasi (1975a) as 6-methoxy flavones; and 8) a common chromosome number of $n = 17$ in a genus where $n = 16$ prevails at the diploid level. I had only herbarium materials available for study of *D. foeniculifolia* Sherff, *D. scapigeroides* Sherff, and *D. dissecta* var. *sublignosa* Sørensen; however, these taxa reveal enough morphological characteristics visible in dried specimens to forego any skepticism as to their relationship with the three taxa on which I carried out more detailed studies.

Now there comes to light a new and startlingly different taxon that possesses four of the eight aforementioned characters: 1) the highly dissected leaves, 2) alternate secondary and tertiary leaflets, 3) outer involucral bracts erect at anthesis, and 4) the crystalline precipitate. This taxon belongs to Section *Entemophyllon* and, accordingly, I offer the following nomenclatural details and description:

Dahlia congestifolia Sørensen. Species novum.

Herba perennis(?), 45 cm alta. Caules folia rosularia superans. Folia principalia bipinnato-pinnatisecta, 13–18 cm longa; stipellis praesentibus ad nodos rachidis 1 ad 4, simplicibus vel compositis. Capitula oblique erecta; involucri squammae exteriores erectae sub anthesi, 5–6 mm longae, 1.8–2 mm latae. Flosculi ligulati lavanduli, 1.5 cm longi.

Perennial(?) herb, 45 cm tall. Stem more or less glabrate, 4–7 mm diam., rather hairy at the nodes, the hairs brown. Leaves tripinnately compound, crowded near base of stem, 13–18 cm long with 7–9 (–11) primary leaflets, basal leaflets 5–8 cm long, opposite, secondary leaflets 2.2–3.2 cm long, alternate on rachillae, tertiary leaflets or ultimate segments elliptic-ovate, 4–10 mm long, 2–5 mm wide, alternate or opposite on their axes, terminal segments slightly larger than more proximal segments, stipels present at 1–4 rachis nodes, these simple or compound, 21–23 mm long; leaf blades acute, pubescent above, especially along the veins, glabrous or sparingly pubescent beneath, becoming rather tomentose at the junction of all divisions, petioles 4–6 cm long, glabrescent. Heads erect or obliquely erect to almost cernuous, 3 primary peduncles, all about 4.5 cm long and subtended by simple linear bracts; outer involucral bracts erect at anthesis, 5–6 mm long, 2 mm or less wide, obtuse, inner bracts 9–12 mm long, 4.5 mm wide, obtuse, tan with hyaline margins; rays up to 1.5 cm long, purple, ovate, disc florets purple-tinged or with purple corolla lobes, anthers yellow; achenes not seen (Figure 1).

Type: MEXICO: Hidalgo: W slopes of Cerro Chulco near rancho Los Valadores, 5 km SW of Apan, 2500–2900 m, *Robert C. West c-18,* 21 June 1966. Holotype: WIS!

On dry, rocky slopes of Cerro Chulco, among scrub of oaks, *Agave, Yucca,* and pines. Flowering in June.

Known only from the holotype.

My choice of the epithet "congestifolia" directs attention to the presence in this new species of the leaves crowded at the base of the stem (see Figure 1), a condition in Section *Entemophyllon* possessed only by this species. Within the genus as a whole, three other taxa, *Dahlia barkerae* Knowles and Westcott, *D. merckii* Lehmann, and *D. scapigera* (A. Dietrich) Knowles and Westcott, all included in Section *Dahlia,* consistently develop a rosette-like growth habit.

With the addition of *Dahlia congestifolia* to Section *Entemophyllon,* the overall morphological diversity in the group increases. In this respect three characteristics evident in the type of *D. congestifolia* seem most apparent: 1) BASAL ARRANGEMENT OF LEAVES. Leafy stems prevail among the taxa of Section *Entemophyllon.* One may view the occurrence in *D. scapigeroides* Sherff of shoots with densely crowded leaves (*fide Moore & Wood 3932,* BH!, GH!, NY!, UC!) as a special circumstance since these congested shoots emerge high on a perennating and somewhat woody stem. Normal shoots of *D. scapigeroides* (*González Q. 3228,* A!, ENCB!) that arise directly from the crown, bear widely-spaced leaves. 2) HERBACEOUS HABIT. Heretofore, *D. dissecta* var. *dissecta* was the only taxon in the section characterized by the herbaceous habit. The remaining taxa regularly sprout new shoots from stems of the previous seasons and thus acquire a suffrutescent habit. 3) Development of a SOLITARY SHOOT. The prevailing mode of development among taxa of Section *Entemophyllon* is to sprout several to many shoots from the crown. Indeed, in my original circumscription of the section (Sϕrensen,

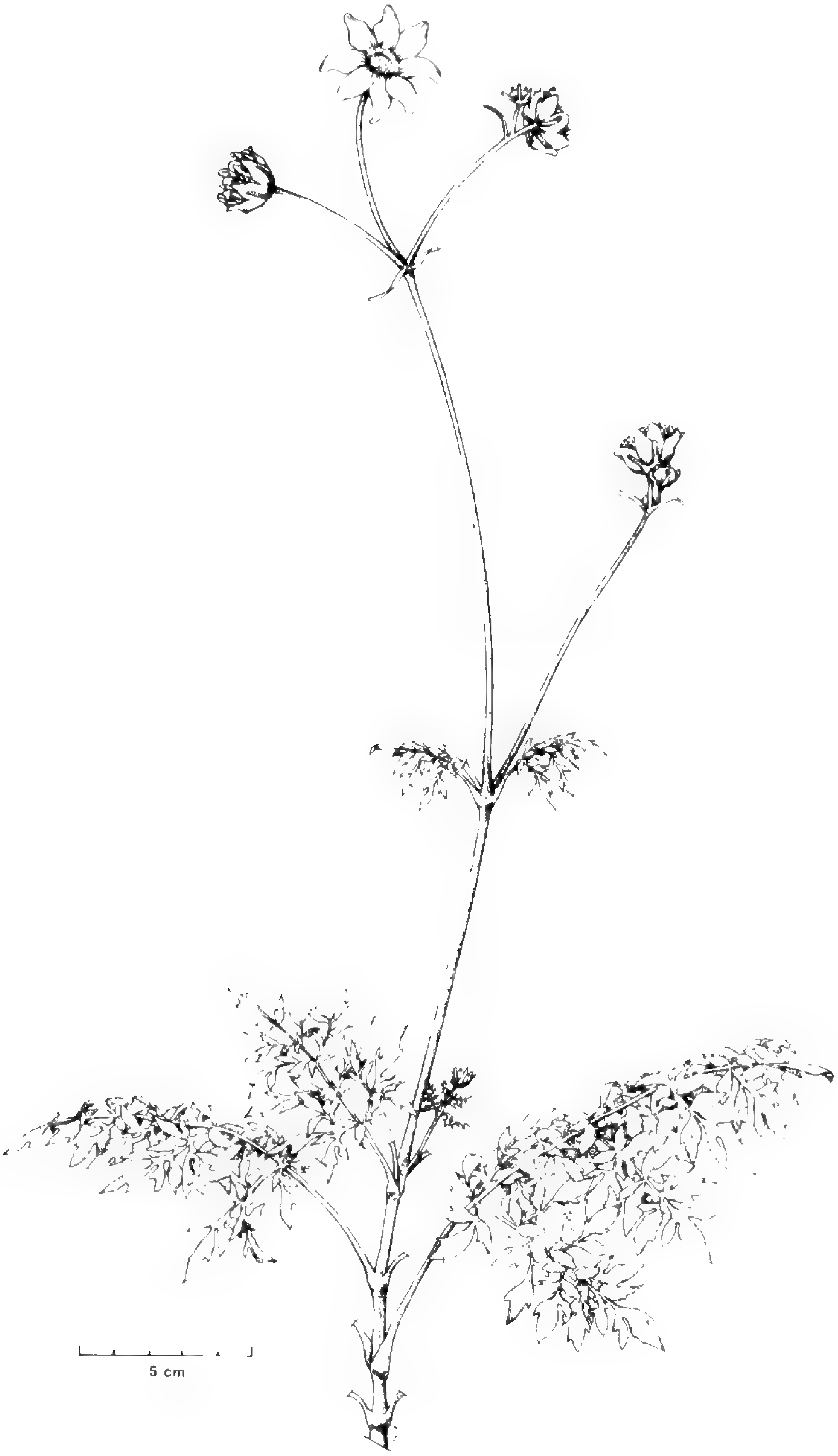

Figure 1. Reconstruction of *Dahlia congestifolia* Sørensen based upon the details of the holotype (WIS), *R. C. West C-18*, and the collector's field notes by Suzanne Stryk.

1969a, p. 340) I used this as a sectional character. With the addition of *D. congestifolia* the range of habit characteristics embraced by the sectional taxa further draws them morphologically closer to the taxa of Section *Dahlia,* wherein the prevailing mode of development is to produce a single main shoot from the crown.

The holotype of *Dahlia congestifolia* shows disc florets that have the upper portions of the corollas colored purple, a feature present among several members of Section *Dahlia* where it earlier served as a basis for establishing some intraspecific taxa of *D. scapigera* (sensu Sherff, 1946, 1947, 1955, & 1959). All those taxa that possess purple or purple-tipped disc florets are also known to have yellow disc florets (see discussion in Sørensen, 1969a, p. 355). In populations with the purple form there are also individuals of the yellow form, often with a range in the population from almost completely purple to completely yellow disc corollas. Apparently this character varies greatly and one can expect to find similar variation in *D. congestifolia* as further collections come forward.

When the type of *Dahlia congestifolia* was collected on 21 June, its central head had already reached anthesis. While not unique, this date is unusually early for flowering in the genus *Dahlia.* Most species commence flowering in mid- or late July, depending upon the onset of the rainy season. Interestingly, the species holding the record for earliest flowering of a wild *Dahlia* is the related *D. scapigeroides,* collected in flower on 8 June (*Rzedowski 7718,* ENCB!).

In attempting to fit this new *Dahlia* into the keys provided in Sørensen (1969a, pp. 322–323) I have found the characters in the key to the Sections adequate as they stand. In using the key to the species of Section *Entemophyllon, D. congestifolia* emerges in the lead to *D. linearis* based upon the length of the peduncles, and from which it readily separates on the character of its herbaceous (not suffrutescent) habit. Another couplet introduced between B_1 and B_2 completes the keys as follows:

B. Peduncles 1.5–10 cm long
  +Current year's growth mostly developing from woody stems, these usually with chambered pith . . . . *D. linearis*
  +Current year's growth wholly herbaceous. . . . . *D. congestifolia*
B. Peduncles 12–37 cm long, etc.

With the publication of *Dahlia congestifolia* the genus embraces 29 species plus six intraspecific taxa (Sørensen, 1969a, b; 1980). Fourteen species (including four of the six in Sect. *Entemophyllon*) occur within a 200 km radius of the city of México suggesting that the evolutionary diversification of the genus centers in the mountainous areas more or less surrounding the basin known as the Valle de México.

In his two treatises dealing principally with biochemical evolution in *Dahlia,* Giannasi (1975a, b) has argued convincingly that Section *Entemophyllon,* on the basis of biochemical characters, represents a more highly evolved group than Sections *Pseudodendron* and *Dahlia* (including Subsection *Merckii* [see Sørensen, 1980]). Nevertheless, he has not questioned—nor do I—that Section *Entemophyllon* is sufficiently distinct that one might even recognize it as a separate genus, a course that would have ample precedence in light of recent work on other groups of Asteraceae. *Dahlia congestifolia* possesses some characters (e.g., the herbaceous and solitary shoot habit, purple-tinged disc corollas, non-leafy stems), hitherto only known from Section *Dahlia,* that suggest this new and perhaps critical species may represent a missing link and that additional study of its biology could further clarify sectional relationships within *Dahlia.* It would be particularly worthwhile to know whether *D. congestifolia* diverges cytologically from the other taxa of Section *Entemophyllon* in a way that corresponds to its morphic divergence.

In an effort to gather additional material of *Dahlia congestifolia* with which to answer the kinds of questions posed above, I visited Cerro Chulco, the type locality, in the extreme southern reaches of Hidalgo State. The site is a small mountain of limestone bedrock and associated karst topography that parallels the Apan–Calpulalpan (Tlaxcala) highway just a few kilometers south-southwest of Apan. I failed to locate plants of this or any other dahlias, perhaps due to lateness in the season (September). Subsequently, Dr. William Hess and Lisa Byrne (MOR) visited the area at a more favorable time of the year (June). They observed and collected *D. merckii,* previously not known from this locality, but did not sight this new species. Now, alas, one may despair of ever seeing it as a living plant. Goats roam freely and in abundance over Cerro Chulco. Their foraging has devastated much of the vegetation and has, perhaps, caused the holotype of *Dahlia congestifolia* to remain a mere museum curiosity and propelled the species into the "absolute emptiness of extinction."

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CAREX PRAEGRACILIS (CYPERACEAE) IN EASTERN NORTH AMERICA: A REMARKABLE CASE OF RAPID INVASION

A. A. REZNICEK AND P. M. CATLING

ABSTRACT

Carex praegracilis W. Boott is a widespread and frequent native species of prairies and meadows throughout much of western North America. It is both salt and drought tolerant. Cumulative maps based on pre-1900, pre-1970 and pre-1984 herbarium specimens were plotted and the differing distributions analyzed. From 1896 to about 1970, sporadic records of its introduction into the east accumulated. These were mostly from near the native range of the species, and often from along railways. From about 1970 on, the species began to occur on saline verges of multilane highways and with incredible rapidity became abundant and widespread in this habitat, at the same time spreading far eastward into the Great Lakes region and beyond. This rapid eastward expansion is attributed to a combination of dispersal opportunities provided by vehicles, by highway construction and maintenance equipment, and provision of more or less continuous corridors of open, saline habitat resulting from roadside mowing and use of de-icing salt.

Key Words: *Carex praegracilis*, phytogeography, halophyte, distributional history, North America

INTRODUCTION

Even before European settlement, the floras of many parts of North America were dynamic due to migration of species in response to major climatic changes. Changes in the flora were slow, however, and usually measurable in millenia or centuries. Extensive recent alteration of the landscape by European settlement has also produced extensive changes in the North American flora. These changes differed from those occurring during pre-settlement times in two important respects: (1) They were often rapid, measurable in decades or years; (2) Commerce and transportation systems allowed species to move vast distances quickly, thus permitting numerous species not native to North America or native to distant parts of the continent to contribute to widespread changes.

Study and documentation of recent changes in species ranges and recent invasions of species into new areas are important for several reasons. The spread of species into new areas can be an indicator of subtle changes in environmental quality. An obvious example is the spread of halophytes due to increasing salinity of roadside habitats (Catling and McKay, 1980, 1981). While some of these halophytes are useful in maintaining roadside vegetation cover, other species expanding their range are potentially serious pests that can reduce or even eliminate some native species. *Lythrum salicaria* L. (Fernald, 1940; Stuckey, 1980a) and the pernicious kudzu (*Pueraria lobata* (Willd.) Ohwi) (Blackwell, 1975; Miller and Edwards, 1983) and japanese honeysuckle (*Lonicera japonica* Thunb.) (Evans, 1984) are well known eastern North American examples of such dangerous invaders. Invading species may, however, occupy niches that few or no native species tolerate. Examples include halophytes along highways, and *Ailanthus altissima* (Miller) Swingle in urban settings (Bassuk, 1983). Some studies of the changing distribution of introduced species have provided insight into plant migration pathways and dispersal rates (e.g., Meriläinen, 1968).

Numerous examples of the invasion of North America by foreign species have been well documented. Excellent recent studies include Meriläinen (1968), Leonard (1972), Stuckey (1979, 1980a, 1981), Catling and Dore (1982), Les and Stuckey (1985), and Soper and Murray (1985). The ranges of many North American species have also shifted in response to human alterations of the landscape. In some instances, ranges of native species have diminished. The decline of *Calypso bulbosa* (L.) Oakes (Catling, 1980) and *Plantago cordata* Lam. (Tessene, 1969) provide good examples. In other instances, native North American species have greatly expanded their ranges. Fewer documented studies of the spread of native species have, however, been published, perhaps due partly to the difficulty of establishing with certainty the pre-settlement range of a species or even establishing whether or not the species was native. The complex story of *Najas marina* L. in North America (Stuckey, 1985) illustrates these difficulties. Examples that have been documented with maps include *Asplenium platyneuron* (L.) Oakes

(Wagner and Johnson, 1981), *Juncus gerardii* Loisel (Stuckey, 1980b), *Lycopus asper* Greene (Stuckey, 1969), *Muhlenbergia asperifolia* (Nees & Meyen) Parodi (Reznicek, 1980), *Najas marina* (Stuckey, 1985), and *Spartina patens* (Aiton) Muhl. (Reznicek, 1980).

A particularly striking example of a native species rapidly expanding its range is *Carex praegracilis*. Formerly confined to western North America from the Great Plains to the Pacific, the species has spread eastward with remarkable rapidity in recent years. Documentation of its local spread in Ontario was provided by Reznicek et al. (1976) and Brunton and Catling (1982), and in Ohio by Cusick (1984). Swink and Wilhelm (1979) noted its recent spread in the Chicago region and gave detailed lists of associated species. In Minnesota *C. praegracilis* "is now adventive in the north-central, northeastern, and extreme east-central portions of the state, particularly along highway verges," Wheeler and Ownbey (1984). We present here a determination of the native range of *C. praegracilis*, documentation of the spread of the species eastward through time, and hypotheses concerning factors responsible for its spread.

METHODS

Specimens of *Carex praegracilis* from CAN, DAO, GH, MICH, MIN, MO, NY, and TRT were examined and label data were recorded for mapping. Selected eastern specimens were also checked in BLH and US. Through our own hazardous and often illegal field work, *Carex praegracilis* was collected along many expressways and other highways in Illinois, Indiana, Michigan, Ohio, Ontario, and New York in order to document the eastern limits of the species' spread. Cumulative maps were made based on specimen records: first, for pre-1900 records to establish the pre-settlement range of the species; second, for records up to 1970, which included a few eastern records; and third, for records up to 1984. Habitats were recorded from specimen labels for all eastern records as well as from a representative sample of western collections.

IDENTIFICATION OF CAREX PRAEGRACILIS

Carex praegracilis belongs to a taxonomically difficult group of sections in *Carex*. Fortunately, only a few similar species, including

C. sartwellii Dewey, *C. foenea* Willd., *C. douglasii* Boott, and *C. eleocharis* L. Bailey, all with long-creeping rhizomes, are found along roads and railways and in waste areas in the east, and then normally not in saline sites. *Carex sartwellii* has the inner band of the sheath green-striate, whereas *C. praegracilis* has the inner band hyaline. *Carex foenea* also has the inner band hyaline, but the perigynia are longer (3.8–6.8 mm long) than in *C. praegracilis* (2.2 3.7 mm long) and are more prominently wing-margined. Furthermore, in both *C. sartwellii* and *C. foenea,* the rhizome scales are brown, whereas in *C. praegracilis,* they are blackish. Both *C. foenea* and *C. sartwellii* are monoecious, but *C. praegracilis* is usually dioecious (Reznicek et al., 1976). *Carex douglasii* and *C. eleocharis* are occasionally found along railways in the east. Both can be distinguished from *C. praegracilis* by having culms smooth (instead of scabrous-angled) below the inflorescences. *Carex douglasii* is dioecious, but *C. eleocharis* has androgynous spikes.

PRE-SETTLEMENT RANGE AND HABITATS

Figure 1 maps all pre-1900 specimens of *Carex praegracilis* examined. The shaded area delimits the putative native range, derived primarily from this map but also incorporating data from more recent collections from areas poorly collected before 1900. Yukon and Alaska records (Hultén, 1968), not covered by our map, were not considered in our work, but they may represent disjunct native occurrences. Similarly, South American material purported to be *C. praegracilis* (Mackenzie, 1931; MacBride, 1936) was not studied.

Within its vast native range, *Carex praegracilis* is a frequent species in a wide variety of periodically moist, open habitats, which are mostly prairie in the eastern part of its range. It is occasional even in quite dry sites and is also salt tolerant, not infrequently occurring in salt marshes. It occurs from sea level to occasionally as high as 3000 m.

EASTWARD SPREAD

Between 1896, the date of the first collection of *Carex praegracilis* east of its native range, and 1970, eastern collections were few, sporadic, and usually close to the native range of the species (Figure 2). Mackenzie (1931) noted that the species was "adventized eastward

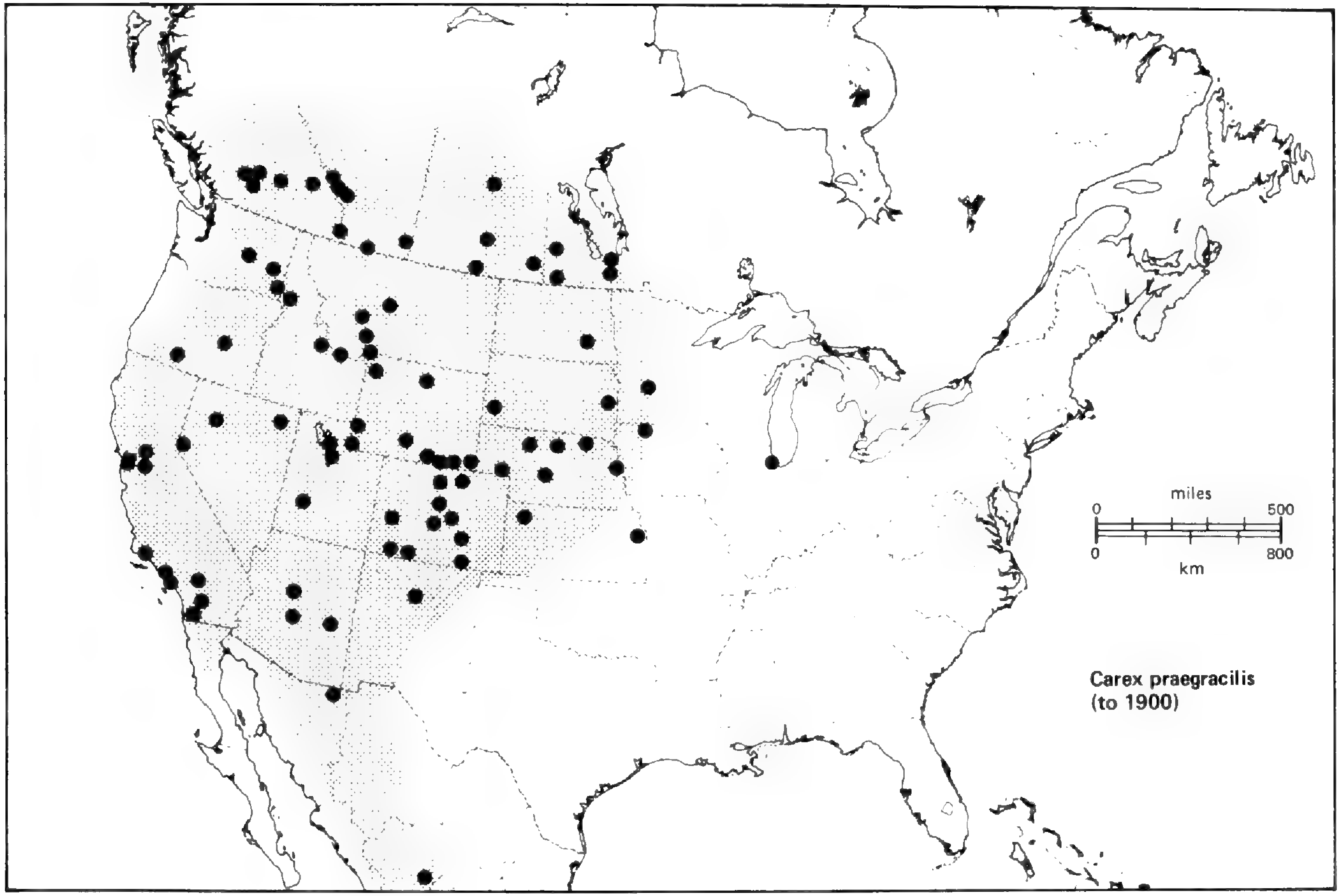

Figure 1. Distribution of *Carex praegracilis* based on pre-1900 specimens. Shaded area is the hypothesized native range.

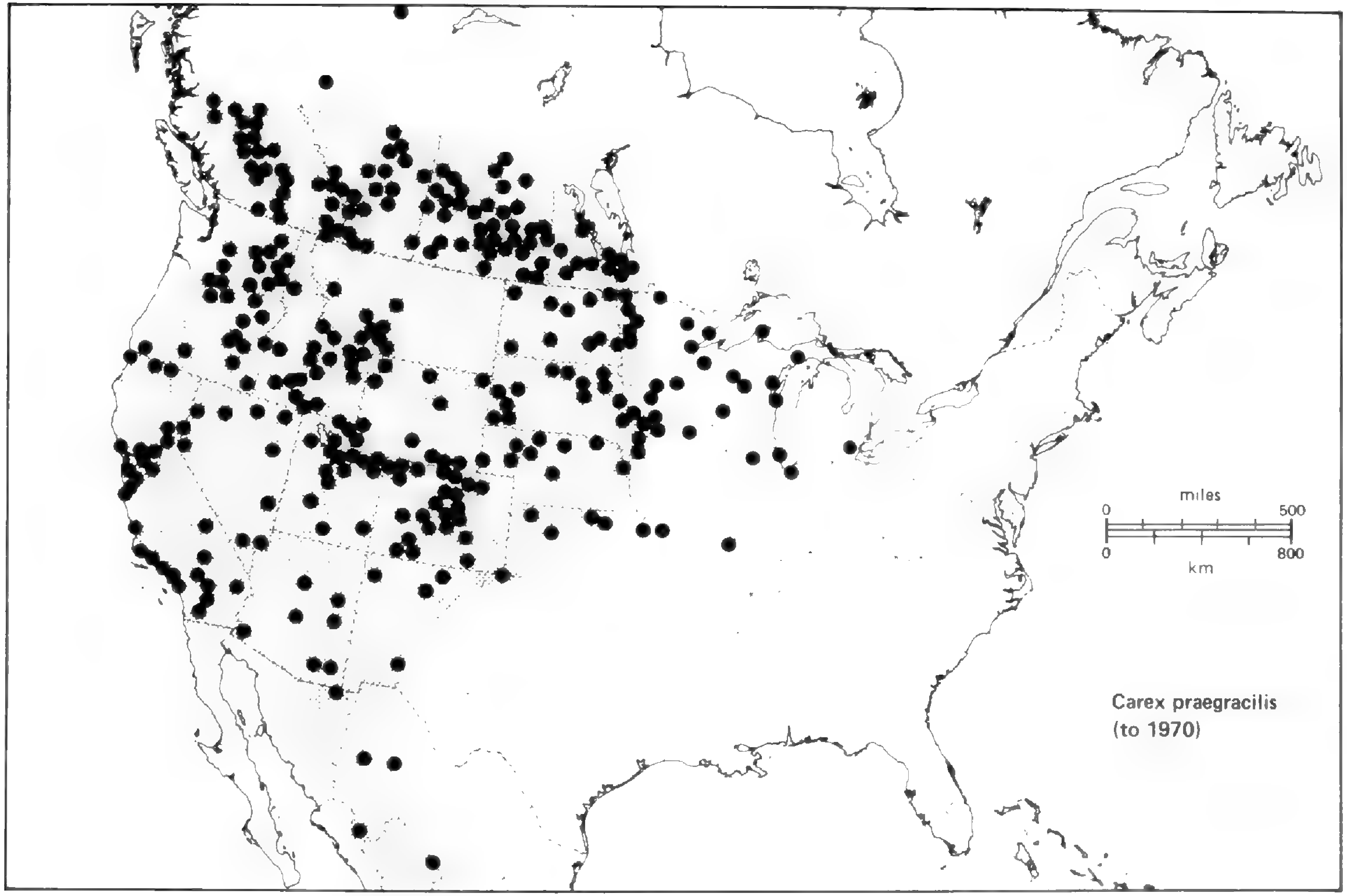

Figure 2. Distribution of *Carex praegracilis* based on specimens up to 1970. Shaded area is the hypothesized native range.

[in] western Missouri and eastern Kansas." This was the first mention of the spread of *C. praegracilis* and was based on two specimens. The earliest (Kansas, Wyandotte Co., *Mackenzie* in 1896, NY) is one of two introduced collections before 1900. The other (Missouri, Sheffield, *Bush 4798* in 1907, NY) has a note written by Mackenzie: "introduced at this station along railroad."

For the period between 1896 and 1970, we discovered 25 introduced occurrences east of the native range of *C. praegracilis*. In 1897 the species was collected in "dry sands" at Chicago. By 1903 the species had reached Pine, Lake County, Indiana. In 1912 it was collected again in a vacant lot in Chicago. Between 1915 and 1917 it was collected at several sites in Wisconsin and at Manistique, Michigan. Additional records up to 1970 slowly filled in gaps, but did not extend the distribution east of Michigan and Indiana. In Figure 2 (and Figure 3), a few records are shown to the north of the species' native range in the Canadian prairie provinces. These collections were from along roads, or otherwise presumably adventive, but were not investigated.

Sites for many early eastern records were along railways, although roadsides and "waste" areas were also represented. Beyond this, there do not appear to be clear trends, although many collection records were not very specific about habitats.

Factors responsible for spread of *Carex praegracilis* during this period are uncertain. James H. Zimmerman (pers. comm., 1981) suspected that the early Wisconsin colonies were introduced with imported western hay perhaps associated with the logging industry. This idea is plausible for early sites elsewhere as well, since rail transport of hay for feed and as packing and insulation would have been common at the turn of the century, and even somewhat later. Records from roadsides and "waste" areas can probably be attributed to accidental dispersal associated with vehicle traffic, although transport of hay could also be involved.

Records during this period from northern Michigan, in particular the Keweenaw Peninsula, have been considered to represent native occurrences (Fernald, 1935; Hermann, 1941; Voss, 1972). Although a disjunct native occurrence of *Carex praegracilis* in northern Michigan is a possibility, we are inclined to doubt for several reasons: 1) Even though the species is both large and conspicuous, all records but one east of Minnesota, Iowa, and Kansas are post-1900; 2) The

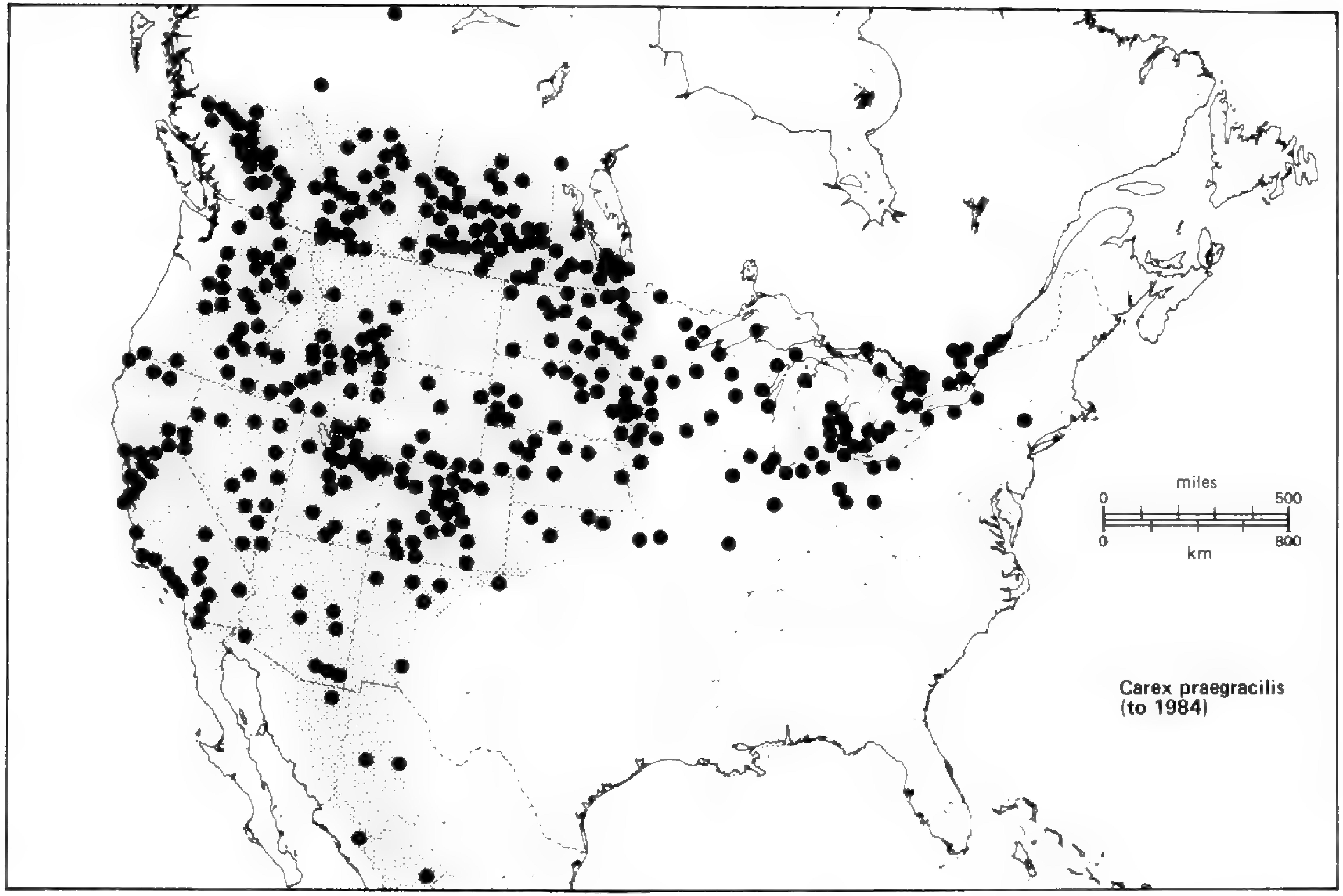

Figure 3. Distribution of *Carex praegracilis* based on specimens up to 1984. Shaded area is the hypothesized native range.

Keweenaw Peninsula had been relatively well botanized by 1900, but the species was not found there until 1934 (A record from Manistique, Schoolcraft County, Michigan, overlooked by Fernald [1935] and Hermann [1941], however, dates from 1915); 3) Even the earliest eastern records are mostly from disturbed sites along railways and roadsides and from "waste" areas; none is from undisturbed prairie.

All records up to 1984 are shown in Figure 3. Here, a striking change from the distribution in Figure 2 is evident. The species has suddenly become common well to the east, reaching almost to the New England States. These recent collections are almost all from saline roadsides; the great majority are in fact from along multilane expressways. Cusick (1984) noted that "the habitat is strikingly uniform. *Carex praegracilis* forms deeprooted clones on the verges of major highways where road de-icing salt is applied repeatedly." So consistent is the occurrence of *C. praegracilis* in such habitats that the common names "tollway sedge" (Swink and Wilhelm, 1979) or "freeway sedge" (Brunton and Catling, 1982) have been coined for it.

Of the many dozens of new records east of Minnesota and Iowa since 1970, we are aware of only 6 from habitats other than verges of major roads. Of these, 3 were from along railways and the others were, respectively, from a disturbed lakeshore, a ditch, and a construction site.

It is, of course, impossible to say how long *Carex praegracilis* was established at a site before it was first collected. However, the fact that most of the multilane highways on which it occurs are recent, some less than 20 years old, allows us to say that the spread really is recent rather than the plant having merely been recently detected. In fact, it appears that within the past 15 years *C. praegracilis* may well have migrated ca. 1100 km eastward along these highways from previously existing sites in Illinois, Indiana, and Michigan. Undoubtedly this feat was done by leaps and subsequent filling in of gaps rather than linear migration, but it is still an impressive migration rate.

EXPLANATIONS FOR THE RAPID SPREAD

Both Reznicek et al. (1976) and Cusick (1984) concluded that the recent spread of *Carex praegracilis* in the east is directly related to creation of open, saline habitats along roads. In fact, *C. praegracilis* seems particularly well adapted to these sites, tolerating sodium levels up to at least 1500 μmg/g (Catling and McKay, 1980) as well as summer drought (Reznicek et al., 1976). Besides salinity and openness, other factors probably also favored survival and spread of *C. praegracilis* in roadside verges. Road verges are usually mowed first in late spring or early summer, but occasionally later in summer. Although fruiting is thus often prevented, vegetative growth is essentially complete by this time and regular fruiting may not be crucial to a species adapted to vegetative spread. Mowing, however, might prevent overtopping of the species by coarser vegetation that could shade it. As well, continuous distribution of vegetated highway verges over long distances not only ensures abundant habitat but also essentially uninterrupted corridors for dispersal. These conditions, including saline open sites, mowing, and long uninterrupted corridors of vegetated verges, are virtually specific to multilane expressways. The recent spread of *C. praegracilis* is therefore qualitatively as well as quantitatively different from the slow and sporadic spread earlier in the century and is probably directly related to the development and maintenance of modern highway networks.

The means of dispersal of *Carex praegracilis* can only be hypothesized. Highway construction and maintenance, with concomitant long-distance movement of often soil-caked equipment, is an obvious possibility for spreading not only fruits, but also rhizomes. During seasons when fruits ripen before mowing, the mowers may disperse fruits. Since *C. praegracilis* sometimes grows on gravel shoulders (Reznicek et al., 1976), grading may also spread rhizomes and fruits. Dispersal of fruits by winter winds over snow and ice along the narrow highway corridors is also a possibility. Incidental spread on vehicles is probably important, and its chances would be greatly increased recently by the tremendous volume of traffic on present-day expressways. The few recent records from railways may have arrived as contaminants associated with shipments from the west or they may even be derived from eastern highway populations.

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We thank Dr. James H. Zimmerman for Wisconsin records of *Carex praegracilis* as well as comments on the origins of the Wisconsin records. Dr. Gerald A. Wheeler provided comments on some

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NEW ENGLAND NOTE

ADDITIONS TO THE FLORA OF CONNECTICUT[1]

GORDON C. TUCKER

ABSTRACT

Three species of vascular plants are newly recorded for the flora of Connecticut. These are: *Linaria dalmatica* L. (Scrophulariaceae); *Eupatorium album* L., and *Aster blakei* (Porter) House (Compositae).

Key Words: *Linaria, Eupatorium, Aster,* new additions, Connecticut flora

During the past several years, three species have been collected in New London Co., Connecticut, that were not recorded as members of the state's flora by Dowhan (1979) or Seymour (1982). Several herbaria were checked for prior collection records: CCNL, CONN, NCBS, GH, NEBC, NYS, MASS, and YU. The species discussed herein were collected in the company of fellow members of the Connecticut Botanical Society. Specimens are deposited at NYS, with duplicates at GH and NCBS.

Linaria dalmatica L. While botanizing with William R. Linke, Jr. and Lois Tefft on 29 May 1984, some conspicuous yellow-flowered plants were collected on a sunny, gravelly roadside of Route 2 in Ledyard (*G. C. Tucker 2415A*). We tentatively identified the plants as *L. dalmatica* using the description given by Gleason (1952). On 11 August 1985, I revisited the locality and made a second collection (*G. C. Tucker 3107*) to confirm that the plants were persisting. Fifty plants were counted, compared to about forty the preceding year. Using the treatment of the genus in *Flora Euro-*

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[1] Contribution number 502 of The New York State Science Service.

paea (Chater et al., 1972), the plants keyed out to *L. genistifolia* subsp. *dalmatica* (L.) Maire & Petitmengin (= *L. dalmatica* L.). My specimens compared well with collections at NYS (NEW YORK: Monroe Co., Point Pleasant, *White 855 & 893;* Ulster Co., Accord, *Smith & Fendt 20248.* OHIO: Lake Co., *Ahles 7422*). Richard S. Mitchell and C. J. Sheviak agreed with the determination. *Linaria dalmatica* is native to southeastern Europe (Chater et al., 1972); in North America it is known as an introduction, found from Nova Scotia to Pennsylvania and Ohio (Fernald, 1950). According to Seymour (1982), *L. dalmatica* has been collected in northern Vermont, southern New Hampshire, and northeastern Massachusetts; I have examined specimens from these places at NEBC. According to J. Kenneth Dean (NYS), *L. dalmatica* is occasionally grown in flower gardens in New York State.

Eupatorium album L. William Linke found a population of this species in Groton, and he and I visited the site on 26 August 1981. Several plants were growing in gravelly soil at the edge of a thicket bordering a cemetery near the Town Hall (*G. C. Tucker 1797*). The plants appeared to be native; the habitat was not weedy or obviously disturbed. Fernald (1950) and Gleason (1952) gave Long Island as the northern limit of this species. The New York State Museum has six collections of *E. album* from Long Island. The nearest station (Manor, Suffolk Co., *Latham s.n.,* 8 July 1923) is some 60 km SW of Groton. Because of the proximity of populations on nearby Long Island and the relatively undisturbed nature of the site in Groton, it seems likely that the Groton population is native.

Aster blakei (Porter) House. Richard Blodgett, Edmund Smith, William Linke and I found plants of this species near Green Falls Pond, Voluntown, on 16 August 1982 (*G. C. Tucker 1789*). About 100 flowering stems were noted along the edge of a path through swampy woods of red maple (*Acer rubrum* L.). With regard to the suggested hybrid nature of the species (Pike, 1970; Brouillet & Simone, 1981), one of the putative parents, *A. acuminatus* Michx., occurred within 50 m of this population. To my knowledge, the nearest population of the other parent, *A. nemoralis* Ait., is at Ell Pond, Hopkinton, R.I. (*G. C. Tucker 3191,* NYS), about 2 km SE of Green Falls Pond. Fernald (1950) stated that *A. blakei* is often found without either parent species being present. According to Pike (1970), *A. blakei* sometimes is found with only one of the parental species present. Pike cited no collections of *A. blakei* from Connecticut, and Brouillet and Simone (1981) showed no stations in Connecticut on their distribution map for the species.

ACKNOWLEDGMENTS

I thank the curators of CCNL, CONN, GH, MASS, NCBS, NEBC, NYS, and YU for access to specimens. Donald M. Swan (NCBS) kindly provided information on specimens in that herbarium. Appreciation is also expressed to Lois Tefft, Bill Linke, Dick Blodgett, and Ed Smith for their pleasant company in the field.

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NEW ENGLAND NOTE

ADDITIONS TO THE FLORA OF WASHINGTON COUNTY, MAINE

ALAN J. LEWIS AND IVAN J. KUSTER

Recent studies of the flora of Washington County coastal islands (Lewis, 1983, 1985; Famous and Campbell, 1984) revealed a relatively large number of new stations for some species listed as rare in Maine (Gawler, 1981). These findings indicate that our perception of the rarity of some species is based on an inadequate survey of the islands and suggested to us that our knowledge of the mainland flora of Washington County might similarly be incomplete.

During the week of August 19-24, 1985 we spent approximately 30 hours extensively searching four towns and partially searching six other towns or townships for species not listed by Richards et al. (1983). We found 13 species and one variety which have not been listed for Washington County. In addition, we discovered another six species previously collected and placed in our herbarium which had not been reported from Washington County.

Twelve of the 19 species and varieties we list have been introduced into Maine (Richards et al., 1983). One of these is *Madia sativa* Mol. var. *congesta* T. & G., a species which has not been reported from any county in Maine. Fernald (1950) listed it as an adventive from the Pacific slope of the U.S. The specimens collected in Washington County are from a population extant on the U.M.M. campus since at least 1981. Individuals are growing in coarse sand and gravel around the edge of an unpaved, 20 × 120 m parking lot.

Bidens cernua L. has been reported from all counties in Maine. The variety *integra* Wieg., however, has not been reported from any county. Fernald (1950) listed its range in the east as extending from Prince Edward Island south, locally, to Massachusetts. We found a large population of this variety growing in standing water in a ditch next to the abandoned Maine Central railroad tracks in Whitneyville.

In the list which follows, species introduced into Maine are indicated by an asterisk. Counties of occurrence as listed by Richards et al. (1983) are also given, with the following abbreviations used: Aro, Aroostook; Pen, Penobscot; Pis, Piscataquis; Som, Somerset; Fra, Franklin; Oxf, Oxford; Han, Hancock; Wal, Waldo; Kno, Knox; Lin, Lincoln; Ken, Kennebec; And, Androscoggin; Sag, Sagadahoc; Cum, Cumberland; Yor, York.

Identification of the species and varieties was confirmed by comparison with specimens on deposit in MAINE. Voucher specimens of our collection material are on deposit in the UMM herbarium. Detailed location and habitat data are available upon request. Nomenclature follows Fernald (1950).

BALSAMINACEAE

***Impatiens glandulifera** Royle Glandular Touch-Me-Not

Very abundant at collection sites, uncommon in county. Eastport: *Bowman (4953)* 1978, *Francis (4853)* 1979; Machias: *Rier (5067)* 1981; Trescott: *Lewis and Kuster (164)* 1985. Listed for Han, Ken, Kno and Yor counties.

BORAGINACEAE

***Myosotis scorpioides** L. True Forget-Me-Not

Abundant at collection site, common in county. Machias: *Lewis and Kuster (567)* 1985. Listed for all counties except Fra, Lin, Pis, Sag and Som.

CAMPANULACEAE

Campanula aparinoides Pursh Bellflower Bedstraw

Abundant, but scattered among graminoids at collection site. Machias: *Lewis and Kuster (867)* 1985. Listed for all counties except Kno, Lin and Sag.

CARYOPHYLLACEAE

Silene antirrhina L. Sleepy Catchfly

Semi-abundant at collection site, occasional in county. Machiasport: *Lewis (5266)* 1980. Listed for all counties except Aro, Fra, Pis, Sag and Som.

COMPOSITAE

Bidens cernua L. var. **integra** Wieg. Nodding Stricktight

Very abundant at collection site, which is the only location listed for the variety in Maine. Whitneyville: *Lewis and Kuster (1058)* 1985.

Helianthus strumosus L. Pale-Leaved Wood Sunflower

Semi-abundant at collection sites, occasional in county. Jonesboro: *Miller (5368)* 1982; Machiasport: *Beal (5566)* 1981; Machias: *Shaw (5467)* 1981; Whitneyville: *Lewis and Kuster (1458)* 1985. Listed for all counties except Aro, Han, Oxf, Pis, Sag and Som.

***Lapsana communis** L. Common Nipplewort

Semi-abundant at collection site. Machias: *Lewis and Kuster (1667)* 1985. Listed for Han, Kno and Yor counties.

***Madia sativa** Mol. var. **congesta** T. & G. Tarweed

Semi-abundant at collection site, which is the only location listed for Maine. Machias: *Lewis and Kuster (6467)* 1985.

CRUCIFERAE

***Hesperis matronalis** L. Dames Rocket

Small populations at collection sites, occasional in county. Machias: *Beal (966)* 1981, and *Miller (1767)* 1982. Listed for all counties except And, Fra, Ken, Lin, Pen and Pis.

HYPERICACEAE

Hypericum gentianoides (L.) BSP. Orangegrass

Very abundant at collection site. Whitneyville: *Lewis and Kuster (1858)* 1985. Listed for Cum, Han, Kno, Lin, Sag, Wal and Yor counties.

LEGUMINOSAE

***Coronilla varia** L. Crown-vetch

Very abundant at collection site, occasional in county. Machias: *Lewis and Kuster (1967)* 1985. Listed for Cum, Han, Kno, Oxf, Pen, Wal and Yor counties.

***Lupinus polyphyllus** Lindl. Many-leaved Lupine

Very abundant throughout Washington County. Eastport: *Bowman (2153)* 1978; Harrington: *Francis (2276)* 1979; Machias: *Klein (2367)* 1979. Listed for Han, Kno, Oxf and Wal counties.

LILIACEAE

Allium schoenoprasum L. var. **sibiricum** (L.) Hartom. Siberian Chives

Small population at collection site. Machias: *Lewis and Kuster (2467)* 1985. Listed for Aro, Ken, Kno, Lin, Pen, Pis and Som counties.

LYTHRACEAE

***Lythrum salicaria** L. var. **tomentosum** (Mill.) DC. Spiked Loosestrife

Small populations at collection sites, rare in Washington County. Machias: *Lewis and Kuster (2567)* 1985; Princeton: *Lewis and Kuster (2723)* 1985; Whitneyville: *Lewis and Kuster (2658)* 1985. Listed for all counties except Aro, Fra, Pen, Pis, Sag and Som.

PAPAVERACEAE

***Chelidonium majus** L. Celandine

Semi-abundant at collection site. Machias: *Lewis and Kuster (2867)* 1985. Listed for all counties except Aro and Pis.

ROSACEAE

Potentilla anserina L. Silverweed

Abundant at collection site and along Washington County coast. Machiasport: *Lewis and Kuster (3066)* 1985. Listed for Aro, Cum, Han, Ken, Pen, Sag and Yor counties.

***Rosa rugosa** Thunb. Wrinkled Rose

Abundant near the coast throughout much of Washington County. Machias: *Webster-Pierce (3367)* 1981; Perry: *Bowman (3544)* 1978; Roque Bluffs: *Green (3373)* 1982. Listed for Cum, Han, Kno, Oxf, Sag, Wal and Yor counties.

VIOLACEAE

***Viola arvensis** Murr. Wild Pansy

Abundant at collection sites. Jonesport: *Sabourin (2074)* 1982; Whitneyville: *Green (6758)* 1982. Listed for Pen and Yor counties.

***Viola tricolor** L. Pansy

Occasional in county. Dennysville: *Francis (6546)* 1979. Listed for all counties except Fra, Kno, Wal, Pis and Sag.

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HISTORICAL NOTE

MARIA L. OWEN, NINETEENTH-CENTURY NANTUCKET BOTANIST

Beatrice Scheer Smith

Maria L. Owen, well known among New England botanists of her day, was born on the island of Nantucket on February 13, 1825. It was said that "her lifelong interest in flowers and trees and in everything that pertained to the science of botany was formed on the fertile hills of the island."[1] Although Owen left Nantucket in 1853, relatively early in her life, she had already laid the foundation for her catalogue of the island's flora, the botanical work for which she is principally remembered.

Owen was born Maria Louise Tallant (although she always spelled her middle name "Louisa"). She was educated in private schools in Nantucket, and these "unusual school advantages were coupled with a sound home course of general reading in an education which at the time was remarkable both for its breadth and depth."[2] After a period of teaching in Boston, she returned to Nantucket where she had her own private school. Later she taught in the Nantucket High School. In 1853 Tallant married Dr. Varillas L. Owen, and they established their residence in Springfield, Massachusetts. The Owen homestead became a center of intellectual life in Springfield. Here Maria Owen lived for more than 50 years, continually active in a wide variety of pursuits in literature, the arts, and matters of community concern.[3] A contemporary said that "she was easily the most cultivated and best-read woman of her time in Springfield."[4] In the midst of this full life, however, Owen could say: ". . . I owe half the happiness of my life directly, and most of the other half indirectly, to the study of botany . . ."[5] The botanical career of this multifacetted woman is our main concern here.

Maria L. Owen

Early in life Owen evinced an interest in the plants growing around her. She was encouraged in her observations by the enthusiasm for botany of other female family members—an aunt, her mother, her sisters. Endowed with a superior memory and a scientific turn of mind, she soon grew beyond all the others. In later years "the remarkable scientific training which she gave herself"[6] made her an able associate of professional botanists. She was listed in the Botanical Directory of the Torrey Botanical Club in 1873. As a teacher she transmitted her broad interest in science and her enthusiasm for it to her students. One of them said:

> In the "early seventies" Mrs. Owen taught botany and French in one private school in Springfield, and two years later, astronomy and physical geography in another. She was a most interesting and inspiring teacher especially in botany, astronomy, and physical geography, which were to her all alive and active, not mere masses of scientific facts to be committed to memory.
>
> The growth and habits of a plant, its power of adaptation to environment, etc., were far more to her then the best mounted specimen, though she valued the herbarium for its practical uses.[7]

Owen wrote many botanical articles over the years, but her two principal contributions to botany are her catalogues of the plants of Nantucket. The first, a *Catalogue of Plants Growing Without Cultivation on the Island of Nantucket,* was published in 1882 as part of a now obscure guidebook of the island.[8] In her introduction to the catalogue Owen says:

> . . . I have with much pleasure prepared the following catalogue. It is far from complete, being based upon collections made over thirty years ago, when I had made no study of the grasses and sedges, and when I had no thought of publishing . . .
>
> I hope to bring out, as soon as I have sufficient material, a more complete list to be published by itself, with such notes on the rarer plants as may be of interest.[9]

Thus the catalogue records plant species collected before 1852, when Owen was a young woman of some 25 years, as well as additional species collected on her frequent visits to the island between 1860 and 1880. Contained in the list are 500 species and varieties, and one

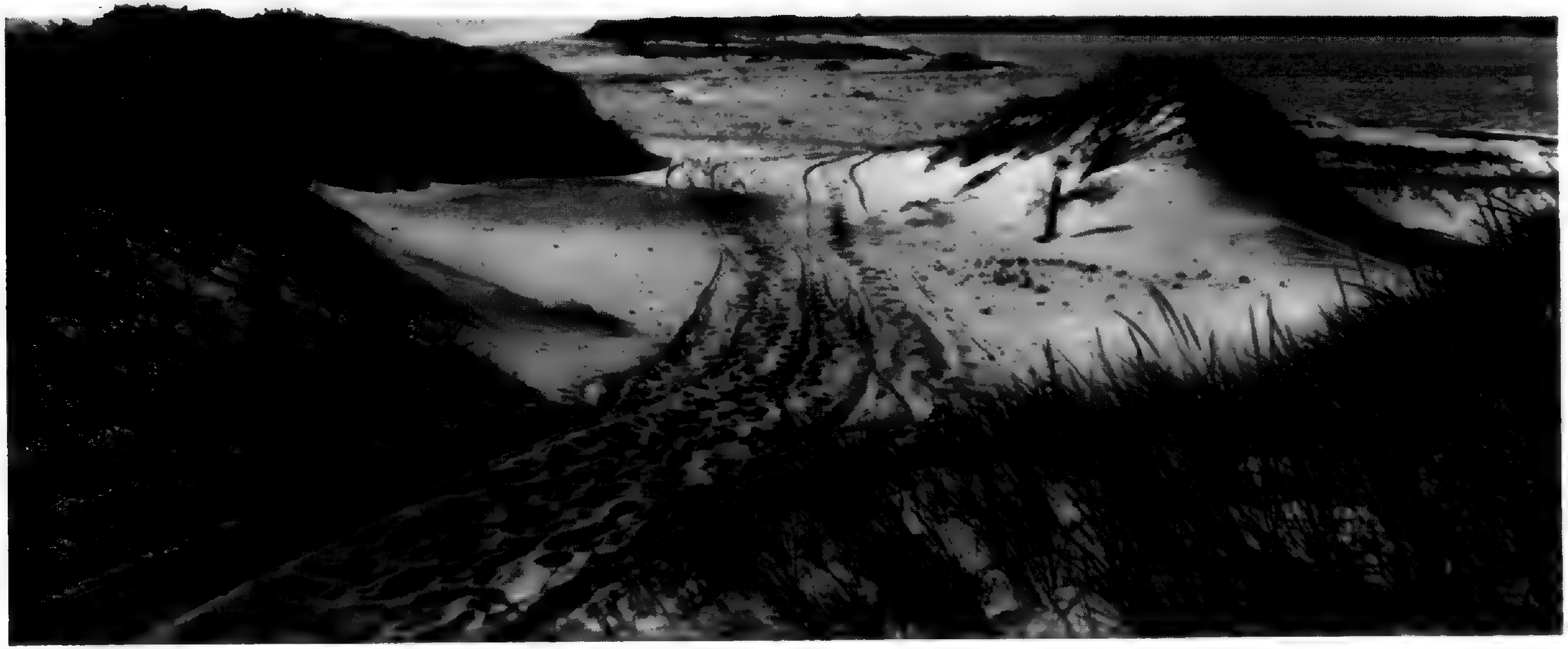

Figure 1. The south shore of Nantucket Island at Hummock Pond as Maria Owen knew it, ca. 1880. (From the collection of the Nantucket Historical Association.)

form, presented in systematic order by their scientific names. Common names are not given, and there are no comments.

The more complete list Owen had long planned was published in 1888 entitled *A Catalogue of Plants Growing Without Cultivation in the County of Nantucket, Mass.*[10] This annotated catalogue, which numbers 787 species and varieties, and one form, includes new collections made by Owen as well as those of other collectors, whose help she welcomed and encouraged. A list of marine algae is again appended.[11] Despite her absence from the island as a resident, her interest in its flora did not diminish, and she continued collecting the plants enthusiastically (Figures 1, 2). Her activities in the years between the two publications are well described by Deane, who shared her enthusiasm for the flora of Nantucket:

> The six years that intervened between these two publications were busy ones. She [Owen] enlisted many botanists to aid her in securing additions to her list and further information in regard to known species; she carried on a large correspondence; and she sent her doubtful species to proper authorities for accurate determination. It was the good fortune of the writer to witness much of this enthusiasm in his visits to the Island to aid the cause. . . It is a work [the 1888 catalogue] that reflects much credit upon its author and will always remain a true representation of the knowledge of the flora of the Island at that time.[12]

Deane sheds further light on Owen's continued interest in Nantucket and its plant life:

> . . . After its publication [the 1888 catalogue] Mrs. Owen carefully kept track of the additional species that were discovered from time to time, the segregates that were made, the extensions of range, etc., and she always meant to publish these data, but advancing years compelled a relaxation in this pleasant, but strenuous work.[13]

Nevertheless, Owen maintained active contact with fellow botanists; she held a corresponding membership in the Torrey Botanical Club in 1891. She kept in touch with the new generation of collectors of Nantucket plants. When consulted in 1911 about an entry in her 1888 catalogue, she replied from her original notes and records.[14] In an article published in her 87th year Owen discussed

Figure 2. A pond in Saul's Hills, Nantucket Island, ca. 1900. (From the collection of the Nantucket Historical Association.)

the location of a particularly elusive Nantucket species and concluded with an enticing challenge for a future collector: "My patch [of *Tillaea*] . . . doubtless still exists, and there is a happy day in store for any botanist who sees it at just the right season."[15]

Shortly after the publication of the Owen catalogue in 1888, one reviewer wrote:

> This addition to the list of local plant catalogues is a model for all of its kind . . . the contents bear every evidence of careful field work and painstaking compilation by the author. Its value does not alone consist in an accurate list of the plants, but also in the many notes, memoranda and local names which are interspersed throughout, giving just the authentic information that will be appreciated by the botanist of the future, when many of the plants now noted have become exterminated.[16]

Not many years passed before a "botanist of the future" proved this prediction an accurate one. Between 1908 and 1919 Bicknell published his catalogue of the ferns and flowering plants of Nantucket, an extensive study comprising 20 installments.[17] He fully recognized the importance of Owen's early documentation of the Nantucket flora. Every part of his catalogue notes "the enthusiastic explorations and studies of Mrs. Owen."[18] In fact, her records repeatedly furnish a frame of reference for his work: Mrs. Owen says ". . . a hedge [was] set out by William Henry Gardner about 1830 . . .;"[19] or, "According to Mrs. Owen its [*Epilobium hirsutum* L.] introduction on the island was in or about the year 1855, when it was raised in a garden in Union Street, subsequently spreading into waste places;"[20] or, "Twenty-seven years ago Mrs. Owen, writing of the chicory [*Cichorium Intybus* L.] as a roadside plant along the south end of Orange Street, said that it had been known there for fifty years."[21] Because of the thoroughness of Owen's collecting, the keenness of her observations, and the completeness of her early records, Bicknell could draw conclusions about the distribution and sometimes disappearance of species, the effects of human-population increase on the flora, and the overall importance of environmental changes on an island ecology.

Almost 80 years after Owen's catalogue and 50 years after Bicknell's, a third major study of the plants of Nantucket was published. This work on the present "intriguing, interesting, and important insular flora" of Nantucket by MacKeever[22] incorporates previous studies and again relies on Owen's catalogue as the first documentation of the island's flora. All three botanists commented on the difficulties of plant collecting in the woods, swamps, bogs, and nearly impenetrable dense thickets of Nantucket's 50 square miles. Owen (1888) also noted that some of her collections were based on a single individual, or two, only found because they grew in places difficult of access or too deep in the swamps even for fire to reach them. In view of these collecting hazards the following notation by MacKeever about the Aquatic Sedge (one of his frequent references to Owen's work) gives us added respect for Owen's skill as an observer and plant collector:

> Mr. Bicknell states: "Nothing was seen of *Carex aquatilis* Wahl., which was named by Mrs. Owen . . . the record of which, on Nantucket, it seems proper, therefore, to place in abeyance until positive evidence of its occurrence is forthcoming." Now, after 76 years, the specimen N789 [the Aquatic Sedge] is the positive evidence required to validate the record of Mrs. Owen. Therefore, I wish to honor her record as the "first report" of this plant as found growing on Nantucket.[23]

When Owen's first list of the Nantucket flora was published, she noted the desirability of forming an herbarium of the island plants,[24] a project that had not come to fruition when the second catalogue was published in 1888. The specimens were housed instead in various private collections as well as in the Gray Herbarium and in the Springfield Botanical Society Herbarium.[25] The presence in the latter herbarium of "the rare plants of Nantucket which are mentioned in Mrs. Owen's catalogue [1888]" was noted by Day in her survey of New England herbaria.[26] The Springfield Botanical Society collections are still extant and have been incorporated into the Luman Andrews Herbarium of the Science Museum in Springfield, Massachusetts.[27] Owen's wish for an herbarium of the island plants has now been well fulfilled by the present extensive collections, including mounted specimens from MacKeever's exhaustive study, housed in the Maria Mitchell Association Herbarium in Nantucket.

Maria Owen's experience with plants extended far beyond the confines of one island or her immediate neighborhood in New England. On her European excursions she collected plants, and "many a rarity she sent to her friends."[28] She pursued her broad botanical interests in a variety of ways, notable among which was her founding of two botanical organizations: the Connecticut Valley Botanical Society and the Springfield Botanical Society. Both of these groups owed their existence to Owen's leadership and enthusiasm. The Connecticut Valley organization was founded in 1873 and remained active for about 25 years. Owen served as secretary from the beginning.[29] Notices of the first annual meeting appeared in the scientific journals:

> The Connecticut Valley Botanical Society held its first annual meeting at Amherst, Mass., Oct. 1. This is a new society, numbering about twenty members, ladies and gentlemen... It is designed as a bond of union among the lovers of botany throughout the Connecticut Valley, both for general study of the science and to ensure a more thorough acquaintance with the flora of this most interesting portion of New England.[30]

The Springfield Botanical Society was founded in 1877. The meetings at first consisted of informal identification and discussion of plant specimens brought by the members. Later at the weekly meetings more formal instruction in botany was provided. As time went on and the fame of the group grew, specimens came to them from outlying areas of the city and State, and thus the knowledge of the flora of the region was expanded. Specimens of rarer plants were preserved in an herbarium.[31] Owen held the office of president of the society for many years and remained honorary president until her death.[32]

Owen's contributions to the science of botany were numerous, as a teacher, organizer, writer, collector, observer, and recordkeeper.[33] Her skill as a field botanist is particularly noteworthy. Her catalogue of the Nantucket flora was the result of this talent, and it remains today as her most important work. Her aim was to describe as completely as possible the island plants and compile a catalogue of the island flora, a task that she pursued intensively at first and intermittently over the years when she was no longer an island resident. This was not for her the popular Victorian hobby of new-species hunting. Her good recordkeeping and species annotations endowed the end result with an importance that has not lessened in the almost one hundred years since Owen wrote her catalogue (a centenary of publication can be observed in 1988), but rather has increased with time. In addition, Owen's initimate acquaintance with Nantucket and its inhabitants allowed her to document conditions that prevailed as early as 1830. Thus present-day scientists are left with records, compiled by a series of workers over a 150-year span, of an insular flora that has been termed both remarkable and intriguing, and about which Asa Gray was moved to say that he was surprised at nothing from Nantucket. From these data conclusions have already been drawn about the appearance-- and disappearance of species; changes in distribution; extensions of range; the effect of man and his expanding civilization upon a flora; and the role of other environmental factors in the survival or loss of a species. These are questions to be explored repeatedly with the passage of time. Few areas offer botanists such a body of knowledge as is available for the island of Nantucket upon which to base their future studies. And Owen's catalogue can only become more important with each passing year. A copy of it was included in the exhibit "Women in Science in Nineteenth-Century America" mounted by the National Museum of History and Technology of the Smithsonian Institution in 1978.

In 1907 Maria Owen left the Owen homestead in Springfield and returned to her native home in Nantucket.[34] She died on June 8, 1913, at the home of her daughter in Plandome, Long Island.

NATURAL HISTORY WRITINGS OF MARIA L. OWEN

1872. Botany in schools. Old and New 6: 245–248.
1879. Nantucket plants. Bull. Torrey Bot. Club 6: 330.
1882. Catalogue of plants growing without cultivation on the island of Nantucket, p. 38–47. *In:* Edward K. Godfrey, The Island of Nantucket, What It Was and What It Is. Boston: Lee and Shepard.
1884. Notes on *Corema Conradii.* Bull. Torrey Bot. Club 11: 117.
1888. A Catalogue of Plants Growing Without Cultivation in the County of Nantucket, Mass. Northampton, Mass.: Gazette Printing Company. 87 p.
1895. *Tillaea simplex.* Bot. Gazette 20: 80–81.
1899. The Connecticut Valley Botanical Society. Rhodora 1: 95–96.
1901. Ferns of Mt. Toby, Massachusetts. Rhodora 3: 41–43.

1907. The early work of the Springfield Botanical Society. 4 p., unnumbered. *In:* The Thirtieth Annual Report of the Springfield Botanical Society, Springfield, Mass.

1908. The three adventive heaths of Nantucket, Massachusetts. Rhodora 10: 173–179.

1912. Frederick William Batchelder. Rhodora 14: 41–45.

1912. *Tillaea* in Nantucket. Rhodora 14: 201–204.

ACKNOWLEDGMENTS

I acknowledge with appreciation the help of Dr. M. Jane Stroup and Eileen P. McGrath, Nantucket Maria Mitchell Association, Nantucket, Massachusetts; Jacqueline Kolle Haring, Nantucket Historical Association, Nantucket, Massachusetts; and Earl H. Reed, Springfield Science Museum. Springfield, Massachusetts.

NOTES AND LITERATURE CITED

1. Unidentified newspaper, June 12, 1913, Springfield City Library files.
2. *Ibid.*
3. DEANE, WALTER. 1914. Maria L. Owen. Rhodora 16: 153-160. Deane gives a good account of Owen's life, including some genealogy and details of her activities other than those related to her botanical interests. The Springfield Women's Club and a Shakespeare Society, both of which she founded, occupied much of her time and thought. Women's suffrage was highly important to her. She ardently supported a vacation school and innumerable projects for the betterment of the city. These interests are also discussed in articles in the *Springfield Sunday Republican,* August 25, 1907; the *Springfield Morning Union,* June 12, 1913; and an unidentified newspaper, June 12, 1913, in the files of the Springfield City Library. In the latter Owen is referred to as "one of the pioneers in the extension of woman's sphere of interests" and further: "A contemporary of Lucy Stone and Elizabeth Cady Stanton, she exerted in her small but no less emphatic way the same influence upon the women of Springfield that more famous women exerted upon the nation. For the creations of the Women's Club and of the botanical society, both largely the work of Mrs. Owen's organizing genius, were merely local assertions of the fact that the feminine mind can and should extend its interests beyond the home and the church sewing society." Other articles about Maria Owen appeared in the *Nantucket Inquirer and Mirror* on June 28, 1913; July 3, 1913; August 9, 1913; and September 4, 1915.
4. *Springfield Morning Union,* June 12, 1913.
5. OWEN, M. L. 1872. Botany in schools. Old and New 6: 245–248. (p. 246).
6. Unidentified newspaper, June 12, 1913, Springfield City Library files.
7. SOULE, CAROLINE GRAY, Brookline, Mass. *Quoted in* Walter Deane, 1914, Maria L. Owen, p. 156.

8. Godfrey, Edward K. 1882. The Island of Nantucket—What It Was and What It Is. Being a Complete Index and Guide to this Noted Resort . . . its History, People, Agriculture, Botany, Conchology and Geology. Boston: Lee and Shepard.
9. Owen, Maria L. 1882. Catalogue of plants growing without cultivation on the island of Nantucket, p. 38–47. *In:* Edward K. Godfrey, The Island of Nantucket—What It Was and What It Is.
10. Owen, Maria L. 1888. A Catalogue of Plants Growing Without Cultivation in the County of Nantucket, Mass. Northampton, Mass.: Gazette Printing Company. Owen's personal copy of the catalogue is in the archives of the Nantucket Historical Association. It was bound to her specifications with blank sheets between pages for her notes on specific locations where plants were found, when, and by whom.
11. Owen consulted Frank S. Collins concerning the identification of algae she gathered from the beaches and ponds of Nantucket. Five letters and a post card to Collins, the authority on the algae of the New England coast from 1875 until his death in 1920, are preserved in the manuscript collections of the Nantucket Historical Association.
12. Deane, Walter. 1914. Maria L. Owen. p. 159.
13. *Ibid.* A copy of the 1888 catalogue, housed in the library of the Science Museum, Springfield, Massachusetts, contains a typed supplement to the species list, prepared by Owen and dated September 14, 1905.
14. Bicknell, Eugene P. 1911. The ferns and flowering plants of Nantucket—VIII. Bul. Torrey Bot. Club 38: 447–460. (p. 449).
15. Owen, Maria L. 1912. *Tillaea* in Nantucket. Rhodora 14: 201–204. (p. 204) Perhaps Owen's "patch" of *Tillaea* (now *Crassula*) has at last been found. The occurrence of this species on the island of Nantucket is being reported by Sorrie in Rhodora 89: 113–196.
16. (A. H.) 1888. Plants of Nantucket. Maria L. Owen. Bull. Torrey Bot. Club 15: 244–245.
17. Bicknell, Eugene P. 1908–1919. The ferns and flowering plants of Nantucket—I-XX. Bull. Torrey Bot. Club, vols. 35–46.
18. Bicknell, Eugene P. 1908. The ferns and flowering plants of Nantucket—I. Bull. Torrey Bot. Club 35: 49–62. (p. 50).
19. Bicknell, Eugene P. 1911. The ferns and flowering plants of Nantucket—VIII. Bull. Torrey Bot. Club 38: 447–460. (p. 456).
20. Bicknell, Eugene P. 1914. The ferns and flowering plants of Nantucket—XII. Bull. Torrey Bot. Club 41: 71–87. (p. 75).
21. Bicknell, Eugene P. 1915. The ferns and flowering plants of Nantucket—XVI. Bull. Torrey Bot. Club 42: 549–570. (p. 549).
22. MacKeever, Frank C. 1968. Native and Naturalized Plants of Nantucket (Ed. by Harry E. Ahles). Amherst, Mass.: Univ. Massachusetts Press.
23. *Ibid.*, p. 32. According to Bruce A. Sorrie, Massachusetts Natural Heritage Program (letter to the author, November 8, 1986), a shadow of doubt still surrounds the positive identification of the sedge identified as *Carex aquatilis* by Owen and reportedly later collected by MacKeever. The wisest course at present regarding this sedge would appear to be to stand by Bicknell's earlier decision, *i.e.*, "to place in abeyance" the record of the species on Nantucket.

24. Godfrey, Edward K. 1882. The Island of Nantucket What It Was and What It Is.
25. Owen, Maria L. 1888. A Catalogue of Plants Growing Without Cultivation in the County of Nantucket, Mass.
26. Day, Mary A. 1901. The herbaria of New England. Rhodora 3: 255 262. (p. 259).
27. Letter, April 3, 1982, to the author from Earl H. Reed, Curator of Natural History and Assistant Director, Science Museum, Springfield, Massachusetts.
28. Deane, Walter. 1914. Maria L. Owen, p. 159.
29. Owen, Maria L. 1899. The Connecticut Valley Botanical Society. Rhodora 1: 95 96.
30. Bull. Torrey Bot. Club 4: 48. 1873. A similar notice appeared in: Amer. Naturalist 7: 690-691. 1873.
31. Owen, Maria L. 1907. The early work of the Springfield Botanical Society. 4 p., unnumbered. *In:* The Thirtieth Annual Report of the Springfield Botanical Society, Springfield, Mass. April 19, 1907. This annual report, secretarial books, other records of the society, and an Owen's scrapbook are in the collections of the Science Museum, Springfield, Massachusetts.
32. Deane, Walter. 1914. Maria L. Owen. p. 156.
33. Owen was one of many 19th-century American women who made contributions to the science of botany that, although significant, have generally gone unrecognized. For more on the part played by women in advancing 19th-century American botanical science, see: Rudolph, Emanuel D. 1982. Women in nineteenth century American botany: a generally unrecognized constituency. Amer. J. Bot. 69: 1346-1355.
34. *Springfield Sunday Republican,* August 25, 1907. Available accounts of Owen's latter years are in disagreement. Deane (1914) reports that Owen went to the home of her daughter in Long Island when she left Springfield.

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BOOK REVIEW

Manual de Herbario. Administración y manejo de colecciones, técnicas de recolección y preparación de ejemplares botánicos. Antonio Lot y Fernando Chiang *compiladores.* 17 × 27 cm, 144 paginas; encuadernación rústica con cubierta plastificada; 29 ilustraciones en blanco y negro. In Spanish. ISBN-968-6144-00-5. March 1986. $6.00 [US]

For persons interested in tropical plants, collecting them, preparing specimens, and preserving them in the herbarium, an interesting, broadly based, and comprehensive new reference has recently become available. It was published at the instigation and with the support of the National Council of the Flora of Mexico. The "Manual de Herbario" includes not only the steps preliminary to the actual insertion of a specimen into an herbarium collection, and its curation, but also discussions of the factors involved in the administration and management of such collections. The manual is composed of two parts and directed to those interested in a professional career as botanists or herbarium technicians, as well as to amateur botanists, teachers at all levels, and interested students who will find here scope for expanding their interests, achieving levels of expertise in special techniques, and developing perhaps casual interests into useful and/or helpful vocations or avocations. The ultimate goal of the National Council of the Flora of Mexico is completion of a flora based on well collected material, with cooperation and collaboration in diverse ways of much of the vast population of Mexico.

As already noted, the manual is comprised of two parts, the first being concerned with the structure and organization of the herbarium, the means and methods of its increase, the processing of specimens, their arrangement and maintenance, both in regard to keeping them pest free and to their curation, including appropriate study and annotation by specialists, by loans of material, exchange of specimens, etc. In this first section, also, the value and potential of computers in the herbarium is discussed briefly; the administration of the herbarium is considered, and the duties of staff briefly defined. Included in addition, is an inventory of the essential minimum requirements of furniture and supplies for an herbarium, a short bibliography of cited literature, and a rather detailed chapter that is a guide to sources of information for the management and administration of herbaria.

The second portion of the Manual is devoted to special techniques for the collection and preparation of herbarium specimens of selected groups of plants. Among these groups are included algae, fungi, lichens, bryophytes, ferns, vascular aquatics, grasses and grasslike plants, succulents, epiphytes (including orchids and bromeliads), palms, and trees. The preparation of specimens for each of these groups requires somewhat different care and handling. Authors of each of the chapters are specialists in the collection and/or study of their respective groups, so as a result we find meticulous and detailed instructions, such as a listing of field data and observations for a collector to make at the field locality, lists of necessary equipment that will vary with the particular group of plants, field label forms indicating salient points to consider and record. In some cases, original outline sketches or drawings are provided to illustrate special characteristics of the plants concerned as well as nuances in the descriptive terminology used. Basics for chemical testing are noted and briefly discussed, as is photography. A brief but relevant bibliography accompanies each chapter.

This small book has been organized, written, and edited with care. Some few typographical errors can certainly be corrected in succeeding editions. The design of the Manual is simple and pleasing; its price, by current standards, is very moderate. The Manual should, indeed, help to fulfill the proposals of the National Council of the Flora of Mexico by its detailed and lucid exposition and clear explanations. It is to be hoped the possibilities will become accomplishments beginning in the near future.

Before concluding this review I should like to urge that botanists and those students from the United States taking part in field work in Mexico or other Latin American country, study this Manual de Herbario with some care. This will help them to gain a better understanding of how botanical activities are progressing in Latin America, and to increase their Spanish botanical vocabularies for better communication with their Spanish speaking hosts.

Copies of the Manual may be purchased from:
Consejo Nacional de la Flora de México, A.C.
Apartado Postal 17-584
Deleg. Miguel Hidalgo
11410 México, D. F., México

or from the:
Departamento de Botánica del Instituto de Biología
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JOINT FIELD MEETING: JUNE 21–25, 1987

The Annual Joint Field Meeting of
The Northeastern Section of the Botanical Society of America
The Torrey Botanical Club, and
The Philadelphia Botanical Club

will be held June 21 through 25 in Southern Maine. Accommodations will be at the University of Southern Maine, in Gorham. The cost will be about $145.00; this includes eleven meals, and four nights' housing (double occupancy), plus trips and programs. Field trips, on Monday through Wednesday, are planned to saltmarshes, rocky shores, coniferous and deciduous woods, and wetlands. Space is limited and prior registration is required. For full details and registration information, contact:

Karl Anderson
Rancocas Nature Center
Mount Holly, NJ 08060
Tel.: (609) 261-2495
(609) 267-2195

INTERNATIONAL CONFERENCE ON LOWLAND HEATHS

An international conference on lowland heaths is planned for May 5–7, 1988, on Nantucket Island, Massachusetts. The meeting will seek to explore the extent, origins, development, management, and conservation of lowland heaths in North America. The conference will emphasize the influence of human land use history on all phases of heath ecology. We plan to publish the conference proceedings.

Nantucket Island, some 30 miles off the coast of New England, supports some of the best developed and preserved heaths in eastern North America. Field trips on Nantucket are planned, both before and after the conference.

The meeting will be hosted by the University of Massachusetts Nantucket Field Station. It is sponsored by the American Society for Environmental Education and co-sponsored by the Nantucket Conservation Foundation and the Massachusetts Audubon Society. At present, researchers from Britain, Atlantic Canada, and the United States have expressed interest in attending and presenting papers.

British and European participants are especially welcome, as their extensive experience with heath associations will aid comparatively recent attempts to understand the ecology of rarer North American heaths.

Interested persons wishing further information should contact the conference chairman, Dr. Wesley N. Tiffney, Jr., University of Massachusetts, Nantucket Field Station, P.O. Box 756, Nantucket, Mass., 02554, U.S.A. Telephone: 617-228-5268.

Vol. 89, No. 857, including pages 1–112, was issued January 30, 1987

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Submission of a manuscript implies it is not being considered for publication simultaneously elsewhere, either in whole or in part.

Manuscripts should be submitted in **triplicate** (an original and two xerographic copies) and *must be double-spaced* (at least 3/8″) **throughout** including tables, figure legends, and literature citations. Please do not use corrasable bond. The list of legends for figures and maps should be provided on a separate page. Footnotes should be used sparingly. Do not indicate the style of type through the use of capitals or underscoring, particularly in the citation of specimens. Names of genera and species may be underlined to indicate italics in discussions. Specimen citations should be selected critically, especially for common species of broad distribution. Systematic revisions and similar papers should be prepared in the format of "A Monograph of the Genus Malvastrum", S. R. Hill, Rhodora 84: 1–83, 159–264, 317–409, 1982, particularly with reference to indentation of keys and synonyms. Designation of a new taxon should carry a **Latin diagnosis** (rather than a full Latin description), which sets forth succinctly just how the new taxon is distinguished from its congeners. Papers of a floristic nature should follow, as far as possible, the format of "Annotated list of the ferns and fern allies of Arkansas", W. Carl Taylor and Delzie Demaree, Rhodora 81: 503–548, 1979. For bibliographic citations, refer to the Botanico-Periodicum-Huntianum (B-P-H, 1968), which provides standardized abbreviations for journals originating before 1966. All abbreviations in the text should be followed by a period, except those for standard units of measure and direction (compass points). For standard abbreviations and for guidance in other matters of biological writing style, consult the *CBE Style Manual,* 5th ed. (original title: *Style Manual for Biological Journals*). In preparing figures (maps, charts, drawings, photos, etc.) please remember that the printed plate will be 4 × 6 inches; be sure that your illustrations are proportioned to reduce correctly, and indicate by blue pencil the intended limits of the figures. (Some "turn-page" figures with brief legends will be 3 1/2 × 6 in.) Magnification/reduction values given in text or figure legends should be calculated to reflect the actual printed size. An Abstract and a list of Key Words should be supplied at the beginning of each paper submitted, except for a very short article or note.

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Rhodora

JOURNAL OF THE NEW ENGLAND BOTANICAL CLUB

Vol. 89 July 1987 No. 859

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Cover illustration

The American elm (*Ulmus americana* L.), official state tree of Massachusetts, has been a familiar sight for decades throughout the Northeast. The largest known living specimen in Mass. is located in Stockbridge. In 1982, it was 119′ high, had a crown spread of 118′, and was 232″ in circumference. In recent years, many of these stately trees have succumbed to Dutch Elm disease, a fungus accidentally introduced from Europe. The article by Ellmore and Phair (Rhodora Vol. 89, No. 857) contains the latest information of the status of this once dominating tree in our flora. Photo courtesy of Rhoda Vanderwall.

Rhodora

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JOURNAL OF THE

NEW ENGLAND BOTANICAL CLUB

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VARIATION IN *CAREX HOSTIANA* (CYPERACEAE)

WILLIAM J. CRINS[1] AND PETER W. BALL

ABSTRACT

Carex hostiana DC. is a variable, amphi-Atlantic calciphile. Multivariate statistical analyses have been used to examine the patterns of morphological variation found within the species. Although several infraspecific taxa have been described, the results of this investigation indicate that there are no discontinuities in the morphological variation which can be clearly correlated with geography. Large plants tend to be most frequent on the North American side of the Atlantic Ocean and in Scandinavia, but large and small plants can be found scattered throughout the entire range of the species. No infraspecific taxa are worthy of recognition.

Key Words: *Carex hostiana,* Cyperaceae, taxonomy, amphi-Atlantic distribution

INTRODUCTION

Carex hostiana DC. is an amphi-Atlantic calciphile occurring in mires and flushes over schistose or other ligneous rock formations where the pH is slightly acidic (Jermy et al., 1982). It is most closely related to *C. flava* L. and its allies in section *Ceratocystis* Dumort. (Chater, 1980; Crins, 1985, Ph. D. thesis, U. of Toronto, Canada). Arguments in support of this relationship will be presented elsewhere. *Carex hostiana* is unique in section *Ceratocystis* in having well-developed short rhizomes; conspicuously pedunculate, short-cylindric pistillate spikes; ascending perigynia; and dark brown, broadly white-rimmed obtuse scales. Its chromosome number is $n = 28$, among the lowest in the section (Heilborn, 1924). It is

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known to hybridize with other members of the section, including *C. flava* (*C.* × *xanthocarpa* Dégl.), *C. viridula* Michx. ssp. *viridula* (*C.* × *appeliana* Zahn), *C. viridula* ssp. *brachyrrhyncha* (Čelak.) B. Schmid (*C.* ×*fulva* Gooden.), and *C. viridula* ssp. *oedocarpa* (N. J. Anderss.) B. Schmid. These hybrids are invariably sterile, failing to set achenes, or producing thin-walled, empty achenes. They also show the distinctive discoloration of the perigynium wall (white, yellow, or pale brown rather than green) characteristic of most interspecific sedge hybrids.

The taxonomic problem surrounding *Carex hostiana* centers on whether or not it is comprised of recognizable infraspecific taxa. Several infraspecific taxa have been described within this species. These and other relevant points of nomenclature are placed in their historical context, and variation patterns within the species have been analyzed using multivariate statistical analyses. The results of the mathematical analyses have been used to draw conclusions on the taxonomic validity of infraspecific taxa.

HISTORY

De Candolle described *Carex hostiana* in 1813. Goodenough (1794) had described *C. fulva* earlier, and his name was often applied to *C. hostiana* during the nineteenth century. Some botanists during that period recognized that *C. fulva* differed from *C. hostiana,* but the basis for these differences was not understood. Hoppe (1824) described *C. hornschuchiana* and although he differentiated it from *C. fulva,* he was apparently unaware of de Candolle's (1813) species (*C. hostiana*), with which he should have compared it. Hoppe went into considerable detail in explaining the misinterpretations of Goodenough's (1794) plant by previous authors. Godron (1843) realized that a sterile variant existed in this group. Although he did not invoke hybridization as the explanation for the sterility, he pointed out that the perigynium differences between *C. hornschuchiana* and *C. fulva* could be attributed to the sterile condition of the latter. The name *C. hornschuchiana* persisted in the European and North American literature until the early twentieth century. Godron also pointed out that the other differences referred to by previous workers were of little or no importance, and he felt that there was no justification for maintaining *C. fulva* at any rank.

Kükenthal (1905) was the first author to state that *C. fulva* was a hybrid between *C. hostiana* and a member of the *C. flava* group.

In 1836, Dewey described *Carex greeniana* from material collected near Boston, Massachusetts (pond at Tewksbury). This plant was considered to be identical with *C. hostiana* by most American authors, but Mackenzie (1910) did not concur with this view. He examined the two original specimens collected by Greene, one of which is labelled *C. greeniana,* the other *C. fulva.* The former specimen, taken to be the holotype, corresponds to the European *C. laevigata* Smith (section *Elatae*). The latter specimen is *C. hostiana* (Mackenzie, 1910; Crins, pers. obs., 1984).

Mackenzie (1910) described *Carex fulvescens* on the basis of specimens from Boston, Anticosti Island, and Miquelon. Later, he designated a specimen from Miquelon as the type (Mackenzie, 1935). He differentiated *C. fulvescens* from the European *C. hornschuchiana* by its larger perigynia and pistillate spikes, its more obtuse and more evidently white-hyaline rimmed scales, and its more prolonged and strongly tinged bract sheaths. He also suggested that the reports of *C. fulva* from Newfoundland were probably referable to *C. fulvescens.*

The North American plants received further attention when Fernald and Wiegand (1911) began travelling to Newfoundland and describing their discoveries. They considered the plants from Newfoundland which they called *Carex hornschuchiana* var. *laurentiana* to be larger in stature, with thicker pistillate spikes and longer perigynia than its European counterpart. After further study, they placed their North American variety of *C. hornschuchiana* under *C. hostiana,* at the same rank (Fernald and Wiegand, 1924). They realized that *C. hostiana* was an earlier name for *C. hornschuchiana.* It is apparent from their paper, however, that they had begun to have doubts about the distinctness of their taxon, pointing out that several European specimens closely approached the dimensions of the North American plants. However, they tentatively maintained it at varietal rank. A further clarification of the morphological diversity within *C. hostiana* was presented by Fernald in 1942. Although Mackenzie (1910) had stated that the perigynia could range up to 6 mm in length, Fernald examined all of the available material and stated that the maximum size was 5 mm. He also stated that specimens from the Saint-Pierre and Miquelon Islands showed the complete range of variation, but he failed to go so far as to say that *C.*

hostiana var. *laurentiana* should be completely submerged within typical *C. hostiana.* He recognized several hybrids that were previously undescribed, and provided them with binomials. *Carex* × *xanthina* was a sterile plant intermediate between *C. flava* and *C. hostiana* var. *laurentiana.* Another new hybrid was *C.* × *pseudofulva,* combining the traits of *C. hostiana* var. *laurentiana* and *C. viridula* ssp. *brachyrrhyncha.*

Carex hornschuchiana var. *eckeroëensis* was described by Lindberg and Palmgren (1916) on a printed label in "Plantae Finlandiae Exsiccatae." It was differentiated from the typical variety by its taller culms, broader leaves, and longer perigynia. They later elevated this taxon to subspecific rank (Palmgren, 1926). Fagerström (1967) continued in the footsteps of his mentor, Alvar Palmgren, in the study of this group. He described a new variety within *C. hostiana,* var. *froedinii,* from Kurdistan. Superficially, *C. hostiana* var. *froedinii* looks very much like a member of section *Ceratocystis,* but an examination of type material clearly shows that it is a member of section *Spirostachyae* Drejer, possessing the diagnostic reddish-brown cellular inclusions in the perigynium walls (Chater, 1980; Crins, 1985, Ph. D. thesis, U. of Toronto, Canada).

MATERIALS AND METHODS

A list of characters used by previous workers to differentiate among taxa within *C. hostiana* was compiled, and this list was augmented by a preliminary examination of specimens from North America and Eurasia. The specimens used in this study were obtained on loan from the following herbaria: CAN, DAO, GH, GZU, H, LAU, MT, NY, QFA, TRT, UC.

Multivariate statistical methods were used to analyze the morphological data. All of the data used in these analyses were obtained directly from mature preserved specimens. The analyses were performed on a data set composed of 72 specimens (29 from North America and 43 from Eurasia; citations available from the senior author). Twenty variables were measured on each specimen. They included culm height, maximum leaf width, upper cauline leaf length and width, upper cauline leaf sheath length and height of ventral extension, staminate spike length and width, lowest pistillate spike length and width, lower bract length and width, lower bract sheath length and height of ventral extension, lower spike peduncle length, perigynium total length, body length, width, beak length, and beak-tooth length. Overall patterns of variation within the data set were analyzed using principal components analysis (PCA). An assessment of the characters contributing to the separation of the North American and Eurasian groups of specimens was accomplished using discriminant functions analysis (DFA). Both techniques are robust to minor deviations from the assumptions of multivariate normality and linearity of character states (Krzanowski, 1977; Lachenbruch and Goldstein, 1979; Sneath and Sokal, 1973).

The algorithm used to perform the PCAs is that included in the NTSYS package of numerical taxonomic techniques (Rohlf et al., 1974). The algorithm used to perform the DFAs is included in the BMDP-83 package of numerical techniques (Dixon, 1983). Both systems are available from the University of Toronto Computing Centre.

RESULTS

The PCA suggests that there is a tendency for North American plants to be larger than the European plants. There is a slight partitioning of the principal component space, particularly on PC I (PCs I and II, Figure 1). However, the region of overlap within the principal component space is considerable. Plants measured from the type specimen of the North American taxon (*Carex hostiana* var. *laurentiana*) are outside of this region of overlap. However, the majority of the North American specimens fall into the overlap region. The Scandinavian specimens (some of which have been named *C. hostiana* var. *eckeroëensis*) also occur mainly within the region of overlap. This fact suggests that perhaps the North American plants have closer affinities with their Scandinavian counterparts than with plants from central Europe. However, many Scandinavian plants are located outside of the region of overlap, and furthermore, many of the central European plants fall within this same overlap region. Thus, although there is a tendency for the North American and Scandinavian plants to be more robust than the central European plants, there is little consistency in the pattern, and no discontinuities exist among the morphological variables examined. Variables contributing to the pattern of variation indicated by PC I include upper cauline leaf width, lower bract width, perigynium length, lowest pistillate spike peduncle length, and

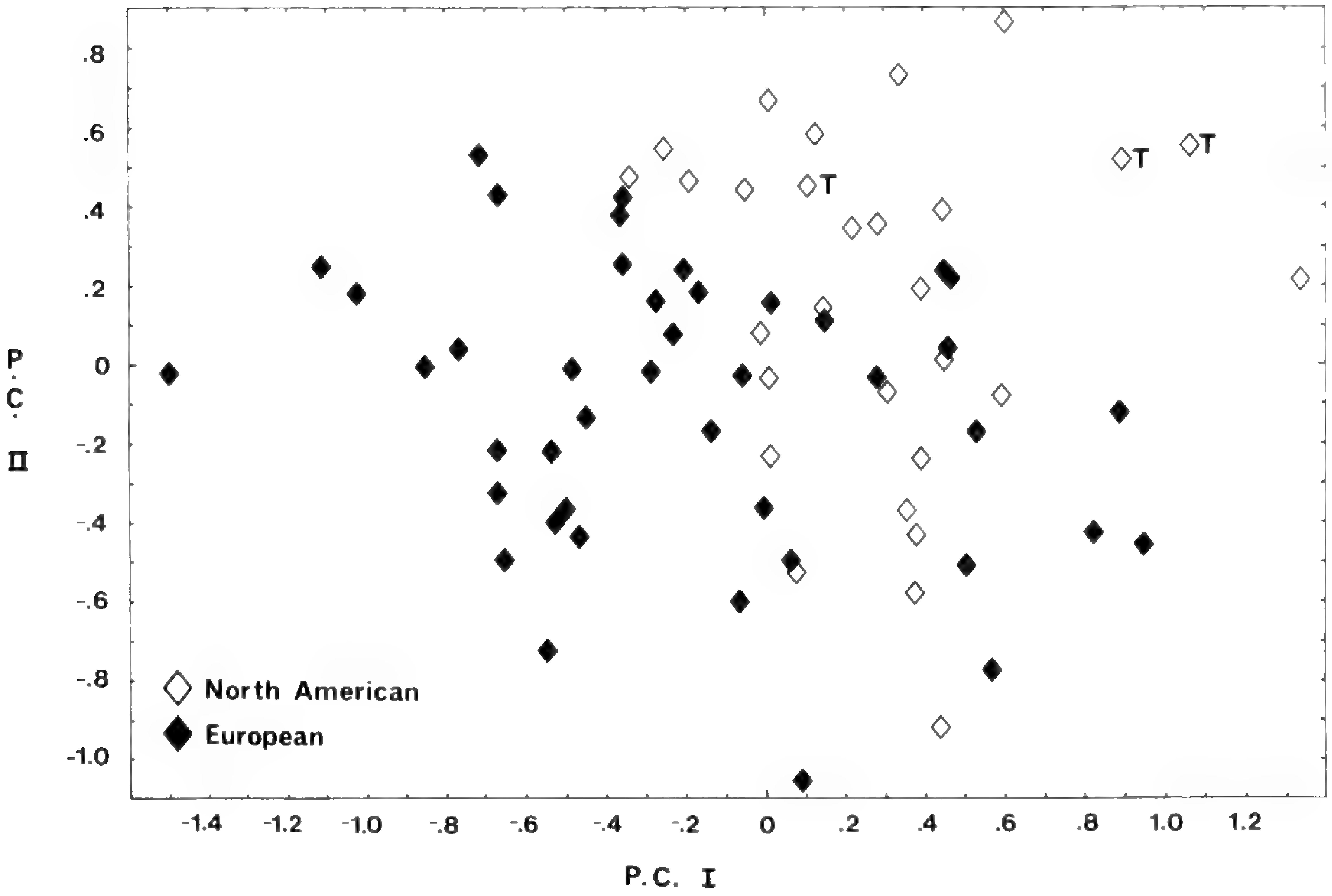

Figure 1. Ordination of specimens of *Carex hostiana* along principal components I and II. (T = specimen from holotype of *C. hostiana* var. *laurentiana*).

upper cauline leaf length. Principal component II is composed mainly of lowest pistillate spike width, perigynium total length, perigynium body length, perigynium width, lowest bract length, staminate spike width, upper cauline leaf sheath length, and upper cauline leaf length. The relative amounts of variation explained by the first two principal components axes are 28.51% and 16.39%, respectively.

Due to the lack of material determined as *Carex hostiana* var. *eckeroëensis* by Palmgren, all European material was pooled into a single group in the DFA. Thus, two groups were analyzed by DFA. Although a fairly efficient separation of groups was achieved, a region of overlap exists (Figure 2). Just under 90% of the specimens are classified correctly using the discriminant function (89.7% for the North American plants and 88.4% for the European plants). The variables contributing to this discriminant function include upper cauline leaf width, lowest pistillate spike length, culm height, perigynium width, lowest bract sheath length, and lowest bract sheath projection height. Thus, the distinction between the North American and European plants is based largely on vegetative features. When the results of the DFA and PCA are considered jointly, there is no justification for recognizing infraspecific taxa within *C. hostiana*. No subunits with morphological and geographical integrity are discernible. The infraspecific taxa recognized by previous authors represent extremes of variation within the species, and these extremes do not appear to be consistent within populations (see locations of specimens of holotype material of *C. hostiana* var. *laurentiana* within the principal component space, Figure 1).

TAXONOMY

Carex hostiana A. P. de Candolle, Cat. Pl. Horti Bot. Monsp. 88. 1813. TYPE: hab. in Austria. (HOLOTYPE: G)

C. hornschuchiana Hoppe, Flora 7: 593–598. 1824. TYPE: AUSTRIA, in Salisburgi pratis humidis, *Hoppe* (LECTOTYPE, here designated, Crins: GZU!, photo TRTE!, ISOLECTOTYPE: GZU!).

C. hornschuchiana f. *angustifolia* Gaudin, Fl. Helv. 6: 100. 1830. TYPE: SWITZERLAND, prope Rheineck (HOLOTYPE: LAU, not found).

C. speirostachya J. E. Smith, Engl. Fl., ed. 2, 4: 98. 1830. TYPE: SCOTLAND, about Mugdoch castle, 9 miles north of Glasgow, *D. Don* (HOLOTYPE: LINN).

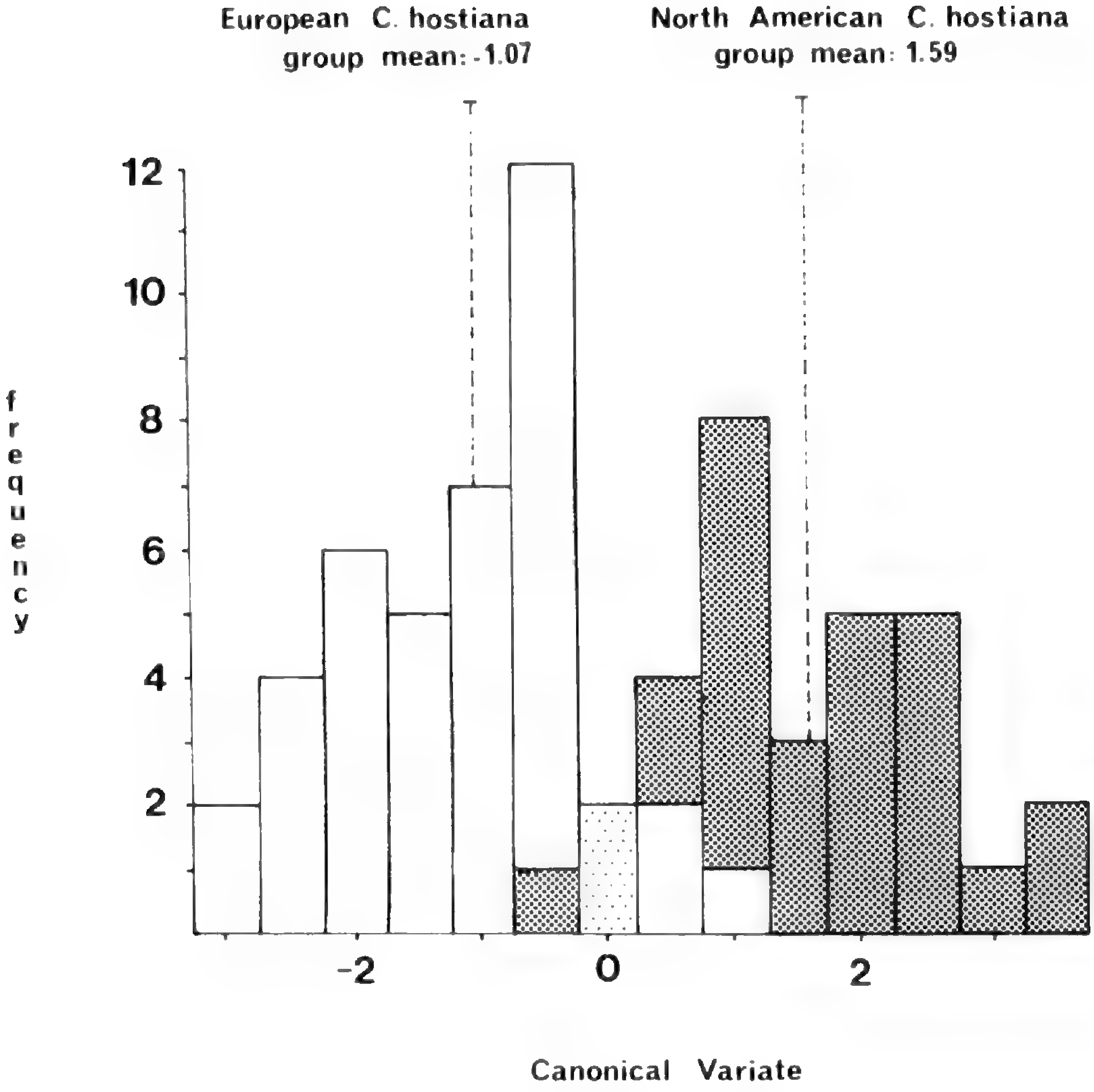

Figure 2. Distribution of specimens of *Carex hostiana* along the canonical variate. (Coarse speckling indicates region of overlap between groups, where frequency in each group is equal).

C. fulvescens Mackenzie, Bull. Torrey Bot. Club 37: 239–241. 1910. TYPE: MIQUELON ISLAND, vallée de la Belle Rivière, Langlade, 28 juillet 1902, *Fr. Louis-Arsène 93* (HOLOTYPE: NY!, photo TRTE!).

C. hornschuchiana var. *laurentiana* Fernald & Wiegand, Rhodora 13: 130. 1911. *C. hostiana* var. *laurentiana* (Fernald & Wiegand) Fernald & Wiegand, Rhodora 26: 122. 1924. TYPE: CANADA, Newfoundland, Region of Port au Port Bay, Table Mountain, 16 August 1910, *M. L. Fernald & K. M. Wiegand 2897* (LECTOTYPE, here designated, Crins: GH!, photo TRTE!, ISOLECTOTYPES: GH!).

C. hornschuchiana var. *eckeroëensis* Lindberg *f.* & Palmgren, *Plantae Finlandiae Exsiccatae no. 537.* 1916 (printed label with Latin diagnosis). *C. hornschuchiana* ssp. *eckeroëensis* (Lindberg *f.* & Palmgren) Lindberg *f.* & Palmgren, *in* C.

A. M. Lindman. Sv. Fanerogamfl., ed. 2: 153. 1926. TYPE: FINLAND, Alandia, par. Eckero, Storby, 15 Iul. 1911, *A. A. Magnusson* (HOLOTYPE: H, ISOTYPE: NY! UC!).

C. fulva auctt. non Goodenough. Trans. Linn. Soc. 2: 177. 1794.

DIAGNOSTIC FEATURES: Culms arising from short, stout, horizontal rhizomes; leaf and bract sheaths with ventral hyaline faces having brown convex projections; staminate spikes on conspicuous peduncles; scales with conspicuous, broad, silvery or white-hyaline margins; pistillate spikes ovoid or elliptic to short-cylindric, erect or ascending, distant, conspicuously pedunculate; perigynia ascending with straight conspicuously serrulate beaks.

DISCUSSION: The small number of segregates that have been recognized within *Carex hostiana* represent morphological extremes within a range of continuous variation. Both of the segregate taxa, ssp. *eckeroëensis* and var. *laurentiana,* refer to large extremes, the former from the Finnish province of Aland, and the latter from North America. However, an examination of specimens from these areas indicates that a considerable amount of size variation exists within populations and within small geographic areas. Although there may be a tendency for the North American and some of the Scandinavian material to be larger than that from central Europe, a wide range of variation can be found everywhere within the range of the species. There is no evidence to support the recognition of the North American plants as taxonomically distinct, as previous authors also suspected after they examined more material (Fernald, 1911a; 1942; Fernald and Wiegand, 1924).

Carex hostiana exhibits an amphi-Atlantic distribution pattern (Figures 3 and 4). It is quite widespread in Europe, but in North America it is restricted to western Newfoundland, the St. Pierre and Miquelon Islands, Anticosti Island, and the Mingan Islands. It has also been recorded from the vicinity of Boston, Massachusetts (Dewey, 1836), where it has never been seen again (Fernald, 1911b). It is possible that the Boston station was a relict population from a period when the species was more widespread on this continent, or that the species had migrated southward in response to glacial advances and deteriorating climates in its present range. On the other hand, it might also represent an isolated introduction or a labelling error. The species appears to be native elsewhere in the

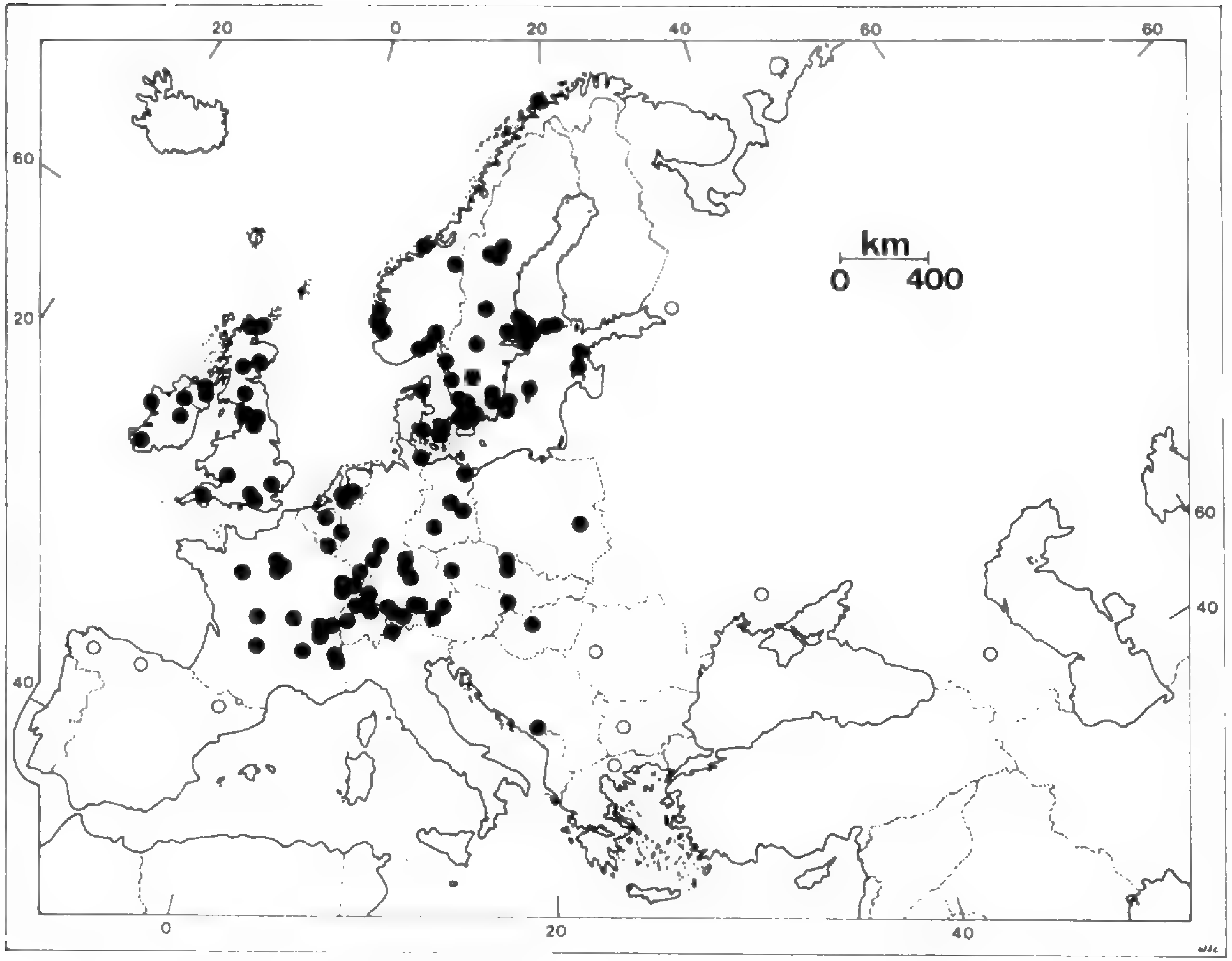

Figure 3. Eurasian distribution of *Carex hostiana*. (Closed symbols represent specimens examined, open symbols represent literature records).

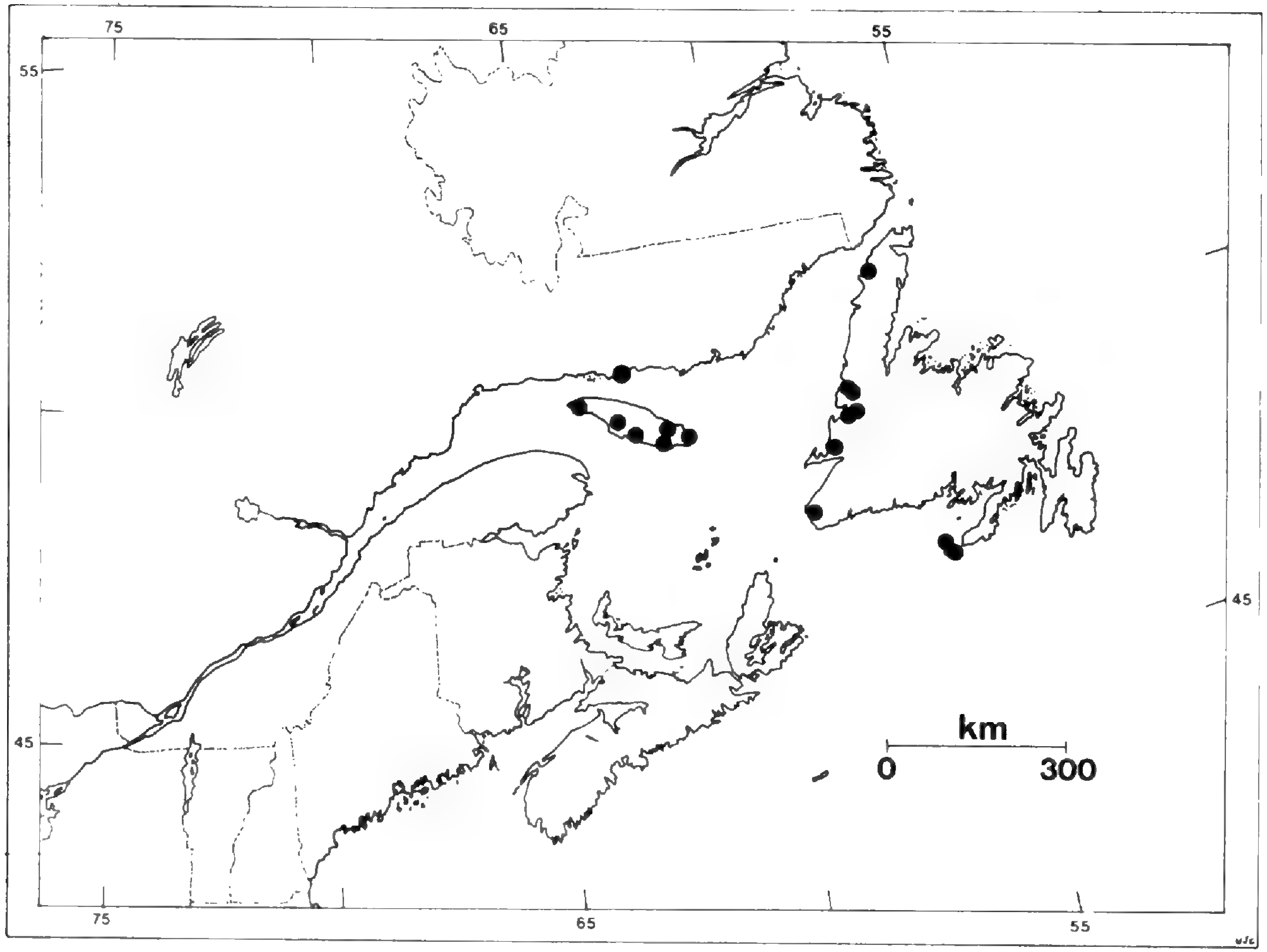

Figure 4. North American distribution of *Carex hostiana*. (Old record from Boston, Massachusetts, not mapped).

North American portion of its range, occurring in moist or wet, open calcareous fens and turfs, as it does in Europe (Jermy et al., 1982).

EXCLUDED TAXON

Carex hostiana var. **froedinii** Fagerström. Acta Soc. Fauna Fl. Fenn. 79(3): 1–14. 1967. TYPE: KURDISTAN, Delan Dere, 20 km SV. om Mukus i so dra delen av Armeniska Taurus, 1800 m o.h., 22 juni 1939, *John Frödin 65* (HOLOTYPE: UPS; ISOTYPES: UPS, H!).

This taxon is a member of the related but distinct section *Spirostachyae,* and is most closely allied with *Carex diluta* Bieberstein. Its exact taxonomic status must await a revision of that section.

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FRESHWATER DIATOMS (BACILLARIOPHYCEAE) FROM THE NORTHEASTERN GLACIAL LAKE DISTRICT OF WISCONSIN. I. *ATTHEYA, CYCLOTELLA, MELOSIRA, RHIZOSOLENIA,* AND *STEPHANODISCUS* (ORDER CENTRALES).

LOUIS L. LIPSEY, JR.[1]

ABSTRACT

Nineteen centric diatom species are described and illustrated from the Highland Lake District of northeastern Wisconsin. Genera treated include *Attheya* West, *Cyclotella* (Kütz.) Bréb., *Melosira* C. A. Agardh, *Rhizosolenia* Brightwell, and *Stephanodiscus* Ehrenberg. Information on the morphological variability of selected taxa and general distribution within the study area is also provided.

Key Words: algae, diatoms, Centrales, Bacillariophyceae, Wisconsin.

INTRODUCTION

The algae of northeastern Wisconsin have been studied extensively since early in the present century. Notable are the exhaustive surveys of G. M. Smith (1916a, 1916b, 1918, 1920, 1924) and Prescott (1944, 1962). Despite these studies, little information on diatoms exists in the literature. Smith (1924) apparently collected them during his extensive investigations. He reported that a manuscript concerning the diatoms from selected inland lakes was in preparation and the material had been sent for review to F. Meister of Zurich; however, it was never published (G. W. Prescott, personal communication, 12 February, 1977). During the summer months of 1935–1937 and prior to the surveys of Prescott, Paul S. Conger obtained plankton and sediment samples from 150 lakes within the

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northeastern glacial lake district (Conger, 1938). After reporting on 23 genera and 85 species of diatoms from sediment core-samples in Crystal Lake (Conger, 1939), he did not pursue the floristics of Wisconsin diatoms. Subsequent studies in more recent times have dealt with periphytic diatoms (Strenski, 1979), planktonic diatoms (Lipsey & Fenwick, 1978, 1979), and Late Pleistocene diatoms (Andrews, 1966).

A comprehensive investigation was undertaken to document more fully the diatom flora of northeastern Wisconsin (Lipsey, Ph.D. dissertation, Southern Illinois University, 1982). This paper is the first in a series providing keys, descriptions, and information on the distribution of diatoms within the Highland Lake District encompassing Forest, Iron, Langlade, Lincoln, Oneida, Price, and Vilas Counties. Species within the centric genera *Attheya* West, *Cyclotella* (Kütz.) Bréb., *Melosira* C. A. Agardh, *Rhizosolenia* Brightwell, and *Stephanodiscus* Ehrenb. are considered first. Pennate diatom genera and species will be treated in subsequent papers.

MATERIALS AND METHODS

Horizontal tow-net samples were collected from the littoral communities of 85 northeastern Wisconsin lakes during the summer months of 1978 and 1979 with a #20-mesh plankton net and preserved in 5% formalin solution. Sixteen Lugol's preserved Kemmerer samples, collected from 1977–1978 by the Wisconsin Department of Natural Resources—Water Resources Section (Bureau of Water Research), have also been studied. A listing of the 101 lakes examined and their geographical locations is available upon request from the author.

Samples were treated in the laboratory to remove organic matter within the diatom cells (Hasle & Fryxell, 1970). The cleaned diatoms were then mounted on glass slides in Hyrax (Patrick & Reimer, 1966). Thirty to forty transects were then scanned on each slide using an oil immersion lens (100×) on a Leitz compound light microscope. Slides were deposited in the general diatom collection of the Academy of Natural Sciences of Philadelphia, Pennsylvania.

The classification system adopted in this investigation follows that of Simonsen (1979). Each genus is briefly characterized, and a key to the species and subspecific taxa follows. Species and subspecific taxa are then treated alphabetically. In general, the name of each taxon is accompanied by the author's name and reference to the original description. Species descriptions, occasional comments, and information on the distribution within the study area follow. Measurements and observations are based on Wisconsin specimens only. Terminology of valve characteristics follows that of Anonymous (1975) and Ross et al. (1979).

SYSTEMATIC TREATMENT OF THE SPECIES

Division Chrysophyta
Class Bacillariophyceae
Order Centrales

Valves circular or polygonal in outline, with radially symmetrical ornamentation; raphe and pseudoraphe lacking.

KEY TO THE GENERA

1. Valves bipolar or conical; frustules in girdle view with numerous segmented girdle bands .... 4.
1. Valves flat or slightly undulate; frustules in girdle view without numerous segmented girdle bands .... 2.
   2. Valves with strongly developed pervalvar axes (i.e., the valve length is usually greater than the diameter); frustules frequently forming long chains (1. Family Melosiraceae) .... *Melosira*
   2. Valves with weakly developed pervalvar axes; frustules solitary, or forming short chains (2. Family Thalassiosiraceae) .... 3.
3. Marginal area of valves with puncta grouped into fascicles; valve margins with distinct spines................ *Stephanodiscus*
3. Marginal area of valves without fascicles; valve margins without spines .... *Cyclotella*
   4. Valve apices with a single long, eccentric spine (3. Family Rhizosoleniaceae) .... *Rhizosolenia*
   4. Valve apices with two divergent spine-like protuberances (4. Family Biddulphiaceae) .... *Attheya*

1. Family Melosiraceae
Melosira C. A. Agardh*

Vegetative cells usually forming chains or colonies; frustules circular in valve view, with punctate or smooth surfaces, usually with highly ornamented mantles, normally with marginal spines; frustules narrowly rectangular in girdle view, at times with a distinct sulcus.

KEY TO TAXA

1. Valves and mantles usually lacking ornamentation . . . . *M. varians*
1. Valves and mantles with evident ornamentation . . . . **2.**
  2. Valves 44–61 μm in diameter; valve faces distinctly striate . . . . *M. undulata*
  2. Valves 3–22 μm in diameter; valve faces typically punctate . . . **3.**
3. Valves with short spines, and usually long coarse spines of unequal length at the margin . . . . **4.**
3. Valves with short spines of equal length at the margin . . . . **5.**
  4. Valves 5–15 μm in diameter . . . . *M. granulata* var. *granulata*
  4. Valves less than 5 μm in diameter . . . . *M. granulata* var. *angustissima*
5. Valve mantles with an incomplete arrangement of puncta within the pervalvar rows . . . . *M. distans* var. *lirata*
5. Valve mantles with a complete arrangement of puncta within the pervalvar rows . . . . **6.**
  6. Valves delicate in structure, and weakly silicified; valves 2.5–6 μm in length . . . . *M. distans* var. *alpigena*
  6. Valves usually robust; valves 6–18 μm in length . . . . *M. italica*

M. distans var. **alpigena** Grun. *In:* V. H., 1882. (Figure 1.)

DESCRIPTION: Valves 6–10 μm in diameter and 2.5–6 μm in length, ornamented with irregularly arranged puncta on the face, with a corona of small spines of equal length at the margin; mantles

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*Simonsen (1979) suggested that many freshwater species of this genus should probably be transferred to the genus *Aulacosira* Thwaites.

with spiraled rows of puncta, 16–20 per 10 μm, puncta within the rows 18–20 per 10 μm.

FOREST CO.: Bug, Deep Hole, Duck, Ground Hemlock, Lucerne, and Mole Lakes. IRON CO.: Third Black Lake. ONEIDA CO.: Minocqua, Nokomis, Rainbow, and Washburn Lakes. VILAS CO.: Black Oak, Ike Walton, Palmer, and Presque Isle Lakes; and Lac Vieux Desert.

M. distans var. **lirata** (Ehrenb.) Bethge, 1925. (Figure 16.)

DESCRIPTION: Valves 8–12 μm in diameter and 3–6.5 μm in length, ornamented with irregularly arranged coarse puncta on the face, with a crown of small spines of equal length at the margin; mantles with parallel rows of puncta, 12–13 per 10 μm, puncta within the rows 12–16 per 10 μm.

IRON CO.: Trude Lake. LINCOLN CO.: Harrison Lake. ONEIDA CO.: Virgin Lake. VILAS CO.: Spider and Trout Lakes.

M. granulata var. **angustissima** Müll., 1899. (Figure 15.)

DESCRIPTION: Valves 3–4.5 μm in diameter and 15–23 μm in length, ornamented with a few irregularly arranged puncta on the face, with short spines, and long coarse spines of unequal length at the margin; mantles with parallel or spiraled rows of puncta, about 14 per 10 μm, puncta within the rows 12–16 per 10 μm.

COMMENTS: Most valve mantles of this variety possess spiraled rows of puncta; however, it is not too unusual to find spiraled rows on one valve of a specimen and parallel rows on the other valve.

LINCOLN CO.: Harrison Lake. ONEIDA CO.: Bearskin, Pelican, and Rainbow Lakes. PRICE CO.: Butternut, Duroy, and Pike Lakes. VILAS CO.: Catfish, McCullough, Palmer, and Rice Lakes.

M. granulata (Ehrenb.) Ralfs var. **granulata.** *In:* Pritchard, 1861. (Figures 3, 14.)

DESCRIPTION: Valves 5–15 μm in diameter and 9–19 μm in length, ornamented with a few irregularly arranged puncta on the face, with short spines, and long coarse spines of unequal length at the margin; mantles with parallel or spiraled rows of puncta, 10–12 per 10 μm, puncta within the rows 8–11 per 10 μm.

COMMENTS: Ornamentation of the valve mantle is extremely variable in this species (Stoermer et al., 1981). The puncta within the rows in some mantles are relatively coarse; however, in others they are fine. Also, finely structured forms occasionally possess only short spines of equal length at the margin.

Commonly found throughout the region.

M. italica (Ehrenb.) Kütz., 1844. (Figure 2.)

Description: Valves 8–18 μm in diameter and 6–18 μm in length, ornamented with a few irregularly arranged puncta on the face, with a crown of small spines of equal length at the margin; mantles with spiraled rows of puncta, 16–18 per 10 μm, puncta delicate to coarse within the rows, about 18–20 per 10 μm.

Comments: This species is extremely variable. Scanning electron micrographs obtained by Sreenivasa & Duthie (1975, p. 175, fig. 17) show that the sulcus in *Melosira italica* is shallow externally, but internally it appears as a deep shelf. Investigators are often misled by this deep shelf and have apparently mistaken it for the wide angular sulcus characteristic of *M. ambigua* (Grun.) Müller. This problem arises as a result of maintaining the focus of the microscope at the subsurface of the valve mantle. Careful examination of internal and surface charactertistics of the valve mantle are, therefore, required for proper identification of *M. italica. Melosira ambigua* as reported by Lipsey (1975, 1976, 1980) and Lipsey & Fenwick (1978), after careful re-examination, has been determined to be in fact *M. italica.* If the above interpretation of *M. italica* is correct, the distribution of *M. ambigua* is perhaps not as extensive in the United States as we are led to believe at the present time.

This taxon is widely distributed throughout the lake district.

M. undulata (Ehrenb.) Kütz., 1844. (Figure 4.)

Description: Valves 44–61 μm in diameter, ornamented with radiating rows of striae of different lengths on the face, about 12–13 per 10 μm, puncta within the rows 16–20 per 10 μm; no frustules were observed in girdle view.

Comments: Stoermer & Yang (1969) report that valve lengths for Lake Michigan specimens range between 20–35 μm and that the mantles are highly ornamented with parallel rows of puncta. Unlike other Wisconsin *Melosira* species, the ornamentation of the valve face in this taxon is very complex.

IRON CO.: Long Lake. ONEIDA CO.: Whitefish Lake. VILAS CO.: North Twin Lake.

M. varians Ag., 1817. (Figure 5.)

Description: Valves 13–22 μm in diameter and 11–17 μm in length, usually without ornamentation on the face; mantles lacking apparent ornamentation.

FOREST CO.: Rice Lake. IRON CO.: Pike Lake, and Lake-of-the-Falls. ONEIDA CO.: Minocqua, Rainbow, and Whitefish Lakes. VILAS CO.: Black Oak, Crab, and Palmer Lakes.

2. Family Thalassiosiraceae

Cyclotella (Kütz.) Bréb.

Vegetative cells usually solitary; frustules circular in valve view, usually with ornamentation arranged in two unlike concentric patterns on the face: an inner region which is smooth or punctate, and an outer peripheral region which contains radiate striae, without marginal spines; frustules narrowly linear in girdle view, often with undulate margins, usually without ornamentation.

KEY TO TAXA

1. Striae 10 or less per 10 μm .... *C. meneghiniana*
1. Striae more than 10 per 10 μm.......................... **2.**
  2. Valves with evident shadow lines between the marginal striae .... *C. comta*
  2. Valves without shadow lines between the marginal striae .... **3.**
3. Valves generally with a stellate central area .... **4.**
3. Valves without a stellate central area .... **5.**
  4. Striae 17–18 per 10 μm; strutted processes conspicuous along the valve margin .... *C. pseudostelligera*
  4. Striae 13–14 per 10 μm; strutted processes usually inconspicuous along the valve margin. .... *C. stelligera*
5. Central area of valves fully ornamented with scattered puncta; valve margins with striae of unequal length ...... *C. ocellata*
5. Central area of valves only half-ornamented with puncta; valve margins with striae of equal length......... *C. michiganiana*

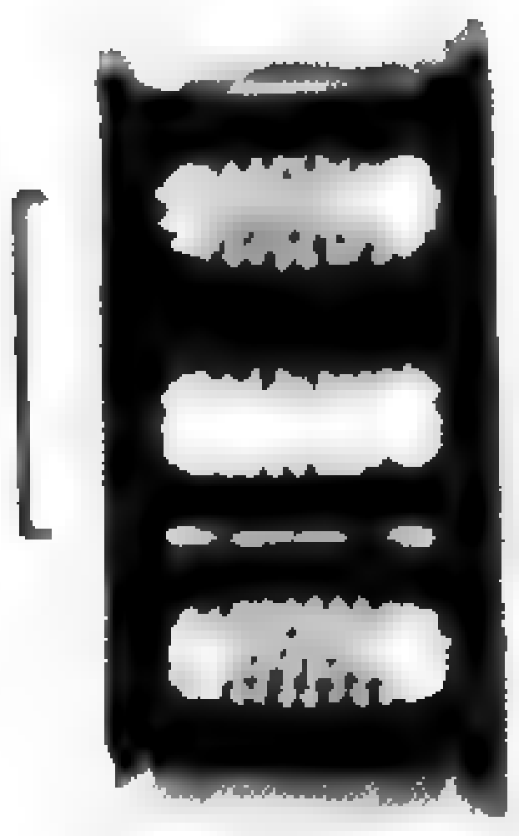
C. comta (Ehrenb.) Kütz., 1849. (Figures 7–8, 10.)

Description: Valves 17–42 μm in diameter; outer region with radiate striae, 12–16 per 10 μm, generally with an isolated stigma at the inner end of several shortened striae; inner region with distinct puncta, irregularly arranged or forming radiating rows.

Commonly found in most alkaline lakes.

C. meneghiniana Kütz., 1844. (Figure 18.)

Description: Valves 12–28 μm in diameter; outer region with large radiate striae, 6–9 per 10 μm; inner region smooth or finely punctate, with an occasional large, isolated punctum.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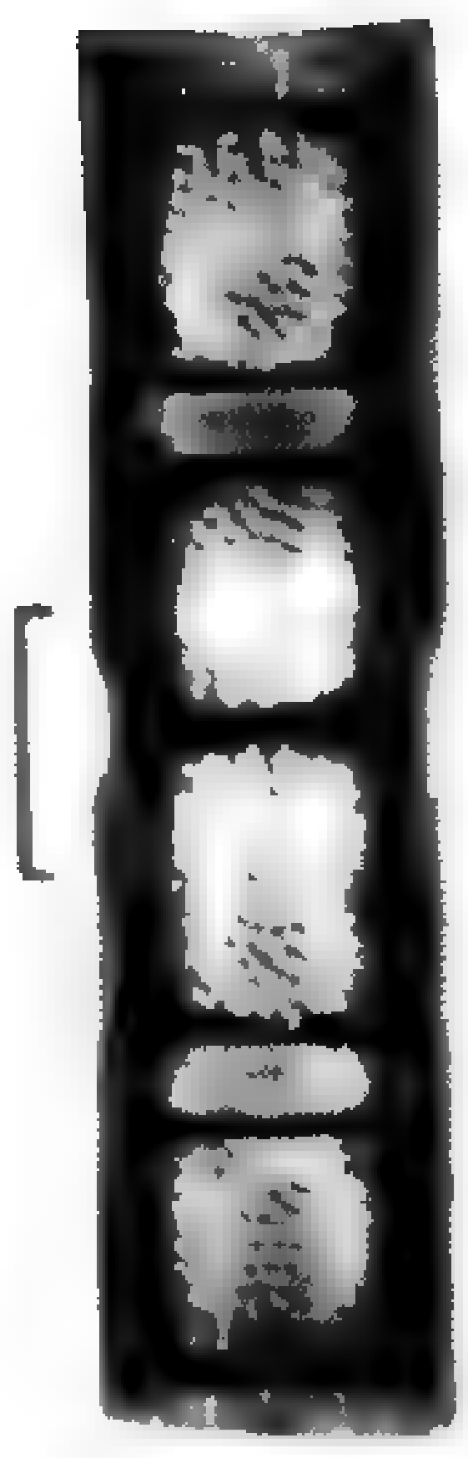
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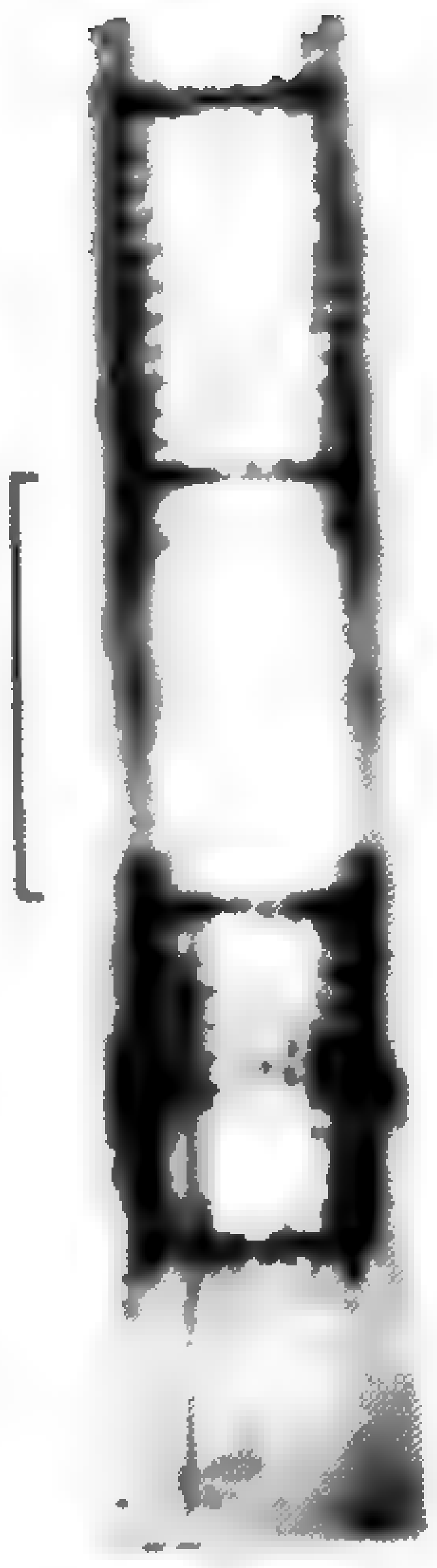
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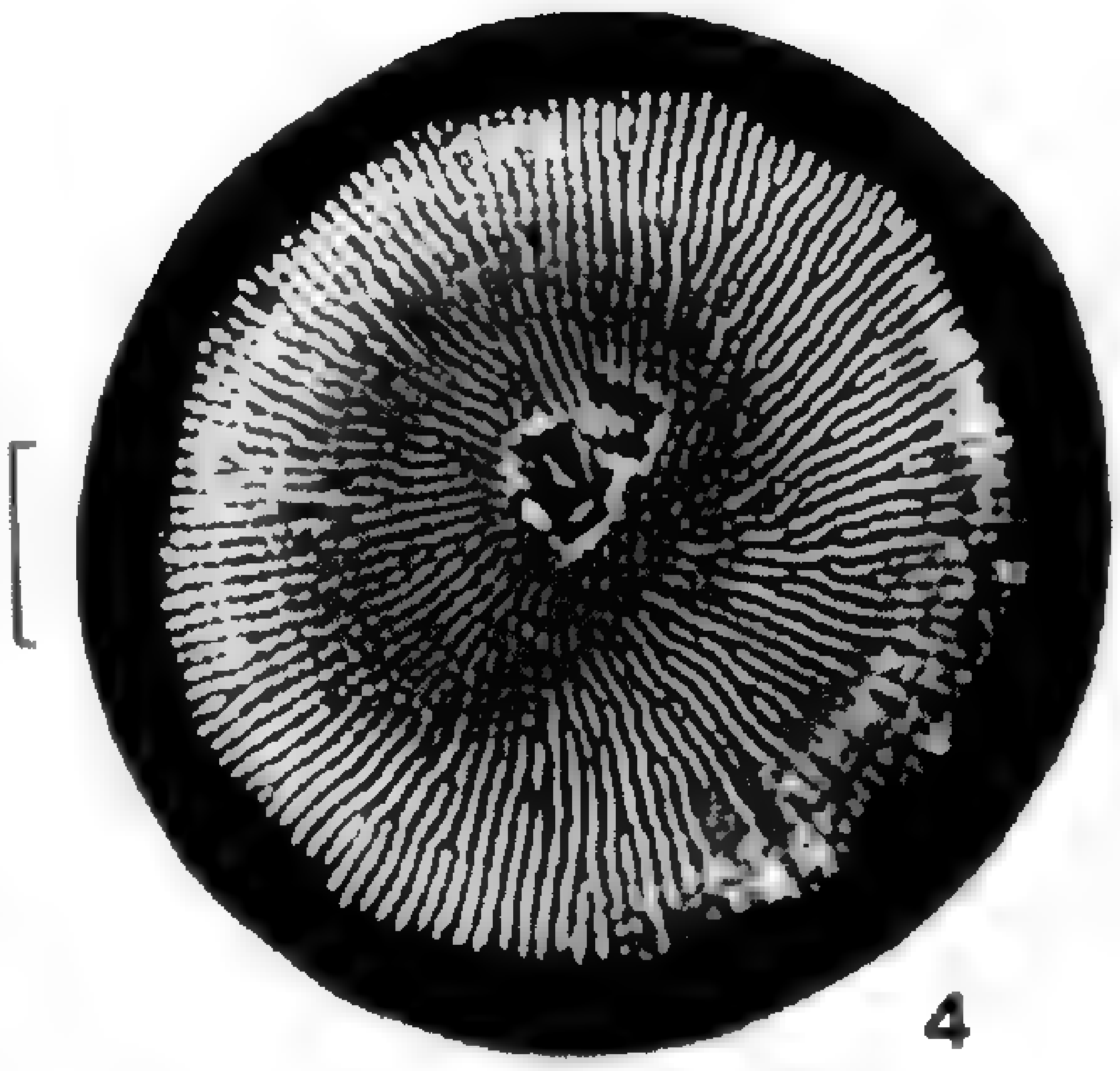
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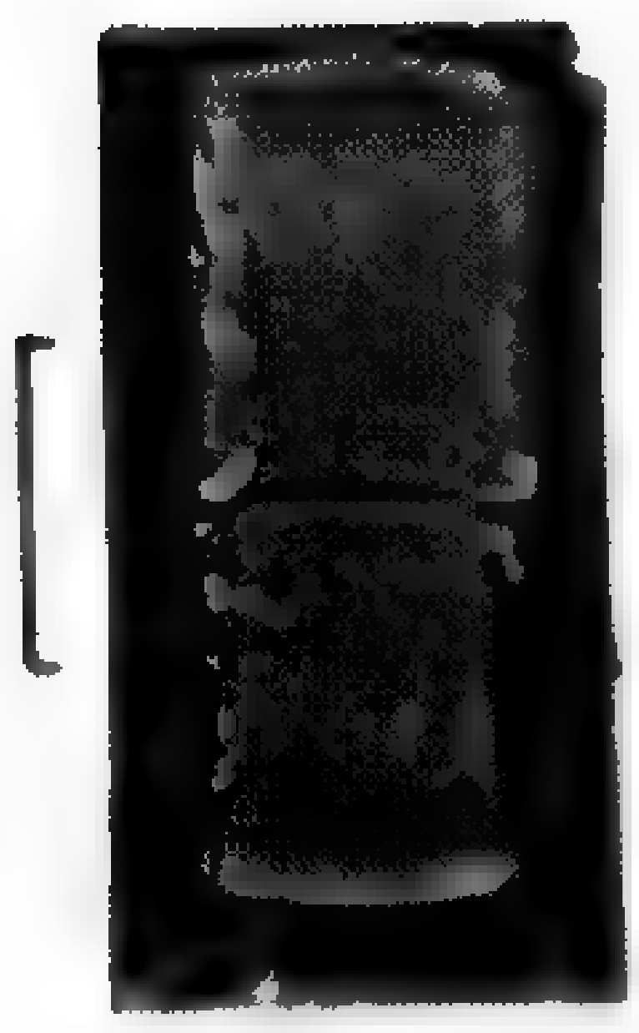
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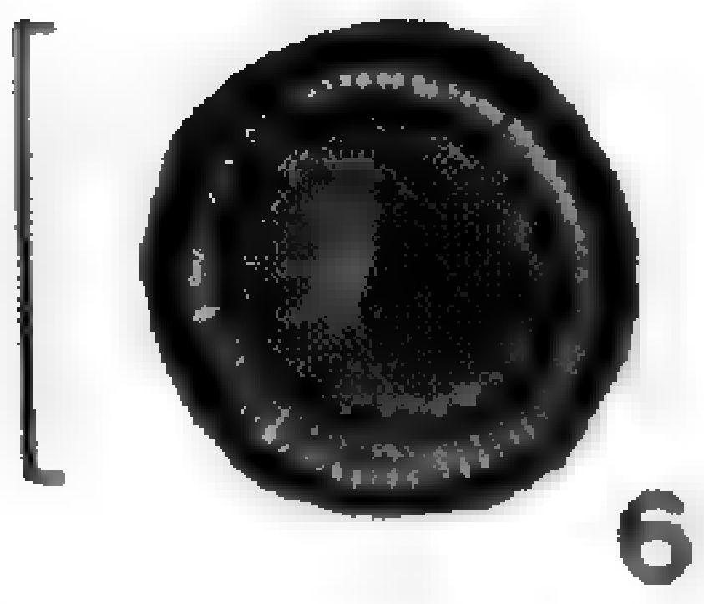
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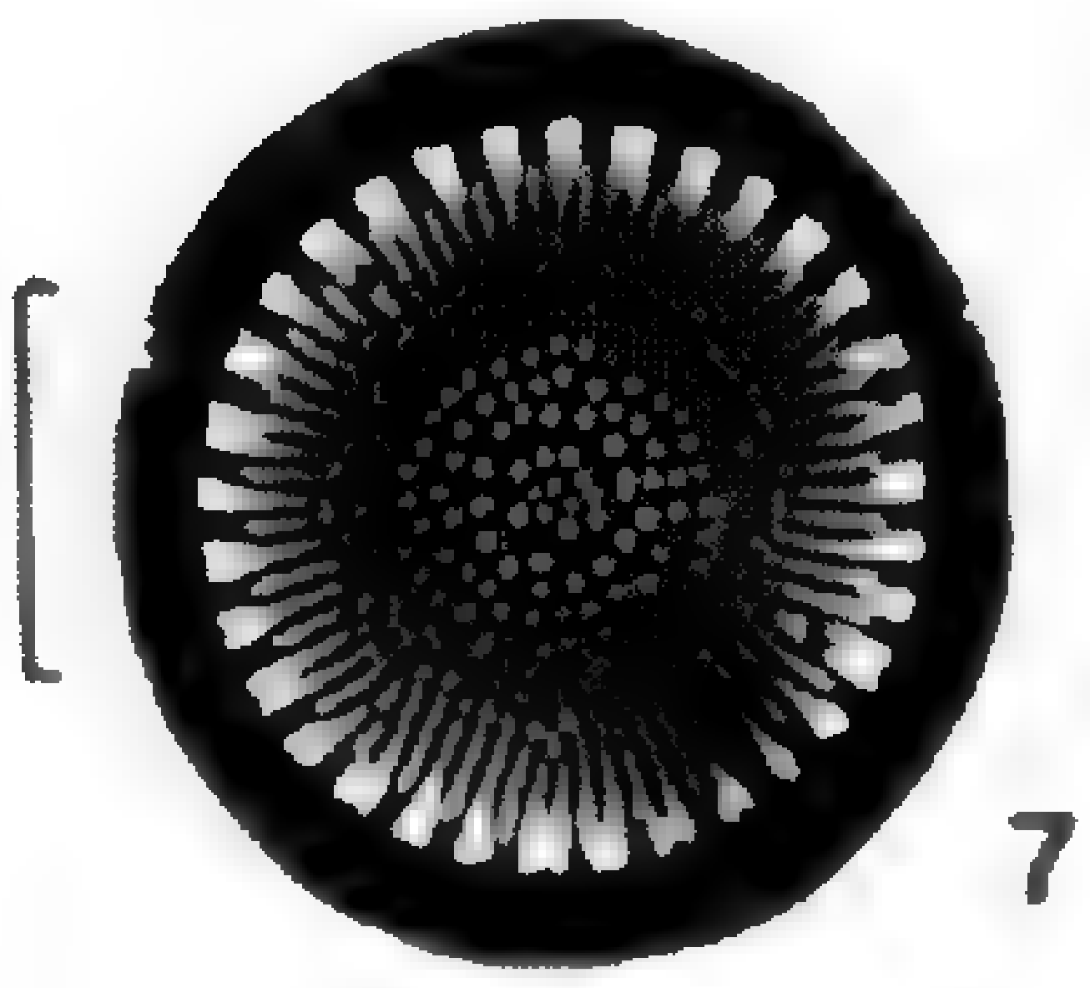
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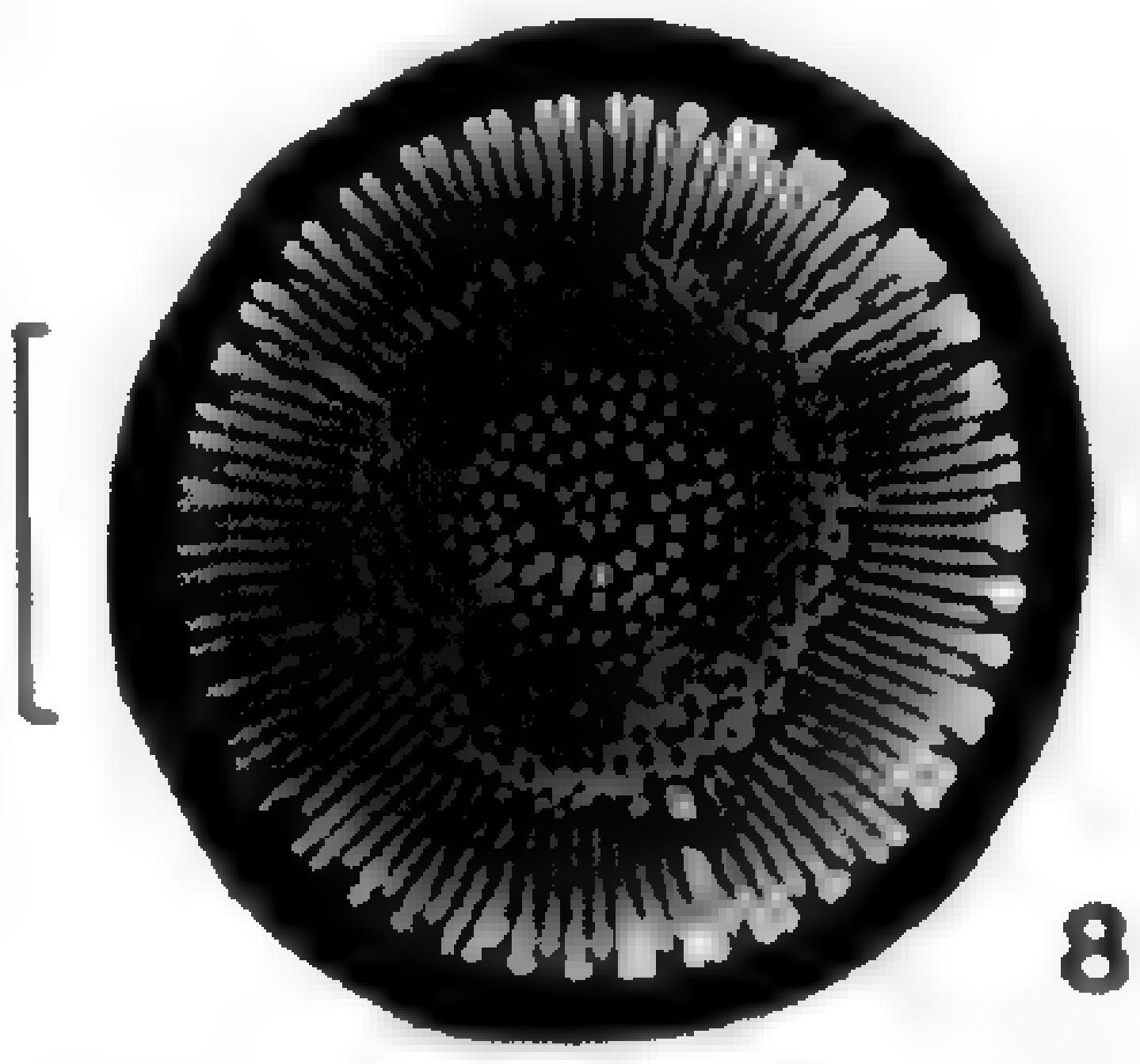
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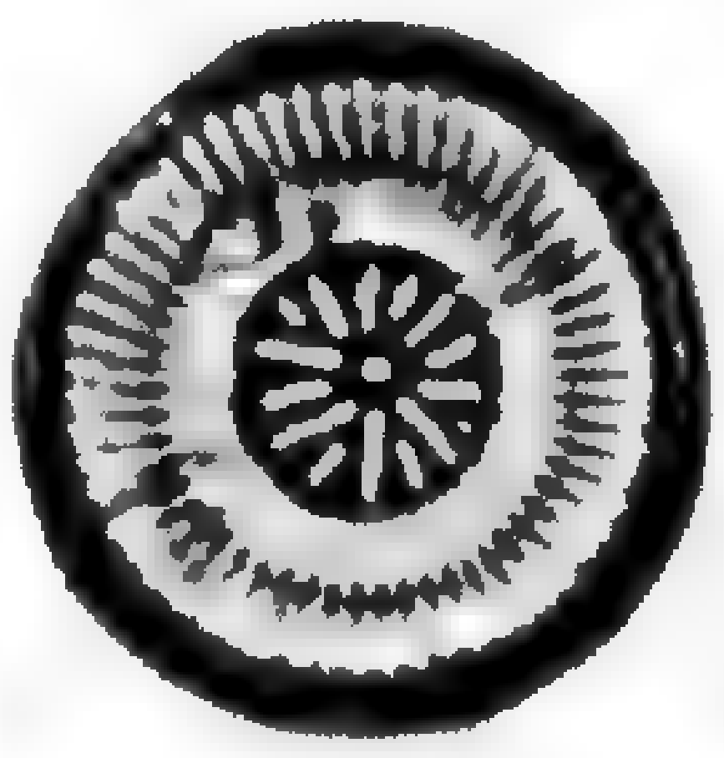
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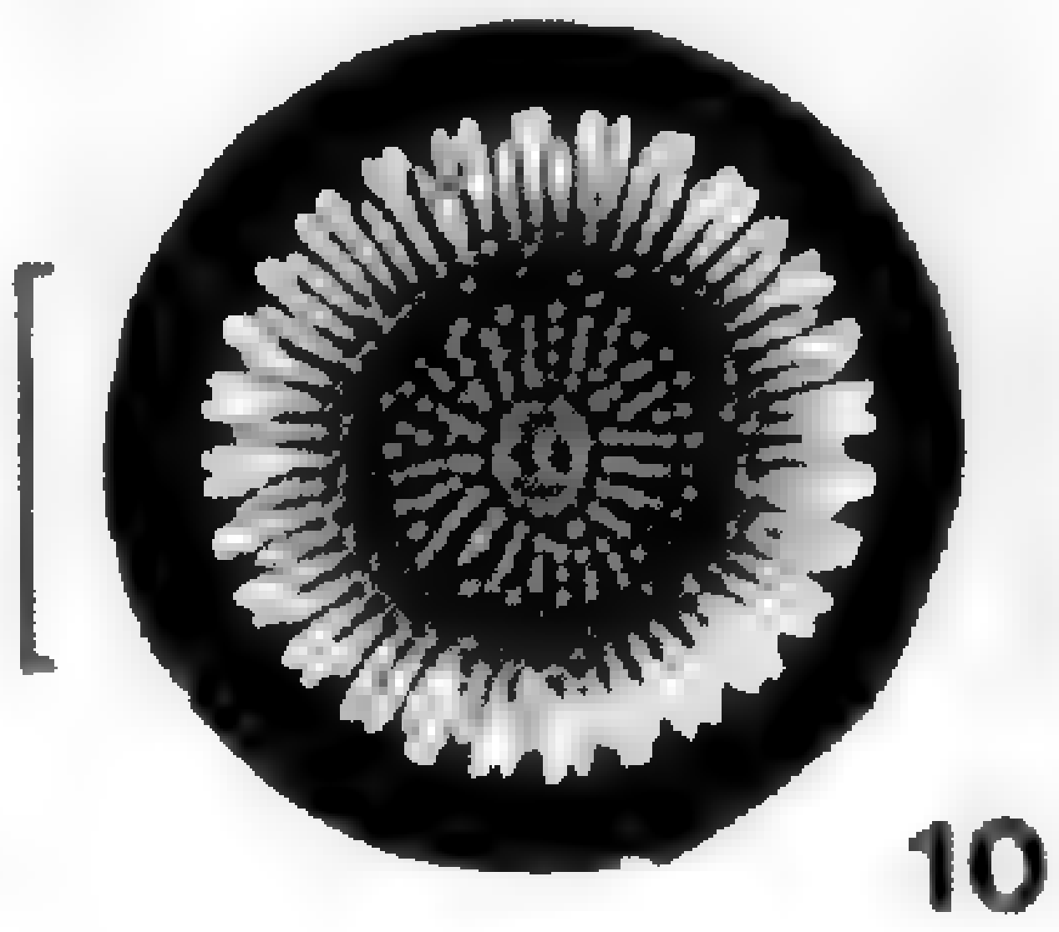
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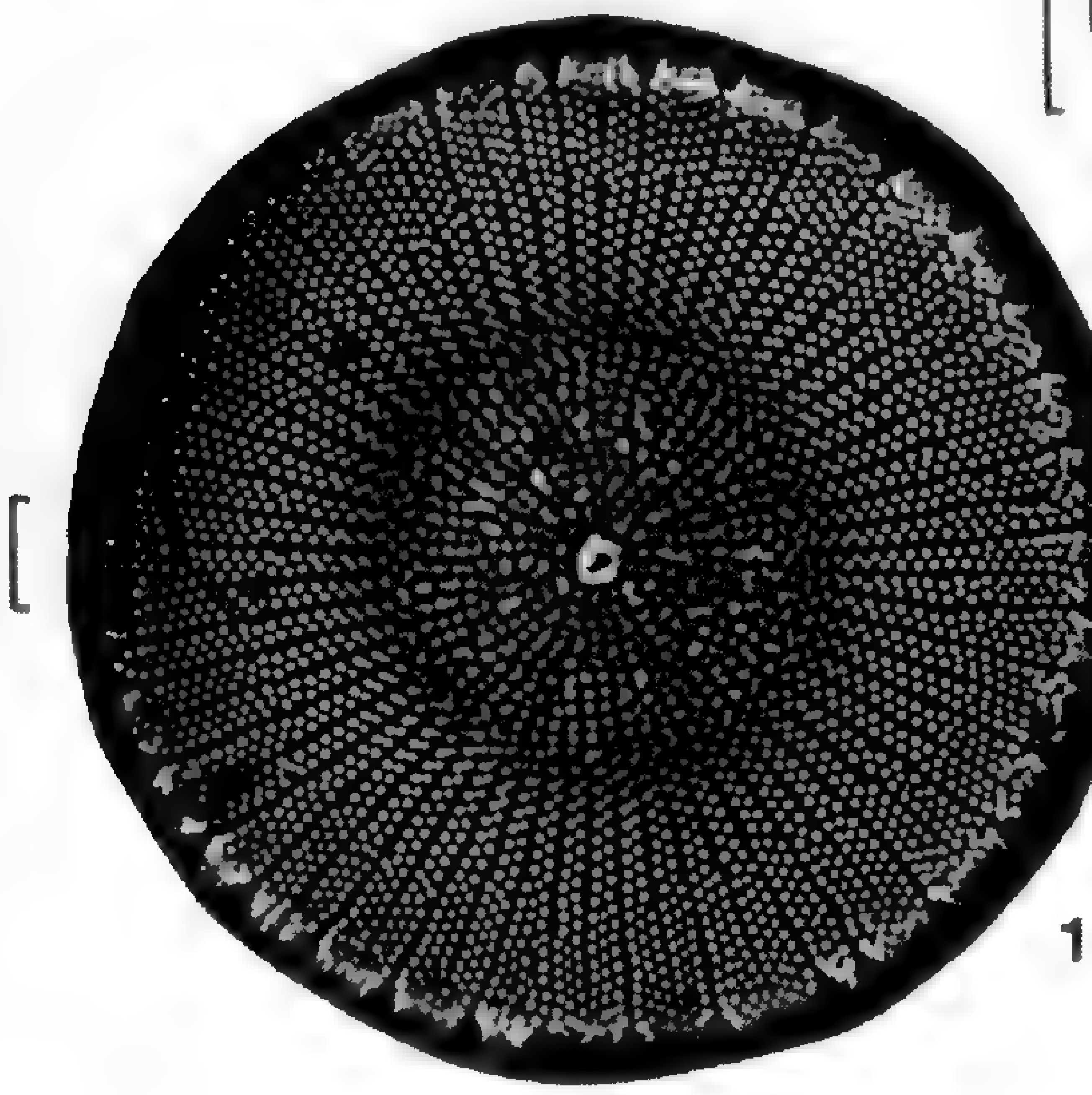
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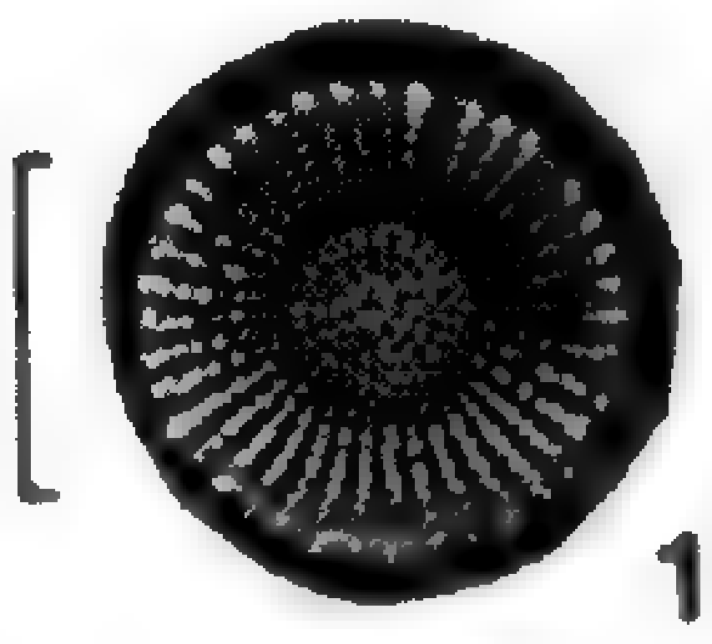
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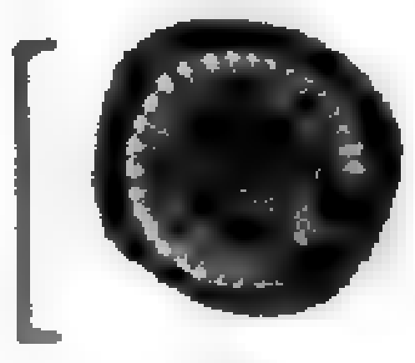
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COMMENTS: This species, although apparently simple in structure, may exhibit a high degree of variability (Schoeman & Archibald, 1980, figs. 1–156.).

FOREST CO.: Himley and Rice Lakes. IRON CO.: Clear and Mercer Lakes. ONEIDA CO.: Virgin and Whitefish Lakes. PRICE CO.: Butternut and Duroy Lakes.

C. michiganiana Skv., 1937. (Figure 6.)

DESCRIPTION: Valves 9–14 μm in diameter; outer region with radiate striae, 14–16 per 10 μm; inner region half-ornamented with scattered puncta.

FOREST CO.: Ground Hemlock, Himley, Silver, and Trump Lakes. IRON CO.: Clear and Long Lakes. LINCOLN CO.: Moraine Lake. ONEIDA CO.: Horsehead, Little Tomahawk, Minocqua, Spirit, Virgin, and Whitefish Lakes. VILAS CO.: Big Sand, Big Muskellunge, Deadman, Fence, Flambeau, Spider, Trout, and Upper Gresham Lakes.

C. ocellata Pant., 1902. (Figure 17.)

DESCRIPTION: Valves 9–18 μm in diameter; outer region with radiate striae, usually irregular in length, about 14–16 per 10 μm; inner region with large scattered puncta.

FOREST CO.: Duck Lake. IRON CO.: Lake-of-the-Falls. ONEIDA CO.: Little Tomahawk Lake. VILAS CO.: Big Sand, Black Oak, Flambeau, and North Twin Lakes.

C. pseudostelligera Hust. *In:* Huber-Pestalozzi, 1942. (Figure 20.)

DESCRIPTION: Valves 5–8 μm in diameter; outer region with radiate striae, usually 17–18 per 10 μm; inner region with puncta and thickened ribs generally arranged in a stellate fashion.

COMMENTS: Due to their extreme length the marginal strutted processes in this species resemble *Stephanodiscus*-spines when viewed under the light microscope. This feature, in combination with its smaller diameter, readily separates this taxon from *C. stelligera.* Belcher et al. (1966) have shown that silica concentrations

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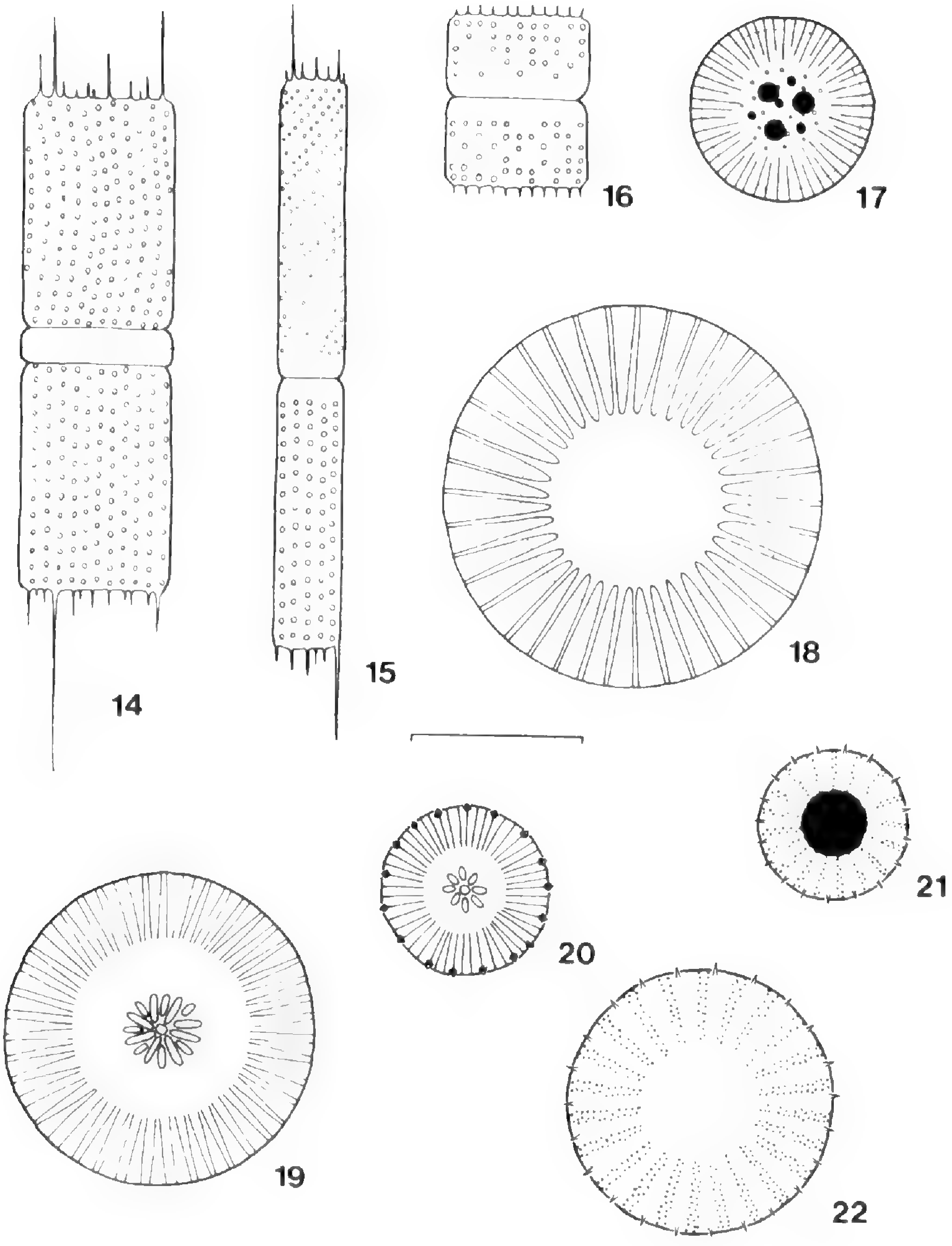
Figures 1–13. Photomicrographs of selected centric diatoms from northeastern Wisconsin. 1. *Melosira distans* var. *alpigena,* Third Black Lake, Iron Co.; 2. *Melosira italica,* Merrill Lake, Vilas Co.; 3. *Melosira granulata* var. *granulata,* Big Lake, Vilas Co.; 4. *Melosira undulata,* Long Lake, Iron Co.; 5. *Melosira varians,* Rice Lake, Forest Co.; 6. *Cyclotella michiganiana,* Upper Gresham Lake, Vilas Co.; 7. *Cyclotella comta,* Fence Lake, Vilas Co.; 8. *Cyclotella comta,* Clear Lake, Iron Co.; 9. *Cyclotella stelligera,* Echo Lake, Iron Co.; 10. *Cyclotella comta,* Fence Lake, Vilas Co.; 11. *Stephanodiscus niagarae,* Lake Metonga, Forest Co.; 12. *Stephanodiscus alpinus,* North Twin Lake, Vilas Co.; 13. *Stephanodiscus minutulus,* Horsehead Lake, Oneida Co. (Scale bar(s) equal 10 μm.)



Figures 14–22. Line drawings of selected Wisconsin centric diatoms. 14. *Melosira granulata* var. *granulata,* Big Lake, Vilas Co.; 15. *Melosira granulata* var. *angustissima,* Rice Lake, Vilas Co.; 16. *Melosira distans* var. *lirata,* Trude Lake, Iron Co.; 17. *Cyclotella ocellata,* Big Sand Lake, Vilas Co.; 18. *Cyclotella meneghiniana,* Himley Lake, Forest Co.; 19. *Cyclotella stelligera,* Echo Lake, Iron Co.; 20. *Cyclotella pseudostelligera,* Long Lake, Price Co.; 21. *Stephanodiscus minutulus,* Palmer Lake, Vilas Co.; 22. *Stephanodiscus hantzschii,* Metonga Lake, Forest Co. (Scale bar equals 10 μm).

have a significant effect on the pattern of valve ornamentation in *C. pseudostelligera,* and when silica deficiency occurs forms may resemble *C. woltereckii* Hustedt. Haworth & Hurley (1984) suspect that this taxon may represent one extreme of the normal range of variation of *C. stelligera.* Lowe (1975) has also observed unornamented valves in collections from the Laurentian Great Lakes.

FOREST CO.: Himley Lake. ONEIDA CO.: Katherine Lake. PRICE CO.: Butternut and Long Lakes. VILAS CO.: Big Gibson, Big Muskellunge, Big Sand, Black Oak, Catfish, Eagle, and Fence Lakes; and Lac-du-Lune and Lac Vieux Desert.

C. stelligera (Cl. & Grun.) V. H., 1882. (Figures 9, 19.)

DESCRIPTION: Valves 7–20 μm in diameter; outer region with radiate striae, 13–14 per 10 μm; inner region with puncta and thickened ribs generally arranged in a stellate fashion.

IRON CO.: Clear, Echo, Long, Lower Springstead, Mirror, Tank, Third Black, and Turtle-Flambeau Lakes; and Lake-of-the-Falls. LINCOLN CO.: Pine Lake. ONEIDA CO.: Nokomis, Rainbow, Sand, Virgin, and Whitefish Lakes. PRICE CO.: Cranberry and Pike Lakes. VILAS CO.: Deadman, McCullough, and Star Lakes.

Stephanodiscus Ehrenb.

Vegetative cells usually solitary, or rarely forming short chains; frustules circular in valve view, ornamented with radial rows of puncta, usually in fascicles, separated by broad and distinct interfascicles on the face: outer regions usually biseriate or occasionally multiseriate, gradually becoming uniseriate or irregularly punctate toward the center, usually with distinct marginal spines; frustules narrowly linear in girdle view, usually without ornamentation.

KEY TO TAXA

1. Marginal spines not alternating regularly with the fascicles at the valve margin, ca. 2–3 spines per 10 μm; valves 42–85 μm in diameter .... *S. niagarae*
1. Marginal spines alternating regularly with the fascicles at the valve margin, usually 8 or more per 10 μm; valves 6–20 μm in diameter .... **2.**
  2. Fascicles and spines 16–20 per 10 μm .... *S. minutulus*
  2. Fascicles and spines 8–10 per 10 μm .... **3.**
3. Valves with a more or less flattened central area; valves delicate, 8–14 μm in diameter .... *S. hantzschii*
3. Valves with a strongly sunken central area; valves typically robust, 17–20 μm in diameter .... *S. alpinus*

S. alpinus Hust., 1942. (Figure 12.)

Description: Valves 17–20 μm in diameter; outer puncta arranged in biseriate fascicles, about 8 per 10 μm, becoming irregularly punctate toward the valve center; spines prominent at the valve margin, usually alternating with the fascicles.

Comments: Håkansson & Stoermer (1984) and Theriot & Stoermer (1982) have shown that this is a highly variable species, with valve diameters often exceeding 30 μm.

ONEIDA CO.: Bearskin Lake. VILAS CO.: Fence and North Twin Lakes.

S. hantzschii Grun. *In:* Cleve & Grunow, 1880. (Figure 22.)

Description: Valves 8–14 μm in diameter; outer puncta arranged in biseriate fascicles, 9–10 per 10 μm, becoming uniseriate toward the valve center; spines prominent at the valve margin, usually alternating with the fascicles.

This taxon was only recorded from Metonga Lake (Forest Co.) in the present study; however, Lipsey & Fenwick (1978) have previously reported it from High Lake (Vilas Co.) suggesting a much wider distribution.

S. minutulus (Kütz.) Cleve & Möll., 1882. (Figures 13, 21.)

Description: Valves 6–9 μm in diameter; outer puncta arranged in biseriate fascicles, 16–20 per 10 μm, becoming uniseriate toward the valve center; spines prominent at the margin, usually alternating with the fascicles.

Comments: This species has been previously referred to as *S. minutus* Grun. *ex* Cleve & Möll. in the Great Lakes Region (Stoermer & Yang, 1969). However, Håkansson (1986) has recently shown that *S. minutulus* and *S. minutus* are distinctly different species.

FOREST CO.: Bug, Deep Hole, Ground Hemlock, and Metonga Lakes. LANGLADE CO.: Otter Lake. ONEIDA CO.: Bearskin, Crescent, Horsehead, and Nokomis Lakes. PRICE CO.: Butternut, Duroy, and Pike Lakes. VILAS CO.: Black Oak, North Twin, and Palmer Lakes.

S. niagarae Ehrenb., 1856. (Figure 11.)

Description: Valves 42–85 μm in diameter; outer puncta arranged in biseriate to multiseriate fascicles, 6–8 per 10 μm, becoming uniseriate toward the valve center; spines robust at the valve margin, usually not alternating with the fascicles, 2–3 per 10 μm.

This species is prevalent in most eutrophic lakes throughout the lake district.

3. Family Rhizosoleniaceae

Rhizosolenia Ehrenb.

Vegetative cells solitary, or forming short chains; frustules calyptrate to conical in valve view, orbicular in cross-section, without ornamentation, apically terminating in a long eccentric spine; frustules elongate in girdle view, with many overlapping segmented bands.

R. eriensis H. L. Smith, 1872. (Figure 23.)

DESCRIPTION: Frustules 33–143 μm long and 2–17 μm in diameter, with several segmented bands, about 2.5–4 per 10 μm, apically terminating in a long eccentric spine which is noticeably shorter than the frustule length.

FOREST CO.: Bug Lake. IRON CO.: Clear, Long, and Tank Lakes; and Lake-of-the-Falls. LINCOLN CO.: Harrison and Pine Lakes, ONEIDA CO.: Little Bearskin, Little Tomahawk, Minocqua, Sand, Spirit, Virgin, and Whitefish Lakes. PRICE CO.: Butternut and Pike Lakes. VILAS CO.: Big Arbor Vitae, Big Muskellunge, Crab, Eagle, Fence, Flambeau, North Twin, Spider, and Star Lakes; and Lac Vieux Desert.

4. Family Biddulphiaceae

Attheya T. West*

Vegetative cells solitary, or forming short chains; frustules bipolar in valve view, slightly elliptic in cross-section, without ornamentation, apically terminating in two long divergent spine-like protuberances; frustules, rectangular in girdle view, with many overlapping girdle bands.

A. zachariasi J. Brun, 1894. (Figure 24.)

DESCRIPTION: Frustules about 60 μm long and 17 μm in diameter, with several girdle bands, usually 4–5 per 10 μm, apically terminating in two divergent spine-like protuberances.

A rare taxon recorded only from Sand Lake (Oneida Co.).

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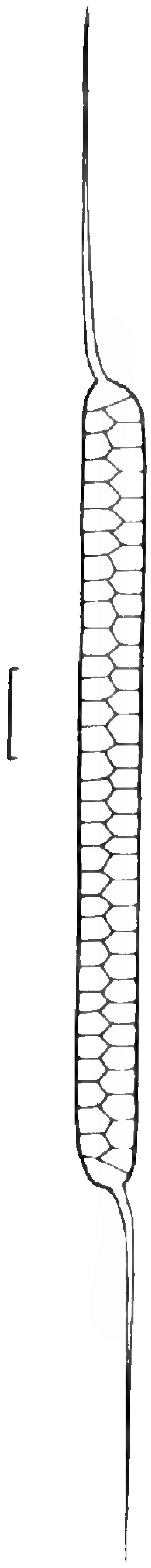
*Simonsen (1979) has proposed that freshwater species should be placed in the genus *Acanthoceras* Honigman.



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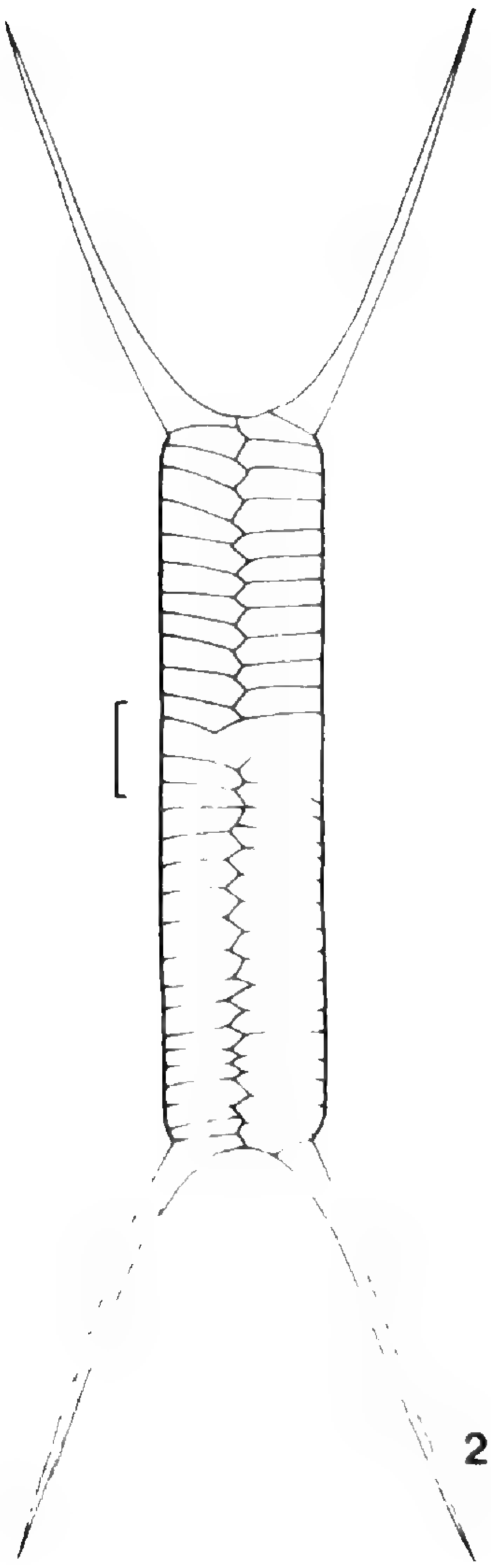

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Figure 23. *Rhizosolenia eriensis,* Virgin Lake, Oneida Co.

Figure 24. *Attheya zachariasi,* Sand Lake, Oneida Co. (Scale bar(s) equal 10 μm.)

DISCUSSION

Attheya zachariasi, Cyclotella ocellata, Melosira distans var. *alpigena, M. distans* var. *lirata, M. undulata,* and *Stephanodiscus alpinus* represent new state records. With the exception of *M. distans* var. *lirata,* however, these taxa apparently have a general distribution throughout the Laurentian Great Lakes (Stoermer & Kreis, 1978; Stoermer & Yang, 1969).

The majority of the nineteen centric diatoms described in this report are planktonic and are characteristically found within the limnetic zones (open water) of alkaline lakes throughout northeastern Wisconsin. Some species (e.g., *Cyclotella ocellata, C. stelligera, Melosira italica,* and *M. varians*), however, are also often found on substrates and other submerged objects as periphyton. *Cyclotella ocellata, C. michiganiana, Melosira undulata,* and *Stephanodiscus alpinus* are observed more frequently in oligotrophic lakes. Conversely, *Cyclotella meneghiniana, Melosira granulata* var. *angustissima, M. granulata* var. *granulata,* and *Stephanodiscus niagarae* are commonly found in eutrophic lakes.

Sloey & Blum (1972) have recorded *Cyclotella meneghiniana, Melosira granulata* var. *angustissima, M. italica, M. varians, Stephanodiscus hantzschii,* and *S. niagarae* from the Winnebago Pool in southeastern Wisconsin. *Cyclotella comta, C. meneghiniana, C. michiganiana, C. pseudostelligera, C. stelligera, M. granulata* var. *angustissima, M. granulata* var. *granulata, M. italica, M. varians, S. hantzschii, S. minutulus* (as *S. minutus*), and *S. niagarae* have also been reported in southwestern Wisconsin, including the border of the main channel of the upper Mississippi River, by Andrews (1966), Strenski (1979), and Vansteenburg et al. (1984).

Vansteenburg et al. (1984) have recorded 17 additional species and subspecific taxa from the Mississippi River. The full extent of these and other centric diatom species ranges, however, will only be determined through continued floristic investigations.

ACKNOWLEDGMENTS

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COMPOSITIONAL-STRUCTURAL RELATIONS IN OLD-GROWTH FORESTS, CAPE BRETON ISLAND

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ABSTRACT

Lowland and upland, old-growth, deciduous forests in northern Cape Breton Island reflect an appreciable representation, in both canopy and sub-canopy layers, of species that reach the northeastern limit of their ranges in the area. A high percentage of arborescent species in the lowland forests are southern in their distributional affinities, whereas upland forests are comprised mainly of species whose distributions are Canadian and boreal. Canopy elements in lowland forests reach considerable heights with size falling off appreciably with increasing altitude. Basal area per acre for stems 4 inches and above in diameter at breast height (D.B.H.) in these old-growth forests varies from 115 to 181 square feet and trees per acre range from 157 to 268.

Key Words: Deciduous forests, distribution patterns, forest composition, geographical affinities, Nova Scotia

INTRODUCTION

Several tracts of undisturbed, old-growth, deciduous forest remain standing in northern Cape Breton Island. Many of the species occurring in these stands reach the northeastern limit of their ranges in this area, which is one of pronounced physiographic diversity. Constituent species, using the nomenclature of Fernald (1950), which demonstrate this pattern of distribution include: American beech, *Fagus grandifolia* Ehrh.; northern red oak, *Quercus rubra* L. var. *borealis* (Michaux f.) Farw.; American elm, *Ulmus americana* L.; sugar maple, *Acer saccharum* Marsh.; and white ash, *Fraxinus americana* L. (Fernald, 1950; Rouleau, 1956, 1978; Little, 1971). The purpose of this paper is to provide information on the characteristics of three of these old-growth forests, and particularly on the composition, geographical affinities, and structural relationships of canopy and sub-canopy layers.

Both upland and lowland forests are considered in the following paragraphs. Lowland forests selected for analysis include, first, those occupying the foot-slopes and alluvial bottom-lands of the lower Grande Anse River Valley, and second, those found on the treads of the extensive strath-terrace complex of the middle reaches of the North Aspy River (Figure 1). The upland forests chosen for discussion occur on the leisurely approaches to the summit-surface of the Cape Breton Plateau (summit-surface elevation: 1450–1600 ft.) in the middle-upper reaches of the Northeast Margaree River. These sites are situated above the break-in-slope separating the steep valley-sides from the gentle approaches to the plateau, and below the altitudinal limit (approximately 1315 ft.) of the range of sugar maple in this region.

METHODS

The field studies upon which this paper is based formed part of a larger program concerned with the water relations, distribution patterns and silvics of forest trees. Preliminary reconnaissance surveys were initiated in 1948. Intensive studies were commenced in the late 1950s and are continuing.

Temporary sample-plots were utilized in the collection of information. Plot shape and area included square and circular forms of 0.1, 0.2 and 0.4 acres. Square, 0.4 acre plots were employed in the construction of stand-tables for the bottom-land and terrace-tread sites of the Grande Anse and North Aspy tracts, characterized by the presence of a modest number of relatively large trees per acre. Alternatively, in the upland forests of the Northeast Margaree watershed square, 0.1 and 0.4 acre plots were utilized, with plot size varying with density and average diameter of stems. Within the square sample-plots all trees of D.B.H. 4 inches and above were tallied by species and diameter. The heights of a number of canopy trees in each plot were determined with the aid of an Abney level. In studies of stand-structure and vertical stratification, where information regarding the identity, D.B.H., crown-class, bearing and distance of each tree from the plot center was required, 0.2 acre, circular sample-plots were employed in both upland and lowland forests. As in the square plots, the heights of a number of canopy trees were determined in each circular plot.

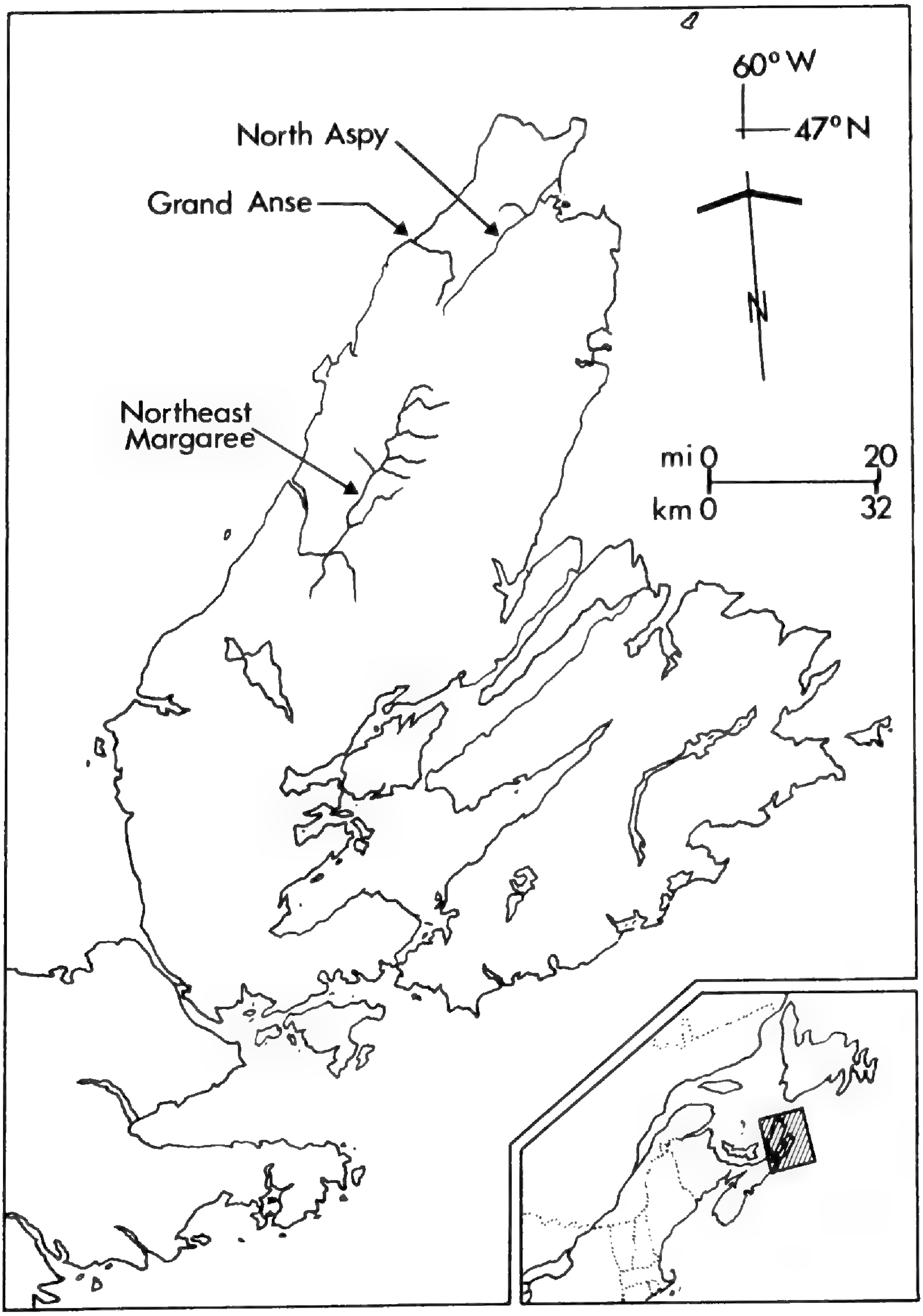

Figure 1. Map of Cape Breton Island, showing location of the three study areas.

In the analysis of the structural aspects of vertical stratification in the sample areas two major height categories have been recognized; namely, canopy and sub-canopy elements. Within the canopy (superior arboreal layer), two tree-classes are included: (a) dominant-class trees which extend somewhat above the main canopy level; and (b) co-dominant-class trees, the crowns of which form the general level of the overstory. Below the canopy three classes of sub-canopy elements have been recognized: (a) intermediate-class trees comprising individuals of canopy-species populations of insufficient stature thus far to have achieved full canopy height; (b) individuals of small-tree-species populations normally demonstrating insufficient height to reach the canopy; and (c) isolated and overtopped individuals of diameters equal to or exceeding 4 inches at breast height.

With reference to abundance and physiognomy, prominent and principal taxa are designated primary species, and populations of lesser abundance are termed secondary or minor species.

OBSERVATIONS

A. Lowland forests

—Grande Anse River: Bottom-lands and foot-slopes
—North Aspy River: Strath-terrace treads

A stand-table illustrating the number of trees by diameter and species for the Grande Anse tract is presented in Table 1. It is evident that the largest number of trees occurs in the smallest diameter-class, and there is a progressive reduction in the number of trees per class with increasing diameter. A plot of the average number of trees per acre per 3-inch diameter interval against middle diameter of interval for the data of Table 1 reflects a concave-upward, curvilinear relationship, an inverted, approximately J-shaped curve often accepted as characteristic of uneven-aged forests (Berglund, 1976; Daniel et al., 1979). Trees per acre in the Grande Anse tract total 190 and basal area per acre approaches 181 square feet, leading to a calculated average distance between trees of 15.2 ft. and an average D.B.H. of 13.3 in. Canopy trees on these alluvial bottom-lands range from 79 to approximately 100 ft. in height.

Table 1 indicates that the primary species of the Grande Anse sample are *Acer saccharum* and *Betula lutea.* These taxa together include approximately 90 per cent of the stems in this forest equalling or exceeding 4 in. D.B.H. Both *Acer saccharum* and *Betula* *lutea* are well distributed over the range of tree diameters found in the Grande Anse tract. Also present in small numbers are representatives of several other broad-leaved species including *Fagus grandifolia, Quercus rubra* var. *borealis, Fraxinus americana* and *Ulmus americana.* Small-tree species present include *Acer pensylvanicum* and *Acer spicatum.* A modest number of small, coniferous stems also occurs in this forest.

Minor variations in composition distinguish the forest of the alluvial bottom-lands of the Grande Anse from that of the foot-slopes. These differences are summarized in Table 2 by grouping total species counts from Table 1. *Acer saccharum* and *Betula lutea* are of approximately equal abundance on the foot-slopes, but on the bottom-lands the density of *Acer saccharum* much exceeds that of *Betula lutea. Fagus grandifolia, Quercus rubra* var. *borealis* and *Ulmus americana,* while tallied on the foot-slopes, did not occur in any of the bottom-land plots, although the presence of *Quercus rubra* var. *borealis* and *Ulmus americana* on the valley-bottom was noted.

Composition and structural relations of canopy and sub-canopy layers of the bottom-land and lower valley-side-slope forests of the Grande Anse tract are illustrated in Table 3. *Acer saccharum* and *Betula lutea* again are the primary species, and, with one exception, these taxa are abundant in all layers. The dominant tree-class comprises *Acer saccharum* exclusively, and of the remaining species two are represented only in the canopy layer (*Acer rubrum* and *Ulmus americana*), one in both canopy and sub-canopy layers (*Fagus grandifolia*) and one solely in the sub-canopy layer (*Picea* sp.).

Table 4 illustrates diameter-class distribution and species composition in the strath-terrace hardwoods of the North Aspy River. As in the Grande Anse tract the largest number of trees occurs in the smallest diameter-class, and there is a similar but seemingly more erratic reduction in the number of trees per diameter-class with increasing diameter. However, a plot of the average number of trees per acre per 3-inch diameter interval against middle diameter of interval for the North Aspy data demonstrates a concave-upward, curvilinear relationship similar to that for the Grande Anse tract (Table 1). The average number of trees per acre in the North Aspy tract is 157 and average basal area per acre is 115.4 square feet, both of which are below those for the Grande Anse sample. The calculated average distance between trees for the North Aspy tract is 16.7

Table 1. Number of trees, Grande Anse tract. Basis: twelve 0.4 acre plots.

	Species									
D.B.H. (in.)	*Acer saccharum*	*Betula lutea*	*Fagus grandifolia*	*Quercus rubra* var. *borealis*	*Fraxinus americana*	*Ulmus americana*	Small-tree species	*Abies balsamea*	*Picea* spp.	Totals
4	46	27	3	–	–	–	8	17	–	101
5	42	33	6	–	1	–	2	11	–	95
6	33	16	4	–	–	–	1	11	1	66
7	29	16	2	1	–	–	1	8	–	57
8	28	15	–	–	–	–	–	2	–	45
9	32	19	2	–	–	–	–	1	–	54
10	36	15	–	1	–	–	–	1	–	53
11	30	26	2	–	–	–	–	--	–	58
12	34	16	–	–	–	–	–	--	–	50
13	16	15	–	2	1	–	–	--	–	34
14	19	19	2	–	–	–	–	--	–	40
15	23	11	1	–	–	–	–	--	–	35
16	16	10	–	1	–	–	–	--	–	27
17	23	9	–	–	1	–	–	--	–	33
18	8	11	1	–	–	–	–	--	–	20
19	17	12	–	–	–	–	–	--	–	29
20	10	10	–	–	–	–	–	--	–	20
21	6	12	–	–	–	–	–	--	–	18
22	5	3	–	–	–	–	–	--	–	8
23	4	9	–	–	–	–	–	--	–	13
24	5	9	–	–	–	1	–	--	–	15
25	1	1	–	–	–	–	–	--	–	2

Table 1. Continued.

	Species									
D.B.H. (in.)	*Acer saccharum*	*Betula lutea*	*Fagus grandifolia*	*Quercus rubra* var. *borealis*	*Fraxinus americana*	*Ulmus americana*	Small-tree species	*Abies balsamea*	*Picea* spp.	Totals
26	1	5	–	–	–	–	–	—	–	6
27	1	4	–	–	–	–	–	—	–	5
28	4	5	–	–	–	–	–	—	–	9
29	2	2	–	–	–	–	–	—	–	4
30	1	1	–	–	–	–	–	—	–	2
31	—	3	–	–	–	–	–	—	–	3
32	2	3	–	–	–	–	–	—	–	5
33	—	—	–	–	–	–	–	—	–	—
34	—	1	–	–	–	–	–	—	–	1
35	—	1	–	–	–	–	–	—	–	1
36	—	—	–	–	–	–	–	—	–	—
37	—	1	–	–	–	–	–	—	–	1
38	—	—	–	–	–	–	–	—	–	—
Totals	474	340	23	5	3	1	12	51	1	910
Percentage	52.1	37.4	2.5	0.5	0.3	0.1	1.3	5.6	0.1	100
Trees per acre	99	71	5	1	0.6	0.2	2.5	11	0.2	190
Basal area per acre	86.17	88.26	2.03	0.85	0.55	0.65	0.30	1.87	0.04	180.72 ft.^{2}

Table 2. Number and percentage of trees, alluvial bottom-lands versus foot-slopes, Grande Anse River Forest. Basis: twelve 0.4 acre plots equally divided between bottom-lands and foot-slopes.

	Species									
Site	*Acer saccharum*	*Betula lutea*	*Fagus grandifolia*	*Quercus rubra* var. *borealis*	*Fraxinus americana*	*Ulmus americana*	Small-tree species	*Abies balsamea*	*Picea* spp.	Totals
Foot-slope	225	217	23	5	2	1	6	37	---	516
Percentage	43.7	42.1	4.5	1.0	0.4	0.2	1.2	7.2	---	---
Bottom-land	249	123	---	---	1	---	6	14	1	394
Percentage	63.2	31.2	---	---	0.3	---	1.5	3.5	0.3	---

Table 3. Vertical stratification in Grande Anse Forest. Basis: five 0.2 acre plots.

		Species											
	Total trees	*Acer saccharum*		*Betula lutea*		*Acer rubrum*		*Ulmus americana*		*Fagus grandifolia*		*Picea* spp.	
Tree class	per class	#	%	#	%	#	%	#	%	#	%	#	%
Dominant	14	14	100	--	--	-	---	-	---	-	---	-	-
Co-dominant	66	57	86	6	9	1	1.5	1	1.5	1	1.5	-	-
Intermediate	37	28	76	8	22	-	---	-	---	1	3.0	--	
Small-tree species	6	---	---	--	--	-	---	-	---	-	---	--	
Overtopped	16	10	63	4	25	-	---	-	---	1	6	1	6
Totals	139	109	---	18	--	1	---	1	---	3	---	1	-

ft. and the average D.B.H. is 11.6 in. Overstory trees in the North Aspy stand are of the order of 85 ft. in height.

The primary species in the North Aspy tract are *Acer saccharum, Betula lutea* and *Acer rubrum* (Table 4). These three taxa together include 85 percent of the stems in this forest equalling or exceeding 4 in. D.B.H. The number of stems of *Acer saccharum* is double that of either *Betula lutea* or *Acer rubrum,* although the ranges of diameters reflected by the primary species are very similar. *Fagus grandifolia, Quercus rubra* var. *borealis* and *Acer pensylvanicum* also are present in the North Aspy sample, and there is a small coniferous element comprising *Picea* sp. and *Abies balsamea* restricted to the smaller diameter classes.

B. Upland forests

—Northeast Margaree River: plateau approaches

Diameter-class distribution and species composition of upland forests in the middle-upper reaches of the Northeast Margaree River are shown in Table 5. As in the Grande Anse and North Aspy stands the largest number of stems occurs in the smallest diameter-class, and there is an irregular decrease in the number of trees per diameter-class with increasing diameter. Again a plot of the average number of trees per acre per 3-inch diameter interval against middle diameter of interval for the data of Table 5 reflects a concave-upward, curvilinear relationship approximating an inverted, J-shaped curve. Trees per acre in the upland sample average 268 and basal area per acre approaches 127 square feet. Density expressed in trees per acre is higher in the upland sample than in the Grande Anse and North Aspy tracts, while basal area per acre is intermediate in magnitude. The calculated average distance between trees on the upland is 12.8 ft. and the average D.B.H. is 9.3 in. The height of canopy trees in the upland sample averages 48 ft.

The primary species of the upland sample are *Acer saccharum, Betula lutea* and *Abies balsamea,* with *Acer rubrum, Betula papyrifera* and *Fagus grandifolia* demonstrating more modest abundance (Table 5). *Betula lutea,* although less abundant than *Acer saccharum,* is distributed over a wider range of diameters, while the diameter range of *Abies balsamea* is similar to that of *Acer saccharum.* A severe outbreak of spruce budworm is now devastating *Abies balsamea* throughout Cape Breton Island, with upland forests suffering particularly heavy damage.

Compositional and structural relations of canopy and sub-canopy layers are illustrated in Table 6. The dominant tree-class comprises *Acer saccharum* and *Betula lutea* and the co-dominant class includes *Acer saccharum, Betula lutea, Fagus grandifolia* and *Acer rubrum. Acer saccharum* and *Betula lutea* are the most abundant species of the intermediate-class trees, while *Acer saccharum* and *Abies balsamea* have the highest densities in the overtopped class. A summary of the stand-characteristics of the sample areas is included in Table 7.

DISCUSSION

Nichols (1935) and Braun (1950) recognized, within the hemlock-white pine-northern hardwood region of eastern North America, four groups of species delineated on the basis of distribution and geographical affinities. Group (A) was comprised of species whose centers of north-south distribution lie far to the south of the region—e.g., *Fagus grandifolia* and *Fraxinus americana.* Group (B) was composed of species whose centers of north-south distribution lie partly within and partly immediately to the south of the region, but which range well to the southward—e.g., *Acer saccharum* and *Quercus rubra* var. *borealis.* Group (C) was comprised of species whose centers of north-south distribution fall within the region and "whose ranges are more or less coextensive with it or some part of it" (Braun, 1950: 339)—e.g., *Betula lutea* and *Picea rubens* Sarg. Group (D) was composed of species whose centers of north-south distribution are disposed to the north of the region and which are widely distributed northward—e.g., *Picea glauca* and *Abies balsamea.* Reference to Tables 1, 4 and 5 indicates that representatives of all four of the preceding groups are present in the hardwood forests of northern Cape Breton Island and supports the inclusion by Braun (1950) and Nichols (1935) of the forests of Cape Breton Island within the hemlock-white pine-northern hardwood region of eastern North America.

Fagus grandifolia, Ulmus americana and *Fraxinus americana,* included in Group (A) of Nichols (1935), approach the northeastern limit of their ranges in the Grande Anse–North Aspy region. Individuals of these species occur as canopy and sub-canopy elements on the alluvial bottom-lands and on foot-slopes in the Grande Anse

Table 4. Number of trees, North Aspy tract. Basis: three 0.4 acre plots.

	Species								
D.B.H. (in.)	*Acer saccharum*	*Betula lutea*	*Acer rubrum*	*Acer pensylvanicum*	*Quercus rubra* var. *borealis*	*Fagus grandifolia*	*Picea* spp.	*Abies balsamea*	Total trees
4	12	5	11	6	–	–	1	2	37
5	5	6	2	5	–	1	–	2	21
6	5	1	2	2	–	–	2	1	13
7	4	1	1	1	–	–	–	1	8
8	4	4	2	2	–	–	–	–	12
9	3	3	3	–	–	–	–	1	10
10	7	—	—	–	–	–	–	–	7
11	4	—	4	–	–	–	–	–	8
12	6	4	1	–	–	–	–	–	11
13	7	3	—	–	–	–	–	–	10
14	2	1	1	–	–	–	–	–	4
15	6	2	1	–	–	–	–	–	9
16	2	2	1	–	–	–	–	–	5
17	5	1	4	–	–	–	–	–	10
18	3	1	—	–	–	–	–	–	4
19	3	—	2	–	–	–	–	–	5
20	2	—	1	–	1	–	–	–	4
21	—	1	—	–	–	–	–	–	1
22	2	1	1	–	–	–	–	–	4
23	1	—	1	–	–	–	–	–	2
24	1	1	—	–	–	–	–	–	2
25	1	—	—	–	–	–	–	–	1

Table 4. Continued.

	Species								
D.B.H. (in.)	*Acer saccharum*	*Betula lutea*	*Acer rubrum*	*Acer pensylvanicum*	*Quercus rubra* var. *borealis*	*Fagus grandifolia*	*Picea* spp.	*Abies balsamea*	Total trees
Totals	85	37	38	16	1	1	3	7	188
Percentage	45.2	19.7	20.2	8.5	0.5	0.5	1.5	3.7	99.8
Trees per acre	70.8	30.8	31.7	13.3	0.8	0.8	2.5	5.8	157
Basal area per acre	62.2	23.5	24.2	2.1	1.8	0.1	0.4	1.1	115.4 ft.^{2}

Table 5. Number of trees, upland old-growth stands, Northeast Margaree River. Basis: eight plots together comprising 2.3 acres.

	Species								
D.B.H. (in.)	*Acer saccharum*	*Betula lutea*	*Betula papyrifera*	*Acer rubrum*	*Fagus grandifolia*	Small-tree species	*Picea spp.*	*Abies balsamea*	Total trees
4	68	15	–	–	2	1	–	31	117
5	40	9	1	–	1	1	–	18	70
6	45	6	–	2	1	–	1	18	73
7	30	5	1	1	1	–	–	8	46
8	38	9	–	3	3	–	–	11	64
9	29	7	–	–	–	–	1	7	44
10	36	9	–	–	–	–	–	2	47
11	23	6	2	–	–	–	–	7	38
12	20	10	–	–	1	–	–	7	38
13	9	1	–	–	–	–	–	1	11
14	7	7	2	–	–	–	–	--	16
15	9	7	–	–	–	–	–	2	18
16	3	1	–	–	–	–	–	1	5
17	1	4	–	–	–	–	–	1	6
18	2	3	–	–	–	–	–	--	5
19	1	6	–	–	–	–	–	--	7
20	--	3	–	–	–	–	–	--	3
21	--	2	–	–	–	–	–	--	2
22	--	1	–	–	–	–	–	--	1
23	--	1	–	–	–	–	–	--	1
24	--	3	–	–	–	–	–	--	3

Table 5. Continued.

	Species								
D.B.H. (in.)	*Acer saccharum*	*Betula lutea*	*Betula papyrifera*	*Acer rubrum*	*Fagus grandifolia*	Small-tree species	*Picea spp.*	*Abies balsamea*	Total trees
25	--	1	–	–	–	–	–	--	1
26	--	--	–	–	–	–	–	--	--
27	--	--	–	–	–	–	–	--	--
28	--	--	–	–	–	–	–	--	--
29	--	--	–	–	–	–	–	--	--
30	--	1	–	–	–	–	–	--	1
31	--	--	–	–	–	–	–	--	--
Totals	361	117	6	6	9	2	2	114	617
Percentage	58.5	18.9	1.0	1.0	1.5	0.3	0.3	18.5	100
Trees per acre	157.0	50.9	2.6	2.6	3.9	0.9	0.9	49.6	268
Basal area per acre	62.15	45.41	1.68	0.74	1.13	0.10	0.28	15.36	126.85 ft.^{2}

Table 6. Vertical stratification in upland old-growth stands, Northeast Margaree River. Basis: five 0.2 acre plots.

		Species									
	Total trees per class	*Acer saccharum*		*Betula lutea*		*Fagus grandifolia*		*Acer rubrum*		*Abies balsamea*	
Tree class		#	%	#	%	#	%	#	%	#	%
Dominant	12	9	75.0	3	25.0	–	---	–	---	–	---
Co-dominant	118	91	77.1	22	18.6	2	1.7	3	2.5	–	---
Intermediate	53	43	81.1	9	17.0	1	1.9	–	---	–	---
Small-tree species	1	–	----	--	----	–	---	–	---	–	---
Overtopped	33	21	63.6	3	9.1	3	9.1	–	---	6	18.2
Totals	217	164		37		6		3		6	

Table 7. Summary of stand-characteristics: Grand Anse, North Aspy and Northeast Margaree samples.

	Region		
Stand-Characteristic	Grande Anse	North Aspy	Northeast Margaree
Site	Bottom-land and foot-slopes	Terrace tread	Upland surface
Trees per acre	190	157	268
Basal area per acre	181 ft.^{2}	115 ft.^{2}	127 ft.^{2}
Average distance between trees	15 ft.	17 ft.	13 ft.
Average D.B.H.	13 in.	12 in.	9 in.
Average height of co-dominant trees	87 ft.	85 ft.	48 ft.

stand (Tables 1, 2 and 3). While *Fagus grandifolia* is well represented in this forest, both *Ulmus americana* and *Fraxinus americana* constitute minor species. In contrast, in the North Aspy stand which occupies the treads of an extensive strath-terrace complex, the only one of the three southern species represented is *Fagus grandifolia* and it is characterized by very low density (Table 4). Similarly, of these same three southern species only *Fagus grandifolia* occurs in the upland forest sample (Table 5), reflecting modest abundance in terms of trees per acre.

Acer saccharum and *Quercus rubra* var. *borealis,* representative of Group (B) of Nichols (1935), similarly are on the periphery of their ranges in northern Cape Breton Island. However, these two species differ radically in their abundance and patterns of distribution in the area. *Quercus rubra* var. *borealis* is found in modest numbers on foot-slopes and occasionally on alluvial bottom-lands in the Grande Anse tract, and is represented on the strath-terrace treads of the North Aspy River (Tables 2 and 4). However, the species apparently is absent from the upland forests of the Northeast Margaree (Table 5). In contrast, *Acer saccharum* is a primary species in both upland and lowland stands. The considerable abundance of *Acer saccharum* over a variety of sites on the periphery of its range is a conspicuous feature of the species in this area.

With reference to species of Group (C) of Braun (1950), *Betula lutea* also constitutes a primary species in the upland and lowland forests of northern Cape Breton Island. Although second in abundance to *Acer saccharum* in terms of trees per acre, the basal area per acre of *Betula lutea* on occasion may exceed that of *Acer saccharum* due to the larger diameters often attained by individual *Betula lutea* stems (Table 1).

Species of Group (D) of Nichols (1935) reflect low to modest abundance in the old-growth, lowland, hardwood forests of northern Cape Breton Island. However, with increasing altitude the percentage of *Abies balsamea* on the hill-slopes increases and ultimately, on the plateau surface, the species became, at least prior to the current destruction of *Abies balsamea* populations by the spruce budworm, a primary element in the upland mixed wood and softwood forests of the region. *Picea* spp., although present in both lowland and upland deciduous forests, constitute minor elements in the old-growth broad-leaved forests of northern Cape Breton Island.

SUMMARY

Old-growth, hardwood forests in northern Cape Breton Island reflect the presence of species of southern, Canadian and boreal distributional affinities.

The southern species, which include *Fagus grandifolia, Quercus rubra* var. *borealis, Ulmus americana, Acer saccharum* and *Fraxinus americana* are on the northeastern extremity of their respective ranges in the area. Nevertheless, individuals of these species reach considerable size, reflect an appreciable representation in canopy and sub-canopy layers and contribute materially to the physiognomy of these forests.

The primary species of the lowland forests of northern Cape Breton Island are *Acer saccharum* and *Betula lutea*. In upland forests, prior to the current spruce budworm epidemic, the primary species were *Acer saccharum, Betula lutea* and *Abies balsamea*.

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ASTER SECTION *BIOTIA* (ASTERACEAE) IN NEW ENGLAND AND THE STATUS OF *ASTER GLOMERATUS*

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ABSTRACT

In his monograph of *Aster* section *Biotia* Burgess listed, as native to New England, 41 of the 84 species that he recognized in the group. Multivariate statistical analyses of morphological measurements that were made on specimens of Biotian asters collected in the region reveal, however, that only the three species, *A. divaricatus, A. macrophyllus,* and *A. schreberi,* are present. The same methods also demonstrate that *A. glomeratus,* a species that is accepted by some authorities as being native to New England, is simply a diminutive variant of *A. schreberi.*

Key Words: *Aster* section *Biotia, Aster glomeratus,* New England.

INTRODUCTION

Members of *Aster* section *Biotia* DC. ex Torrey & Gray are native to eastern North America. These plants are rhizomatous perennials that inhabit woodland, wooded riverbank, and woodland edge habitats from Manitoba, Ontario, Quebec, New Brunswick, Prince Edward Island, and Nova Scotia, to Missouri, Illinois, Tennessee, Alabama, and Georgia. The group is distinguished from other asters by the following combination of characters: basal and lower cauline leaves long-petiolate, cordate-based, the blades toothed; upper cauline leaves toothed; capitulescence corymbiform; cypselas linear to fusiform with seven or more prominent ribs; phyllaries in the outermost whorl of the involucre densely ciliolate, obtuse to rounded at the apex. Chromosome numbers reported for the group are $2n = 18$, 54, and 72.

Burgess (1906), the only monographer of *Aster* section *Biotia,* recognized 84 species in North America. Nevertheless, only the seven species, *A. commixtus* (Nees) Kuntze, *A. divaricatus* L., *A.*

furcatus Burgess in Britton and Brown, *A. glomeratus* (Bernh. ex Nees) Burgess in Britton and Brown, *A. macrophyllus* L., *A. mirabilis* Torrey & Gray, and *A. schreberi* Nees, are listed in one or both of the current classifications of North American asters (Jones, 1980, 1984; Semple and Brouillet, 1980a).

For the New England states, Gleason and Cronquist (1963) listed the three species, *Aster divaricatus, A. macrophyllus,* and *A. schreberi.* Seymour (1982) also listed three species for this area, relegating *A. schreberi* to varietal status under *A. macrophyllus,* but recognizing *A. glomeratus* as a separate species. Fernald (1950) accepted all four of the above species. According to Burgess (1906), though, at least 41 of the 84 Biotian *Aster* species that he recognized are native to New England. Because of this dramatic difference in taxonomic opinion between Burgess and the other authorities cited, this paper addresses the question: How many species in *Aster* section *Biotia* are native to New England?

The simplest null hypothesis concordant with my own field, herbarium, and laboratory experience is that in New England there are three species belonging to *Aster* section *Biotia: A. divaricatus* ($2n = 18$), *A. macrophyllus* ($2n = 72$), and *A. schreberi* ($2n = 54$). The alternative hypothesis is that more than three Biotian *Aster* species exist in the region.

Chromosome number is not the only character that distinguishes these species. Stipitate-glandular trichomes on the peduncles and abaxial sides of the phyllaries and violet or violet-tinged ligules separate *Aster macrophyllus* from the two eglandular and white-liguled species, *A. divaricatus* and *A. schreberi.* Furthermore, both *A. macrophyllus* and *A. schreberi* differ from *A. divaricatus* in having larger stem diameters, taller involucres, longer and wider phyllaries, and twice as many teeth along the margins of the lower cauline leaves. These morphological distinctions, when combined with the chromosome number differences, support the acceptance of at least three species for New England.

The null hypothesis is tested using three statistical methods: principal component analysis, linear discriminant analysis, and discriminant coordinate analysis. As is usual in the testing of statistical hypotheses, the null hypothesis is assumed true, and statistics are computed from the observed data (Lehmann, 1959; Silvey, 1975). These statistical results are then examined in order to determine whether they support the initial assumption that the null hypothesis is true.

The taxonomic validity of each of the individual species accepted by Burgess need not be considered separately unless the null hypothesis is rejected. However, because *Aster glomeratus* has been cited as native to New England by Fernald (1950), Semple and Brouillet (1980a, 1980b), and Seymour (1982), the possibility that it may be a good species is considered separately at the end of this paper.

All putative interspecific hybrids were excluded from the statistical analyses performed. In particular, *Aster* × *herveyi* A. Gray, which has been demonstrated to be an intersectional hybrid of *A. macrophyllus* and *A. spectabilis* Aiton (Uttal, 1962), was not considered.

An abbreviated version (Lamboy, 1986) of some of the results discussed here was presented at the August 1986 AIBS meeting in Amherst, Massachusetts.

MATERIALS AND METHODS

The specimens examined

Specimens from the following herbaria were examined for possible inclusion in the analyses: ALU, CAN, CAS, CM, DS, F, GA, GH, ILL, ILLS, IND, ISC, KY, MICH, MIL, MO, MOR, NCU, NEB, NEBC, NY, NYS, OS, PENN, PH, TENN, UARK, UNA, US, WIS. Abbreviations used are from Index Herbariorum (Holmgren et al., 1981). Prior to performing the statistical analyses, each specimen was identified, using the characters mentioned in the introduction, as *Aster divaricatus, A. macrophyllus,* or *A. schreberi.*

Measurements were made on two independent sets of specimens from New England. The first set of 108 specimens consisted of duplicates (i.e., sheets of the same number collected by a single collector) from 54 different New England localities. These specimens represent all the duplicate specimens that were available to me at the time the analyses were conducted. Since members of *Aster* section *Biotia* reproduce vegetatively, it is reasonable to assume that all or most of the pairs of duplicate specimens represent collections from the same clone. At the very least they are specimens from the same population. Duplicates were analyzed in order to determine if

Table 1. Characters used in the statistical analyses.

Character name—character description (list of values, if character was measured on a discrete scale)

sd—stem diameter
nn—number of nodes below the capitulescence

For the lowest measurable cordate leaf:

cpl—petiole length
cbl—maximum blade length
cbw—maximum blade width
clmx—length along midvein from apex to point of maximum width
clmx4—width at a point 1/4 the distance clmx
nth—number of teeth along one side

For highest measurable leaf below the capitulescence:

ncpl—petiole length
ncbl—maximum blade length
ncbw—maximum blade width
ncnth—number of teeth along one side

lvscb—leaf surface of cordate leaves (0 = not scabrous, 1 = scabrous)
rh—nonglandular trichomes in the capitulescence (0 = no, 1 = yes)
gh—stipitate-glandular trichomes in the capitulescence (0 = no, 1 = yes)
sh—stem height
ih—capitulescence height

For representative phyllary from the second whorl:

p2l—length
p2w—maximum width
p2t—shape of apex (0 = acuminate, 1 = acute to blunt, 2 = distinctly rounded)
p2s—overall shape (0 = ovate, 1 = oblong or elliptic, 2 = obovate)

For representative phyllary from third whorl:

p3l—length
p3w—maximum width
p3t—shape of apex (0 = acuminate, 1 = acute to blunt, 2 = distinctly rounded)
p3s—overall shape (0 = ovate, 1 = oblong or elliptic, 2 = obovate)
pt—apex of phyllaries reflexed (0 = no, 1 = yes)
nh—number of mature heads present
lp—length of typical peduncle
invl—height of involucre (when pressed)
lfl—length of ligulate floret
lfw—maximum width of ligulate floret
lfll—length of limb of ligulate floret (excluding the tube)
dl—length of disk florets
dll—length of lobes of disk florets
ch—trichomes on cypselas (0 = glabrous, 0.5 = intermediate, 1 = either in a few lines or scattered, 1.5 = intermediate, 2 = trichomes in a uniform covering)

Table 1. (Continued)

Character name—character description (list of values, if character was measured on a discrete scale)
ppl—pappus length
crlw—the ratio cbl/cbw
cr4—the ratio clmx/clmx4
cnthl—the ratio ncnth/cbl
soi—the ratio sh/ih
p2lw—the ratio p2l/p2w
p3lw—the ratio p3l/p3w
nhsh—the ratio nh/sh
lflinv—the ratio lfl/invl
dflinv—the ratio dl/invl

the statistical results were consistent for both specimens from the same clone and to obtain information on within-clone variability. Knowledge of this variability provided a means of evaluating more realistically the taxonomic significance of observed differences between specimens of a single species.

Measurements made on a second set of 80 specimens were also analyzed. This independent group of specimens, selected at random, included none of the collections from the first data set. Analysis of a second data set made it possible to determine if the results obtained from both data sets were congruous.

A computer-generated listing of the raw data is available from the author.

The characters measured or computed

For specimens in both data sets thirty-six characters were measured directly, and another nine characters were computed as ratios of some of the measured characters. A list of characters, their names, and an indication of their scale of measurement (discrete or continuous) is given in Table 1. Not all the characters were utilized in each of the statistical analyses. Only that subset of the characters was used that was shown by statistical testing to be important in a particular analysis.

Statistical methods used

Five different statistical methods were employed in testing the three-species hypothesis. One-way analysis of variance (Scheffé, 1959; Searle, 1971), was used to select continuous characters for inclusion in the principal component analyses. Only those characters that differed between species at the $p < 0.0001$ significance level were utilized.

A chi-square test (Sokal and Rohlf, 1969) was conducted in order to determine which discrete characters were significantly different between species. Only those characters that differed between species at the $p < 0.0001$ significance level were included in the principal component analyses.

Principal component analysis (Morrison, 1976; Seber, 1984), forward stepwise linear discriminant analysis (Anderson, 1958; Rao, 1973; SAS Institute, 1985b), and discriminant coordinate analysis (Seal, 1964; Seber, 1984; Gittins, 1985) were used to test the three-species hypothesis. Each of these statistical methods is sensitive to different features of the data, and each can independently provide evidence that the null hypothesis should be rejected. Thus, testing of the hypothesis by three methods is more stringent than testing by fewer methods (Crovello, 1974).

All analyses were performed using the statistical program SAS (SAS Institute, 1985a, 1985b) on an IBM 4341 Computer running under the CMS operating system at the University of Illinois.

RESULTS AND DISCUSSION

One-way analysis of variance

Table 2 shows the results of the one-way analysis of variance of each character for both data sets. Twenty-three characters were significantly different between species at the $p < 0.0001$ level in both sets. Two characters were significantly different between species in the first data set but not in the second, and one character was significantly different in the second data set but not in the first. Although this analysis was performed primarily in order to determine which characters would be useful in the principal component analyses, it also shows that the putative species differ significantly with respect to over twenty morphological characteristics. Because the results from two independent data sets are nearly identical, the observed differences are almost certainly not artifactual.

Chi-square tests

Table 2 also shows for both data sets the discrete characters that were statistically different between species at the $p < 0.0001$ significance level as determined by the chi-square test. Two characters were significantly different between species in both data sets, and one was significant only in the second data set. Thus the chi-square analysis also shows that the species differ in a number of characteristics, lending additional support to the three-species hypothesis.

Principal component analyses

For the first data set a plot of the first principal component versus the second principal component is shown in Figure 1. Only characters that differed significantly either by one-way analysis of variance or by the chi-square test were used. Loosely interpreted, the first principal component is a measure of overall plant size, while the second principal component is a measure contrasting the size of the vegetative parts of the plant with size of the reproductive parts. Points representing specimens of *Aster divaricatus* are almost completely separated from those of the other two species. Points representing specimens of *A. schreberi* and *A. macrophyllus* are, in my judgment and experience, reasonably well separated. One would need to delete only six of the specimens in order to remove all overlap between the two species. Furthermore, no feature of the graph indicates that additional species should be recognized.

In Figure 1, for each of the three species, one pair of points representing duplicate specimens is connected by solid lines, and another pair is joined by dotted lines. Those connected by solid lines represent that pair of specimens exhibiting the greatest range (difference between the maximum and minimum values) for the first principal component. Those joined by dotted lines show the greatest range for the second principal component. The purpose in focusing on these specimens is to emphasize the magnitude of the within-clone variation relative to the within-species variation displayed by these Biotian asters.

For *Aster divaricatus* the minimum and maximum observed values for the first principal component are -1.78 and -0.06, respectively, for a range of 1.72. Yet for the pair of specimens connected by the solid line, the values for the first principal component are

Table 2. Results of one-way analysis of variance and chi-square test of independence. All characters listed are, by one-way analysis of variance, significantly different between two or more of the species, *Aster divaricatus, A. macrophyllus,* and *A. schreberi.* Characters preceded by an asterisk (*) are also significant by the chi-square test.

Characters significant at the $p < 0.0001$ level	
Data set 1	Data set 2
sd	sd
cpl	cpl
cbw	cbw
clmx4	clmx4
nth	nth
ncnth	ncnth
* lvscb	* lvscb
	* rh
* gh	* gh
sh	
p2l	p2l
p2w	p2w
p3l	p3l
p3w	p3w
lp	lp
invl	invl
lfl	lfl
lfw	lfw
lfll	
dl	dl
ppl	ppl
crlw	crlw
cr4	cr4
cnthl	cnthl
lflinv	lflinv
dflinv	dflinv

−1.78 and −0.52, for a range of 1.26. Thus, 73% (1.26 / 1.72 × 100%) of the observed species variability in the first principal component is exhibited by a pair of specimens from a single clone. The same quantities computed for *A. macrophyllus* and *A. schreberi* are 67% (1.14 / 1.69 × 100%) and 66% (0.99 / 1.51 × 100%), respectively.

The results for the second principal component are similar. Points joined by dotted lines were used in computing the percent of within-clone variability relative to the within-species variability for the

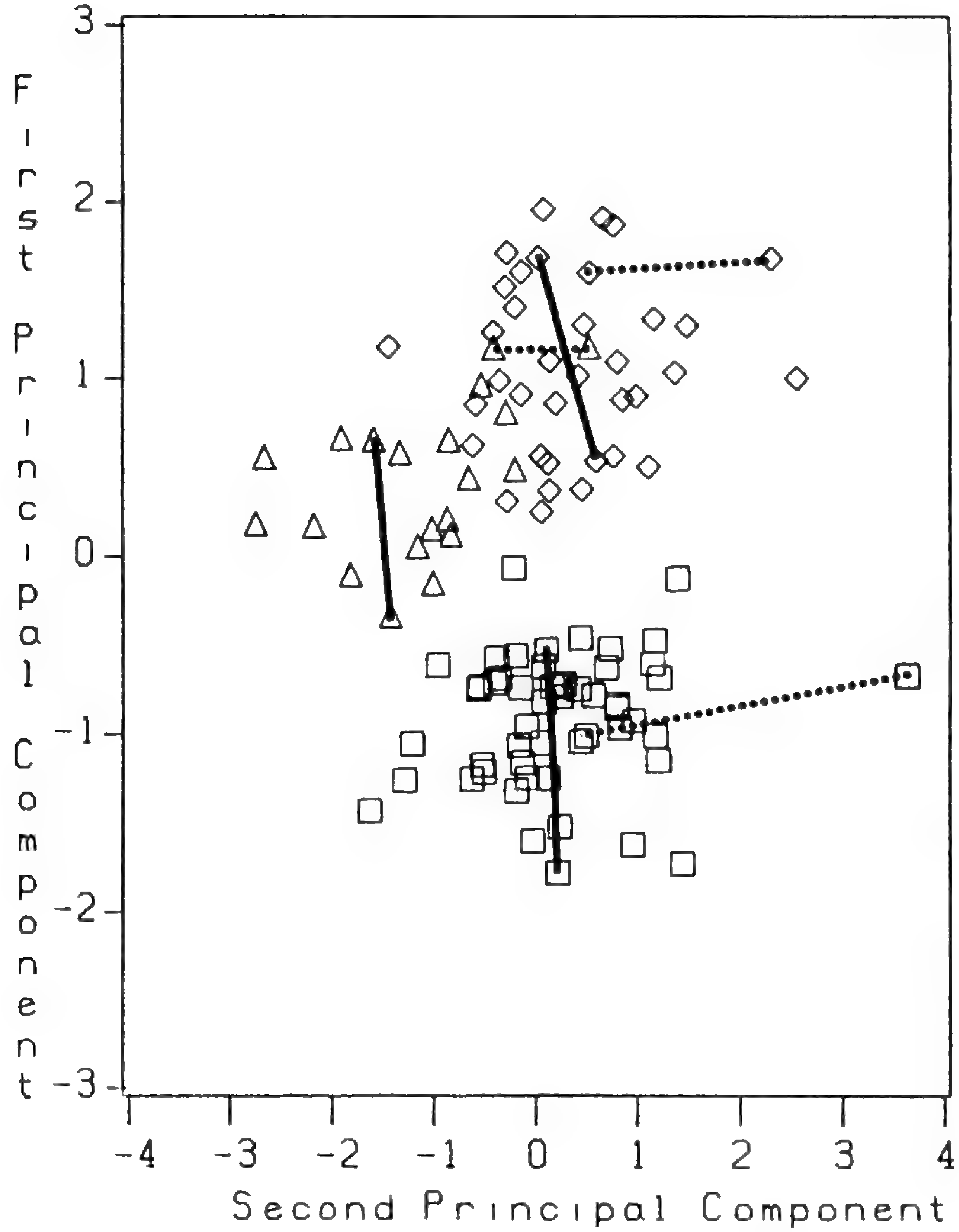

Figure 1. Plot of first principal component versus second principal component for data set 1. Points connected by solid or dotted lines represent particularly divergent duplicate specimens. In all figures, squares represent specimens of *Aster divaricatus,* triangles represent specimens of *A. schreberi,* and diamonds represent specimens of *A. macrophyllus.*

second principal component. These calculations yielded values of 53%, 65%, and 28%, for *Aster divaricatus, A. macrophyllus,* and *A. schreberi*, respectively. Thus, in five of the six instances, a pair of specimens from a single clone showed variation in the principal component that represented over 50% of the variation observed for the entire species. Given this extremely high level of within-clone morphological variability, it would be difficult to justify the recognition of any additional species in *Aster* section *Biotia* based on morphological criteria alone.

The results of the principal component analysis of the second data set are shown in Figure 2. Again, only characters that showed significant differences between species were used. The separation of species is quite similar to that of Figure 1, confirming that the observed patterns are not the result of anomalies in a particular data set. Again there is no evidence indicating the presence of additional species.

Linear discriminant analyses

A forward stepwise linear discriminant analysis was performed on both data sets using those characters that satisfied the F-to-enter criterion of $p < 0.10$ (as recommended by Costanza and Afifi, 1979). The characters used in forming the classification functions are listed in Table 3. Unfortunately, the mathematics of linear discriminant analysis does not allow the character "gh" (see Table 1), which is a perfect discriminator between *Aster macrophyllus* and the other two species, to be included in the analysis because its value is constant for each species.

The classification functions computed from data set 1 were used to classify the specimens from data set 1, resulting in the misclassification of only two (< 2%) specimens. When these same functions were used to classify specimens from data set 2, however, 15 of 80 (19%) were misclassified (Table 4).

Only two (2.5%) of the specimens from data set 2 were misclassified when the functions computed from that data set were used. On the other hand, when the same functions were used to classify the specimens from data set 1, 21 of 108 (19%) were misclassified (Table 5).

Thus, at least 97% of the specimens were correctly identified when the classification functions used for identification were computed

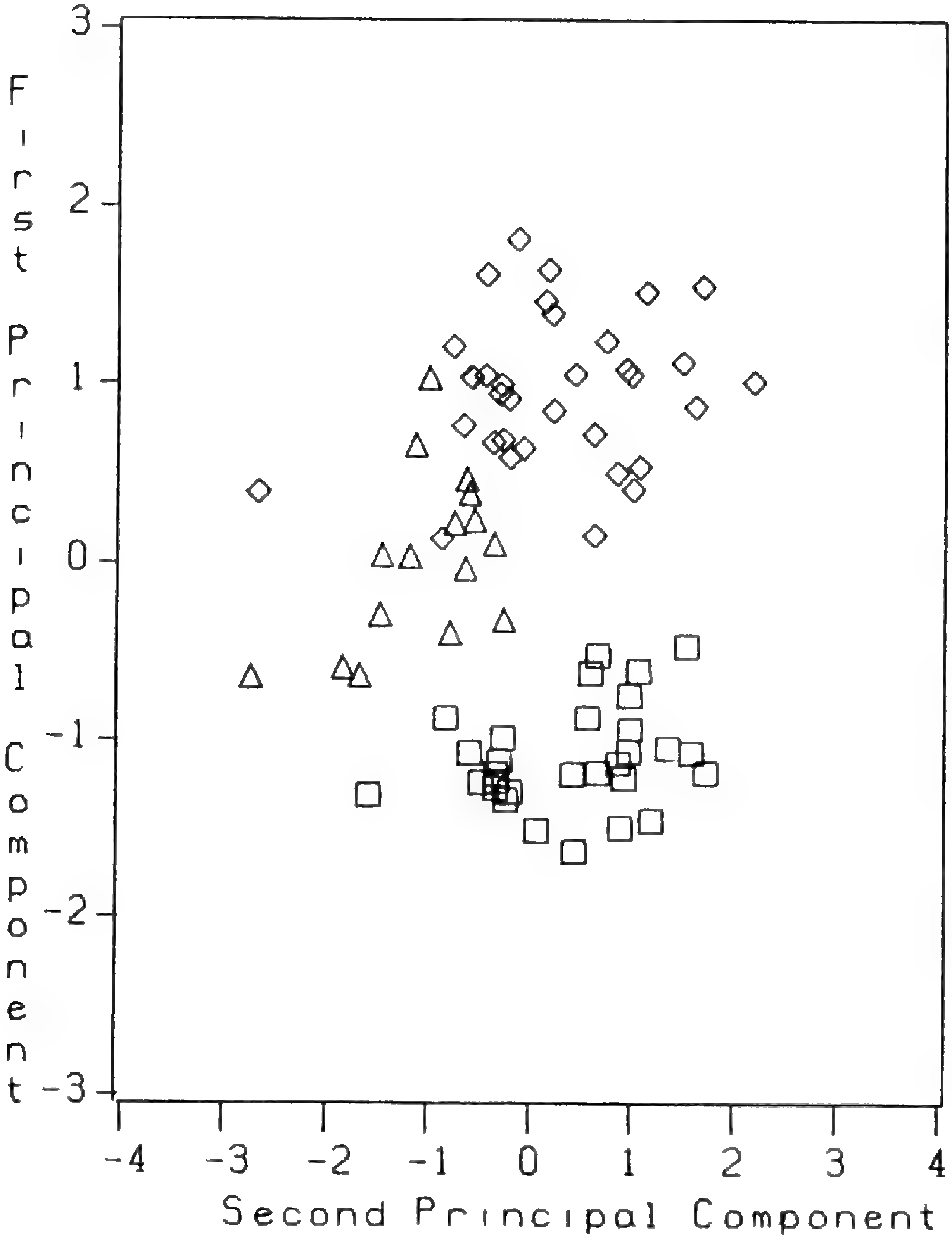

Figure 2. Plot of first principal component versus second principal component for data set 2.

from the data set containing the specimens to be classified. These results are consistent with the three-species hypothesis. Furthermore, despite the variation evident in the data, the classification functions computed from one data set correctly classified over 80%

Table 3. Results of forward stepwise linear discriminant analyses. Characters listed were used in computing the classification functions.

Characters significant at the $p < 0.10$ level	
Data set 1	Data set 2
invl	invl
lflinv	cr4
p2w	rh
nth	lp
soi	nth
p3s	lvscb
lvscb	ch
nh	p3w
p3t	ncpl
nn	lfw
ih	lfll
nhsh	
cnthl	
cr4	
lfw	
dflinv	

of the specimens from the other, thereby confirming the existence of between-species morphological differences that are recognizable by means of a purely objective mathematical method.

Twenty-one specimens from the first data set (containing duplicate specimens) were misclassified using the classification functions from the second data set. For nine of these misclassified specimens, though, the duplicate specimen was correctly classified. This indicates a within-clone variability of such a magnitude as to make it impossible for the linear discriminant analysis to separate the meaningful from the meaningless variation exhibited by these specimens. This variability reemphasizes the difficulty in recognizing and upholding any additional species.

Discriminant coordinate analyses

The results of discriminant coordinate analysis for the first data set are shown graphically in Figure 3, where the first canonical variate is plotted against the second. One specimen of *Aster macrophyllus* lies closer to the *A. schreberi* specimens than to other *A. macrophyllus* specimens, but otherwise the three species are clearly separated. There are no other clusters of points displayed that might indicate the presence of additional unrecognized species.

Table 4. Results of linear discriminant analysis of specimens from data set 1. (Abbreviations used: div = *Aster divaricatus*, mac = *A. macrophyllus*, sch = *A. schreberi*).

Classification of specimens from data set 1

Identified as:	Classified using data set 1 as:			Classified using data set 2 as:		
	div	mac	sch	div	mac	sch
div	52	0	0	47	0	5
mac	0	35	1	0	22	14
sch	0	1	19	0	2	18

A graph showing the results of the analysis of the second data set (Figure 4) also shows distinct separation of the three species. No other groups of specimens cluster together into what might be interpreted as additional species.

Conclusions based on the statistical analyses

The statistical analyses discussed above provided no evidence to contradict the three-species hypothesis. The hypothesized species were separated by all three methods, indicating that the differences between them are real. No additional groups of points, which might be construed as representing unrecognized species, clustered out in either the principal component or the discriminant coordinate analysis. All three analyses evinced a high level of within-species and within-clone variability in members of *Aster* section *Biotia*.

Known chromosome numbers are consistent with the three-species hypothesis. Without exception the reported chromosome numbers, plus unreported counts made by myself and by A. G. Jones, for specimens of these Biotian asters are: *Aster divaricatus*, $2n = 18$ (a total of 32 counts); *A. schreberi*, $2n = 54$ (8 counts); and *A. macrophyllus*, $2n = 72$ (41 counts). When considered together, all these results make it impossible to support the recognition of any additional species in this group of asters in the New England region. The three-species hypothesis cannot be rejected.

THE STATUS OF *ASTER GLOMERATUS*

Nees von Esenbeck (1832) was the first *Aster* expert to recognize *A. glomeratus* (under the name *Eurybia glomerata*) as a separate species. He described and named this species on the basis of a single dried specimen given to him by Bernhardi. According to Nees,

Table 5. Results of linear discriminant analysis of specimens from data set 2. (Abbreviations as for Table 4.)

Classification of specimens from data set 2

Identified as:	Classified using data set 2 as:			Classified using data set 1 as:		
	div	mac	sch	div	mac	sch
div	30	0	0	29	1	0
mac	0	33	1	2	25	7
sch	0	1	15	1	4	11

A. glomeratus is closely related to *A. schreberi.* Plants of *A. glomeratus,* however, have ovate-obtuse phyllaries, ligules that are shorter than the involucre, and thyrsoid capitulescences, whereas plants of *A. schreberi* possess oblong-obtuse phyllaries, ligules longer than the involucre, and corymbiform capitulescences. Judging from my own field experience, however, the character states that supposedly differentiate *A. glomeratus* from *A. schreberi* are simply those found in plants of *A. schreberi* that are depauperate, late-blooming, or in early anthesis.

Fernald (1950), Semple and Brouillet (1980a, 1980b), and Seymour (1982) list *Aster glomeratus* as a separate species that is native to New England. Even though the statistical results described above supply strong evidence that only three Biotian species are present in the region, the possibility that *A. glomeratus* is a good species is considered below.

Since the original specimen examined by Nees could not be located by Burgess (1906), he neotypified *Aster glomeratus* with a specimen now at NY (Lamboy and Jones, 1987). Consequently, in order to determine whether *A. glomeratus* is conspecific with *A. schreberi,* measurements were made on this neotype for all forty-five characters, and the resulting data were carried through the same analyses as described above. For the purpose of these additional analyses the measurements from the first and second data sets were combined with those from the neotype.

The plot resulting from the principal component analysis (Figure 5) shows that *Aster glomeratus* is most similar to the smaller specimens of *A. schreberi.* This is precisely the result one would expect if the neotype were simply a diminutive specimen of that species. In addition, a forward stepwise linear discriminant analysis yielded a probability of 0.998 that the neotype of *A. glomeratus* is a specimen of *A. schreberi* and a probability of 0.002 that it is a specimen of

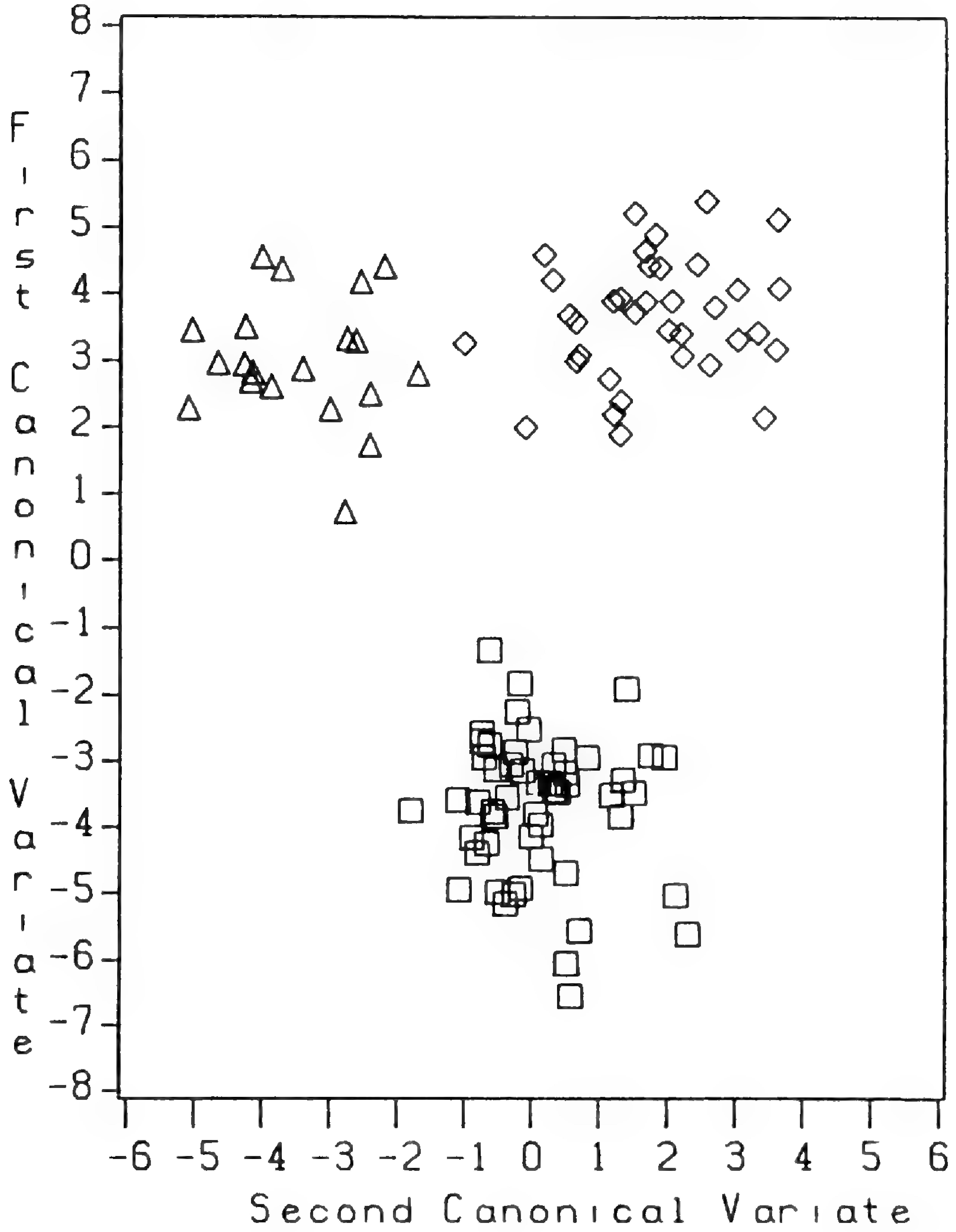

Figure 3. Plot of first canonical variate versus second canonical variate for data set 1.

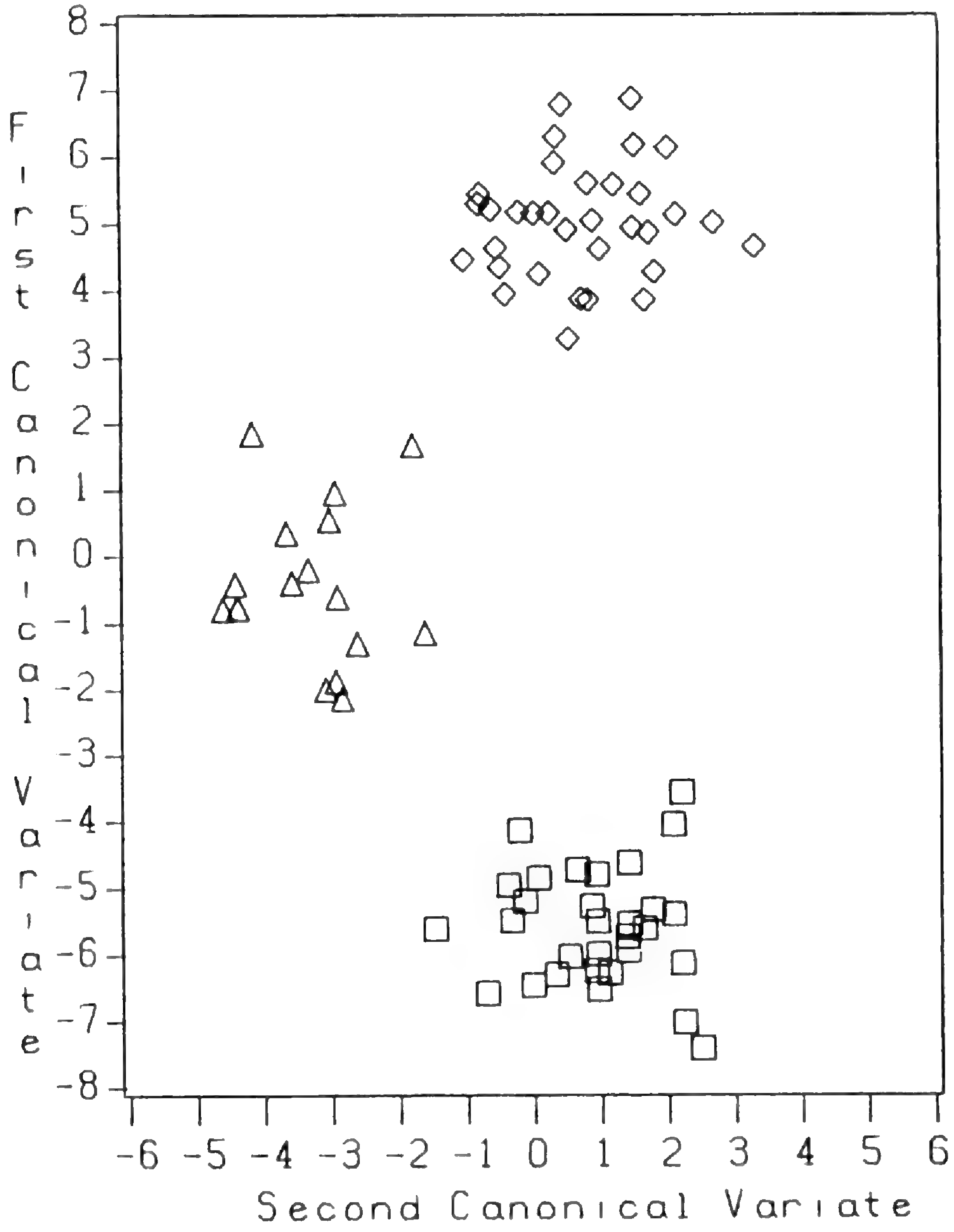

Figure 4. Plot of first canonical variate versus second canonical variate for data set 2.

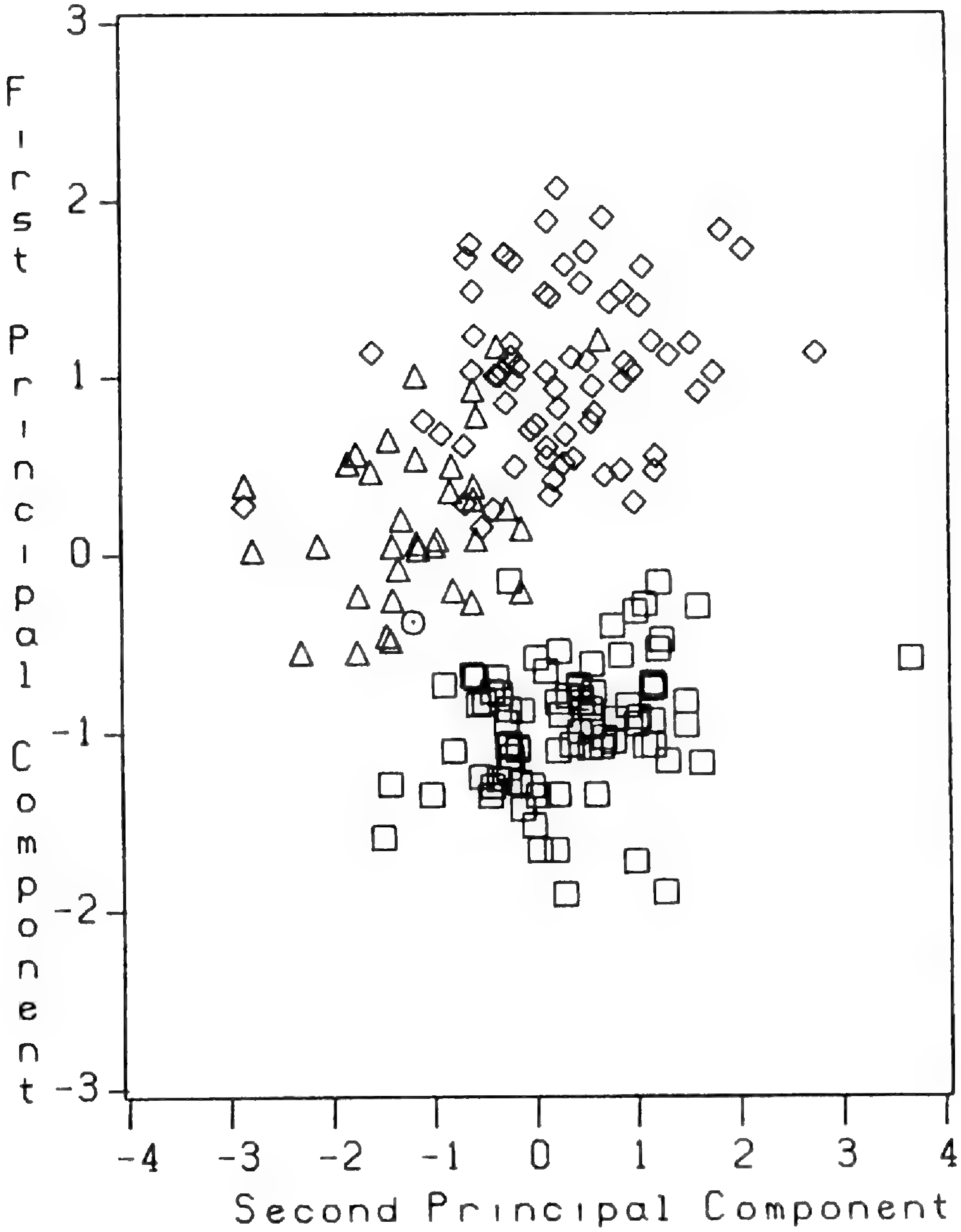

Figure 5. Plot of first principal component versus second principal component for combined data from sets 1 and 2 and the neotype of *Aster glomeratus* (represented by a circle enclosing a dot).

A. divaricatus. The discriminant coordinate analysis (Figure 6) shows that the point representing the neotype of *A. glomeratus* clusters with those points representing specimens of *A. schreberi*. Thus, there is no statistical evidence to contradict the hypothesis that the neotype is a specimen of *A. schreberi*. Furthermore, Semple and Brouillet (1980b), and Semple et al. (1983) obtained chromosome counts of specimens that they identified as *A. glomeratus*, and as expected, reported a chromosome count of $2n = 54$, the same as for plants of *A. schreberi*.

Since the type specimen of *Aster glomeratus* fits comfortably within the range of variability displayed by specimens of *A. schreberi*, the two species should be regarded as conspecific. The name *A. glomeratus* therefore should be placed in synonymy under *A. schreberi*, since the latter name has priority.

ACKNOWLEDGMENTS

A grant from the New England Botanical Club supported field work in New England during the summer of 1985. The J.B. Hansen Fund of the Department of Plant Biology, University of Illinois, provided funds for travel to the 1986 AIBS meeting in Amherst, Massachusetts. Almut G. Jones supplied valuable suggestions for improving the manuscript. The reviewers' constructive comments and especially careful reading of the manuscript are appreciated. Loans of specimens from the herbaria mentioned are gratefully acknowledged.

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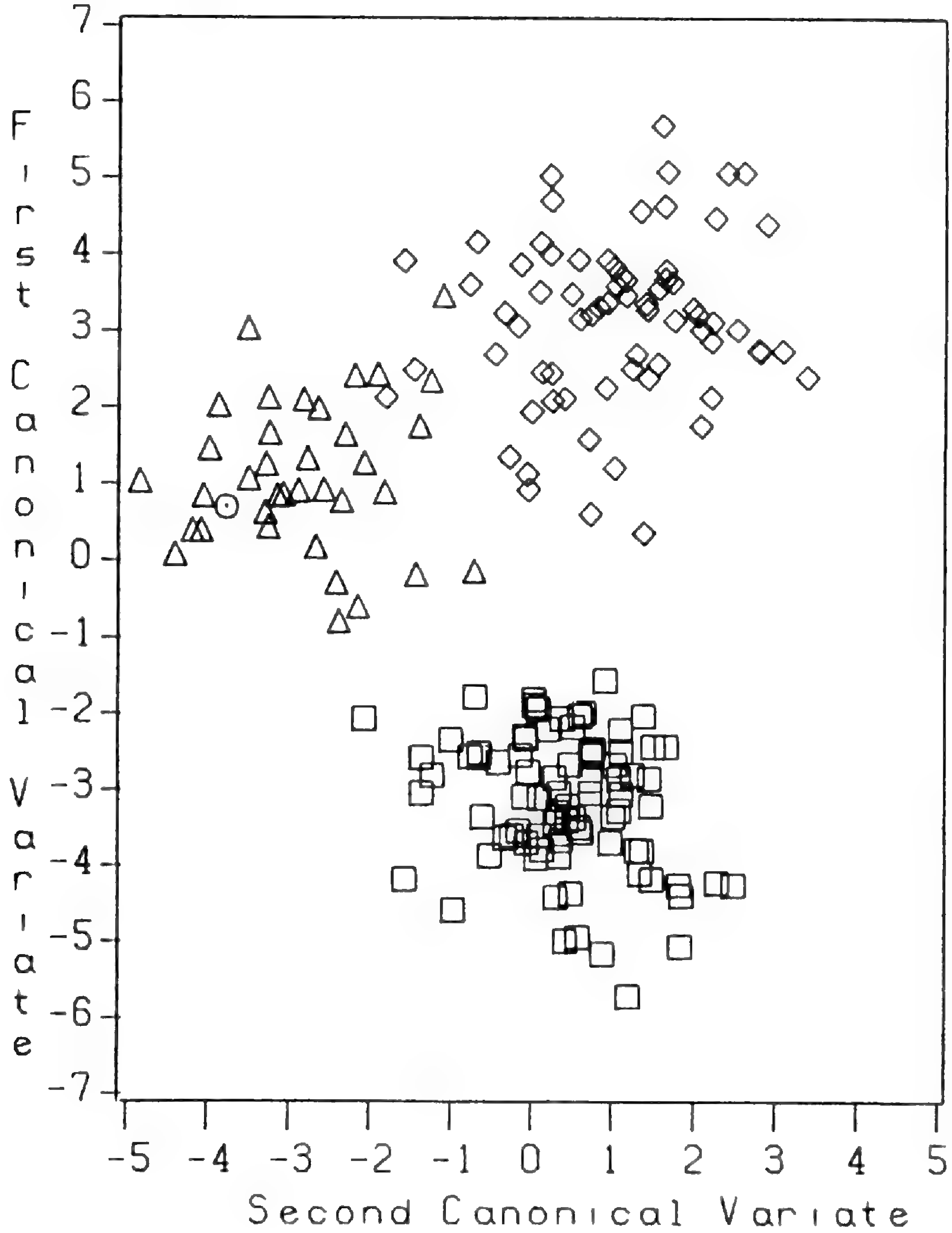

Figure 6. Plot of first canonical variate versus second canonical variate for combined data from sets 1 and 2 and the neotype of *Aster glomeratus* (represented by a circle enclosing a dot).

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CHROMOSOME NUMBER DETERMINATIONS IN FAM. COMPOSITAE, TRIBE ASTEREAE.
II. ADDITIONAL COUNTS

JOHN C. SEMPLE AND JERRY G. CHMIELEWSKI[1]

INTRODUCTION

Biosystematic studies are enhanced by knowledge of variation in chromosome number within and between taxa (Strother, 1972). The determinations listed below are reported without comment as contributions to such studies. This is the second in what is expected to be a continuing series of general reports on Astereae by the first author's laboratory (Semple, 1985).

MATERIALS AND METHODS

Meiotic counts were made from pollen mother cells dissected from buds fixed in the field in 3:1/EtOH: acetic acid, and subsequently stored under refrigeration in 70% EtOH. Mitotic counts were made from root tip cells taken from transplanted rootstocks. Root tips were pretreated in 0.01% colchicine for 2–3 h, fixed in Modified Carnoy's Fixative (4:3:1/chloroform: EtOH: acetic acid), and hydrolyzed before squashing in 1N HCl for 30 min at 60°C. Anther sacs containing PMC's and meristematic root tips were squashed in 1% acetic orcein and counts of chromosomes were made from freshly prepared material. Permanent slides were made in most cases and remain in the possession of J. C. S.

Vouchers for all counts are deposited in WAT. Guy Nesom confirmed identifications of some of the *Erigeron* collections.

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RESULTS AND DISCUSSION

The chromosome numbers of 220 individuals representing 86 taxa and four interspecific hybrids from 12 genera are reported for the first time (Table 1). The counts confirm previous reports for the taxa and are presented without comment. Supernumerary chromosomes were found in *Aphanostephus skirrhobasis* var. *skirrhobasis, Virgulus fendleri,* and *V. novae-angliae.*

Table 1. Chromosome number determinations of Astereae from Canada and the United States arranged alphabetically. Vouchers were collected by Semple & Heard unless otherwise indicated: B = L. Brouillet; Ch = J. Chmielewski; S = J. Semple.

Amphiachyris dracunculoides (DC.) Nutt. $2n = 4_{II}$. **Texas.** Jeff Davis Co.: TX-118 SE of Fort Davis, *8204.*

Aphanostephus skirrhobasis (DC.) Trel. var. *skirrhobasis.* $2n$ = ca. $3_{II}+1\text{–}2_{II}$ supernumeraries. **Texas.** Kent Co.–Scurry Co. line: TX-208 N of Snyder, *8227.*

Aster acuminatus Michx. $2n = 18$. **Ontario.** Prescott-Russell Reg. Mun.: Reg. Rd.-16 E of Lemieux, *8350.*

A. anomalus Engelmann. $2n = 16$. **Oklahoma.** Leflore Co.: OK-1 E of Talimena, *8270.*

A. borealis (Torr. & Gray) Provancher. $2n = 32$. **Ontario.** Bruce Co.: N of Oliphant, *Ch 2282.*

A. drummondii Torr. & Gray. $2n = 16$. **Arkansas.** Boone Co.: US-62 2 km SW of Zinc, *8310.*

A. dumosus L. $2n = 16$. **Arkansas.** Fulton Co.: US-62 E of Agnos, *8319.*

A. foliaceus Lindl. $2n = 64$. **Colorado.** Delta Co.: CO-65 S of Grand Mesa, *7793.* $2n = 80$. **New Mexico.** Lincoln Co.: NM-532 W of Alto, *8141.*

A. glaucodes Torr. & Gray. $2n = 9_{II}$. **Utah.** Emery Co.: UT-29 W of Orangeville, *7801.* $2n = 18$. **Colorado.** Gunnison Co.: Kebler Pass Rd. 20 km E of CO-133, *7776.*

A. lanceolatus Willd. ssp. *hesperius* (Gray) Semple & Chmielewski. $2n = 64$. **Colorado.** Delta Co.: CO-133 E of Hotchkiss, *7784.* **New Mexico.** Lincoln Co.: junc. of NM-532 and NM-21 W of Alto, *8135, 8137.*

A. lanceolatus × *A. lateriflorus* (L.) Britton. $2n = 32$. **Ontario.** Haldimand-Norfolk Reg. Mun.: 7 km SE of Simcoe, *Ch 1932.*

A. macrophyllus L. $2n = 72$. **Ontario.** Haldimand-Norfolk Reg. Mun.: Nelson Rd. W of Port Dover, *8361.* Waterloo Reg. Mun.: Kitchener, Pinnacle Rd., *8358.*

A. nemoralis Ait. $2n = 18$. **Ontario.** Prescott-Russell Reg. Mun.: Alfred Bog, *8351.*

A. occidentalis Nutt. $2n = 32$. **Colorado.** Delta Co.: CO-65 S of Grand Mesa, *7792.* Gunnison Co.: Kebler Pass Rd. 20 km E of CO-133, *7778.*

A. parviceps (Burgess) Mackenzie & Bush. $2n = 32$. **Arkansas.** Fulton Co.: US-62 E of Agnos, *8318, 8322, 8323, 8324.*

A. pauciflorus Nutt. $2n = 9_{II}$. **Utah.** Emery Co.: UT-10 S of Clawson, *7800.*

A. pilosus Willd. var. *pilosus.* $2n = 32$. **Arkansas.** Boone Co.: US-62 SW of Zinc, *8311.* Polk Co.: N of Acorn, *8277.* $2n = 48$. **Illinois.** Union Co.: IL-146 1 km E of I-75, *8326.*

A. pilosus × *A. oolentangiensis* Riddell. $2n = 32$. **Ontario.** Haldimand-Norfolk Reg. Mun.: Townsend Twp., 3.7 km S of Waterford, *Ch 1928.*

A. praealtus Poir. var. *praealtus.* $2n = 32$. **Indiana.** White Co.: US-421 N of Reynolds, *8340.*

A. porteri Gray. $2n = 16$. **New Mexico.** San Miguel Co.: NM-3 N of Sapella, *8038.*

A. retroflexus Lindl. $2n = 48$. **Tennessee.** Sevier Co.: Chilhowee Mt., *Thomas et al. 91530.*

A. turbinellus Lindl. $2n = 96$. **Arkansas.** Polk Co.: US-71 N of Acorn, *8280.*

Chrysothamnus nauseosus (Pallas) Britton. $2n = 9_{II}$. **Utah.** Sevier Co.: 1.3 km W of South Utah Fuel Co. Coal Mine No. 1, *7812.*

Erigeron acris L. var. *asteroides* (Andrz. ex Bess.) DC. $2n = 27$. **Montana.** Beaverhead Co.: MT-43 just W of Wisdom, *S. & Bt 7024.*

E. acris L. var. *debilis* Gray. $2n = 18$. **Colorado.** Summit Co.: Arapahoe Basin Ski Area below Loveland Pass, *S 6615.*

E. caespitosus Nutt. $2n = 18$. **Idaho.** Custer Co.: ID-75 5.9 mi N of Clayton, *S & Bt 7044.*

E. delphinifolius Willd. ssp. *neomexicanus* (Gray) Cronq. $2n = 9_{II}$. **Arizona.** Gila Co.: AZ-87 just NW of Payson, *7925.* Pima Co.: Mt. Lemmon, near summit, *7946.*

E. divergens Torr. & Gray. $2n = 27$. **Idaho.** Lehmi Co.: Stormy Pk. Rd. W of Carmen, *S & Bt 7033.* $2n = 18_{II}$. **Utah.** Beaver Co.: UT-153 5 km E of Beaver, *7822.* Washington Co.: W of Leeds, Silver Reef Rd., near Leeds Creek, *7865.* $2n =$ ca. 18_{II}. **Arizona.** Coconino Co.: AZ-87 15 km NE of Strawberry, *7920.* $2n = 36$. **Arizona.** Coconino Co.: US-180 S of Tusayan, *S. 5538.* $2n = 27_{II}$. **Arizona.** Greenlee Co.: US-666 2.8 km S of Robinson Mesa Trail, *8019.*

E. flagellaris Gray. $2n = 18$. **Colorado.** Teller Co.: Twin Rocks Rd. 3.9 mi W of US-24, E of Florissant, *S & Bt 7256.*

E. formosissimus Greene var. *formosissimus.* $2n = 18$. **Arizona.** Coconino Co.: 5.4 mi N of Parks, *S 5556.*

E. glaucus Kerr. $2n = 18$. **California.** Mendocino Co.: CA-1 S of Mendocino, *S 5682.* Monterey Co.: CA-1, 1 mi S of Carmel Heights, *S 5661.*

E. ochroleucus Nutt. $2n = 18$. **Wyoming.** Albany Co.: WY-130 at Snowy Mt. Pass, *S & Bt 7239.*

E. speciosus (Lindl.) DC. $2n = 18$. **Colorado.** La Plata Co.: W of Durango, junc. of US-160 and CO-550, *S 5515.* **Idaho.** Lehmi Co.: US-93 5.2 mi N of Gibbonsville, Twin Creek Campground, *S & Bt 7031.*

E. strigosus Muhl. ex Willd. $2n = 18$. **Nebraska.** Nehama Co.: US-136 7 mi W of Auburn, *S & Bt 7355.*

E. subtrinervis Rydb. $2n = 18$. **Colorado.** Teller Co.: US-24 just E of Florissant, *S & Bt 7246.*

Euthamia gymnospermoides Greene. $2n = 18$. **Arkansas.** Yell Co.: E of Danville, AR-10 4 km W of AR-7, *8291.*

E. occidentalis Nutt. $2n = 9_{II}$. **Colorado.** Delta Co.: CO-133 E of Hotchkiss, *7783.*

Gutierrezia sarothrae (Pursh) Britt. & Rusby. $2n = 4_{II}$. **Utah.** Washington Co.: UT-9 just W of Springdale, *7873.*

Gymnosperma glutinosa (Spreng.) Less. $2n = 8_{II}$. **Arizona.** Cochise Co.: W of Portal, near Stewart Campground, *7990.* **Texas.** Jeff Davis Co.: TX-118 SE of Fort Davis, *8203.*

Machaeranthera australis (Greene) Shinners. $2n = 4_{II}$. **Texas.** Kent Co.-Scurry Co. line: TX-208 N of Snyder, *8228.*

M. bigelovii (Gray) Greene. $2n = 4_{II}$. **New Mexico.** Taos Co.: NM-68 2.5 km N of Pilar, *8054.*

M.(Psilactis) boltoniae (Greene) Turner & Horne. $2n = 4_{II}$. **Texas.** Jeff Davis Co.: TX-118 NW of Fort Davis, *8201.*

M. canescens (Pursh) Gray. $2n = 4_{II}$. **Arizona.** Coconino Co.: US-89 N of Flagstaff by For. Serv. Rd.-420, *7902.*

M. (Sideranthus) gracilis (Nutt.) Shinners $2n = 2_{II}$. **Arizona.** Coconino Co.: AZ-87 6.6 km SW of county line, SW of Winslow, *7911.* Gila Co.: AZ-87 NW of Payson, 0.3 km NW of East Verde River, *7924.* Pima Co.: Mt. Lemmon, Mile 11 on Catalina Hwy, *7972*; Catalina Hwy N of Old Prison Campsite, *7979.*

M. linearis Greene. $2n = 4_{II}$. **Arizona.** Cochise Co.: W of Portal, near Stewart Campground, *7989.* Pima Co.: Mt. Lemmon, ca. Mile 4 of Catalina Hwy, *7981.* **Utah.** Washington Co.: W of Leeds on Silver Reef Rd., *7860.*

M. parviflora Gray. $2n = 5_{II}$. **Texas.** Hudspeth Co.: US-62 E of Salt Flat, *8163.*

M. rubricaulis Rydb. $2n = 4_{II}$. **Colorado.** Lincoln Co.: I-70 E of Arriba, *7711.* Mesa Co.: CO-65 7 km E of Mesa, *7797.*

M. tanacetifolia (H.B.K.) Nees. $2n = 4_{II}$. **Arizona.** Coconino Co.: AZ-87 6.6 km SW of county line, SW of Winslow, *7910.* **Utah.** Kane Co.: UT-9 1 km E of Zion Natl. Park, *7878.*

Solidago altissima L. var. *altissima.* $2n = 36$. **Arkansas.** Boone Co.: US-62 SW of Zinc, *8307-A, 8307-B.* Scott Co.: US-71 N of 'Y' City, *8284.* $2n = 54$. **Arkansas.** Yell Co.: Ar-10 E of Danville, 13.9 km W of AR-7, *8285-A, 8285-B.*

S. altissima L. var. *gilvocanescens* (Piper) Semple. $2n = 18_{II}$. **Oklahoma.** Stephens Co.: OK-7 E of Oklahoma Hills, *8246B.* $2n = 36$. **Colorado.** Yuma Co.: junction of US-34 and US-385, *7706.* **Oklahoma.** Alta Co.: OK-7 W of Farris, *8257.* Stephens Co.: OK-7 E of Oklahoma Hills, *8246A.*

S. arguta Ait. $2n = 18$. **Tennessee.** Blount Co.: along base of Bearwallow Mt., *Thomas et al. 91474;* E of Wallard, Chilhowee Mt., *Thomas et al. 91449.*

S. caesia L. $2n = 18$. **Louisiana.** Ouachita Parish: SW of West Monroe, Rogers Creek, *Dutton et al. 4060.* **Ontario.** Frontenac Co.: W of Sharbot Lake Prov. Park, *Ch 2320.*

S. canadensis L. (montane form) $2n = 18$. **Colorado.** Gunnison Co.: 3.3 km W of Crested Butte on Kebler Pass Rd., *7753, 7755.* $2n = 36$. **New Mexico.** Lincoln Co.: NM-532 at NM-21, W of Alto, *8129A.*

S. canadensis L. var. *canadensis.* $2n = 18$. **Illinois.** Johnson Co.: US-45 N of Vienna, junc. County Rd.-990E, *8329.*

S. delicatula Small. $2n = 18$. **Oklahoma.** Leflore Co.: OK-1 E of Talimena, *8269.*

S. flexicaulis L. $2n = 18$. **Ontario.** Bruce Co.: S of Wolseley, *Ch 2278.*

S. gigantea Ait. $2n = 54$. **New Mexico.** Lincoln Co.: NM-532 W of Alto, junc. NM-21, *8130.*

S. hispida Muhl. $2n = 9_{II}$. **Arkansas.** Polk Co.: US-71 N of Acorn, *8273.* $2n = 18$. **Arkansas.** Fulton Co.: US-62 NW of Glencoe, *8315.* Searcy Co.: AR-16 S of Witts Springs, *8298.*

S. juncea Ait. $2n = 18$. **Maryland.** Anne Arundel Co.: S of Priest Ridge, *S & Ringius 7654.* **Ontario.** Lambton Co.: Ipperwash, *Ch 2238.* Ottawa-Carleton Reg. Mun.:

SW of North Gower, *Ch 2316.* **Pennsylvania.** Franklin Co.: Tuscarora Mt. W of Ft. Loudon, *S. & Ringius 7666.*

S. missouriensis Nutt. $2n = 18$. **Arkansas.** Boone Co.: US-62 SW of Zinc, *8312.* Fulton Co.: US-62 E of Agnos, 2.6 km W of AR-289, *8320.*

S. mollis Bartl. var. *angustata* Shinners. $2n = 9_{II}$. **Oklahoma.** Greer Co.: OK-9 E of Reed, *8235.*

S. multiradiata Ait. $2n = 18$. **Colorado.** Delta Co.: CO-65 S of Grand Mesa, *7789.* **Utah.** Beaver Co.: UT-153 1.0 km E of Mt. Holly Rd., *7828.* Piute Co.: UT-153, Fish Lake Natl. For., ca. 10,000′, *7836.*

S. ohioensis Riddell. $2n = 18$. **Ontario.** Bruce Co.: junc. of Hwy 6 and Dorcas Bay Rd., *Ch 2287;* E of Oliphant, *Ch 2279;* N of Red Bay, *Ch 2284.* Grey Co.: E of Craigleith, *Ch 2290.* Haldimand-Norfolk Reg. Mun.: S of town of Long Point, *Ch 1944.* Manitoulin Dist.: Manitoulin Is., Causeway by Wolsey Lake, *Ch 2304.* Simcoe Co.: E of Collingwood, *Ch 2291.*

S. parryi (Gray) Greene. $2n = 18$. **Colorado.** Delta Co.: CO-65 S of Grand Mesa, *7791.* Gunnison Co.: Kebler Pass, *7769.* **Utah.** Piute Co.: UT-153 S of Puffer Lake, *7837.*

S. petiolaris Ait. var. *angusta* Torr. & Gray. $2n = 9_{II}$. **Oklahoma.** Leflore Co.: OK-1 E of Talimena, *8268.* $2n = 18$. **Arkansas.** Fulton Co.: US-62 NW of Glencoe, *8313.* Polk Co.; US-71 N of Acorn, *8274.* Searcy Co.: AR-16 SE of Witts Springs, 5.1 km SE of AR-27, *8299 & 8300.*

S. petiolaris Ait. var. *petiolaris.* $2n = 9_{II}$. **Kansas.** Osborne Co.: US-281 12.5 mi S of Osborne, *S & Bt 7328.*

S. radula Nutt. $2n = 18$. **Louisiana.** Winn Parish: LA-126 2.0 mi NW of US-167 in Dodson, *Thomas & Kessler 79082.*

S. rugosa Mill. $2n = 18$. **Ontario.** Bruce Co.: McGlinn Lake, *Ch 2267.* Grey Co.: W of Crawford, *Ch 2271,* W of Glascott, *Ch 2275,* Glenelg Twp, Traverston Creek, *Ch 2273;* N of Holland Centre, *Ch. 2277.* Lambton Co.: Ipperwash, *Ch. 2237.* Muskoka Dist.: ca. 40 km S of Parry Sound, *Ch 2293, Ch 2295.* Nipissing Dist.: S of North Bay, *Ch 2299.* Lanark Co.: W of Perth, *Ch 2318.* Renfrew Co.: E of Deep River, *Ch 2313, Ch 2314.* **Quebec.** Hwy 101 7 km N of Laniel, *Ch 2310.* $2n = 36$. **Oklahoma.** Pushmataha Co.: US-271 SE of Clayton, Hardy Creek, *8264.*

S. rugosa × *canadensis.* $2n = 18$. **Ontario.** Manitoulin Dist.: Manitoulin Is., Hwy-582 W of Sandfield, *Ch 2303.*

S. sparsiflora Gray. $2n = 9_{II}$. **Arizona.** Gila Co.: AZ-87 0.7 km N of Payson, *7926.* **Utah.** Washington Co.: Silver Reef Rd. W of Leeds, *7863.* $2n = 18$. **Colorado.** Gunnison Co.: Kebler Pass Rd. 14.8 km E of CO-133, E of Somerset, *7779;* 1.4 mi E of CO-133, *7780.* **New Mexico.** Catron Co.: US-80 3.3 km W of Luna *8028.* Lincoln Co.: NM-532 W of Alto, *8120;* 8 km W of NM-32, *8142.* **Utah.** Garfield Co. UT-12 NW of Bryce Canyon Natl. Park, E of Red Rock Canyon, *7846.* Kane Co.: UT-14, 0.6 km E of road to Navajo Lake, *7852.* $2n = 36$. **New Mexico.** Taos Co.: NM-3 SW of Ranchos de Taos, *8059.*

S. speciosa Nutt. var. *rigidiuscula* Torr. & Gray. $2n = 9_{II}$. **Texas.** Cottle Co., US-82 N of Paducah, 2.7 km S of North Pease R., *8234.*

S. squarrosa Muhl. $2n = 18$. **Ontario.** Frontenac Co.: Hwy-7 W of Sharbot Lake Prov. Park, *Ch 2319.* Nipissing Dist.: W of Mattawa, *Ch 2311;* Verner, *Ch 2301.*

Renfrew Co.: W of Stonecliffe, *Ch 2312*. Timiskaming Co.: NE of New Liskeard, *Ch 2307*. **Quebec.** Ile du College, *Ch 2308*.

S. ulmifolia Muhl. $2n = 18$. **Arkansas.** Pope Co.: AR-27 N of Hector, 17.5 km S of AR-16, *8296*. Yell Co.: AR-10 E of Danville, 13.9 km W of AR-7 , *8287*.

S. wrightii Gray. $2n = 9_{II}$. **Arizona.** Cochise Co.: Portal Rd. W of Portal, *7988*. Greenlee Co.: US-666 N of Morenci, *8005*. $2n = 18$. **New Mexico.** Grant Co.: E of Kingston, W of Gallinas Canyon, *8038*. Lincoln Co.: NM-37 N of Ruidoso, *8147*.

Townsendia parryi D. C. Eaton. $2n = 36$. **Alberta.** *Chinnappa 1103*, seedlings.

Virgulus adnatus (Nutt.) Reveal & Keener. $2n = 20$. **Alabama.** Conecuh Co.: AL-83, 6.3 mi S of AL-47, *S & Ch 6357*. **Florida.** Wakulla Co.: US-319 S of Sopchoppy, *S 7434*.

V. × *amethystinus* (Nutt.) Reveal & Keener. $2n = 10$. **Ontario.** Wellington Co.: SE of Guelph, *S 7394*.

V. campestris (Nutt.) Reveal & Keener. $2n = 10$. **British Columbia.** BC-5 S of Kamloops, *Hanner s.n.*

V. carolinianus (Walt.) Reveal & Keener. $2n = 18$. **Florida.** Dade Co.: SW of Homestead, *S 5385*. US-41 16.5 mi W of FL-27, *S 5393*. Hillsborough Co.: along Hillsborough R. S of Morris Bridge Rd., *S 4569*. Marion Co.: I-75, 30 mi S of Ocala, *S 5419*. Osceola Co.: N of Davenport, *S 5343;* Holopaw, *S 5352*. Wakulla Co.: St. Marks, *Godfrey 77401*.

V. concolor (L.) Reveal & Keener. $2n = 8$. **Florida.** Levy Co.: US-98 7.4 mi NW of Inglis, *S, Bt & Canne 3957*. Marion Co.: N of Ocala, *S 7453*. Putnam Co.: FL-19 S of Rodman, *S, Bt & Canne 3994*. Taylor Co.: Perry, *S, Bt & Canne 3917*. **Georgia.** Laurens Co.: US-411 4.8 mi N of county line, *S, Bt & Canne 4040*. **Mississippi.** Simpson Co.: MS-13 S of Mendelhall, *S, Bt & Canne 3814*. **North Carolina.** Montgomery Co.: S of Seagrove, *Ch & Hart 375*. Scotland Co.: E of Hamlet, *Ch & Hart 367*. **South Carolina.** Williamsburg Co.: N of Rhems, *S & Ch 6119*. **Virginia.** Buckingham Co.: N of Dillwyn, *Ch & Hart 331*. $2n = 16$. **Florida.** Santa Rosa Co.: W of Harold, *S, Bt & Canne 3880*.

V. fendleri (Gray) Reveal & Keener. $2n = 5_{II}$. **Kansas.** Barton Co.: S of Russell, *S & Bt 7323*. Russell Co.: US-281 1 mi N of Saline R., *S & Bt 7324*. $2n = 10$. **Colorado.** El Paso Co.: Manitou Springs, Garden of the Gods, *S & Bt 7274*. **Kansas.** Osborne Co.: N of Osborne, *S & Bt 7333*. $2n = 5_{II} + 1_{II}$ or 2_{I} supernumeraries. **Nebraska.** Webster Co.: S of Red Cloud, *S & Bt 7336*.

V. georgianus (Alex. in Small) Semple. $2n = 50$. **South Carolina.** Chesterfield Co.: W of Jefferson, *S & Ch 6104*.

V. grandiflorus (L.) Reveal & Keener. $2n = 60$. **North Carolina.** Randolph Co.: N of Seagrove, *Ch & Hart 389*. Richmond Co.: S of Norman, *Ch & Hart 374*.

V. novae-angliae (L.) Reveal & Keener. $2n = 5_{II}$. **Illinois.** Bureau Co.: I-80 W of Princeton, *7691*. $2n = 10$. **Illinois.** White Co.: IL-1 S of Grayville, *8831*. Clark Co.: N of Martinsville, *S, Bt & Canne 3739*. **Iowa.** Iowa Co.: W of Ladora, *S & Bt 4516*. **Manitoba.** W of Austin, *S & Bt 4184*. MAN-1 2 mi E of road to Lenore by Oak Lake, *S & Bt 4193*. **New York.** Chautauqua Co.: S of Jamestown, *Ch & Hart 439*. **Vermont.** Addison Co.: W of New Haven, *S 6910*. **Virginia.** Highland Co.: N of Monterey, *Ch & Hart 413*. **Wisconsin.** Wood Co.: W of Pittsville, *S & Ch 5062*. $2n = 10 + 2\text{–}3$ supernumeraries. **Pennsylvania.** York Co.: US-15 5.7 km N of county line, *Ch & Hart 293*.

V. oblongifolius (Nutt.) Reveal & Keener. $2n = 5_{II}$. **Oklahoma** Comanche Co.: W of Lawton, *8239*. **West Virginia.** Pendleton Co.: N of Franklin, *S & Ch 5892*.

V. patens (Ait.) Reveal & Keener var. *gracilis* (Hook.) Reveal and Keener. $2n = 5_{II}$. **Oklahoma.** Murray Co.: OK-7 W of Sulphur, junc. of OK-12, *8252*.

V. patens (Ait.) var. *patentissimus* (Torr. & Gray) Reveal & Keener. $2n = 10_{II}$. **Arkansas.** Boone Co.: US-62 SW of Zinc, *8308*. **Oklahoma.** Atoka Co.: OK-7 W of Farris, W of Muddy Boggy Creek, *8262*. $2n = 20$. **Missouri.** Callaway Co.: S of Fulton, *S & Ch 5304*.

V. pratensis (Raf.) Reveal & Keener. $2n = 10$. **Texas.** Grimes Co.: N of Keith, *S & Ch 6437*. Walker Co.: US-190 2.6 mi E of side road to Phelps, *S & Ch 6434*. $2n = 20$. **Texas.** Milam Co.: E of Rockdale, *S & Ch 6443*.

V. sericeus (Vent.) Reveal & Keener. $2n = 10$. **Manitoba.** SW of Carlowrie, Indian Res. 2A, *S 6709*. **Minnesota.** Crow Wing Co.: MN-371 S of Brainerd, *8795-1*. **Ontario.** Rainy River Dist.: N of town of Rainy River, *8787-1*. **Wisconsin.** Iowa Co.: WI-23 just E of Tower Hill St. Pk., *S & Ch 5200*. Jackson Co.: E of Osseo, *S & Ch 5069*. Trempeleau Co.: E of Osseo, *S & Ch 5071*.

V. walteri (Alex. in Small) Reveal & Keener. $2n = 20$. **Georgia.** Charleston Co.: Folkston, *S 7552*. **North Carolina.** Harnett Co.: NE of Pineview, *S & Ch 6062*. **South Carolina.** Williamsburg Co.: N of Rhems, *S & Ch 6118*.

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THE NEW ENGLAND DISTRIBUTION OF *OPUNTIA HUMIFUSA* (RAF.) RAF.

ROBERT S. WALLACE AND DAVID E. FAIRBROTHERS

ABSTRACT

The distribution of the eastern prickly-pear cactus, *Opuntia humifusa* in New England is presently restricted to Connecticut and Massachusetts. The northern limit of the range of this species is delimited at approximately 42 degrees north latitude.

Key Words: Cactaceae, *Opuntia humifusa, Opuntia compressa,* prickly-pear, New England.

The eastern prickly-pear cactus, *Opuntia humifusa* (Raf.) Raf. (syn. *O. compressa* (Salisb.) Macbr.; *O. rafinesquei* Engelm.) is one of the most widely distributed species of cacti in North America (Fernald, 1950; Benson, 1982) with New England as its northern limit east of the Great Lakes. This flat-stemmed species (Subgenus *Opuntia sensu* Benson; *Platyopuntia* Engelmann) is usually associated with coastal (dune) habitats, pine barrens, granite or shale outcrops, and other areas that are subject to occasional disturbance (Hanks and Fairbrothers, 1969; Benson, 1982). Although primarily a species of the coastal plain, it may also be found inland at higher elevations, or in association with rock outcrops near river systems.

Previous ecological and systematic studies (Hanks and Fairbrothers, 1969; Benson, 1982; Wallace and Fairbrothers, 1986) have determined that *Opuntia humifusa* is a single species throughout its range in the northeastern United States, and that this species is particularly vulnerable to loss by natural succession. Without frequent disturbance, the prostrate-growing cactus is rapidly replaced by more vigorous vegetation.

To evaluate the historic distribution of *Opuntia humifusa* in New England, a survey of 68 herbaria was made. Distribution data were obtained from 14 herbaria in which New England specimens are deposited. The data are summarized in Figure 1. The earliest record of collection in New England was in 1852 from Branford, Connecticut, near Saltonstall Lake. The majority of vouchered localities represented in the herbaria are from Connecticut (25 sheets, 18 localities), and are previous to 1950. Graves et al. (1910) reported seven localities for this species; only two localities were reported by Seymour (1969). Development of coastal habitats has probably extirpated all but a select few populations in Connecticut. Six extant populations have been verified since 1975 in Fairfield, Middlesex, and New Haven Counties as part of the Natural Diversity Data Base (N. Murray, pers. comm., 1985). The species is not listed as rare or endangered in Connecticut (Mehrhoff, 1978) although it has presently been assigned "questionable status" (K. Metzler, pers. comm. 1985).

Within Massachusetts, Coddington and Field (1978) assigned the status of "few" to this species and reported three extant populations located in Barnstable and Nantucket Counties. Herbarium records from 26 sheets provide data for seven native (?) localities plus one introduction. The populations on Cape Cod (Barnstable Co.) are presumed to be introduced (B. Sorrie, pers. comm., 1986) since they are often associated with buildings and other anthropogenically disturbed areas. Such disturbance may have contributed to the persistence of native populations of the cactus at these localities. Collins (1914) described such populations in Wellfleet and Truro being newly discovered at that time. Two additional introduced populations in Essex County are recorded (Robinson, 1880) but no herbarium documentation of these was found. Harris (1975) has excluded the prickly-pear from his updated flora of this county.

Based on a single herbarium sheet (US No. 637935, *J.N. Rose, P. C. Standley,* and *P. G. Russell No 15057,* 26 April 1916) prepared from a cultivated plant supposedly sent by E. Gillett, the documentation of a native population in Hampden County (Southwick), Massachusetts, is questionable. Although possessing seemingly ideal habitats for this species, the Elizabeth Islands, Penikese Island, Martha's Vineyard, and Monomoy Island have not been found to support populations of *Opuntia* (Jordan, 1874; Lewis, 1924; Fogg, 1930; Moul, 1948, 1961, 1969). Bicknell (1914) and MacKeever (1968) included *O. humifusa (O. compressa)* as present, but rare on Nantucket Island. The introduction of *O. humifusa* into a granite

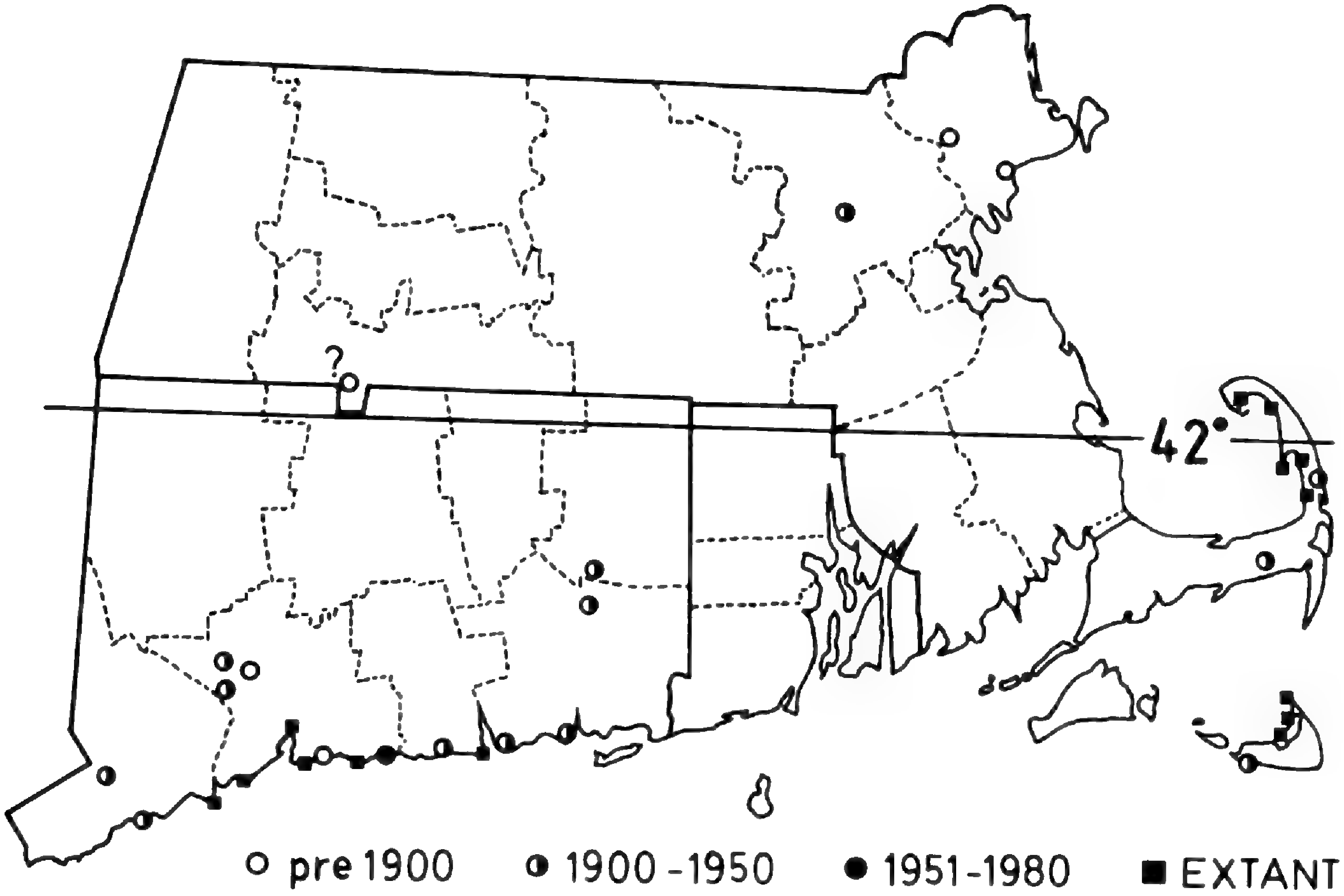

Figure 1. The New England distribution of *Opuntia humifusa*. The most recent collection records for each locality are shown. ? = population of questionable validity.

schist outcrop in Concord, Middlesex County, was reported previously (Eaton, 1938), as was a population near North Reading (Dame and Collins, 1888). No vouchered specimen of collections from Rhode Island was found. Reports of the prickly pear from the south shore of Block Island remain unverified (R. Enser, pers. comm., 1985).

The northern limit of the geographical range of *Opuntia humifusa* may be defined by a line approximately 42 degrees north latitude. The coastal populations (although perhaps introduced) in Barnstable County, Massachusetts, are near this latitude. Voucher collections from Mt. Merion, Greenport, New York (Columbia Co.; 42° 14′ N) and from near Kingston, New York (Ulster Co.; ca. 41°56′ N) provide additional support for this limit. The specimen(s) cited by Benson (1982, p. 924) in Cortland County, New York (ca. 42°37′ N) are actually specimens from Van Cortlandt Park (40°53′ N) in Bronx County, New York City (*E.P. Bicknell, s.n.,* 1904, NY; 1921, NYS). The distribution of *O. humifusa* in Ontario also indicates that this 42°N latitude line is the northern limit east of Michigan (Reznicek, 1982). In his distribution map for this species, Benson (1982) shows populations in west central Michigan and southern Wisconsin (to ca. 43°30′ N). We have not verified if these more northerly specimens are *O. humifusa* or if they might be *O. macrorhiza* Eng. or putative hybrid products of the two species.

The data we have presented refute a recent statement which indicated that the range of *Opuntia humifusa (O. compressa)* is the "Entire United States except approximately [the] northwest third and Maine" (Weniger, 1984). Prudent management of *O. humifusa* in New England requires that the few remaining extant populations be protected, given rare status, and those in jeopardy of succumbing to successional changes be maintained through controlled disturbance of their habitats.

ACKNOWLEDGMENTS

We wish to thank the curators and technicians from the following herbaria that provided access to and data from specimens of *Opuntia humifusa:* BH, CACO, CHRB, HNH, CONN, MO, NEBC, NY, NYS, PH, SCHN, US, VT, and YU. We also thank Kenneth Metzler, Nancy Murray, Bruce Sorrie, and Rick Enser for information on extant populations and the current status of this species in CT, MA, and RI.

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CALAMAGROSTIS PICKERINGII IN MAINE

CRAIG W. GREENE

ABSTRACT

Calamagrostis pickeringii (Poaceae) has been found growing in Maine for the first time. The population, growing in Corea Heath, a costal peatland in Gouldsboro, Hancock County, helps fill a large gap in the species' range in northeastern North America. Its post-glacial northward migration from southern unglaciated stations is suggested as generating its present distribution. Disjunctions in its range may reflect both limited availability of suitable peatland habitats and incomplete documentation of peatlands in east costal Maine and New Brunswick.

Key Words: *Calamagrostis,* Poaceae, migration, Maine

The recent discovery of a population of *Calamagrostis pickeringii* Gray in Maine marks the first documented record of the species in the state. The grass was found growing in abundance along the edge of Corea Heath, a coastal raised peatland in Gouldsboro, just west of the village of Corea, in Hancock County. Voucher specimens (*Greene 1328*) are deposited in the College of the Atlantic Herbarium and at MAINE and NEBC. Earlier reports of *Calamagrostis pickeringii* in Maine refer to a misidentified specimen of *C. stricta* (Timm) Koeler (*C. neglecta* (Ehrh.) Gaertn., Mey. & Scherb.) from Mt. Katahdin (Richards et al., 1983).

Calamagrostis pickeringii is distributed from Newfoundland and Nova Scotia to mountainous areas of New Hampshire and New York, and to lowland bogs or ponds in Massachusetts, Long Island and New Jersey. The Maine station helps fill the considerable gap in the species' distribution between New Hampshire and Nova Scotia (Figure 1). Fernald (1933) suggested that the disrupted distribution of *C. pickeringii* was a consequence of pre-Wisconsin dispersal to the isolated stations where it persists. However, considerable geological evidence (Wynne-Edwards, 1937; Morisset, 1971) rendered

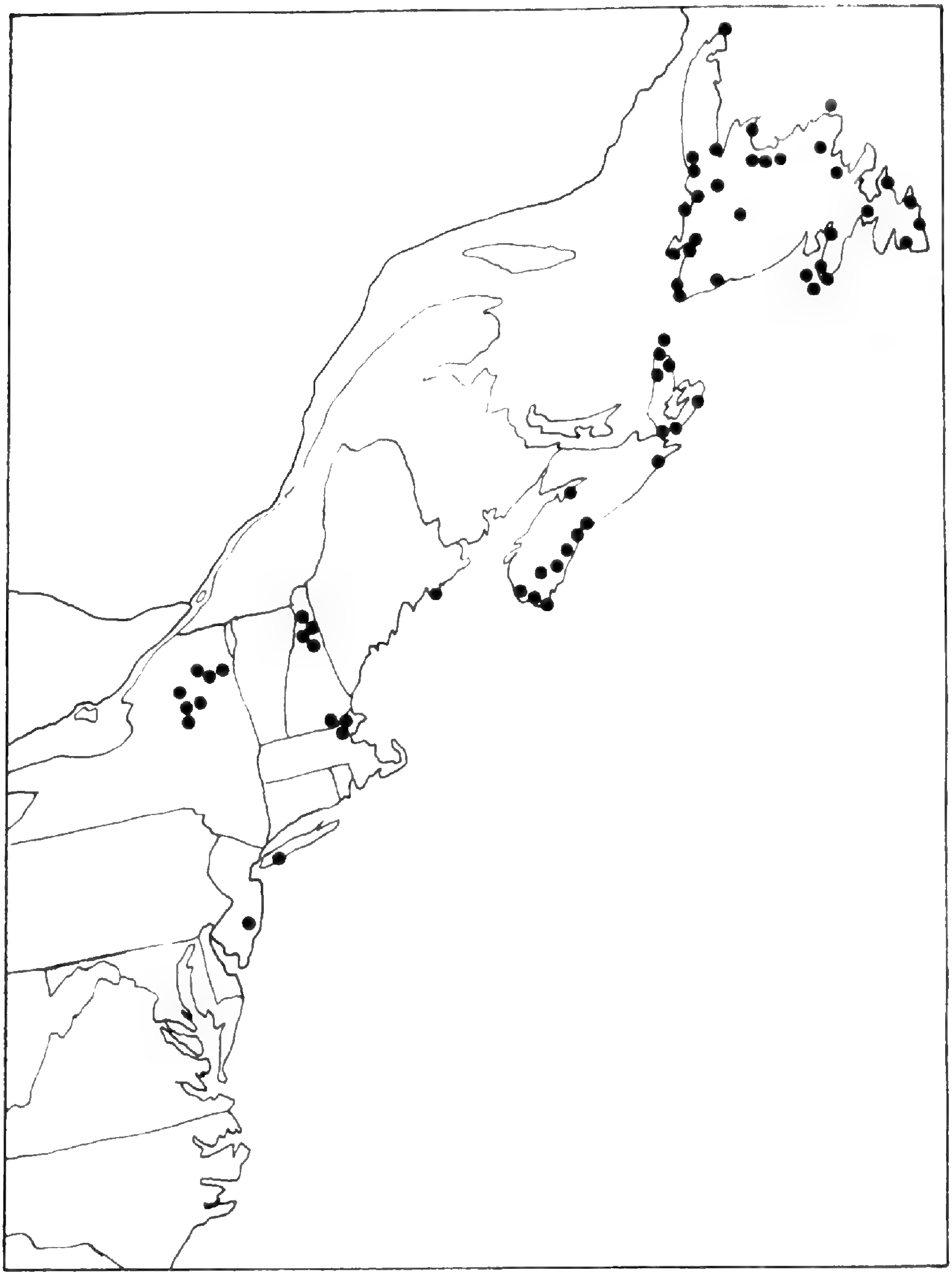

Figure 1. Distribution of *Calamagrostis pickeringii* in eastern North America. Records are based on representative herbarium specimens at CAN, DAO, GH, NEBC and NY.

Fernald's interpretation untenable; most of the species' range was overridden by glaciers in Wisconsin times. It is much more likely that the species survived glaciation in coastal regions of eastern North America south of the limit of glaciation and spread northward in early post-glacial times. Most disjunctions in the present range of the species were probably generated more recently with changing climate and accompanying decline of suitable habitats. Its apparent absence from vast regions of Maine covered by *Sphagnum* peatlands and other seemingly suitable habitats for the species remains somewhat of an anomaly. East coastal Maine and New Brunswick, however, have not been explored botanically as thoroughly as have other regions within the range of *C. pickeringii.* Careful searching, such as in coastal raised peatlands of eastern Maine that Worley (1982) cataloged, may well reveal additional populations of the species.

Calamagrostis pickeringii thrives in sphagnous peatlands, wet meadows, peaty alpine soils and margins of mountain ponds and streams. Within its range, *C. pickeringii* is one of the few grasses that grows in open mats of *Sphagnum* in peatlands, where it forms scattered culms from long, spreading rhizomes. Along streams or in finer soils, rhizomes may be shorter, resulting in tussock formation.

Several workers (Fernald, 1933; Louis-Marie, 1944; Löve & Löve, 1966) have suggested that *Calamagrostis pickeringii* is closely related to *C. porteri, C. perplexa, C. purpurascens, C. fernaldii,* and *C. lacustris* (the latter two now included as variants of *C. stricta* subsp. *inexpansa* [Gray] C. W. Greene; Greene, 1984). This inference is based primarily on the twisted and bent awn that characterizes each. But in other respects, *C. pickeringii* is clearly divergent from all of them and occupies an isolated position in the genus. In contrast with the others, *C. pickeringii* has leaves that are usually smooth above, its lemma is rather thick and strongly scabrous, and its short callus and rachilla hairs are more like those in some species of *Agrostis* than other species of *Calamagrostis*. *Calamagrostis pickeringii* is tetraploid ($2n = 28$), sexual, and self-incompatible, whereas the other above-named species are octoploid or higher in chromosome number. *Calamagrostis porteri* and *C. perplexa* are sexual, but *C. purpurascens* and *C. stricta* subsp. *inexpansa* tend to reproduce asexually by agamospermy (Nygren, 1954, 1958; Greene, 1980 [Ph.D. thesis, Harvard Univ., Cambridge, MA], 1984).

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IN MEMORIAM

Richard Jefferson Eaton
1890–1976

In the history of the New England Botanical Club only two members have dedicated themselves actively and continuously to the affairs of the Club for a period of sixty years or more. One of these is Richard Jefferson Eaton. His membership began on December 11, 1916 and ended only with his passing on June 11, 1976. During these six decades he served as President (1946–1948), Treasurer (1922–1943), Phanerogamic Curator and Curator of Vascular Plants (1959–1971), and Councillor (1958) for the Club. In addition to these Council positions he served on the following committees: Field Excursions (Chairman: 1943, 1950), Flora of the Metropolitan Reservations, Flora of the Boston District (Chairman: 1936–1941), Flora of Massachusetts (Chairman: 1949–1950), History of New England Botany (Chairman: 1962), Plant Distribution, and the Herbarium Committee (following his tenure as Curator until his death).

As Treasurer he guided the Club's finances through the difficult Depression years. As Curator of the Club's Vascular Herbarium he made significant improvements by promoting an active loan program (resulting in greater critical examination of Club specimens), by adding much new, professionally mounted material (increasing the Club holdings from about 222,000 to 243,000 sheets), by having many specimens repaired, and by replacing many worn folders. He took great interest in verifying the identification of Club specimens.

One of the most noteworthy aspects of Mr. Eaton's botanical career was his deep interest in the flora of Concord, Massachusetts. He was born in that historic township on November 13, 1890, the youngest son of William Lorenzo Eaton, a long-time teacher and Principal of the Concord High School, and Florence (Taft) Eaton of

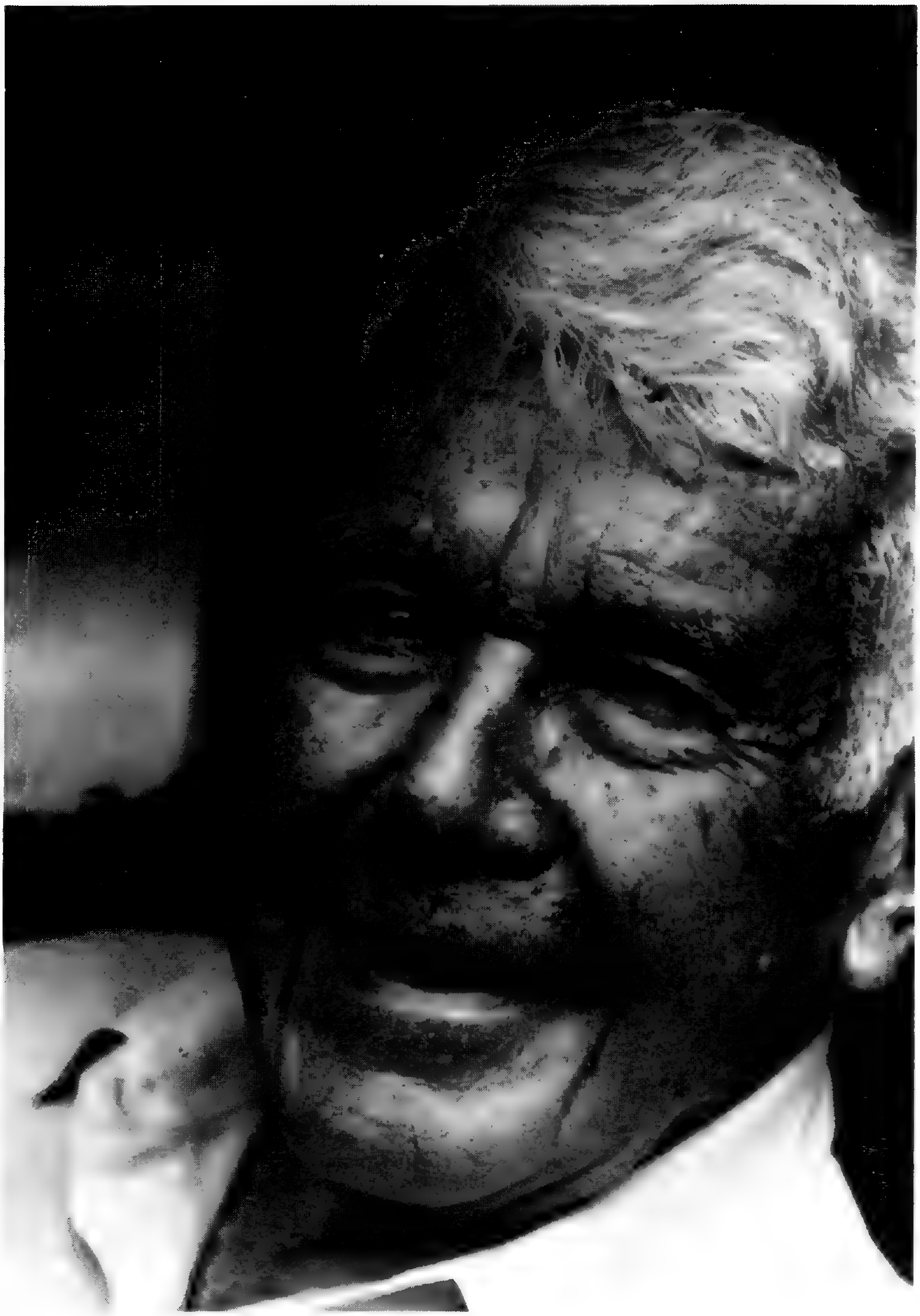
Uxbridge, Massachusetts. During his boyhood a few of the lesser Concord literary luminaries remained in their old age. One of these, Franklin Sanborn, Abolitionist and friend of Henry Thoreau, lived next door. Mr. Eaton remembered shovelling snow for him at ten cents an hour. Mr. Eaton's early interest in Concord's flora was nurtured by his older brother Fred, who was a good friend of Thoreau's disciple and avid Concord botanist, Alfred W. Hosmer. Fred would seat his small brother on the handlebars of his bicycle and ride the three miles to Sandy Pond in nearby Lincoln to visit the early-flowering and locally rare *Hepatica americana* (at the same site to which Mr. Eaton later led his own family on many spring pilgrimages).

After attending the local high school Mr. Eaton proceeded to the alma mater of his father (Class of 1873) and three older brothers, Harvard University, from which he received his A.B. in 1912. He completed the requirements in three years due in part to advanced credits in Greek and Latin. His "intention was to emulate the younger Agassiz, make a competence within ten years, and then become a famous scientist or something," possibly in the mold of Mr. Eaton's revered professor, Oakes Ames.

Mr. Eaton began a business career as an office boy for a cotton firm at $6 per week. He worked for the firm in Providence, R.I. until 1916 when he spent "a summer on horseback on the Mexican Border as an enlisted man in the Rhode Island Battery." From 1917–1919 he was an officer on active duty in the field artillery in France, participating in a number of military actions including the second Battle of the Marne. Just prior to leaving the armed services he spent a "wholly delightful interlude" of four months at Cambridge University studying social science.

Returning from the war he continued with his former employer until 1923 when he co-founded the cotton firm of Eaton & Balch, Inc. in Boston which continued until its liquidation in 1928. He married Gertrude Gouverneur Sturgis in 1925 in Cambridge. They had four children: Richard Jefferson Jr. (who died in infancy), John Hubbard Sturgis, Katharine Hosmer, and Jefferson Taft.

During the Depression Mr. Eaton devoted much of his energy to charitable organizations. He was director of the Family Welfare Society of Boston and of the Cambridge Y.M.C.A. His service as a member of the Overseers Committee to visit the Gray Herbarium



extended from 1930 through 1943. In 1931 he began a long term as a trustee of the Suffolk-Franklin Savings Bank of Boston. Soon thereafter he joined Houghton Mifflin Company where he managed their private library department which published leather-bound sets of books for personal collections.

Responding again to the call of duty in the Second World War, Mr. Eaton accepted a commission in the Army which led to duty in Military Government. He served in Great Britain, France, Belgium and in Germany where he became Military Governor of Leipzig until this city was regretfully turned over to the Soviets. He was discharged as lieutenant colonel with a Bronze Star in 1945.

The following year he became treasurer of a small engineering firm. The business was sold in the early 1950's at which time Mr. Eaton retired. In retirement he continued and enlarged his civic and natural history pursuits. He was a member of the planning board of Lincoln, Massachusetts from 1951 to 1955 (Chairman in 1954). The preservation of Lincoln's rural character owes much to the change in residential zoning (from one to two acres) that his board put through. He was part of a town committee that contested Julian DeCordova's will in order that the estate could be put to practical use. The successful case resulted in the establishment of the DeCordova Museum.

Mr. Eaton's first wife died in 1967. In December 1969 he remarried. His second wife was Gertrude ("Patsy") Livingston Kittredge whose husband, Henry Kittredge, a Harvard classmate, had also died in 1967. The Eatons removed to Barnstable, Massachusetts where after six happy years Mr. Eaton died on June 11, 1976 after a brief illness. Memorial Services were held at the First Parish Church in Lincoln, and he was buried in Concord's Sleepy Hollow Cemetery (where lie other Concord figures of literary, historical and botanical note). Mrs. Eaton presently lives in Orleans, Massachusetts.

Mr. Eaton was one of the primary links in a long line of Concord botanists which extends before and includes Henry Thoreau. It was upon Mr. Eaton's recommendation that the greater part of Thoreau's herbarium was transferred from the Concord Free Public Library to Harvard University in 1959. Mr. Eaton consulted Thoreau's specimens at Harvard and in the Club Herbarium extensively and supplemented the rich collections from Concord with many specimens of his own. The crowning achievement of Mr. Eaton's botanical career was the publication of his *A Flora of Concord* in 1974. This book, which includes 1,313 taxa, crystallized the work of Concord's amateur botanists over the preceding 151 years in a systematic inventory of the town's vascular plants. Dr. Ernst Mayr and Dr. Carroll Wood of Harvard have been using this detailed local study to test a hypothesis about the separability of plant species in a limited area.

Over the years Mr. Eaton published numerous botanical notes and articles, chiefly in *Rhodora*. Some of the more noteworthy of these include articles on *Arceuthobium pusillum, Lemna minor,* the trees and shrubs of the Concord Town Forest, and *Lycopodium inundatum*. In this latter article he named a new variety (*Lycopodium inundatum* L. var. *robustum* R. J. Eaton).

In his later years he devoted much attention to the flora of Cape Cod. Together with friend and fellow botanist Dr. Henry Svenson he helped build the herbarium collection of the Cape Cod Museum of Natural History, where a new Herbarium will be dedicated to him and Dr. Henry Svenson. At the time of his death Mr. Eaton was in the midst of a project to construct keys to the vascular plant species of Middlesex County, Massachusetts.

Mr. Eaton's other great love was bird-watching. He became a member of the Nuttall Ornithological Club in 1929. His involvement extended over a long period (serving as Councillor: 1942–1943, 1948–1953, 1959–1964; Trustee: 1940–1943; and Vice-President: 1957–1959). He was an early birdbander, belonging to the Northeastern Bird-Banding Association. From 1936–1943 he served as a Director of the Massachusetts Audubon Society. As in botany, he published a number of articles and notes in this field in *The Auk* and *Bird-Banding*. He shared (and helped inspire) an interest in botany with his ornithologist friends, among whom were Ludlow Griscom and Dr. G. W. Cottrell of Harvard. In the 1960's when his ability to hear bird calls began to wane he naturally began to favor his interest in botany.

The Concord woods, meadows and rivers of Mr. Eaton's youth inspired a number of life-long outdoor pursuits. As an avid cross-country skier he explored the woods and fields. All his life he enjoyed the rivers by canoe and on skates. Until his mid-seventies he unfurled on frozen meadows the skate sail he had made as a boy.

The fields of his native town yielded a treasure of Indian relics and arrow-heads which he collected. Wherever he lived he maintained a large vegetable garden and orchard. His two and two thirds acre property in Lincoln became a delightful arboretum and wildflower garden. He took much pleasure in cataloging its flora in a paper published in *Rhodora.* The vegetable garden was described as "professionally perfect" by a neighbor.

Mr. Eaton was also an active tennis player into his seventies and with neighbor Charles Jenney was Lincoln Town's Men's Doubles Champion for ten years after World War II. The competitive spirit also made him a keen chess and bridge player. His complete collection of Indian head pennies reflected his collecting instinct.

Like a Renaissance man Mr. Eaton's intellectual curiosity and knowledge ranged over many fields, especially in science and history, from keeping abreast of current scientific developments to acquiring a detailed knowledge of the history of the Revolutionary War era. He was an avid reader. More importantly he was able to communicate his understanding and insights clearly and effectively to others through his writing and personal contacts.

Mr. Eaton embodied many traditional New England values—Yankee frugality, diligence, and self-reliance. He recycled papers and cans, saved string, mended china, chairs and socks, and believed in the brown bag lunch. It was as though his Concord upbringing had imbued him with all the practical wisdom and experience of a New England farmer. Until he was 75 he always cut and split his own firewood and did not buy a power mower until age 65. He was never afraid to get his hands dirty or work in the blazing sun. There was little he could not repair using his collection of sharpened, oiled and neatly stored tools (except for television sets which he never owned).

When Mr. Eaton spoke it was with authority from a position of knowledge. In identifying a pressed plant specimen he would (almost in one jerky motion) bend down close to the sheet with his hand lens, make his observation, quickly bring his head back up and announce his decision. Being a perfectionist he gave much attention to detail and had a compelling desire to "get it right."

Acquaintances portray Mr. Eaton as having a formal, commanding presence, dressed invariably in tweed jacket and tie, even in the field. Friends remember the warmth of his smile and the twinkle in his eyes. His correspondence and informal writings are notable for their liveliness and humorous style. He was particularly courteous, considerate and very generous with his time and expertise. In this last respect he was effective in encouraging the endeavors of a number of amateur botanists including the present writer.

Dick Eaton was one of the last of a tradition of "gentleman botanists" who played such a vital role in the Club during the first half of this century. His dedication, talent, and kindness are missed, but the example he set will remain to inspire present and future amateur naturalists. [Raymond Angelo]

INTERNATIONAL CONFERENCE ON LOWLAND HEATHS

An international conference on lowland heaths is planned for May 5–7, 1988, on Nantucket Island, Massachusetts. The meeting will seek to explore the extent, origins, development, management, and conservation of lowland heaths in North America. The conference will emphasize the influence of human land use history on all phases of heath ecology. We plan to publish the conference proceedings.

Nantucket Island, some 30 miles off the coast of New England, supports some of the best developed and preserved heaths in eastern North America. Field trips on Nantucket are planned, both before and after the conference.

The meeting will be hosted by the University of Massachusetts Nantucket Field Station. It is sponsored by the American Society for Environmental Education and co-sponsored by the Nantucket Conservation Foundation and the Massachusetts Audubon Society. At present, researchers from Britain, Atlantic Canada, and the United States have expressed interest in attending and presenting papers.

British and European participants are especially welcome, as their extensive experience with heath associations will aid comparatively recent attempts to understand the ecology of rarer North American heaths.

Interested persons wishing further information should contact the conference chairman, Dr. Wesley N. Tiffney, Jr., University of Massachusetts, Nantucket Field Station, P.O. Box 756, Nantucket, Mass., 02554, U.S.A. Telephone: 617-228-5268.

Vol 89, No. 858, including pages 113–246, was issued April 30, 1987

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Cover illustration

The American elm (*Ulmus americana* L.), official state tree of Massachusetts, has been a familiar sight for decades throughout the Northeast. The largest known living specimen in Mass. is located in Stockbridge. In 1982, it was 119′ high, had a crown spread of 118′, and was 232″ in circumference. In recent years, many of these stately trees have succumbed to Dutch Elm disease, a fungus accidentally introduced from Europe. The article by Ellmore and Phair (Rhodora Vol. 89, No. 857) contains the latest information of the status of this once dominating tree in our flora. Photo courtesy of Rhoda Vanderwall.

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ON THE OCCURRENCE OF *PLATANTHERA LEUCOPHAEA* IN LOUISIANA AND ARKANSAS[1]

CHARLES J. SHEVIAK

ABSTRACT

Recent herbarium studies have disclosed a specimen supporting reports of *Platanthera leucophaea* (Nutt.) Lindl. in Louisiana, but specimens cited in the past from Arkansas are neither of this species nor were they collected in that state.

Key Words: *Platanthera leucophaea, Platanthera praeclara,* Arkansas, Louisiana

INTRODUCTION

Literature reports of *Platanthera leucophaea* (Nutt.) Lindl. in Louisiana and Arkansas (Ames, 1910; Correll, 1950) have not been verified by local workers (Pridgeon and Urbatsch, 1977, and Smith, 1980, respectively), and the species is not known to be extant in these states. Present interest in this rare species under state and federal endangered species and natural areas programs has made these reports of more than floristic interest. Furthermore, the recent recognition of *P. praeclara* Sheviak & Bowles (Sheviak and Bowles, 1986) has brought into question the identity of the specimens which served as the bases of the earlier reports. I provide here determinations of the specimens and notes on the collection localities.

LOUISIANA

A specimen of *Platanthera leucophaea* at AMES (originally at GH) was cited from Louisiana by Ames (1910). Correll (1950) cited

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[1] Contribution number 494 of the New York State Science Service.

the species from "Louisiana (*Hale*)." Josiah Hale lived in Alexandria, Louisiana, on the Red River, along which *P. leucophaea* was first collected upstream in what is now southeastern Oklahoma. Hale collected rather widely, and routinely worked at least as far upstream as Natchitoches, Louisiana (Ewan, 1977). Prairies occurred locally in various portions of the state, and a group of them was located several miles downstream from Alexandria (Darby, 1816, 1817). The AMES specimen, however, bears no reference to Hale, rather only the handwritten "Louisiana" and a separate label with "ex herb. Geo. Thurber." Comparison of the handwriting with samples of Hale's published by Ewan (1969) and on Hale specimens deposited at KNOX established that the hand was not Hale's. If Correll's citation was of another specimen, it has not been located.

The AMES specimen in all likelihood was collected in the present state of Louisiana, but without date or collector the label data cannot be taken as unequivocal evidence of the species' occurrence within the present political boundaries of the state. Although Louisiana achieved statehood very early in the history of the region, the use of the name to cover much of the area of the original Louisiana Purchase persisted through the early period of botanical exploration in the region.

ARKANSAS

Platanthera leucophaea has been reported from White Co., Arkansas (Ames, 1910; Correll, 1950), based on a specimen at GH cited by Ames as "Westpoint, *Gunnison* (no. 16)." Two specimens of this collection were located during this study, and both are of *P. praeclara.* On both sheets, however, the locality is clearly "Westport." The GH specimen (now at AMES), bearing Ames' annotation, is labeled: "No 16. Westport. Arkansas. Gunnison. Exped." A second sheet, at NY (from the Torrey Herbarium), bears: "16_{II}. Prairies beyond Westport. Ark." These data clearly establish the origin of these specimens from a locality well outside the present state of Arkansas.

Captain J. W. Gunnison commanded the expedition that explored a central route for a railroad to the Pacific. The fitting-out camp was established after arriving "at Kansas, which is near the western border of the State of Missouri, and about a mile and a quarter below the junction of the Kansas river with the Missouri.... Our encampment was some five miles from Westport and the western line of the State of Missouri...." (Beckwith, 1855). The meteorological tables in this report place the camp three miles west of Westport. The Westport camp was occupied by mid-June; on the 23rd the party headed west, reaching the Arkansas River in the present state of Kansas on 16 July. The origin of the reference to Arkansas on the specimens is unclear. It may refer to the river, the locality then being rather far "beyond Westport." The low number on the sheets, however, suggests an early collection, although the species may have been encountered more than once. Torrey and Gray (1855), however, reported the plant from "Prairies near Westport" without reference to Arkansas. They reported other species from more than one locality, and various references to "Arkansas river," "Upper Arkansas," and "the Arkansas" are included. The confusion probably stems from the death of the expedition botanist, F. Creutzfeldt, along with Gunnison and several others, before the completion of the trip. Torrey and Gray obviously faced considerable difficulties in interpreting field notes made by a German botanist in a remote wilderness with only vaguely established geographic names, and some ambiguity in their publication is to be expected. Irrespective of any confusion regarding the precise collection locality, however, it is clear that these specimens were not collected within the present state of Arkansas.

ACKNOWLEDGMENTS

I thank the curators and staffs of the herbaria that lent specimens for this study, including AMES, BKL, BM, DAO, DEK, F, ILL, IND, KANU, KNOX, KSC, MICH, MINN, MO, MWI, NEB, NY, NYS, OCLA, OKL, OKLA, OS, SDU, TEX, UARK, UMO, US, WIS. I also appreciate the efforts made to locate Hale or other critical specimens at CGE, DUKE, DWC, E, G, K, LIV, LSU, MANCH, NLU, NO, OXF, VDB. I am indebted to E. A. Gossen, New York State Museum Library, for uncovering the biographical and archival sources that were essential to this report.

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CHROMOSOME NUMBERS FROM THE FLORA OF THE JUAN FERNANDEZ ISLANDS. II.

DAVID M. SPOONER, TOD F. STUESSY, DANIEL J. CRAWFORD, AND MARIO SILVA O.

ABSTRACT

Eighteen chromosome counts are reported from populations in 12 species from the Juan Fernandez Islands, Chile, plus three counts from taxa of the adjacent mainland. First reports are given for *Lobelia tupa* ($n = 21$), *Wahlenbergia masafuerae* ($n =$ ca. 11), and *Raphithamnus spinosus* ($n =$ ca. 18). These data help extend chromosomal information for endemic taxa of the archipelago as part of broad evolutionary studies on the origin and development of its vascular flora.

Key Words: chromosome numbers, Juan Fernandez Islands, evolution

INTRODUCTION

The Juan Fernandez Islands, located 360 mi W of continental Chile, contain an unusual assemblage of angiosperms of which 69% are endemic (Skottsberg, 1922). Eighteen percent of the genera are also found only in the archipelago, as is one family, the Lactoridaceae (Lammers et al., 1986). Since the discovery of the islands more than 400 years ago, a number of additional angiosperm species has also been introduced there, and the number of weedy taxa now equals that of the native flora (Skottsberg, 1922; Sanders et al., 1982).

Current investigations on the angiosperm flora of the Juan Fernandez Islands have focused on their patterns and processes of evolution (e.g., Stuessy et al., 1984). An important aspect of such studies is to determine chromosomal divergence during speciation. Toward this end, cytological material has been collected routinely during two previous expeditions to the islands in 1980. Results from these collections already have been published (Sanders et al., 1983). During a more recent expedition to the archipelago in 1984, additional bud materials for cytological analysis were collected whenever possible. Analyses of these new collections have yielded the results reported here.

MATERIALS AND METHODS

Materials and methods used in this study are the same as those described by Sanders et al. (1983). Either Snow's stain (Snow, 1963) or acetocarmine were used. Vouchers are on deposit in OS, with duplicates in CONC.

RESULTS

The 18 new chromosome counts for taxa of the Juan Fernandez Islands, plus three from taxa of continental Chile, are listed in Table 1. First reports are from *Lobelia tupa, Wahlenbergia masafuerae* (both Campanulaceae), and *Raphithamnus spinosus* (Verbenaceae). Other counts confirm previously reported numbers and give cytological information for other conspecific populations in the archipelago. It is most important to document additional populations to determine cytological constancy within taxa before reaching conclusions on evolutionary modes (e.g., Stuessy, 1971). The circa reports are accurate to plus or minus one chromosome. Extreme rarity of some of the taxa precludes the availability of additional material for more extensive examination and perhaps definitive verification.

DISCUSSION

Of the taxa reported chromosomally in this study (Table 1), three groups of species exist: (1) endemics, (2) natives, and (3) introduced weeds. Most of the taxa counted chromosomally here are endemics. The only apparently native taxon, so judged by its common occurrence in the higher elevation forests on Masatierra and Masafuera plus being found also on continental Chile, is *Peperomia fernandeziana* (Skottsberg, 1922). *Conium maculatum, Galium aparine,* and *Lobelia tupa* are introductions. The former two are originally from the Mediterranean region and from Eurasia, respectively, and the latter is from mainland Chile. Two of the collections reported here chromosomally of *Lobelia tupa,* in fact, have come from the adjacent continent. Detailed comments in this paper focus on taxa reported for the first time. General statements on numbers of species counted within genera and their chromosomal data come from the standard chromosomal indexes (Darlington and Wylie, 1955; Cave, 1958–65; Ornduff, 1967–69; Federov, 1969; Moore, 1970–77; Goldblatt, 1981–85).

The count of $n = 27$ for *Erigeron* cf. *rupicola* is interesting because of the unusual morphology of the voucher material from which the count was made. The number $n = 27$ is known (Sanders et al., 1983) from *E. fernandezianus* and *E. rupicola,* both endemic species of the archipelago. This unusual collection was obtained on Masafuera from above 200 m in Quebrada Casas in a zone of natural vegetation. The leaves are larger than in *E. rupicola* and slightly dentate toward the apex, whereas in *E. rupicola* they are smaller and entire. Although our voucher has old receptacles only, it clearly has few flowering heads, similar to the condition commonly found in *E. rupicola* and quite different from that of *E. fernandezianus, E. luteoviridis* Skottsb. and *E. ingae* Skottsb., also known on Masafuera. A better understanding of the biological significance of this voucher material will have to await completion of cladistic and phenetic studies now underway by Mr. Hugo Valdebenito in our laboratory.

Lobelia tupa belongs to a complex of seven species endemic to mainland Chile, which were treated by Wimmer (1953) as an unnamed series within subg. *Tupa* sect. *Tupa.* Our determination of $n = 21$ is the first count for the complex*, and is the first report of the hexaploid level in sect. *Tupa.* Six of the 69 species of this section have been counted as $n = 7$ and $n = 14$. Other hexaploid counts are known from subg. *Lobelia* sect. *Lobelia* (Bowden, 1959) and subg. *Tupa* sect. *Isolobus* (Lee, 1972).

The first report of $n =$ ca. 11 for *Wahlenbergia masafuerae* is significant. Five species of the genus are endemic in the archipelago with four of them restricted to Masatierra. *Wahlengbergia fernandeziana* was counted earlier (Sanders et al., 1982) as $n = 11$, as well as again here, but the other three taxa on Masatierra (*W. berteroi* H. & A., *W. grahamae* Hemsl., and *W. larraini* [Bert. ex Colla] A. DC.) have not yet been counted. The first count for *W. masafuerae* is for the only endemic species on the younger island, Masafuera.

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*Note added in proof: No chromosome count is listed for *Lobelia tupa* in any of the available indexes. However, in the course of monographic studies on Lobelioideae in our laboratory by Mr. Thomas Lammers, an incidental mention of a count for *L. typa* of $2n = 42$ was discovered in Mabberley (1974, Kew Bull. 29: 554) with neither voucher citation nor literature reference. In examining Fedorov (1969) once more, a citation (1927, Vilmorin and Simonet, Compt. Rend. Soc. Biol. Paris 96: 166) is listed for *L. trapa* L., which is now known to be an orthographic variant of *L. tupa* (Wimmer, 1953; T. Lammers, pers. comm.). In this early paper an $n = 21$ count is given for this taxon, and our meiotic count therefore confirms this report.

Table 1. Chromosome numbers of taxa from the Juan Fernandez Islands and adjacent mainland Chile.

Taxon	Gametic chromosome number[a]	Voucher[b]
APIACEAE		
Conium maculatum L.	11	MASATIERRA: Pangal Gorge, *SCRL 6204.*
ASTERACEAE		
Dendroseris neriifolia (Dcne.) H. & A.	18	MASATIERRA: up main valley from Puerto Frances, *SCVL 6624, VL 6661;* La Pascua, at S end of island, *SC 6655.*
Erigeron fernandezianus (Colla) Solbrig	27	MASATIERRA: trail from Mirador Selkirk to Valle Villagra, *SCPVRL 6238, V 6542.*
Erigeron cf. *rupicola* Phil.	27	MASAFUERA: Quebrada Las Casas, *PR 6401*
Gnaphalium viravira Mol	14	MAINLAND CHILE: CONCEPCIÓN: San Pedro, near Concepción, *SCPL 6697.*
CAMPANULACEAE		
* *Lobelia tupa* L.	21	MASATIERRA: path to Quebrada Pangal, *SCRL 6200.*
	ca. 21	MASATIERRA: path from La Hosteria to San Juan Bautista, *SC 6310;* MAINLAND CHILE: CONCEPCIÓN: San Pedro, near Concepción, *SCPL 6681.*
Wahlenbergia fernandeziana Skottsb.	11	MASATIERRA: path from Mirador Selkirk to Valle Villagra, *SC 6489.*
* *Wahlenbergia masafuerae (Phil.) Skottsb.*	ca. 11	MASAFUERA: Quebrada Las Casas, *PR 6408.*
FLACOURTIACEAE		
Azara serrata R. & P. var. *fernandeziana* (Gay) Reiche	9	MASATIERRA: path from Mirador Selkirk to Valle Villagra, *SC 6485.*
PIPERACEAE		
Peperomia berteroana Miq.	ca. 22	MASATIERRA: Valle Villagra, *LRV 6527;* Valle Ingles, *SCVL 6550.*
Peperomia fernandeziana Miq.	23 + 2	MASATIERRA: path from Valle Villagra to Mirador Selkirk, *SC 6498.*

Table 1. (Continued.)

Taxon	Gametic chromosome number[a]	Voucher[b]
	ca. 22	MASATIERRA: Valle Ingles, *SC 6579*.
Peperomia skottsbergii C. DC.	ca. 23	MASAFUERA: Quebrada Las Casas, *PR 6399*.
RUBIACEAE		
Galium aparine L.	32	MASAFUERA: Quebrada Las Casas, *PR 6394*.
VERBENACEAE		
**Rhaphithamnus spinosus* (A. Juss.)Moldenke	ca. 18	MAINLAND CHILE: CONCEPCIÓN: 7.7 km E of Fundo San José, *SCPL 6699*.

[a] All bivalents

[b] C = Crawford; L = Landero; P = Pacheco; R = Ruiz; S = Stuessy; V = Valdebenito.

*First report for the taxon

This finding indicates that there has been little or no change in chromosome number in the evolution of this species from relatives on the older island.

Raphithamnus is a genus of only two species, with one taxon (*R. spinosus*) in central and southern Chile, and the other (*R. venustus* (Phil.) Skottsb.) in the Juan Fernandez Islands on Masatierra and Masafuera. Because of the young age of the archipelago and the occurrence of generic relatives in the Neotropics (such as *Citharexylum* L.), it is almost certain that *R. venustus* evolved from the former (or at least from a taxon similar to it). The previous count of $n =$ ca. 18 for *R. venustus* (Sanders et al., 1982) and now $n =$ ca. 18 for *R. spinosus* indicates that there apparently has been no change in chromosome number in the evolution of the island taxon from that on the mainland. This idea was first suggested by Sanders et al. (1983), and is supported by this new count.

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We are pleased to acknowledge: CONAF of Chile for permission to collect in the Juan Fernandez archipelago and for facilitating our work generally; Gaston Gonzalez, former Chief of the Robinson Crusoe National Park, for his help, support, and kindness during our field studies there; Thomas Lammers for helpful information on

Lobelia tupa and its relatives; the National Science Foundation for support to TFS and DJC under grant BSR-8306436; and to CONICYT of Chile, OEA, and the Universidad de Concepción, for support to MSO.

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A NEW SPECIES OF *CAREX* (CYPERACEAE: SECTION *OLIGOCARPAE*) FROM THE SOUTHEASTERN UNITED STATES

CHARLES T. BRYSON, ROBERT KRAL AND JAMES R. MANHART

ABSTRACT

Carex impressinervia Bryson, Kral and Manhart is described from the southeastern U.S. This taxon has characters which, collectively, clearly place it in section *Oligocarpae*: staminate terminal spikes; female spike scales with harsh cusps and costae; perigynia with many impressed nerves and short, toothless beaks. It is distinguished most easily from the other *Oligocarpae* by the presence of persistent brownish fibrils of old leaf bases. This taxon appears to be quite rare, known only from four collections from the upper coastal plain and plateau regions of Alabama, Mississippi, and North Carolina.

Key Words: *Carex, Oligocarpae,* Cyperaceae, southeastern U.S.

In 1980 while studying mounted specimens of *Carex* in the section *Laxiflorae,* the senior author noted specimens that were similar to *C. striatula* Michaux and *C. hitchcockiana* Dewey but upon closer inspection differed significantly from both of these taxa. The specimens differed from *C. striatula* by having perigynia with impressed nerves and tighter basal sheaths, from *C. hitchcockiana* by possessing glabrous sheaths that subtend pistillate and staminate spikes, and from both taxa by having fibrous vegetative remains from the previous season. Further investigation resulted in the discovery that both junior authors had also observed similar discontinuities. When material of *C. hitchcockiana, C. oligocarpa* Schkuhr and the recently named *C. ouachitana* Kral, Manhart and Bryson (Kral et al., 1987) was studied, it became clear that this *Carex* is a distinct, undescribed taxon that squarely belongs in the *Oligocarpae.* The new *Carex* is described as follows:

Carex impressinervia Bryson, Kral and Manhart, *sp. nov.,* e sectione *Oligocarpae* (Figures 1 and 2).

Planta perennis, 55–65 cm longa, dense cespitosa, foliis principalibus culmo leviter brevioribus, basibus foliorum brunneolis fibrillis foliorum veternorum obtectis. Cataphylla sub foliis oblonga vel ovata, ca. 5–15 mm longa, multicostata, distaliter carinata, cuspidata vel acuta, obscure brunneola. Culmi, erecti vel expansi, graciles, trigoni, scabriduli. Pseudoculmi lateralibus sterilibus foliosissimis. Folia principalia versus basin culmi longissima et approximata; vaginae foliorum brevissimae, pallide albovirides, multicostatae, subteretes, laeves, ventraliter subscariosae praeter leviter incrassata subtruncata orificia; ligula erecta, squamae similis, angusta, ca. 1 mm lata, hippocrepica; laminae expansae vel recurvatae, compressae, anguste lineares, 14–42 cm longae, 2.0–3.6 mm latae, apicem versus attenuatae, triquetrae, margine scabridulae, pagina ad medium foliorum superna scabrella, praeter nervos principales laterales impressinervia, inferna elevatinervia, costa valde elevata scabridula. Spicae 2–4, lineares, spica ultima omnino mascula, anguste lineari-ellipsoidea vel anguste clavata, 2.7–3.4 cm longa, 2.5–2.6 mm crassa, straminea vel pallide viridis, in pedunculis gracilibus costato-angulatis 2.7–7.0 cm longis, ultimam spicam feminam multo superans. Bractea spicae masculae sine vagina, 8–10 mm longa, valde cuspidata, cuspide compressa, obtusa, scabrociliata; glumae masculae dense imbricatae, scariosae, zona costali angusta, viridi, leviter elevata, matrice scariosa, lata, alba vel pallide brunneola. Antherae tres, lineares, ca. 4 mm longae. Pedunculi spicarum feminarum laxi, filiformes, scaberuli, 1.5–15 cm longi, infimi longissimi; bracteae ut in foliis, infimae longissimae, vaginis (1.5–) 4 (–7) cm longis, laminis erectis, leviter brevioribus quam spicis vel spicas multo supenantibus. Spicae laterales omnino feminae aut (parum) 1–2 flosculos masculos terminaliter habentes, pauci-vel multiflorae, 2–4 cm longae, 2–3 mm crassae, (3–) 4–9 (–10)-florae, basin versus interruptae, ad apicem flosculis plus approximatis; glumae feminae ovatae vel lanceolatae, naviculares, cum cuspide aut mucro 3.8–5.8 mm longae, zona costali viridi, 3–5-costatae, lateribus scariosis albidis vel pallide brunneolis, apicibus glumarum infernarum valde cuspidatis. Perigynia late fusiformia, 3.7–5.0 mm longa, 1.5–2.0 mm lata, obscure trigona, in medio superficiebus planis vel leviter concavis, ad fructus maturitatem impressinerviis, brunneolis, rostro leviter excurvato. Achenia stipitato-obovoidea, cum leviter excurvato rostro ca. 2.5 mm longa, trigona, praeter apicem et basim arcte inclusa, minute et uniformiter papillosa, superficiebus leviter concavis.

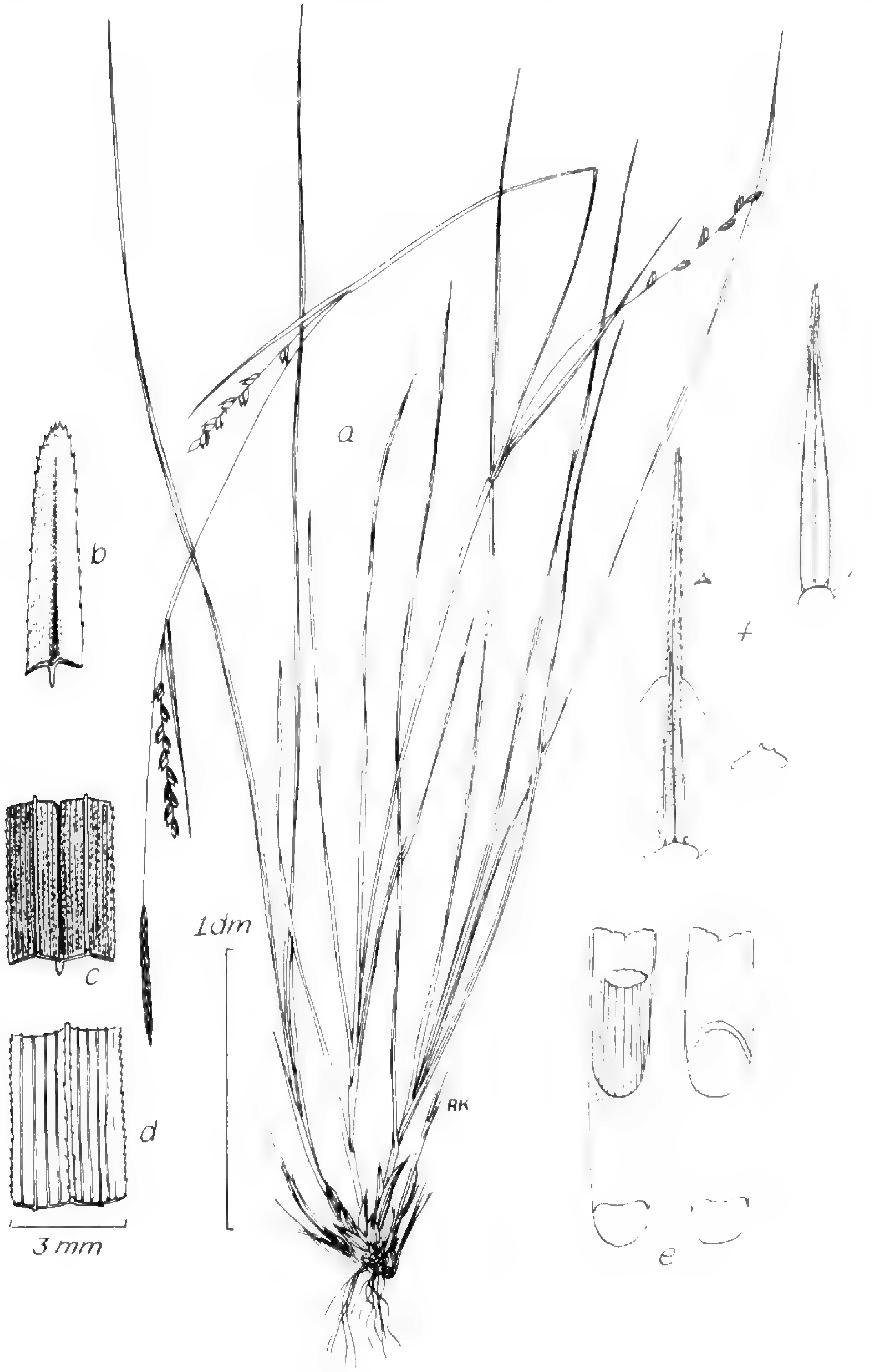

Figure 1. *Carex impressinervia* Bryson, Kral & Manhart (from type). **a.** habit sketch illustrating fertile culm, sterile vegetation and fibrilous base; **b.** leaf tip; **c.** midsector of leaf blade, upper side; **d.** midsector of leaf blade, lower side; **e.** ventral side of leaf at sheath apex, right hand sketch showing ligule; **f.** lower (at left) pistillate scale and upper (at right) pistillate scale.

Perennial, 55–65 cm long, densely cespitose, the principal leaves slightly shorter than the culm, the bases covered by brownish fibrils of old leaf bases. Cataphylls below leaves oblong to ovate, ca. 5–15 mm long, multicostate, distally carinate, cuspidate to acute, brown. Culms erect to spreading, slender, trigonous, scabridulous. Pseudoculms lateral, sterile, very leafy. Principal leaves approximate and longest toward culm base; sheaths very short, pale greenish-white, multicostate, subterete, smooth, ventrally subscarious, except for the slightly thickened subtruncate orifice; ligule an erect narrow scale, ca. 1 mm wide, horseshoe-shaped; blades spreading to recurved, flattened, narrowly linear, 14–42 cm long, 2.0–3.6 mm wide, attenuate toward apex, triquetrous, marginally scabridulous, the surface at midleaf above scabrellous, except for the principal laterals impressed-nerved, beneath elevated-nerved, the midnerve strongly elevated, scabridulous. Spikes 2–4, linear, the terminal one male, narrowly ellipsoid-linear to narrowly claviform, 2.7–3.4 cm long, 2.5–2.6 mm thick, stramineous to pale green, on a slender, costate-angled peduncle 2.7–7.0 cm long, much overtopping the upper female spike. Male spike bract sheathless, 8–10 mm long, strongly cuspidate, the cusp flattened, obtuse, scabriciliate; male scales densely imbricate, scarious, the costal zone narrow, green, slightly elevated, the matrix scarious, broad, white to pale brown. Anthers three, linear, ca. 4 mm long. Peduncles of female spikes lax, filiform, scaberulous, 1.5–15 cm long, the lowest longest; bracts as leaves, the lowest longest, with sheaths (1.5–) 4 (–7) cm long, the blades erect, shorter than the spikes or much exceeding them. Lateral spikes all female or (rarely) having 1–2 male flowers terminally, few-to-many flowered, 2–4 cm long, 2–3 mm thick, (3–) 4–9 (–10) flowered, toward base interrupted, at apex with flowers more approximate; female scales ovate to lanceolate, navicular, including cusp or mucro 3.8–5.8 mm long, the costal zone green, 3–5-ribbed, the sides scarious, white or pale brown, the tips of the lower ones strongly cuspidate. Perigynia broadly fusiform, 3.7–5.0 mm long, 1.5–2.0 mm broad, obscurely trigonous, the faces at middle flat to slightly concave, at fruit maturity impressed-nerved, brownish, the rostrum slightly excurved. Achene stipitate-obovoid, including the slightly excurved beak ca. 2.5 mm long, trigonous, except for apex and base tightly included, minutely and uniformly palpillose, with faces slightly concave.

TYPE: ALABAMA. Bibb County: 6 mi SE of Centreville, sandy loam of rich hardwood ravine by US Hwy 82, 13 April 1975, *R. Kral*

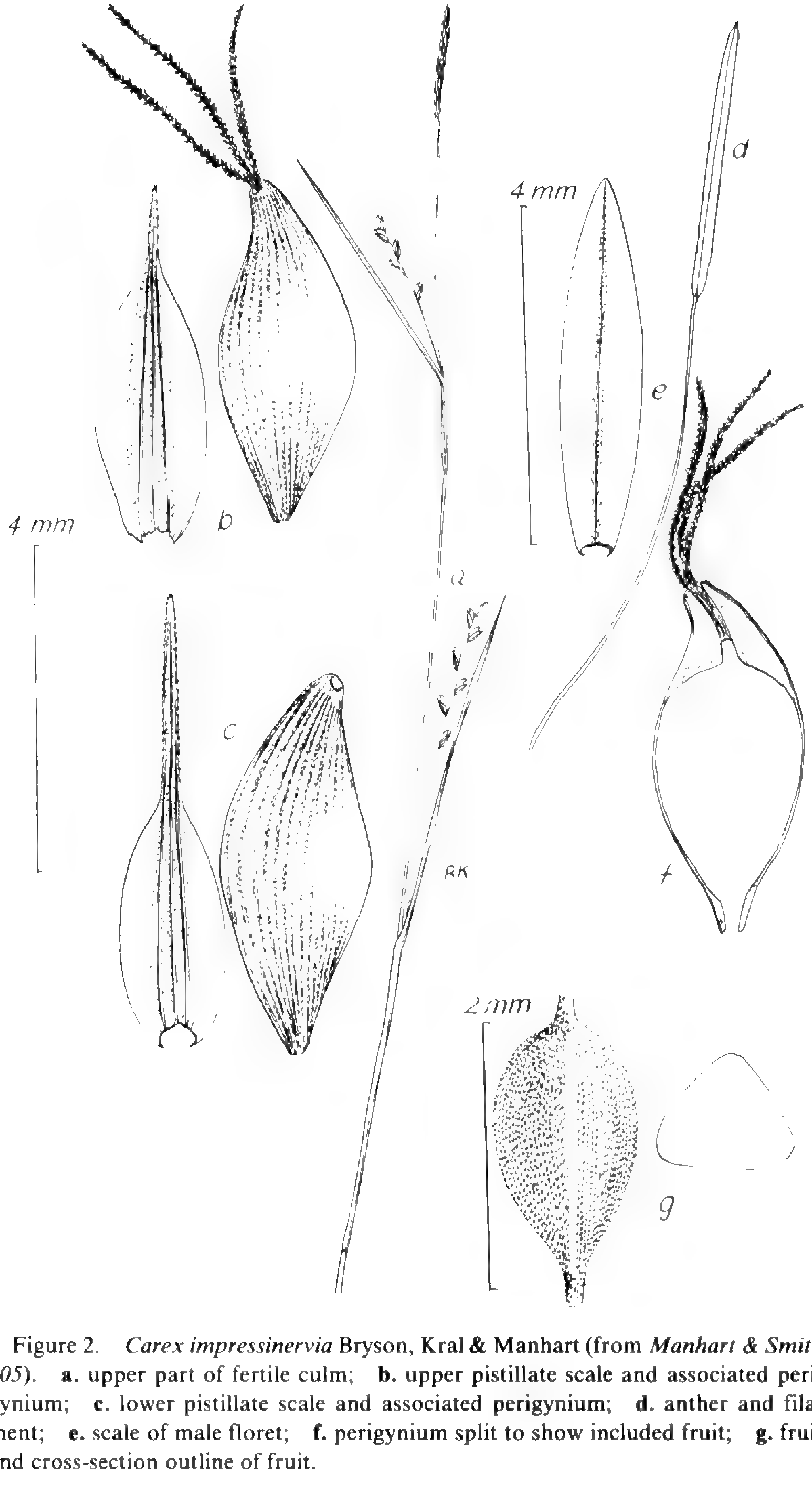

Figure 2. *Carex impressinervia* Bryson, Kral & Manhart (from *Manhart & Smith 305*). **a.** upper part of fertile culm; **b.** upper pistillate scale and associated perigynium; **c.** lower pistillate scale and associated perigynium; **d.** anther and filament; **e.** scale of male floret; **f.** perigynium split to show included fruit; **g.** fruit and cross-section outline of fruit.

55015 (HOLOTYPE: GH; ISOTYPES: [to be distributed] BM, Charles T. Bryson personal herbarium, MICH, MO, NY, US, VDB).

ADDITIONAL COLLECTIONS EXAMINED (PARATYPES): **Mississippi.** Forrest County: Ragland Hills, rich deciduous woods, 15 April 1971, *Ken E. Rogers 6155* (MISS); **North Carolina.** Montgomery County: Uwharrie National Forest, Park's Place Road, low woods along west fork of McLean Creek, 18 May 1970, *S. W. Leonard, A. E. Radford, D. Wells, and E. Wells 3202* (MICH, MISS, UNA, University of Southern Mississippi); low woods bordering creek near Uwharrie Wildlife Road, infrequent, 29 May 1981, *J. R. Manhart and G. L. Smith 305* (Charles T. Bryson personal herbarium, GA, VDB).

Carex impressinervia possesses a combination of characters that include staminate terminal spikes, female spike scales with harsh cusps and costae, and perigynia with many impressed nerves and short, toothless beaks which place this sedge in the section *Oligocarpae.*

The *Oligocarpae* was first used by Carey in Asa Gray (1848) but not formally given the rank of section. Kükenthal (1909) submerged *C. oligocarpa,* the only species of the section *Oligocarpae* that he recognized, under the section *Griseae.* Mackenzie (1931–1935) recognized the *Oligocarpae* at the nomenclatural rank of section and his work was followed by Fernald (1950). This section consisted of two taxa, *Carex hitchcockiana* and *C. oligocarpa,* until recently when an additional species, *C. ouachitana,* was described from the arenaceous oak-hickory-pine uplands in Arkansas and Oklahoma (Kral et al., 1987).

Carex impressinervia is densely cespitose. This character more closely aligns it with *C. hitchcockiana* and *C. oligocarpa* than *C. ouachitana* which produces ligneous, strong, imbricate-scaly rhizomes. The staminate and pistillate spikes are also more like those of *C. hitchcockiana* and *C. oligocarpa* in length, width and number of perigynia than those of *C. ouachitana.* However, the perigynium beak is shorter in *C. impressinervia* than in *C. hitchcockiana* and *C. oligocarpa.* The sheaths subtending the pistillate and staminate spikes of *C. impressinervia* and *C. oligocarpa* are glabrous, unlike the hispidulous sheaths of *C. hitchcockiana.* Basal sheaths of *C. impressinervia* are greenish-white to light tan unlike the purple basal sheaths of *C. oligocarpa* or the brownish-tinged ones of *C. hitchcockiana.* However, the most obvious diagnostic character separating *C. impressinervia* from the other taxa in the *Oligocarpae* is the presence of persistent brownish fibrils of old leaf bases.

The habitat preferences of *Carex impressinervia* are surprisingly diverse. It is found in the upper coastal plain and in plateau regions at the base of hills, transition zones between hills and bottomland woods, and bottomland woods along streams. In spite of this diversity of habitats, this taxon is homogeneous morphologically. None of the other *Oligocarpae* has been found in association with *C. impressinervia* and there is no evidence available that would indicate it is a hybrid involving taxa within the *Oligocarpae, Griseae* or *Laxiflorae.*

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A NEW STATION FOR *STELEXOMONAS DICHOTOMA* LACKEY (CHRYSOPHYTA, MONOSIGALES) IN NORTH AMERICA

Louis L. Lipsey, Jr.[1]

ABSTRACT

Stelexomonas dichotoma, an oligothermal colonial chrysophycean species, is reported from the phytoplankton of Lake Erie. Notes on its morphological variability are also provided.

Key Words: algae, Chrysophyta, *Stelexomonas,* Lake Erie

Stelexomonas dichotoma was described by James B. Lackey from the Tennessee River about forty miles below Chattanooga, in 1942. Since then it apparently has been reported only from Europe (Bourrelly, 1957, 1981; Skuja, 1956; Starmach, 1985; Willén, 1963). An oligothermal colonial chrysophycean phytoplanktonic species of the Order Monosigales (Starmach, 1985), its collared uniflagellate cells are typically found at the edges of cylindrical, dichotomously branched, hyaline receptacles (Lackey, 1942).

Winter phytoplankton samples collected from December 9, 1984 to February 2, 1985 in offshore stations from Lake Erie (for methodology refer to Lipsey, 1987) during the 1984 Great Lakes National Program Office cruise season have yielded conspicuous fragments of *Stelexomonas dichotoma* Lackey. Lakewide concentrations, in general, range from 16 to 106 cells/mL. Maximum concentrations were recorded in the December samples from the western basin, which historically receives excessive tributary loading (Rathke, 1984), in concentrations ranging from 565 to 1186 cells/mL. Water

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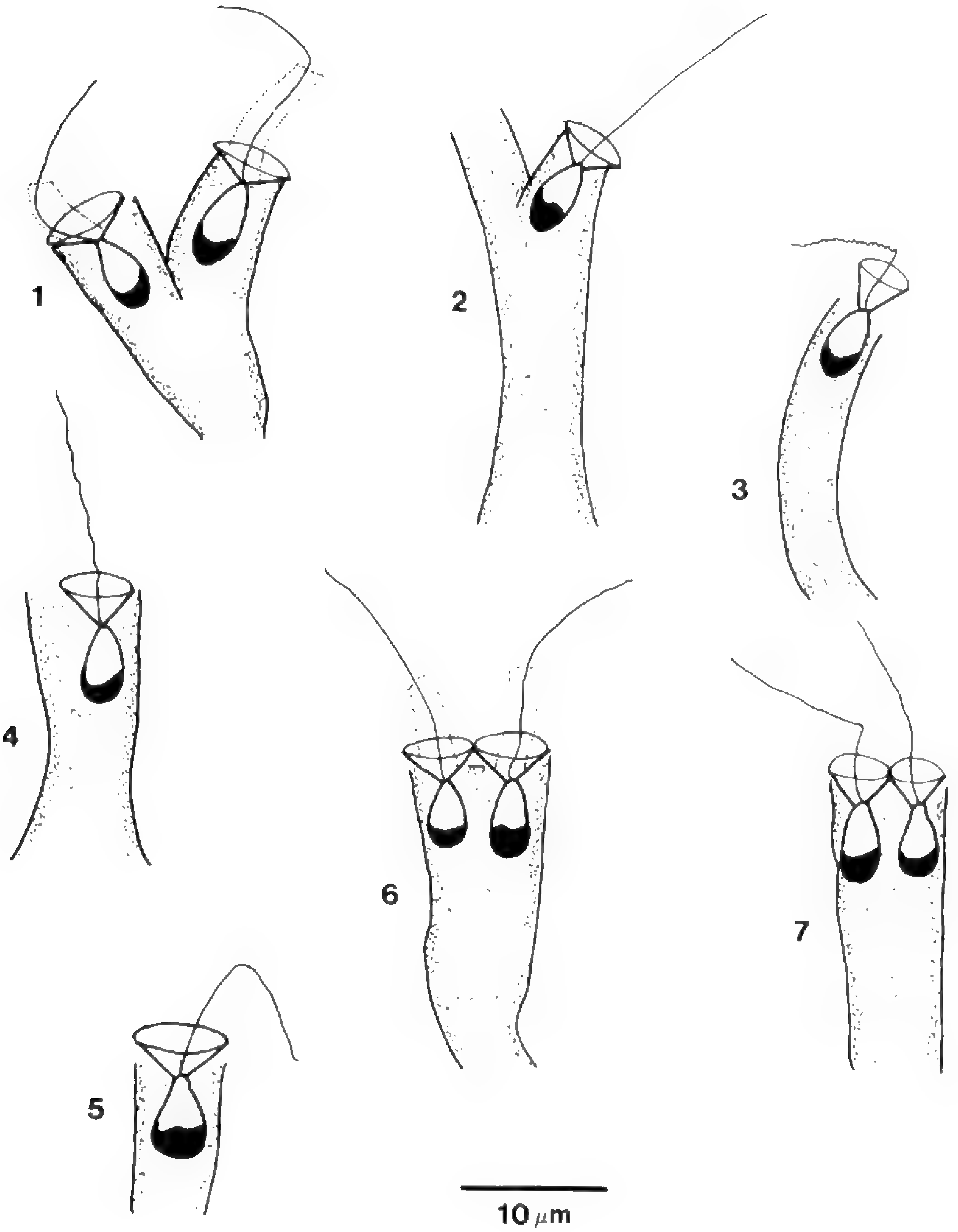

Figures 1–7. Morphological variability of *Stelexomonas dichotoma* from Lake Erie. **1, 2.** Receptacles with dichotmous branching. **3–5.** Non-branched receptacles with single monads. **6, 7.** Non-branched receptacles containing two monads.

temperatures varied from 0 to 3°C. Most fragments are dichotomously branched, possessing a single monad near the edge of each receptacle (Figures 1, 2). However, unbranched specimens also occur in the samples (Figures 3–7) and occasionally fragments contain two monads per receptacle (Figures 6, 7). The monads, distinctly ovoid in outline, measure 4.5–8.5 μm in length and 2.5–5 μm in diameter. The length of the flagellum ranges between 12 and 24 μm. At times "mucilage" is readily apparent along the lower half of the flagellum (Figures 1, 6), suggesting early stages of colony development.

Lackey (1942) reported that *Stelexomonas dichotoma* collected from the Tennessee River showed practically no variation and was uncertain as to how the hyaline receptacles were secreted. Shortly thereafter, Skuja (1956) observed monads with two collars, and noted that isolated cultures from Sweden and Finland frequently contained incompletely developed unbranched colonies. Present evidence suggests that *S. dichotoma* is a highly variable species; however, a more thorough examination of cultured and wild material seems necessary to define it more fully.

DISCLAIMER

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NATURAL HYBRIDIZATION IN THE GENUS *CIRSIUM: C. FLODMANII* × *C. UNDULATUM*

Simon Dabydeen[1]

ABSTRACT

Cytological and morphological data showed that natural hybridization between *Cirsium flodmanii* and *C. undulatum* occurred occasionally in Nebraska and that the high degree of hybrid sterility was correlated with meiotic irregularities.

Key Words: *Cirsium flodmanii, C. undulatum,* hybridization, hybrid sterility, Nebraska.

Taxonomically the genus *Cirsium* (family *Compositae,* tribe *Cynareae*) is regarded as difficult and complex because of variability and intergradation of diagnostic characters. The difficulty is explained by the occasional breakdown of sterility barriers between closely related species, thus permitting interspecific hybridization (Bloom, 1977; Ownbey, 1951, 1964; Davidson, 1963).

Cirsium flodmanii (Rydb.) Arthur and *C. undulatum* (Nutt.) Spreng. are two closely related sympatric species. They are usually distinguishable morphologically without much difficulty, but confusing phenotypic similarities do exist (Ownbey, 1952). This paper is a report of natural hybridization between *C. flodmanii* and *C. undulatum.*

MATERIALS AND METHODS

In August 1980, three plants differing phenotypically from *Cirsium undulatum* and *C. flodmanii* were observed growing in a roadside ditch one mile east of Minden, Kearney County, Nebraska.

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These specimens, thought to be hybrids, were sampled along with specimens of *C. undulaturm* and *C. flodmanii*, both growing nearby in mixed populations.

Immature capitula and cypselae from 31 plants of *Cirsium flodmanii*, 34 plants of *C. undulatum* and the three putative hybrids were collected. Capitula were bisected and fixed in a mixture of 100% ethyl alcohol and glacial acetic acid (3:1, v/v). Cypselae were germinated in a growth chamber to obtain root tips for chromosome counts. Only four of thirty-six cypselae of hybrid origin germinated; those from each of the two species all germinated.

Microsporocytes and root tips were stained either according to the method of Snow (1963) or Feulgen-Rossenbach (1924) and photographed using an American Optical microscope-camera system with 5 × 97 ocular-objective combination. Data for morphological comparison were obtained from measurements of nineteen characters (Table 1). The mean values of 10 measurements for each character of each plant were used. Voucher specimens are deposited at NEB.

Table 1. Comparison of character measurements of *Cirsium flodmanii*, *C. undulatum*, and their hybrid derivative. (All measurwments in millimeters)

Characters	*C. flodmanii*		*C. flodmanii* × *C. undulatum*		*C. undulatum*	
	*	#	*	#	*	#
Involucre: length	25.4	0.61	29.5	0.50	36.3	1.22
width	15.8	0.60	18.5	1.50	21.6	1.09
Phyllary: no. of rows	8.0	0.17	9.0	1.0	8.8	0.23
spine length	3.7	0.16	4.4	0.16	4.6	0.22
inner: length	22.9	0.47	27.2	0.73	33.6	1.13
inner: width	1.4	0.07	1.0	0.07	1.7	0.11
Pappus length	24.6	0.61	26.3	0.52	34.9	1.04
Corolla: lobe length	7.8	0.20	9.7	0.34	10.3	0.36
tube length	7.7	0.30	9.3	0.26	11.3	0.35
Stamen length	13.4	0.37	15.4	0.31	19.3	0.69
Stigma length	5.2	0.18	5.1	0.23	6.2	0.23
Style length	25.9	0.70	28.2	0.39	42.1	1.40
Leaf: length	89.5	4.70	106.3	5.53	104.9	4.57
width	7.0	0.44	16.2	0.36	18.3	1.03
lobe length	17.9	1.03	27.1	0.81	24.9	1.42
lobe base width	7.3	0.46	14.3	0.30	16.0	1.07
spine length	4.1	0.30	3.9	1.5	5.5	0.35
Internode length	31.1	3.22	32.2	0.18	27.0	1.53
Flower length	31.1	0.73	32.4	0.81	48.3	1.48

* = Mean # = Standard error of the Means

OBSERVATION AND DISCUSSION

Measurements of nineteen characters of the hybrid individuals showed that twelve were intermediate compared to the parental types. Five characters were larger than those of the parental types whereas two characters were smaller than either of the parental types (Table 1). *Cirsium flodmanii* and *C. undulatum* have a normal complement of $2n = 22$ and $2n = 26$ chromosomes respectively (Figure 1 a, i). The hybrid individuals have a complement of 24 chromosomes (Figure 1 g). All complements observed at mitotic metaphase are composed of metacentric to submetacentric chromosomes. Meiotic analysis of putative hybrid specimens revealed an array of cytological features. Some of the bivalents were closely associated on an end-to-end basis and gave the impression of chain formation. In Figure 1 b, two chains of six chromosomes, one chain of four chromosomes, three bivalents and two univalents (arrows) are shown. From these observations it appeared that 11 chromosomes of *C. flodmanii* and 11 chromosomes of *C. undulatum* are homologous or homoeologous and that reciprocal translocation is involved in the formation of the meiotic configuration. The two univalents must have come from *C. undulatum.*

Lagging chromosomal material was indicative of meiotic aberration due to the lack of synapsis (Figure 1 c, d, e). Because of clumping, it was not possible to determine whether the delayed segregating materials were chromosomes or chromatids but it was speculated that the four lagging structures (Figure 1 d) were chromatids arising by separation of the two univalents of *Cirsium undulatum.* These lagging chromatids either move to the poles or remain at the equatorial region and become incorporated into micronuclei (Figure 1 h, arrows). All the end-products of microsporogenesis were found to include at least two micronuclei. Non-disjunction was also frequently observed. In Figure 1 f, three nuclei resulted during anaphase II as a consequence of non-disjunction in one of the two meiosis I nuclei. Whether or not disjunction would have taken place at a later date was not known.

The failure of many ovaries of the hybrid plants to mature may be due to a lack of fertilization or some genetic aberration attributable to hybridity. There was no insect damage or any other external evidence of damage that would prevent fruit formation. The aborted ovaries were often shrivelled or extremely flattened. The extremely low rate of viability of cypselae may be due to hybridity. Bloom (1977) studied hybrids of two closely related species, *Cirsium altissimum* and *C. discolor,* and attributed the high degree of sterility of

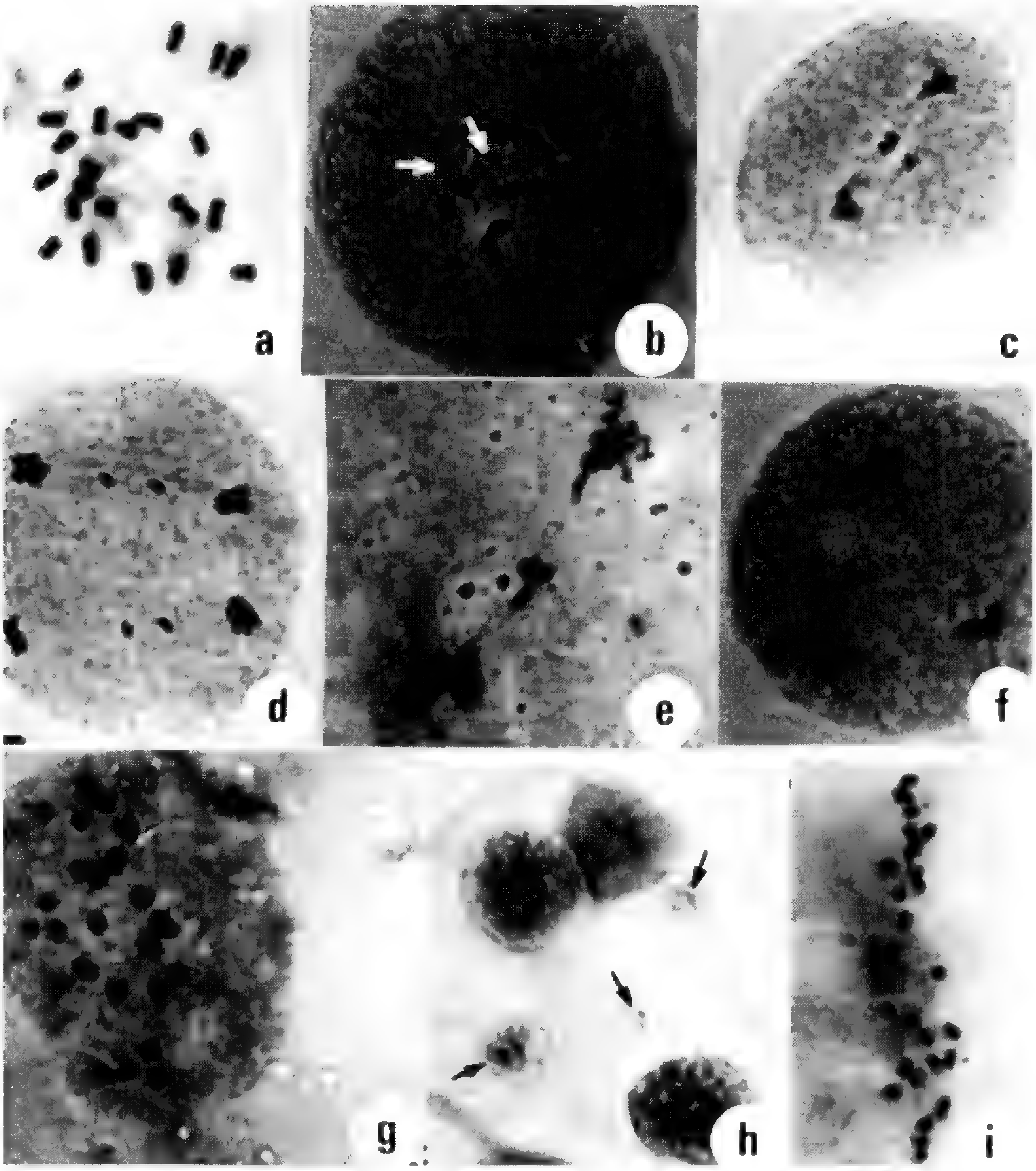

Figure 1. Photomicrographs of mitotic and meiotic chromosome complements of the genus *Cirsium*, × 800 unless otherwise stated.

a. *C. flodmanii:* mitotic metaphase, $2n = 22$.

b.-h. *C. flodmanii* × *C. undulatum*, **b.-f.**: microsporocytes; **b.** metaphase I showing 2 chains of 3 bivalents, 1 chain of 2 bivalents, 3 bivalents, 2 univalents (arrows); **c.** anaphase I showing delayed segregation; **d.** anaphase II showing delayed segrationa during anaphase I; **f.** nondisjunction of one set of chromosomes during telophase II; **g.** mitotic metaphase, $2n = 24$; **h.** abnormal microsporogenesis and micronuclei (arrows) × 300.

i. *C. undulatum:* mitotic metaphase, $2n = 26$.

these hybrids to meiotic irregularities arising from chromosomal rearrangements.

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MOSSES NEW AND RARE FOR NEW YORK STATE

P. M. Eckel

ABSTRACT

Weissia hedwigii, Pottia truncata var. *major,* and *Pottia starkeana* ssp. *minutula* are reported as new to the flora of New York State. *Pottia starkeana* ssp. *minutula* may be a weedy introduction from the Old World. The occurrence of *Desmatodon porteri* is confirmed for the State.

Key Words: Musci, floristics, *Weissia hedwigii, Pottia truncata* var. *major, Pottia starkeana* ssp. *minutula, Desmatodon porteri,* New York

Although mosses have been collected by western New York State botanists throughout the past 125 years, much remains to be learned about the regional distribution of these plants. The following reports represent three additions to the State flora and confirmation of a literature citation. All specimens cited are deposited at BUF.

Weissia hedwigii Crum

A curious specimen of *Weissia,* found misfiled in BUF, proved to be a moss new to New York State (cf. Ketchledge, 1980). The material was in fruit and demonstrated the reduced capsule mouth of *Weissia hedwigii* Crum (= *Weissia microstomum* (Hedw.) C. Muell. of most reports). Crum and Anderson (1981) reported this species as rare in northeastern North America. The gametophyte is much like *Weissia controversa* and *Astomum* spp., but the sporophyte is exserted and lacks a peristome.

Specimen Examined. USA, New York, Niagara Co.: Wheatfield, 1 mile N of NY 429 on US 62, grassy field, roadside, on clay with grasses, *Zander 4819.*

Desmatodon porteri James ex Aust.

Specimens of *Desmatodon porteri* James ex Aust. were also encountered at BUF both as part of collections of bryophytes made in western New York in the 1970's by Ann Glowny, a worker at the Buffalo Museum of Science with a special interest in bryology, and among the collections made in the Niagara River gorge in 1976 by the present curator of botany at BUF, R. H. Zander.

Ketchledge (1980) listed only a literature report for this species in New York State. Crum and Anderson (1981) reported that the "original collections [of this taxon] were made on rocks at College Hill, Easton, Pa. (Thomas C. Porter), and at Niagara Falls (George W. Clinton)," although whether in Canada or the United States was not specified for the latter. This moss is confined to eastern North America where it is infrequent (Crum and Anderson, 1981). I have found it to be locally abundant on limestone boulders in shaded, moist stations in limestone gorges and ravines of the Niagara region in Canada and the United States.

SPECIMENS EXAMINED. USA, New York, Niagara Co.: City of Niagara Falls, gorge of the Niagara River, below the Devil's Hole, bottom of W-facing slope, rock, with *Didymodon rigidulus, Zander 3509a.* Erie Co.: Amherst, corner of Millersport and Eggert Rds, calcareous rock in copse, *Zander s.n.;* limestone of escarpment, Scotland Rd. by Akron Airport, *Glowny 11042;* limestone outcrop on Scotland Rd. near Akron Airport, Newstead, *Glowny 1169;* Newstead, Akron Falls of Murder Creek, on Onondaga Escarpment, calcareous boulder, *Zander 4233.* Genesee Co.: Darien, Colby Rd. and Rt. 20, *Glowny 240.*

Pottia truncata var. **major** (Web. & Mohr) BSG.

Pottia truncata var. *major* was also discovered in the Niagara Gorge. Although *P. truncata* var. *turncata* appears in the New York checklist (Ketchledge, 1980), var. *major* does not. There is considerable difference of opinion whether var. *major* is best recognized as a variety of *P. truncata* or as a species, (viz. *P. intermedia* (Turn.) Fuernr.). Recently Chamberlain (1978) discussed *P. intermedia* in Europe as a possible hybrid between *P. truncata* and *P. lanceolata* (Hedw.) C. Muell., since it frequently grew with one or both species. *Pottia lanceolata,* however, has not yet been found in North America. Crum and Anderson (1981) maintained the varietal status of this material, citing the intergradation evident in American populations. I recently found both varieties of *P. truncata* growing in proximity with one another on the Niagara gorge crest on the Canadian side; the typical variety was easily distinguished from var.

major with the unaided eye. At this locality the typical variety was growing on thin, dense limy clay over exposed dolomite. This clay has resisted colonization by vascular plants for several years. Variety *major,* however, grew on loose soil with grasses. Visits to this station in subsequent years produced specimens of var. *truncata* only on the clay, and no mosses on the disturbed humic soils.

Chamberlain (1978) mentioned that *Pottia truncata* var. *truncata* has "Occasional gigas forms, about twice the size of typical plants with larger spores ... encountered either as solitary plants in a normal population or as a pure population." One possibility is that two taxa are involved: *P. intermedia* may be a European species, and American *P. truncata* var. *major* may be the gigas form of var. *truncata* noted by Chamberlain (1978).

Specimen Examined. USA, New York, Niagara Co.: City of Niagara Falls, gorge of Niagara River, between steps at Whirlpool Park and the Whirlpool, halfway up dolomite talus slope, with *Didymodon rigidulus* var. *rigidulus, Encalypta procera, Tortula mucronifolia, Eckel 522386.*

Pottia starkeana ssp. **minutula** (Schleich. ex Schwaegr.) Chamberl.

A patch of moss with a reddish cast growing on the margin of a lawn where thin soil lay upon the exposed dolomite bedrock at the crest of the Niagara River Gorge proved to be a population of *Pottia starkeana* ssp. *minutula* (Schleich. ex Schwaegr.) Chamberl., new to New York State (cf. Ketchledge, 1980).

Pottia starkeana ssp. *minutula* has been frequently discussed (as *P. davalliana*) by Canadian bryologists, since this moss is fairly common in Ontario (C. Williams, 1966; H. Williams, 1959, 1961; Ireland & Cain, 1975). Three stations in Michigan were noted by Crum and Anderson (1981). The present reports for western New York State seem in keeping with the association of this species with calcareous, disturbed soil derived from limestone or dolomitic bedrock at or close to the surface. This substrate is common to all stations cited in the literature.

A study of species of *Pottia* with erostrate opercula by Chamberlain (1969) led him to the conclusion that two North American species, *Pottia davalliana* (Sm. ex Drake) C. Jens. and *P. texana* Wareh. were *P. starkeana* ssp. *minutula* and ssp. *conica,* respectively. Crum and Anderson (1981) considered these taxa *(P. davalliana* and *P. texana)* distinct, with stations of *P. davalliana* in Michigan and Ontario, and *P. texana* in western and southern regions.

There is a lack of consensus on the distribution of *Pottia davalliana* from *P. texana.* Floristic treatments, such as that of Mahler (1980) for Texas mosses, have treated *P. texana* as synonymous with *P. davalliana* probably following Williams (1961). Williams (1961) could find examples of Ontario collections with intermediate morphology. Crum (1969) indicated that *P. texana* was both morphologically and geographically distinct from *P. davalliana.* Stations reported as *P. davalliana* or *P. texana* have been given for California, Texas, and Baja California in Mexico (Williams, 1961). Two publications cite collections of *P. davalliana* from Nebraska (Koch, 1971; O'Keefe van der Linden and Farrar, 1983). All the collections made outside of Michigan and Ontario may instead be *P. texana* (note the citation from Nebraska "on soil of floodplain, sand-pit lakes" by Crum and Anderson, 1981). Zander (1986, in preparation) recognized only *Pottia starkeana* ssp. *conica* (= *P. texana*) as occurring in Mexico, further emphasizing the southern and western distribution of this taxon.

It is significant that *Pottia starkeana* ssp. *minutula* (= *P. davalliana*) occurs in Michigan, Ontario and New York on immature and disturbed soils associated with limestone pavements, an area north of the glacial boundaries. There is a possibility that *P. starkeana* ssp. *minutula* is not endemic to the North American moss flora, but is instead a weedy introduction from the Old World where the subspecies occurs throughout north and central Europe (Smith, 1978). The weedy character of this species (as *P. davalliana*) was hypothesized for Australia by Catcheside (1980).

SPECIMENS EXAMINED. USA, New York, Niagara Co.: City of Niagara Falls, gorge of Niagara River, Devil's Hole, upper pavement in dolomite caprock overlooking the river, *Eckel 631685;* Genesee Co.: Alabama, bare soil in wasteland, N side of West Shore RR, E side of Morgan Rd., S of Rt. 63, west of Alabama-Oakfield town line, immature with calyptra, *Glowny 932.*

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CYTOGEOGRAPHY OF *PITYOPSIS* NUTT., THE GRASS-LEAVED GOLDENASTERS (COMPOSITAE: ASTEREAE)

JOHN C. SEMPLE AND FRANK D. BOWERS

ABSTRACT

Chromosome numbers are reported for all taxa in the goldenaster genus *Pityopsis,* which until recently usually has been included in *Chrysopsis* sensu lato. *Pityopsis* has a base number of $x = 9$ and includes diploids, tetraploids and one hexaploid race. After the identities of vouchers for all previous reports were brought into line with the classification indicated below, general patterns of cytotype distributions within taxa in the southeastern United States were recognized. Only diploids are known in *P.* sect. *Pityopsis,* and all species have restricted distributions. Polyploidy is frequent in *P.* sect. *Graminifoliae;* the cytotypes in species with more than one ploidy level have different, but overlapping, ranges. Reports for the following are documented: *Pityopsis aspera* var. *adenolepis,* $2n = 9_{\mathrm{II}}$, 18, 18_{II}, 36; *P. aspera* var. *aspera,* $2n = 9_{\mathrm{II}}$; *P. falcata,* $2n = 9_{\mathrm{II}}$; *P. flexuosa,* $2n = 9_{\mathrm{II}}$, 18; *P. graminifolia* var. *aequilifolia,* $2n = 9_{\mathrm{II}}$, 18; *P. graminifolia* var. *graminifolia,* $2n = 18$; *P. graminifolia* var. *latifolia,* $2n = 18_{\mathrm{II}}$, 36; *P. graminifolia* var. *tenuifolia,* $2n = 9_{\mathrm{II}}$, 18; *P. graminifolia* var. *tracyi,* $2n = 54$; *P. oligantha,* $2n = 18_{\mathrm{II}}$; *P. pinifolia,* $2n = 9_{\mathrm{II}}$, 18; and *P. ruthii,* $2n = 9_{\mathrm{II}}$.

Key Words: Astereae, *Pityopsis,* cytogeography, goldenasters, southeastern North America

INTRODUCTION

Pityopsis Nutt. is one of three genera of goldenasters (Compositae: Astereae). Although now there is much evidence supporting generic level status for the grass-leaved goldenasters, traditionally the taxa included here in *Pityopsis* have been included in *Chrysopsis* (Nutt.) Ell. sensu Gray (1884) as a section or merely as a species group. When Shinners (1951) proposed merging *Chrysopsis* sensu Gray into the third goldenaster genus *Heterotheca* Cass., some taxa included here in *Pityopsis* were transferred to *Heterotheca.* Shinners based the merger on the fact that the fruit differences between *Heter-*

otheca and *Chrysopsis* sensu Gray were not significant because occasionally usually heterocarpic species in *Heterotheca* sensu stricto produced homocarpic ray and disc fruit, a condition that is typical for *Chrysopsis*. Following Shinners (1951), Ahles (1964), Harms (1968, 1969), and Shinners (1969) placed additional grass-leaved goldenaster taxa in *Heterotheca*. Following the lead of these authors, Bowers treated the grass-leaved goldenasters as a section of *Heterotheca* in his unpublished Ph.D. dissertation (University of Tennessee, Knoxville, 1972). However, on cytological grounds Semple (1977) divided the goldenasters into a large genus *Heterotheca* with $x = 9$, including species of *Pityopsis*, and a small genus *Chrysopsis* with $x = 5$ and derived base numbers of $x = 4$ and $x_{II} = 9$. Upon additional study, *Pityopsis* was treated as distinct from *Heterotheca* by Semple, Blok and Heiman (1980) on the basis of morphological, anatomical and ecological features. Diagnostic differences were presented in a key to the genera and sections of goldenasters. Members of *Pityopsis* have grass-like stem leaves with pseudo-parallel venation and distinctive anatomy, elongated fusiform achenes, and long thin anastomosing stem and leaf hairs (*see* scanning electron micrographs in Semple et al., 1980).

Pityopsis has been revised recently by Semple and Bowers (1985). The seven grass-leaved goldenaster species recognized by Semple and Bowers (1985) were grouped into two sections on the basis of rosette and stem leaf traits. *Pityopsis* sect. *Pityopsis* includes *P. falcata* (Pursh) Nutt., *P. flexuosa* (Nash) Small, *P. pinifolia* (Ell.) Nutt., and *P. ruthii* (Small) Small; these lack greatly elongated rosette leaves at anthesis and are apparently vicariant descendants of an ancestor native to the coastal plain or piedmont east of the Appalachian Mountains. *Pityopsis* sect. *Graminifoliae* (Small) Semple includes *P. aspera* (Shuttlew. ex Small) Small, *P. graminifolia* (Michx.) Nutt., and P. *oligantha* (Chapman) Small; these usually have much elongated basal rosette and lower stem leaves, a center of distribution in Florida, and ranges that include much of the southeastern United States with disjunct populations in the Bahamas and northern Central America. Chromosome counts for all taxa were included as part of the taxa descriptions presented by us in our revision of *Pityopsis* (Semple and Bowers, 1985), but location and voucher data and the revised identity of previous reports were not given.

MATERIALS AND METHODS

Meiotic chromosome number determinations were made as part of Bowers's 1972 study (unpubl. Ph.D. thesis, U. of Tennessee, Knoxville) in the following manner: capitulescence buds were fixed in the field in a modified Carnoy's solution (6:3:1/EtOH:chloroform: propionic acid); anthers were dissected out of individual florets and macerated in 2% acetic-lactic orcein stain and squashed. Vouchers for these reports have been deposited in TENN.

Meiotic and mitotic chromosome numbers determined by J. Semple were made following the procedures of Semple (1977). Vouchers for these have been deposited in WAT.

RESULTS AND DISCUSSION

Seventy-one previously unreported chromosome counts are listed with locality and voucher data in Table 1. Because chromosome numbers were included in the descriptions of the taxa in our revision of *Pityopsis* (Semple and Bowers, 1985), none of the counts is a first report. The following counts are documented here (Table 1) for the first time: *Pityopsis aspera* var. *adenolepis* (Fern.) Semple, $2n = 9_{II}$, 18, 18_{II}, 36; *P. aspera* var. *aspera*, $2n = 9_{II}$; *P. falcata*, $2n = 9_{II}$; *P. flexuosa*, $2n = 9_{II}$, 18; *P. graminifolia* var. *aequilifolia* Bowers & Semple, $2n = 9_{II}$, 18; *P. graminifolia* var. *graminifolia*, $2n = 9_{II}$, 18; *P. graminifolia* var. *latifolia* (Fern.) Semple & Bowers, $2n = 18_{II}$, 36; *P. graminifolia* var. *tenuifolia* (Torrey) Semple & Bowers, $2n = 9_{II}$, 18; *P. graminifolia* var. *tracyi* (Small) Semple, $2n = 54$; *P. oligantha*, $2n = 18_{II}$; *P. pinifolia*, $2n = 9_{II}$, 18; and *P. ruthii*, $2n = 9_{II}$.

All previously published reports are listed in Table 2 along with location, voucher, and literature citation data. Nearly all previous reports were listed under synonyms (Table 2) in *Chrysopsis* or *Heterotheca*. Also, the name changes in our revision of *Pityopsis* (Semple and Bowers, 1985) make it difficult to correlate earlier reports with those in Table 1. This problem is particularly true in the case of reports for *P. graminifolia*, since it was determined that 1) the holotype of the species does not belong to the variety that most systematists had treated as typical (e.g., Cronquist, 1980; Semple, 1985) and 2) the older name var. *tenuifolia* (Torrey, J. Ann. Lyc. N.Y. 2: 212. 1828) replaced the name var. *microcephala* (Small, J. Fl. S.E. U.S. 1182, 1339. 1903). Therefore, Table 2 is necessary to make sense of

Table 1. Chromosome number determinations in *Pityopsis* from the United States with location and voucher data (TENN or WAT). *B* = F. Bowers; *Bt* = L. Brouillet; *C.* = J. Canne; *Ch* = J. Chmielewski; *S* = J. Semple; *W* = E. Wofford.

Pityopsis aspera (Shuttlew.) Small var. *adenolepis* (Fern.) Semple & Bowers. $2n = 9_{II}$. **North Carolina.** Moore Co., *B 70-109.* $2n = 18$. **Georgia.** Coffee Co., N of Broxton, *S, Bt & C 4029.* **North Carolina.** Harnett Co., SE of Pineview, *S & Ch 6069.* $2n = 18_{II}$. **Florida.** Escambia Co., *B 72-270, B 72-275.* **Georgia.** Taylor Co., *B 71-562.* Thomas Co., *B 70-470.* **North Carolina.** Burke Co., *B 72-230.* McDowell Co., *B 72-232.* Montgomery Co., *B 70-101.* **Virginia.** Essex Co., *S & Ch 5968.* James Co., *B 72-220.* Southhampton Co., *B 72-228.* $2n = 36$. **Florida.** Santa Rosa Co., *S & Godfrey 3157.*

P. aspera var. *aspera.* $2n = 9_{II}$. **Florida.** Hamilton Co., *B & W 71-561.* Leon Co., *B. 70-481.*

P. falcata (Pursh) Nutt. $2n = 9_{II}$. **New Jersey.** Atlantic Co., *B 72-210.* Burlington Co., *B 72-215.* Ocean Co., *B 72-205, Morton s.n.* **New York.** Suffolk Co.; Riverview, *S 6858.*

P. flexuosa (Nash) Small. $2n = 9_{II}$. **Florida.** Leon Co., *B 70-484.* $2n = 18$. **Florida.** Leon Co., *Godfrey 75754-2.*

P. graminifolia (Michx.) Nutt. var. *aequilifolia* Bowers & Semple. $2n = 9_{II}$. **Florida.** Lake Co., *B & W 71-558.* Manatee Co., *B & W 71-559.* Martin Co., Hobe Sound, *Turner F-45* (count provided by B. L. Turner). $2n = 18$. **Florida.** Marion Co., *S, Bt & C 3992.*

P. graminifolia var. *graminifolia.* $2n = 9_{II}$. **Florida.** Lake Co., *B & W 71-557a.* $2n = 18$. **Georgia.** Clinch Co, N of Homerville, *S, Bt & C 4013.*

P. graminifolia var. *latifolia* (Fernald) Semple & Bowers. $2n = 18_{II}$. **Alabama.** Baldwin Co., *B 71-202.* **Florida.** Duvall Co., *Morton 4626.* Leon Co., *B 70-482.* **North Carolina.** Bladen Co., *B 71-490.* Columbus Co., *B 71-465.* **Tennessee.** Pickett Co., *B 68-305.* Polk Co., *B 721-581.* Roane Co., *B 69-301.* $2n = 36$. **Alabama.** Calhoun Co., SE of Anniston, *S & Ch 6309.* **Florida.** Hillsborough Co., N of Sun City Center, *S 5406.* Levy Co., *S, Bt & C 3953.* Manatee Co., *S 5411.* Pasco Co., *S 5416.* Polk Co., N of West Frostproof, *S 7484.* Santa Rosa Co., E of Navarre, *Blyth s.n.* Sumter Co., *S, Bt & C 3977.* **North Carolina.** Pitt Co., *S & Ch 6045.*

P. graminifolia var. *tenuifolia* (Torrey) Semple & Bowers. $2n = 9_{II}$. **Alabama.** Baldwin Co., *B 72-203.* **Arkansas.** Ashley Co., *B 72-250, B 72-255.* Dallas Co., N of Princeton, *S & Ch 6406.* Drew Co., *B 72-240.* Polk Co., N of Acorn, *S. & Heard 8272.* **Florida.** Alachua Co., *B 72-550.* Collier Co., Imokalee, *S 5399.* Escambia Co., *B 72-278.* Hamilton Co., *B & W 71-561-e.* Leon Co., *B 70-481.* Volusia Co., *B & W 71-553.* **Mississippi.** Hancock Co., *B 72-260.* **Texas.** Polk Co., N of Seven Oaks, *S & Ch 6432.* $2n = 18$. **Florida.** Marion Co., *S, Bt & C 3992.*

P. graminifolia var. *tracyi* (Small) Semple. $2n = 54$. **Alabama.** Etowah Co., N of Attalla, *S & Ch 6303* (see text for discussion of this report). **Florida.** Manatee Co., E of Parrish, *S 5410.* Okeechobee Co., E of Okeechobee, *S 7514.*

P. oligantha (Chapman) Small. $2n = 18_{II}$. **Alabama.** Baldwin Co., *B 71-201.* **Florida.** Liberty Co., *B 72-120.* Wakulla Co., *B 72-117.*

P. pinifolia (Ell.) Nutt. $2n = 9_{II}$. **Georgia.** Taylor Co., *B & W 72-562-a.* **North Carolina.** Moore Co., *B 70-110.* $2n = 18$. **North Carolina.** Harnett Co., NE of Pineville, *S & Ch 6067.* Moore Co. line, SE of Cameron, *S & Ch 6068.*

P. ruthii (Small) Small. $2n = 9_{II}$. **Tennessee.** Polk Co., *B 71-580, Odenwelder & B 45578.*

Table 2. Previously reported chromosome number determinations in *Pityopsis* from the United States with location, voucher and publication data: *B* = Bowers (et al.); *G* = Godfrey; *S* = Semple (et al.).

P. aspera (Shuttlew.) Small var. *adenolepis* (Fern.) Semple & Bowers. $n = 9$. **South Carolina.** *Jones 6122; P. adenolepis* (Jones and Smogor, 1984). $2n = 18$. **Georgia.** *S 4041;* as *P. adenolepis* (Semple, 1985). $n = 18$. **Alabama.** *Smith 475;* as *Chrysopsis aspera* (Smith, 1965). $2n = 36$. **Florida.** *G 75757, G 75753, G75812;* all as *Heterotheca aspera* (Semple, 1977).

P. falcata (Pursh) Nutt. $n = 9$. **New York.** *S 2033, S 2035, S 2038;* all as *H. falcata* (Semple, 1977).

P. flexuosa (Nash) Small. $2n = 18$. **Florida.** *Godfrey 75754;* as *H. flexuosa* (Semple, 1977).

P. graminifolia (Michx.) Nutt. var. indet. $n = 9$. **Florida.** *Turner 4672;* as *C. graminifolia* (Turner et al., 1961). **Georgia.** *Jones 6175;* as *P. graminifolia* (Jones and Smogor, 1984).

P. graminifolia var. *aequilifolia* Bowers & Semple. $n = 9$. **Florida.** *S 2501; as H. graminifolia* (Semple, 1977).

P. graminifolia var. *graminifolia.* $n = 9$. **Mississippi.** *Jones 3502;* as *H. graminifolia* (Jones, 1966). $2n = 18$. **Florida.** *G. 75744;* as *H. graminifolia* (Semple, 1977).

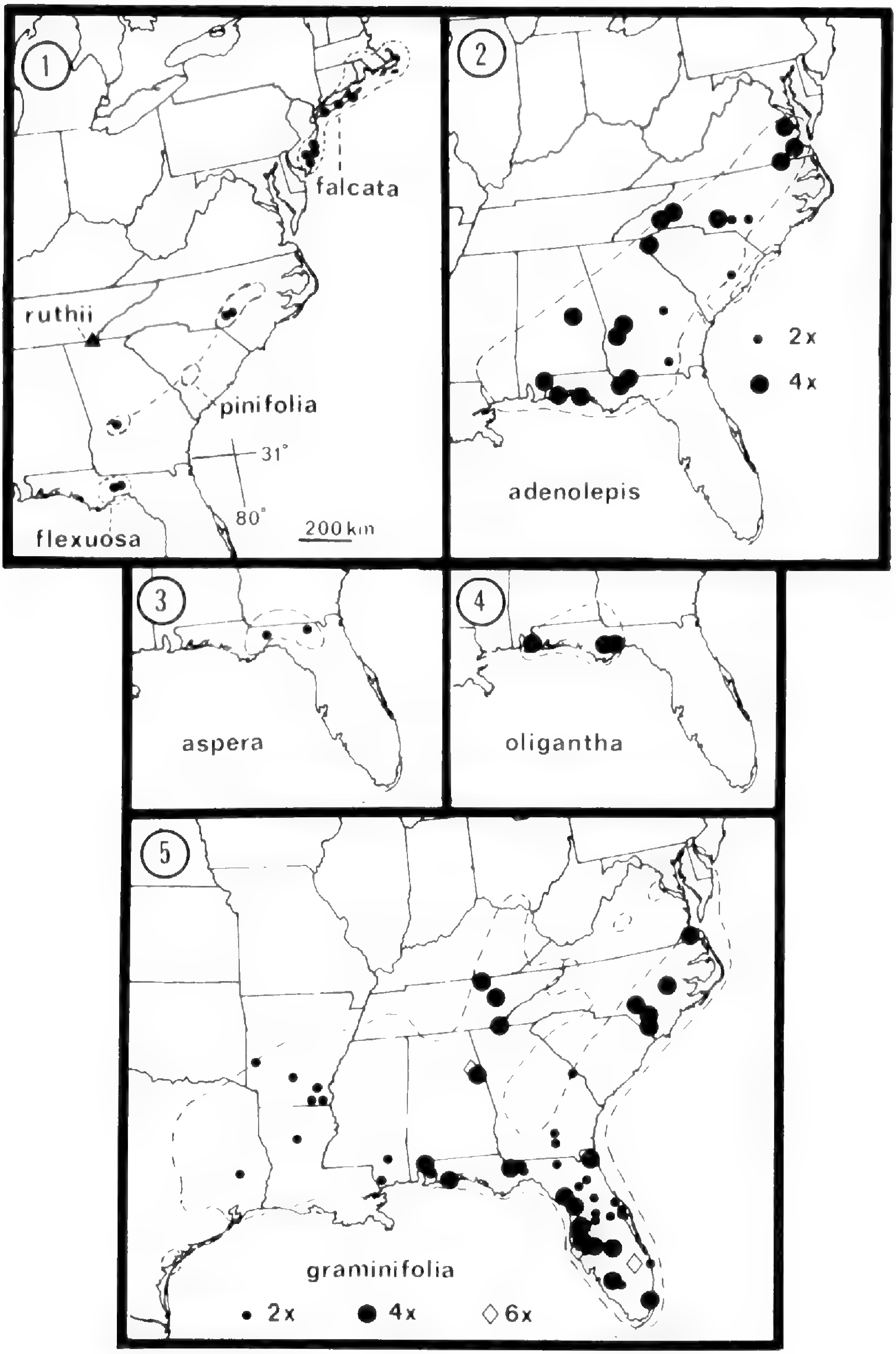
P. graminifolia var. *latifolia* (Fern.) Semple & Bowers. $n = 18$. **North Carolina.** *Keil K11607;* as *P. g.* var. *latifolia* (Keil et al., in press). $n = \text{c.}18$. **Florida.** *Turner F-33;* as *C. graminifolia* (Turner, 1978). $2n = 36$. **Florida.** *S 5400;* as *P. graminifolia* var. *graminifolia* (Semple, 1985).

P. graminifolia var. *tenuifolia* (Torrey) Semple & Bowers. $n = 9$. **Florida.** *S 2569, S 2559, S2533, S 2540;* as *H. graminifolia* (Semple, 1977). **Texas.** as *C. graminifolia* (Turner & Ellison, 1960). $2n = 18$. **Florida.** *S 4001;* as *P. graminifolia* var. *microcephala* (Semple, 1985).

P. ruthii (Small) Small. $n = 9$. **Tennessee.** *B 45573;* as *H. ruthii* (Bowers, 1972).

the earlier reports. Once the synonymy had been sorted out, some patterns could be recognized.

The geographical locations of populations for which all counts are reported both here and previously are shown in Figures 1–5; these figures also show the range of each species in the southeastern United States. *Pityopsis pinifolia, P. falcata, P. flexuosa* and *P. ruthii* have restricted to very restricted ranges, and all four are diploid $2n = 18$; these four comprise sect. *Pityopsis* (Figure 1). The diploids in sect. *Graminifoliae* are confined to the outer coastal plain of the southeastern United States with the exception of *P. graminifolia* var. *tenuifolia* in Arkansas, Louisiana, and eastern Texas. Diploid *P. graminifolia* var. *graminifolia* occurs from central Mississippi to the outer coastal plain of the Carolinas and south into the northern third of Florida peninsula. Only diploids are known in typical *P. aspera* (Figure 3). Diploids in *P. aspera* var. *adenolepis* (Figure 2) are more restricted in distribution (the eastern Carolinas


1
falcata
ruthii
pinifolia
31°
80°
200 km
flexuosa
2
• 2x
● 4x
adenolepis
3
aspera
4
oligantha
5
graminifolia
• 2x
● 4x
◇ 6x

and eastern Georgia) compared to tetraploids (eastern Virginia to southern Alabama). The two cytotypes appear to be allopatric; the sample size is small, however.

In *Pityopsis graminifolia* the documented distribution of tetraploids is limited to the range east of the Mississippi embayment. All known tetraploids in the species are members of var. *latifolia,* which occurs throughout the entire range of the species indicated in Figure 5, including the area west of the Mississippi embayment (Semple and Bowers, 1985). The lack of tetraploids in this area may be a sampling error. The first author collected only diploids on a trip to Florida in late September of 1976, but collected diploids, tetraploids and hexaploids during trips made later in November and December in subsequent years. Plants with higher ploidy levels had not matured sufficiently for buds to be collected during the 1976 trip. Therefore, the lack of tetraploid collections west of the Mississippi embayment could be due to the time of sampling rather than to any real lack of such plants.

Hexaploids were found in samples from only three locations (Figure 5). Two of these plants were in central Florida and are members of *Pityopsis graminifolia* var. *tracyi.* The third hexaploid was obtained from seedlings grown from fruit collected in northeastern Alabama. Semple and Bowers (1985) discussed the possibility that this fruit originated from tetraploid parents, one of which contributed an unreduced gamete. The ovulate parent plant of the hexaploid seedling was well past bloom when collected in early November and could only be tentatively assigned to either var. *tracyi* or var. *latifolia.* If the former assignment is correct, then the plant would be far out of the known range of var. *tracyi.* If the parent plant is a member of var. *latifolia,* then the progeny represent the only hexaploids for the variety.

No chromosome numbers have been determined from plants in Central America. Both taxa known from this region are known only as tetraploids elsewhere in their ranges. *Pityopsis graminifolia* var.

Figures 1–5. The geographic distribution of cytotypes in *Pityopsis.* Plotted on state outline maps of portions of the eastern and southeastern United States are the locations of $2x$, $4x$, and $6x$ reports ($x = 9$); range of each species is indicated by broken lines; scale is the same in all figures. **1.** *Pityopsis* sect. *Pityopsis;* all reports $2x$. 2–5. *Pityopsis* sect. *Graminifoliae.* **2.** *P. aspera* var. *adenolepis.* **3.** *P. aspera* var. *aspera.* **4.** *P. oligantha.* **5.** *P. graminifolia,* all varieties; the species also occurs in parts of Central America and the Bahamas.

latifolia has been collected many times in southern Mexico, Guatemala, Belize, and very rarely in northwestern Honduras (Semple and Bowers, 1985). One collection of *P. oligantha* from southeastern Mexico was not seen until 1987; the species was considered to occur only in the Florida Panhandle area in our 1985 treatment. Other reports of *P. oligantha* from Central America were based on misidentifications (*see* Semple and Bowers, 1985).

Chromosome numbers have been determined from two or more populations of each species and variety of *Pityopsis*. The same statement cannot be made about karyotypes. Bowers (1972, unpubl. Ph.D. thesis, U. of Tennessee, Knoxville) did not include karyotype investigations in his study. Difficulties in growing and maintaining plants of sect. *Pityopsis* under greenhouse conditions in Waterloo prevented completion of karyotype work. In contrast, individuals of sect. *Graminifoliae* were grown without difficulty. Karyotype studies, therefore, remain to be done on sect. *Pityopsis*.

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CYTOTAXONOMIC STUDIES IN THE GENUS *ARNICA* (COMPOSITAE: SENECIONEAE)

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ABSTRACT

A total of 128 original chromosome counts representing 16 taxa of the genus *Arnica* is presented. A first count for *A. lonchophylla* ssp. *chionopappa* ($2n = 76$), a northeastern North American disjunct, is reported. In addition, new counts are reported for *A. angustifolia* ssp. *attenuata* ($2n = 76$) and *A. chamissonis* ssp. *chamissonis* ($2n = 76$). The latter account for formation of previously reported triploids via hybridization between diploid and tetraploid races. The rare Klamath region endemics are diploid, while their more widespread congeners are largely polyploid. The genus contains several mature polyploid complexes, and exhibits both maximum species diversity and cytological diversity in the Rocky Mountains of Colorado and Wyoming.

Key Words: *Arnica,* Compositae, cytotaxonomy, polyploidy, North America

INTRODUCTION

The genus *Arnica* L. consists of about 30 species confined primarily to montane western North America, with a few taxa being circumboreal or eastern North American disjuncts (Maguire, 1943). Previous studies have demonstrated that the genus is cytologically diverse, and contains many apomictic polyploid series based on a chromosome base number of $x = 19$ (Ornduff et al., 1963, 1967; Wolf, 1980; Wolf and Denford, 1984a). Barker (Ph.D. dissertation, U. Wash., Seattle, 1966) noted that within the genus the diploid level indicates amphimixis while the polyploid level indicates apomixis. Barker further noted that within the genus in general, diploids are restricted largely to unglaciated areas while polyploids are more widespread, particularly in glaciated areas. These observations have largely been confirmed in subsequent investigations (Wolf, 1980; Downie and Denford, 1986).

The genus contains widespread species, rare taxa endemic to particular regions, and widely disjunct taxa. For example, several species of the subgenus *Austromontana* are quite rare and are restricted to the Klamath region of northwestern California and southwestern Oregon (Wolf and Denford, 1984a). It has previously been demonstrated that these rare endemics are largely diploid while their more widespread congeners are largely polyploid (Wolf, 1980; Wolf and Denford, 1984a). This same cytological pattern has been noted in several other groups which contain both widespread polyploid taxa and diploid taxa restricted to the Klamath region, e.g., *Crepis* L. (Babcock and Stebbins, 1938) and *Sedum* L. section *Gormania* (Britton) R. T. Clausen (Denton, 1979).

Additionally, some taxa of the genus *Arnica* are disjunct between eastern and western North America (Maguire, 1943; Downie and Denford, 1986) or between western and central North America (Wolf and Denford, 1984a), while some rare taxa are restricted to northern New England and adjacent Canada (Maguire, 1943; Ediger and Barkley, 1978). Raven and Axelrod (1978) stressed that biosystematic studies of endemics and their more widespread congeners are necessary in order to clarify their evolutionary relationships. Grant (1971) considered a wide geographical sampling of chromosome numbers prerequisite to the study of polyploid complexes. Such a geographic sampling of polyploidy in *Arnica* has begun (Wolf, 1980), and the present paper represents continuing research into polyploidy and distribution within the genus *Arnica* as a prelude to wider biosystematic investigations.

In this publication, 128 original chromosome counts representing 16 taxa of the genus *Arnica* are presented (Table 1). New chromosome numbers are reported for two taxa and a first count is reported for an additional taxon. The taxonomy follows that of Maguire (1943), with the exception of *A. angustifolia* which follows Douglas and Ruyle-Douglas (1978), and the subgenus *Austromontana* which follows Wolf and Denford (1984a). Discussion is provided where appropriate.

METHODS

Immature capitula were fixed in the field in modified Carnoy's fixitive (4 chloroform: 3 ethanol: 1 glacial acetic acid) and floret buds were stained with iron-acetocarmine. Mitotic counts were obtained from germinated achenes according to procedures previously outlined by Wolf (1980).

RESULTS AND DISCUSSION

Arnica angustifolia Vahl. ssp. **attenuata** (Greene) G. W. Douglas & G. Ruyle-Douglas

This taxon is confined to the central Alaska-Yukon region and is part of a large and cytologically diverse circumpolar arctic-alpine complex of seven subspecies (Maguire, 1943). Previous workers have reported both diploid and triploid races for this taxon (Moore, 1973; Wolf, 1980). The first reports of tetraploid races (Table 1) account for the probable production of the triploid race via hybridization between diploid and tetraploid races.

Arnica cernua Howell

This taxon is a rare serpentine endemic of the Klamath region and is thought to have been derived from the more widespread *A. cordifolia* (Wolf and Denford, 1984a). Four diploid counts for this species have previously been reported (Barker, Ph.D. dissertation, U. Wash., Seattle, 1966; Straley, 1982; Wolf and Denford, 1984a). The five additional diploid counts reported in the present study (Table 1) support previous hypotheses that it is probably entirely sexual and diploid (Barker, Ph. D. dissertation, U. Wash., Seattle, 1966; Wolf and Denford, 1984a).

Arnica chamissonis Less. ssp. **chamissonis**

Both diploid and tetraploid counts have previously been reported for this taxon (Downie, 1985; Straley, 1979; Wolf, 1980) which ranges from Alaska through Washington and Alberta. The first report of a tetraploid race for this taxon (Table 1) may account for the production of the triploid race via hybridization between diploid and tetraploid races.

Arnica cordifolia Hook.

This is one of the most widely distributed species of *Arnica* and has previously been recognized as a mature polyploid complex (*sensu* Stebbins, 1971) by Wolf (1980). Only a few widely scattered diploid populations are known, tetraploids are widespread throughout its entire range, triploids are restricted primarily to the front ranges of the Rocky Mountains and a few pentaploid races have been found in Colorado. Results of the present investigation confirm this observation. Including the 39 new counts reported in Table 1, almost 200 populations, representing the entire range of this taxon, have been cytologically examined (Wolf, 1980; Wolf and Denford, 1984a). Two more triploids were found in the front ranges of the Rocky Mountains and an additional 37 widely scattered tetraploids were located.

Arnica discoidea Benth.

This taxon is restricted primarily to California, but a few populations extend into Oregon and southern Washington (Wolf and Denford, 1984a). Although previous studies have reported diploid, triploid and tetraploid races for this taxon (Straley, 1979, 1982; Wolf, 1980; Wolf and Denford, 1984a), it has been noted that the diploids occur only in the Klamath region while the polyploids are widespread and occur mostly outside this area (Wolf and Denford, 1984a). Based on these cytological data, in addition to morphological and chemical data, Wolf and Denford (1983, 1984b) suggested that *A. discoidea* was probably derived from *A. cordifolia* in the Klamath region and the diploids represent relictual populations. The additional diploid counts from the Klamath region reported in the present investigation (Table 1) add further support to this hypothesis.

Arnica gracilis Rydb.

Previous investigations have demonstrated that this species, which ranges from Alberta through Wyoming and northward to southern British Columbia, is a hybrid between *A. cordifolia* and *A. latifolia* (Wolf and Denford, 1984c). Previous triploid (Straley, 1982) and tetraploid (Ornduff et al., 1967; Wolf, 1980) counts have been reported for this taxon. Two additional tetraploid counts are reported in the present study (Table 1).

Arnica lanceolata Nutt.

This species is very rare and occurs in the extreme northeastern United States and adjacent Canada. Barker (Ph. D. dissertation, U. Wash., Seattle, 1966) did not include it in his study; but Löve and Löve (1964, 1966) reported tetraploid counts for it from Mount Washington, New Hampshire. Ediger and Barkley (1978) concluded that it is probably an apomictic tetraploid. An additional tetraploid count (Table 1) supports this hypothesis.

Arnica latifolia Bong.

This taxon is another widely distributed western species. Previous studies have indicated that it is almost entirely diploid with the exception of a few tetraploid races reported from northwestern Montana and adjacent Idaho and Alberta (Wolf, 1980; Wolf and Denford, 1984a). Results of the present investigation, in which 22 additional diploid counts are reported (Table 1), support this observation.

Arnica lonchophylla Greene ssp. **chionopappa** (Fern) Maguire
This taxon represents the eastern disjunct phase of the western *A. lonchophylla* ssp. *lonchophylla.* No previous counts have been reported for the eastern subspecies; however, Wolf (1980) reported triploid and tetraploid counts for the western subspecies. Barker (Ph. D. dissertation, U. Wash., Seattle, 1966) was unable to determine the exact chromosome number for ssp. *chionopappa;* nevertheless, he concluded that it is probably polyploid and apomictic. Results of the present study, in which three tetraploid counts are reported (Table 1), support his conclusion.

Arnica longifolia D. C. Eaton
Battaglia (1952) first reported a count of $n = 5$ for this taxon from material at the botanical garden of the University of Copenhagen. Ornduff et al., (1967) re-examined this material and reported counts of $2n = 76$. Barker (Ph. D. dissertation, U. Wash., Seattle, 1966) could not establish an exact count for this species, but he noted that it appeared to be polyploid and apomictic, particularly in northwestern Wyoming. Results of the present investigation, in which two tetraploids are reported (Table 1), support Barker's observations.

Arnica mollis Hook.
This taxon is restricted primarily to the mountains of western North America south of Alberta and British Columbia (Ediger and Barkley, 1978). However, Hultén (1968) has recorded one disjunct population in central Alaska, and an additional locality for this taxon in central Alaska is reported here (Table 1). *Arnica mollis* has previously been recognized as a mature polyploid complex with a cytological pattern similar to *A. cordifolia;* i.e., few diploids are known, triploids are restricted to the front ranges of the Rocky Mountains, tetraploids are widespread, and higher ploidy levels occur in the Colorado-Wyoming region (Wolf, 1980). Results of the present study confirm this. An additional two diploids as well as two triploids from the front ranges of the Rocky Mountains, and 14 widely distributed tetraploids are reported here (Table 1).

Arnica parryi A. Gray ssp. **parryi**
Barker (Ph. D. dissertation, U. Wash., Seattle, 1966) concluded that this widespread, western, montane taxon is entirely apomictic

and polyploid. Triploid (Straley, 1979) and tetraploid counts (Ornduff et al., 1967; Wolf, 1980) have previously been reported for this subspecies. A diploid count has been reported for the other subspecies *sonnei* (Greene) Maguire (Moore, 1977), which is restricted to California and adjacent Nevada and Oregon (Maguire, 1943; Ediger and Barkley, 1978). Additionally, Ornduff et al. (1967) reported a pentaploid count for ssp. *sonnei* from Colorado. However, since this subspecies does not occur in Colorado and the rays of ssp. *parryi* are sometimes ampliate, making it appear rayed like ssp. *sonnei,* this count may be from ssp. *parryi.* Results of the present study, in which three triploid and 14 tetraploid counts are reported for ssp. *parryi,* support Barker's hypothesis that it is probably entirely polyploid.

Arnica rydbergii Greene
Both diploid and tetraploid races have previously been reported for this taxon (Straley, 1979; Wolf, 1980) which occurs at high elevations from Alberta and British Columbia south to Colorado and northern California (Maguire 1943). An additional four tetraploids are reported in the present study (Table 1).

Arnica sororia Greene
Barker (Ph.D. dissertation, U. Wash., Seattle, 1966) considered this taxon, which occurs at low elevations from Alberta south to Wyoming and northern California (Maguire, 1943), to be entirely diploid. Further investigations (Straley, 1979; Downie and Denford, 1987; Table 1) have confirmed this observation.

Arnica spathulata Greene
This species is a narrow endemic restricted primarily to serpentine areas of the Klamath region (Wolf and Denford, 1984a). In contrast to Barker's previous hypothesis, this taxon is almost entirely diploid and sexual (Wolf, 1980; Table 1). Only three tetraploid counts have been reported (Barker, Ph.D. dissertation, U. Wash., Seattle, 1966; Wolf and Denford, 1984a), while all other counts have been diploid.

Arnica venosa H. M. Hall
This species is a very rare Klamath region endemic known from only a few populations near western Shasta County, California (Wolf and Denford, 1984a). It has previously been hypothesized that this taxon is entirely diploid and sexual (Barker, Ph.D. dissertation, U. Wash., Seattle, 1966; Wolf and Denford, 1984a) and results of the present study (Table 1) support this hypothesis.

CONCLUSIONS

In general, the present investigation has confirmed previous hypotheses concerning polyploidy and distribution within the genus *Arnica.* It has confirmed the existence of and extended the known geographical ranges of several previously recognized polyploid complexes, "filled in the gaps" for some incomplete polyploid series, and documented new counts for three taxa. As previously noted (Wolf, 1980), the formation of triploids probably requires the sympatric occurrence of both diploids and tetraploids. The newly reported tetraploid counts for *A. angustifolia* ssp. *attenuata* and *A. chamissonis* ssp. *chamissonis* account for the establishment of previously reported triploids via this means. Results of the present study also support the recognition of *A. angustifolia, A. cordifolia* and *A. mollis* as mature polyploid complexes. Additionally, the latter two species, along with several others, again demonstrate that the genus *Arnica* exhibits its maximum cytological diversity in the Colorado-Wyoming region (Wolf, 1980). As previously noted, this diversity is probably due to both historical factors such as glaciation and the sympatric occurrence of up to six species in many areas in this region (Wolf, 1980). Finally, the present study has further supported the hypothesis that the rare endemics of the Klamath region, as well as Klamath region populations of *A. discoidea* (an otherwise wide-ranging polyploid complex), are almost exclusively diploids.

Table 1. New chromosome counts in *Arnica*

A. angustifolia ssp. *attenuata* $2n = 76$*. **Yukon Territory:** 29 km N of Carcross, *W497;* Squanga Lake, km 1354 of Alaska Hwy., *W506.*

A. cernua $2n = 38$. **California:** Humboldt Co.: Horse Mt., *W546.* **Oregon:** Josephine Co.: Onion Peak Rd., *W535;* Eight Dollar Mt. Rd., *W539;* Lookout Mt. Rd., *W545;* Little Rock Creek, *W543.*

A. chamissonis ssp. *chamissonis* $2n = 76$*. **Alaska:** Seward Cemetery, *W502;* N of Summit Lake, on Kenai Peninsula, *W501.* **British Columbia:** 8 km N of Chilkoot Pass, *P. Wolf s.n.*

A. cordifolia $2n = 57$. **Colorado:** Chaffee Co.: Monarch Pass, *W631;* Mineral Co.: Wolf Creek Pass, *W621.* $2n = 76$. **Colorado:** Eagle Co.: Shrine Pass, *W641;* Gunnison Co.: Schofield Pass, *W629;* Lake Co.: Independence Pass, *W634;* 4.8 km E of Independence Pass, *W636;* La Plata Co.: Coal Bank Pass, *W623;* Rocky Mountain Nat'l Park: 11.6 km up Old Fall River Rd., *W644;* San Juan Co.: Molas Pass, *W626.* **Idaho:** Clearwater Co.: Hwy. 12, 9.3 km W of Orofino, *W565;* Fremont Co.: Howard Springs, on Hwy. 20, *W581;* Lewis Co.: Hwy. 12, 0.8 km E of Clearwater Co. line, *W566;* Nez Perce Co.: Hwy. 12, 28.9 km W of Orofino, *W564.* **Montana:** Carbon Co.: Hwy. 212, 6.4 km N of Wyoming border, *W594;* Gallatin Co.: Beaver Creek Campground, off Hwy. 287, *W580;*

Missoula Co.: Howard Creek Rd., 27.4 km W of Lolo City, *W571;* Park Co.: Hwy. 212, 3.2 km E of Silver Gate, *W587;* 4.8 km E of Cooke City, *W588;* Ravalli Co.: Hwy. 38, near Hamilton, *W573;* 8 km S of Sula, on Hwy. 93, *W575.* **Oregon:** Douglas Co.: Cow Creek Rd., 38 km W of Glendale, *W532;* Grant Co.: 8 km E of Granite, *W559;* Umatilla Co.: Umatilla Nat'l. Forest, ca. 11.7 km S of Kooskooskie, Washington, *W551;* Union Co.: 3.2 km E of Blue Mt. Summit, *W552;* Wallowa-Whitman Nat'l. Forest Rd. No. 51, 17.7 km S of Hwy. 244, *W560;* Wallowa Co.: Hwy. 82, near Union Co. line, *W553;* Lostine River Rd., *W554;* 1.6 km S of Hurricane Creek Campground, *W555;* Wallowa-Whitman Nat'l. Forest, km 14, Imnaha Creek Rd., *W556;* km 37 *W557;* km 45, *W558.* **Washington:** Yakima Co.: Wenatchee Nat'l. Forest, 0.6 km E of Pleasant Valley Campground, *W561;* **Wyoming:** Albany Co.: 6.3 km E of Snowy Pass, *W617;* Carbon Co.: Ryan Park Campground, on Hwy. 130, *W608;* Park Co.: Yellowstone Nat'l. Park, 4.8 km S of Dunraven Pass, *W583;* Muddy Creek Rd., off Hwy. 212, *W590;* 15.8 km S of Beartooth Pass, *W597;* Hwy. 212, near Beartooth Lake, *W600;* Teton Co.: Hwy. 287, 25.7 km E of Teton Nat'l. Park, *W606.*

A. discoidea $2n = 38$. **California:** Trinity Co.: Underwood Rd., off Hwy. 299, *W547;* Shasta Co.: Shasta-Trinity Nat'l. Forest, W of McCloud Bridge *W550.*

A. gracilis $2n = 76$. **Wyoming:** Park Co.: Hwy. 212, S of Beartooth Lake, *W592; W604.*

A. lanceolata $2n = 76$. **Quebec:** Gaspé Peninsula, Mount Logan, *Bain 232.*

A. latifolia $2n = 38$. **British Columbia:** 8 km N of Chilkoot Pass, *P. Wolf s.n.* **Colorado:** Gunnison Co.: Schofield Pass, *W630;* Rocky Mountain Nat'l. Park, 11.6 km up Old Fall River Rd., *W645.* **Idaho:** Idaho Co.: Badger Creek Rd., off Hwy. 212, *W567;* 3.5 km W of Lolo Pass, *W568;* Elk Meadows Rd., off Lolo Pass, *W569;* Lemhi Co.: Lost Trail Pass, *W557.* **Montana:** Beaverhead Co.: Hwy. 43, E of Chief Joseph Pass, *W579;* Carbon Co.: Hwy. 212, 6.4 km N of Wyoming border, *W595;* Missoula Co.: West Lee Creek Rd., off Hwy. 12, *W570;* Howard Creek Rd., 27.3 km W of Lolo City, *W572;* Park Co.: 4.8 km E of Cooke City, on Hwy. 212, *W589;* Ravalli Co.: 4 km N of Sula, on Hwy. 93, *W574;* West Camp Creek Rd., N of Lost Trail Pas, *W576.* **Oregon:** Clackamas Co.: Mt. Hood, *W563.* **Washington:** Pierce Co.: Mt. Rainier Nat'l. Park, Hwy. 123, 1.6 km S of Hwy. 410, *W562.* **Wyoming:** Albany Co.: 6.3 km E of Snowy Pass, *W618;* Park Co.: Hwy. 212, 7.2 km S of Beartooth Pass, *W596;* 15.8 km S of Beartooth Pass, *W598;* near Beartooth Lake, *W601;* 1.6 km S of Beartooth Lake, *W591;* Yellowstone Nat'l. Park, 4.8 km S of Dunraven Pass, *W584.*

A. lonchophylla ssp. chionopappa $2n = 76$**. **Newfoundland:** Port au Port District, Table Mountain, *Bain 264, Bain 265, Bain 266.*

A. longifolia $2n = 76$. **Wyoming:** Park Co.: Yellowstone Nat'l. Park, 1.6 km N of Dunraven Pass, *W586;* Beartooth Lake, *W593.*

A. mollis $2n = 38$. **Wyoming:** Carbon Co.: Hwy. 130, 14.2 km W of Albany Co. line, *W611;* Teton Co.: near Togwotee Pass, *W607.* $2n = 57$. **Colorado:** Lake Co.: near Independence Pass, *W635;* Fremont Pass, *W639.* $2n = 76$. **Alaska:** Hatcher Pass, NW of Palmer, *W504.* **Colorado:** Eagle Co.: Shrine Pass, *W642;* La Plata Co.: Coal Bank Pass, *W623;* Rocky Mountain Nat'l. Park, 11.6 km up Old Fall River Rd., *W646;* San Juan Co.: Red Mt. Pass, *W627.* **Montana:** Beaverhead Co.: near Chief Joseph Pass, *W578;* **Oregon:** Klamath Co.: Crater Lake, *W513.* **Wyoming:** Albany Co.: Brooklyn Lake, E of Snowy Pass, *W619;* Carbon Co.:

Hwy. 130, 3.2 km W of Albany Co. line, *W613;* Park Co.: near Beartooth Lake, *W599.*

A. parryi ssp. *parryi* $2n = 57$. **Colorado:** Chaffee Co.: near Monarch Pass, *W632;* San Juan Co.: Red Mt. Pass, *W628.* **Wyoming:** Carbon Co.: Hwy. 130, 1.9 km W of Albany Co. line, *W616.* $2n = 76$. **Colorado:** Eagle Co.: Shrine Pass, *W643;* Lake Co.: 4.8 km E of Independence Pass, *W637;* Fremont Pass, *W638;* La Plata Co.: Coal Bank Pass, *W625;* Mineral Creek Co.: near Wolf Creek Pass, *W622;* Rocky Mountain Nat'l. Park, 11.6 km up Old Fall River Rd., *W647.* **Idaho:** Fremont Co.: Howard Springs, off Hwy. 20, *W582.* **Wyoming:** Albany Co.: Brooklyn Lake, E of Snowy Pass, *W620;* Carbon Co.: Ryan Park Campground, on Hwy. 130, *W609;* 14.2 km W of Albany Co. line, on Hwy. 130. *W610;* 3.2 km W of Albany Co. line, *W614;* Park Co.: Yellowstone Nat'l. Park, 4.8 km S of Dunraven Pass, *W585;* Beartooth Lake, *W603;* Teton Co.: Hwy. 89, 1.6 km N of Teton Natl. Park, *W605.*

A. rydbergii $2n = 76$. **Colorado:** Chaffee Co.: near Monarch Pass, *W633;* Lake Co.: Fremont Pass, *W640.* **Wyoming:** Carbon Co.: Hwy. 130, 5.3 km W of Snowy Pass, *W612;* Hwy. 130, 1.9 km W of Albany Co. line, *W615.*

A. sororia $2n = 38$. **Idaho:** Idaho Co.: White Bird Summit, *W348.* **Oregon:** Wallowa Co.: Wallowa State Park, *W636.*

A. spathulata $2n = 38$. **Oregon:** Douglas Co.: Cow Creek Rd., near Glendale, *W533;* Josephine Co.: Onion Peak Rd., *W534;* near Store Gulch Guard Station, *W536;* Siskiyou Natl. Forest Rd. No. 4103, 12.1 km W of Hwy. 199, *W537;* 3.4 km W of Hwy. 199, on Store Gulch Guard Station Rd., *W538;* Road to Tennessee Lookout, *W541;* Jct. of Fish Creek Rd. and West Side Rd., near Kirby, *W542;* 7.7 km W of O'Brien, on Lookout Mt. Rd., *W544.*

A. venosa $2n = 38$. **California:** Shasta Co.: Brandy Creek, S of Whiskeytown Lake, *W548;* Road to Squaw Creek, W of Shasta Dam, *W549.*

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*New number for this taxon.

**First count for this taxon.

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THE STATUS OF *CALOPOGON TUBEROSUS* VAR. *LATIFOLIUS* WITH COMMENTS ON THE APPLICATION OF VARIETAL RANK

Paul M. Catling and Zoe Lucas

ABSTRACT

To determine whether *Calopogon tuberosus* var. *latifolius* is worthy of recognition, and if so what rank is appropriate, data from herbarium material and uniform cultivation were analyzed. Plants corresponding to the original concept of *Calopogon tuberosus* var. *latifolius* from Sable Island were found to represent the tail end of a continuum of variation, making their formal taxonomic recognition inappropriate. In cultivation the Sable Island plants generally retained their short stature and wide leaves. Although there is a genetic component to the pattern of variation, the limits are arbitrary and some plants from Sable Island initially referable to one variety became referable to the other variety in subsequent years of cultivation. The concept of *varietas* is considered useful only in the sense of morphological discontinuity involving one or a few differences that have a geographic basis. The unique and genetically-based pattern of variation in *Calopogon tuberosus* on Sable Island is nevertheless of interest and is part of a general pattern involving both plants and animals.

Key Words: *Calopogon,* Orchidaceae, varietal rank, Sable Island, Nova Scotia

INTRODUCTION

Many botanists in northeastern North America know the familiar Grass Pink orchid as *Calopogon pulchellus* (Salisb.) R. Brown, as it appears in Fernald (1950) and Gleason and Cronquist (1963). However, Mackenzie (1925) demonstrated that *Calpogon tuberosus* (L.) BSP. is the correct name for this species, and this name has been used by most recent authors (e.g., Voss, 1966, 1972; Seymour, 1969; Brackley, 1985; Whiting and Catling, 1986).

Three infraspecific taxa have been proposed in *Calopogon tuberosus* (L.) BSP. in northeastern North America. One of these, Nieuwland's (1913) var. *nanum* (*Limodorum tuberosum* L. var.

nanum Nieuwland), described from coastal Newfoundland, was distinguished by its relatively small size, and few and relatively small flowers. The fact that small plants are at least occasionally found throughout the northeastern distribution of the species has made varietal rank of this Newfoundland plant inappropriate. Not surprisingly, var. *nanum* has not been recognized as a distinct entity.

As part of his study of the flora of Sable Island, St. John (1921) described *Calopogon pulchellus* f. *latifolius,* a wide-leaved entity which was later elevated to varietal rank:

Calopogon tuberosus (L.) BSP. var. **latifolius** (St. John) Boivin, Naturaliste Canad. 94: 521. 1967.

Calopogon pulchellus (Salisb.) R. Br. f. *latifolius* St. John, Proc. Bost. Soc. Nat. Hist. 36: 69. 1921.

Limodorum tuberosum L. f. *latifolium* (St. John) House, Bull. N.Y. State Mus. 243–244: 51. 1923.

Cathea pulchella Salisb. f. *latifolia* (St. John) House, Bull. N.Y. State Mus. 254: 244. 1924.

Calopogon pulchellus (Salisb.) R. Br. var. *latifolius* (St. John) Fernald, Rhodora 48: 188. 1946.

St. John described f. *latifolius* as having leaves oblong- or elliptic-lanceolate, 7–11 cm long and 1.3–2.8 cm wide. He noted that the typical form of the species also occurred on Sable Island. When Fernald (1946) elevated f. *latifolius* to the rank of variety, he noted that material from Îles-de-la-Madeleine (Magdalen Islands) was transitional between var. *latifolius* and the typical variety. The var. *latifolius* was maintained in the 8th edition of Gray's Manual (Fernald, 1950), in Boivin's enumeration of Canadian plants (Boivin, 1967), and in Roland and Smith's flora of Nova Scotia (Roland and Smith, 1969). The latter authors added Peggy's Cove on the Nova Scotian mainland to the stations of var. *latifolius.* Correll (1950) also accepted var. *latifolius,* but he used the name for plants at the northern range limit in general (for which the correct epithet should have been var. *nanum*). Scoggan (1978), in his Flora of Canada, recognized f. *latifolius,* indicating its presence on Sable Island and the Magdalen Islands. Other recent authors have not recognized either a variety or forma *latifolius,* including for example Gleason and Cronquist (1963) in their manual of the northeastern flora, Luer (1975) in his "Orchids of the United States and Canada", and Maher et al. (1978) in their list of the rare plants of Nova Scotia.

During a recent botanical survey of Sable Island, we found plants similar to those which St. John had described, and we noted that our preliminary studies suggested that they may be worthy of taxonomic recognition (Catling et al., 1984). The work presented here was undertaken to determine whether formal taxonomic recognition could be supported with data from herbarium specimens, field observations, and cultivated plants.

METHODS

Herbarium and Field Study

Measurements of plant height (top of corm to uppermost pedicel), leaf width, leaf length and flower number were recorded from all northeastern North American plants of *Calopogon tuberosus sensu lato* in CAN and DAO, and in some additional material selected from AMES, MT and QFA (acronyms from Holmgren et al., 1981). This herbarium sample included 808 plants from stations scattered throughout the northeast (Figure 1). Of these, 21 were from Sable Island, 54 were from the Magdalen Islands, 22 were from St. Pierre and Miquelon, and the remaining 711 were from elsewhere in the northeast. Included in the sample from Sable Island were 3 plants on the type sheet of f. *latifolius* (*St. John 1195*, AMES!). In addition to this herbarium study, Lucas gathered data (as described above) on 419 plants randomly selected from various parts of Sable Island. The plants from the three insular locations and the remainder of the northeast were compared using scatter diagram plots of various character pairs.

Uniform Culture

Twelve plants from Sable Island and ten plants, referable to var. *tuberosus,* from eastern Ontario were transplanted to a glass house where they were grown for two years under uniform conditions. The twelve plants from Sable Island included four that were clearly referable to var. *latifolius* and eight that were close to it, but were nevertheless referable to var. *tuberosus.* Measurements of plant height, leaf width and leaf length were recorded from the plants before transplanting and then again at one-year intervals during the period of cultivation. The first year's data represented appearance of these plants in their native habitats, whereas the two subsequent years' data represented the appearance of both groups of plants cultivated under uniform conditions in the glass house. The position of each plant with respect to the three characters was portrayed on scatter diagrams with the points representing initial appearance and subsequent appearance in cultivation joined by lines.

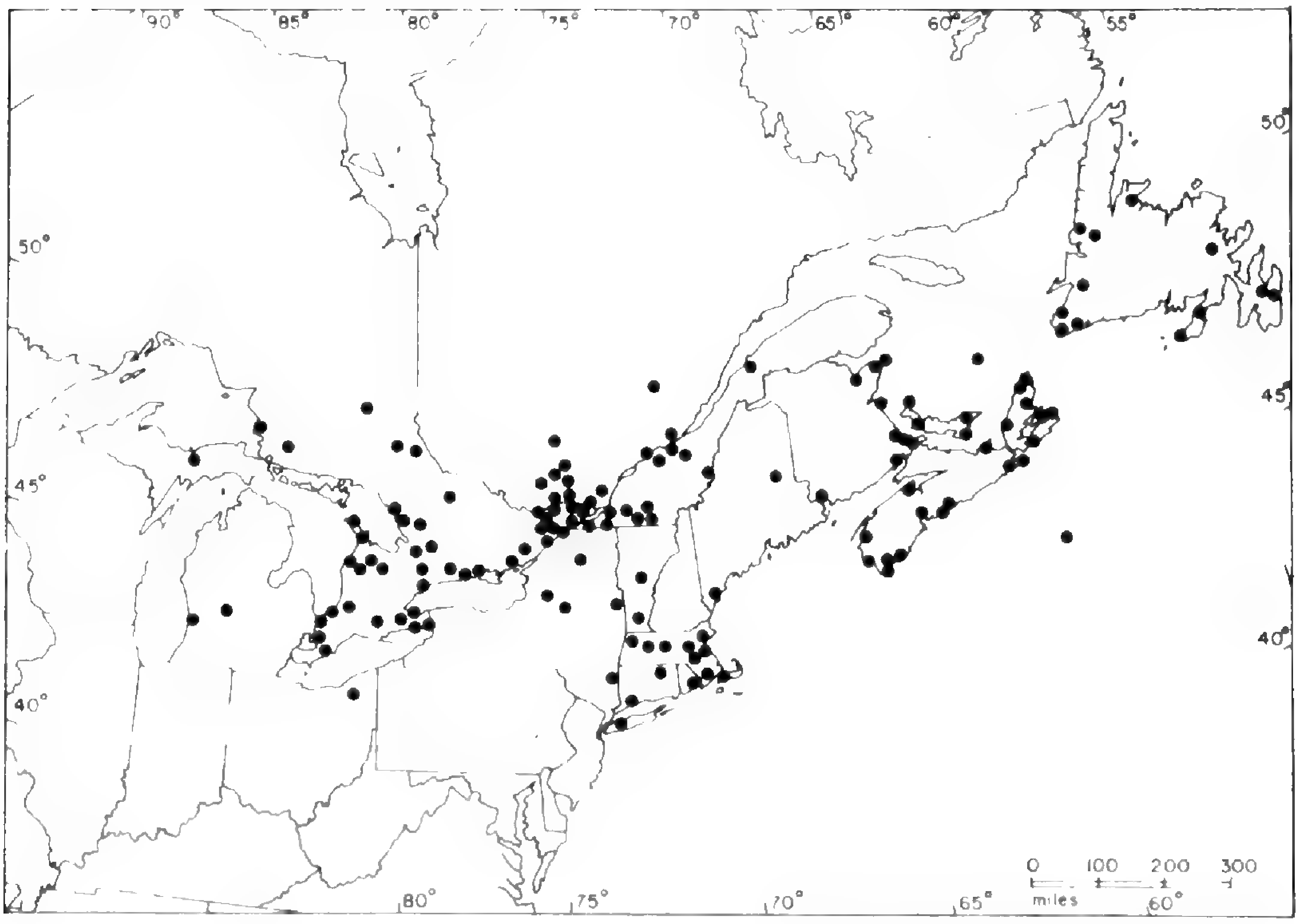

Figure 1. Northeastern North America with dots representing origins of specimens measured.

RESULTS

Herbarium and Field Study

The non-insular northeastern plants (Figure 2, top) formed a relatively tight group on the left side of the diagram ranging from relatively long-leaved to relatively short-leaved plants. Density decreased toward the right side of the diagram where all dots represent robust plants from the Massachusetts coastal plain. These few robust plants are readily separated from St. John's concept of f. *latifolius* by their great size and long leaves, despite the fact that the leaves are relatively wide.

Material from within many locations throughout the northeast resulted in widely scattered dots on the left side of the diagram (Figure 2, top), and no geographic pattern of variability was detected. Indeed, some locations have small plants with short leaves in open sandy flats only a few metres away from tall, long-leaved plants in adjacent bogs or graminoid fens.

Only plants from Sable Island (Figure 2, middle and bottom), including plants from the type sheet of f. *latifolius,* occupying that part of the diagram where leaf widths exceed 13 mm and leaf lengths

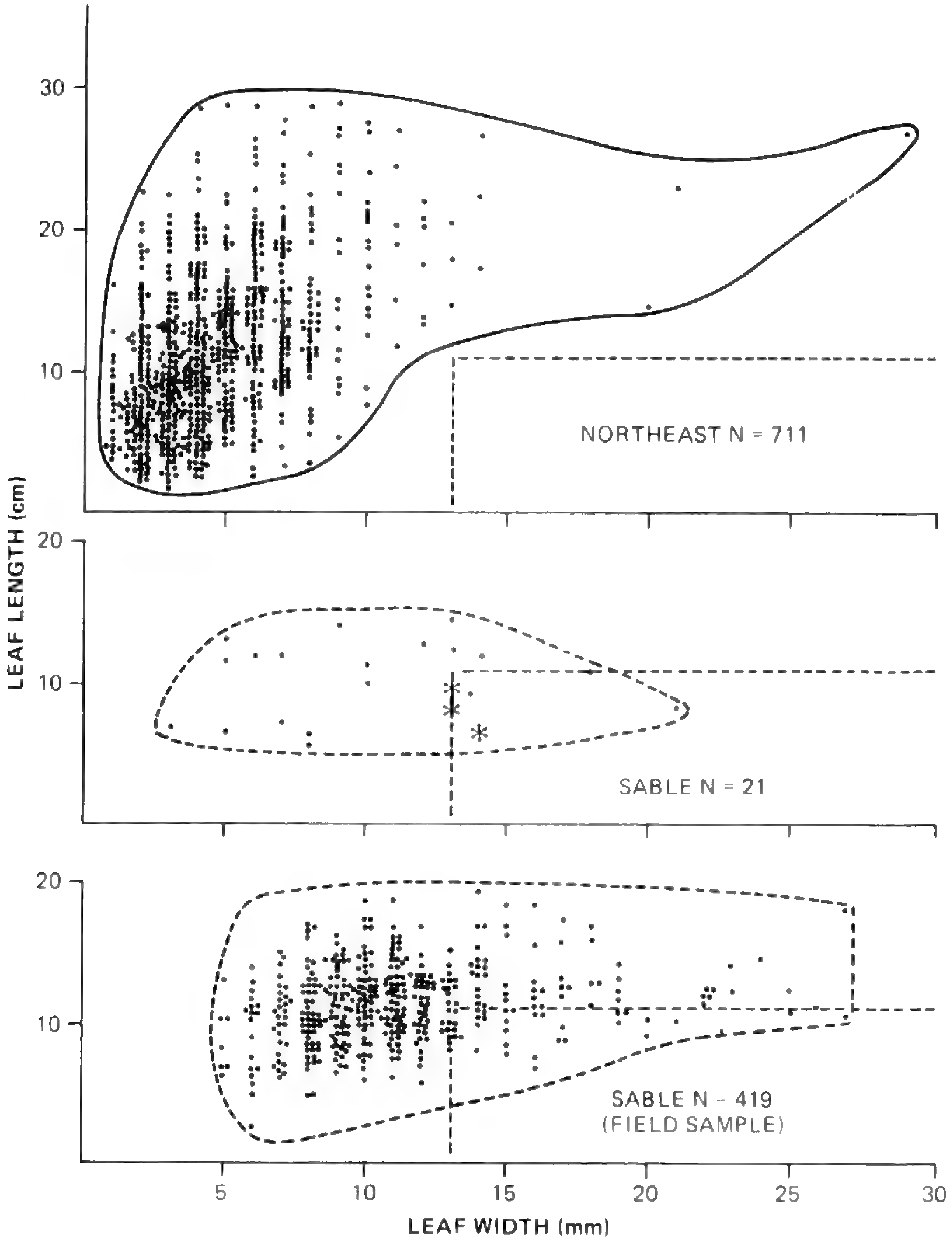

Figure 2. Scatter diagrams portraying the relationship between leaf width and leaf length in plants from northeastern North America (top), Sable Island based on herbarium specimens (middle), and from Sable Island based on field surveys (bottom). The lower limits of leaf width and leaf length corresponding to St. John's concept of f. *latifolius* are shown with a dashed line.

are less than 11 cm. These plants are the only ones seen in the northeastern herbarium material examined that conform to St. John's concept of the taxon. Portions of the Sable Island clusters overlap extensively with the material from the Magdalen Islands, from St. Pierre and Miquelon, and with material from elsewhere in the northeast (Figures 2, 3, 4). The plants from all of the islands tend to have both relatively shorter and relatively wider leaves; some of those from Sable Island are extreme in this respect and unlike plants from anywhere else. The overlap of characters of both Sable Island herbarium specimens and the field sample with characters of specimens from elsewhere in the northeast (Figure 4, upper) however, actually represents a continuum of variation (Figure 4, lower) without any indication of discrete groups.

When leaf width is considered with regard to plant height, a similar pattern emerges, with some of the Sable Island plants, including specimens from the type sheet of f. *latifolius,* occupying a unique position, but the variation again represents a continuum. The plants referred to var. *latifolius* also tend to differ from other northeastern plants in having a relatively large number of flowers with respect to their height, but again discrete groups do not exist.

Uniform Culture

In cultivation under uniform conditions, var. *latifolius* (*sensu* St. John) and similar plants from Sable Island generally maintained both their short stature and relatively wide leaves, while inland plants from eastern Ontario maintained their tendency to have relatively narrow and long leaves (Figures 5, 6, 7). However, both groups of plants demonstrated plasticity in leaf shape with substantial variation from year to year. For example, one plant referable to var. *latifolius* with leaves 14 mm wide and 10 cm long in the wild, became referable to var. *tuberosus* in the second year of cultivation with leaves 9.5 mm wide and 10 cm long. Another was referable to var. *latifolius* in the first year of glass house cultivation with leaves 13 mm wide and 9 cm long, but in the second year of glass house culture this plant had leaves 10 mm wide and 14.5 cm long, and it closely approached the group of eastern Ontario plants (Figure 6). Two of the four plants initially referable to var. *latifolius* remained referable to it and actually became even more extreme. Other plants, distinctive in their wider and short leaves initially, became even more distinctive with leaves 30 mm wide at the end of the second year of glass house culture (Figure 6). Despite substantial year to year variation, leaf shape was maintained within limits, and a genetic basis for leaf shape is strongly suggested.

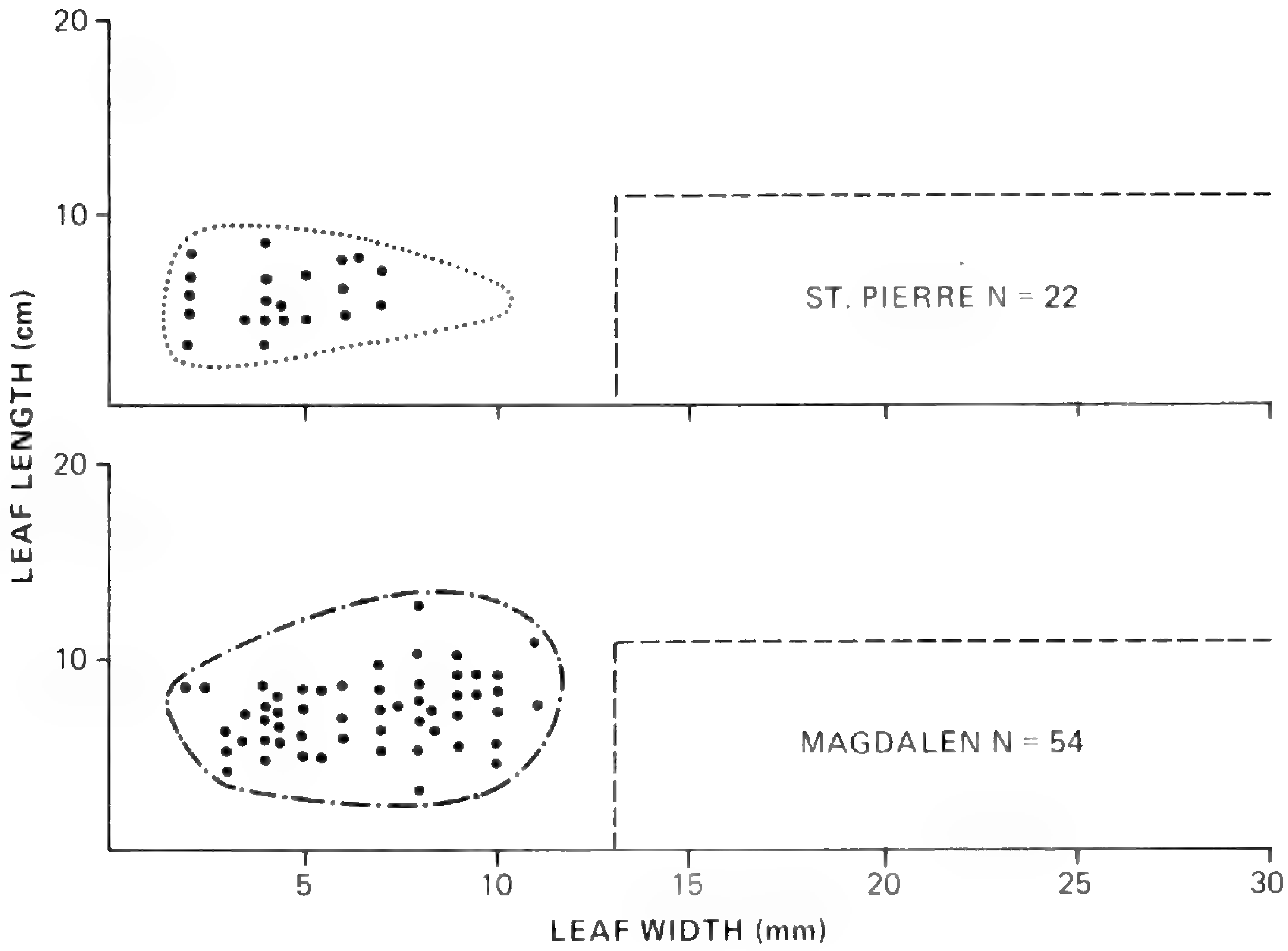

Figure 3. Scatter diagrams portraying the relationship between leaf width and leaf length in plants from St. Pierre and Miquelon and the Magdalen Islands, based on herbarium specimens. The lower limits of leaf width and leaf length corresponding to St. John's concept of f. *latifolius* are shown with a dashed line.

When leaf width is considered with respect to plant height (Figure 7) less plasticity is evident. Both the eastern Ontario plants and the Sable Island plants varied from year to year, but remained as relatively discrete groups. In the Sable Island group there was much more year to year variation in leaf width than in plant height, but it was still clear that some plants that may not be regarded as f. *latifolius sensu* St. John initially, later developed wide leaves while retaining short stature. The significant tendency in the cultivated plants from Sable Island is toward an increase in leaf width. Only one of 12 plants in one of two consecutive years showed a decrease. Figure 7 suggests that leaf width and plant height are characters with a genetic basis.

The Sable Island plants demonstrated greater plasticity (Figures 6 & 7). The reason for this plasticity is not clear but it might be related to the fact that the glass house environment differed more from their natural environment than it did for the Ontario plants.

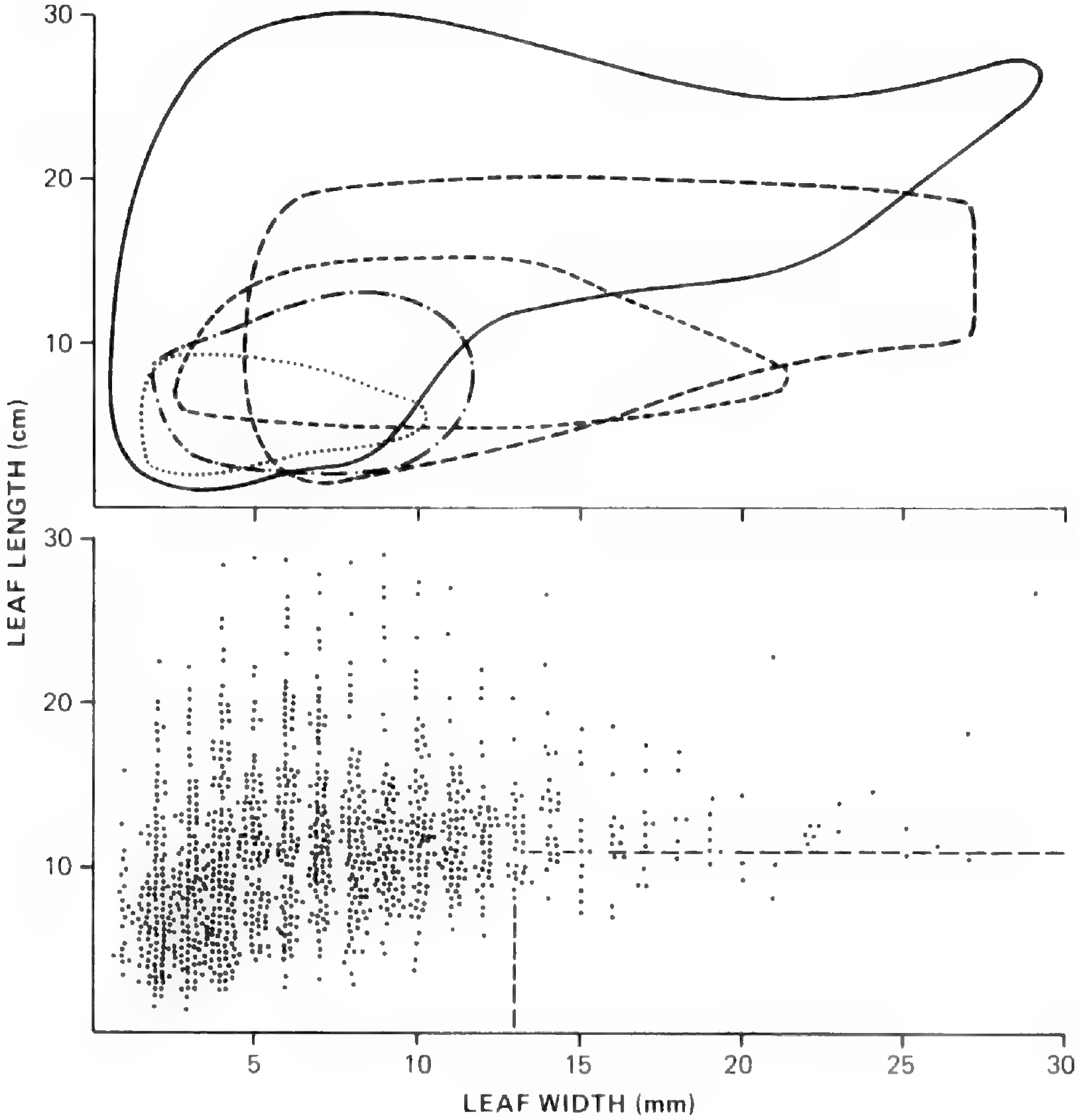

Figure 4. Above: Limits of scatter plots of leaf width versus leaf length for four geographic regions of the northeast (see Figures 2 & 3). Below: Combined plot of leaf width versus leaf length for four geographic regions of the northeast (incorporating Figures 2 & 3).

Other Characters

As noted by Correll (1950) and Fernald (1950), plants referable to var. *latifolius* often have relatively large, dark-colored corms up to 2 cm in diameter, and the leaves are often paired. Although there is a tendency for the wide-leaved plants from Sable Island to have paired leaves and large corms, not all of the wide-leaved plants possess these features. As with leaf width and plant height, there appears to be continuous variation in corm size and in the extent to which plants have two leaves, both on Sable Island and throughout the northeast.

Figure 5. Plants of *Calopogon tuberosus* var. *latifolius* (3 at right) beside a single plant of *C. tuberosus* var. *tuberosus* (left) in the second year of glass house cultivation.

DISCUSSION

The uniform culture experiments indicate that the short stature and wide leaves of the plants referred to var. *latifolius* have a genetic basis. However, the fact that plants can and did "change" from one variety to another during the period of cultivation indicates the

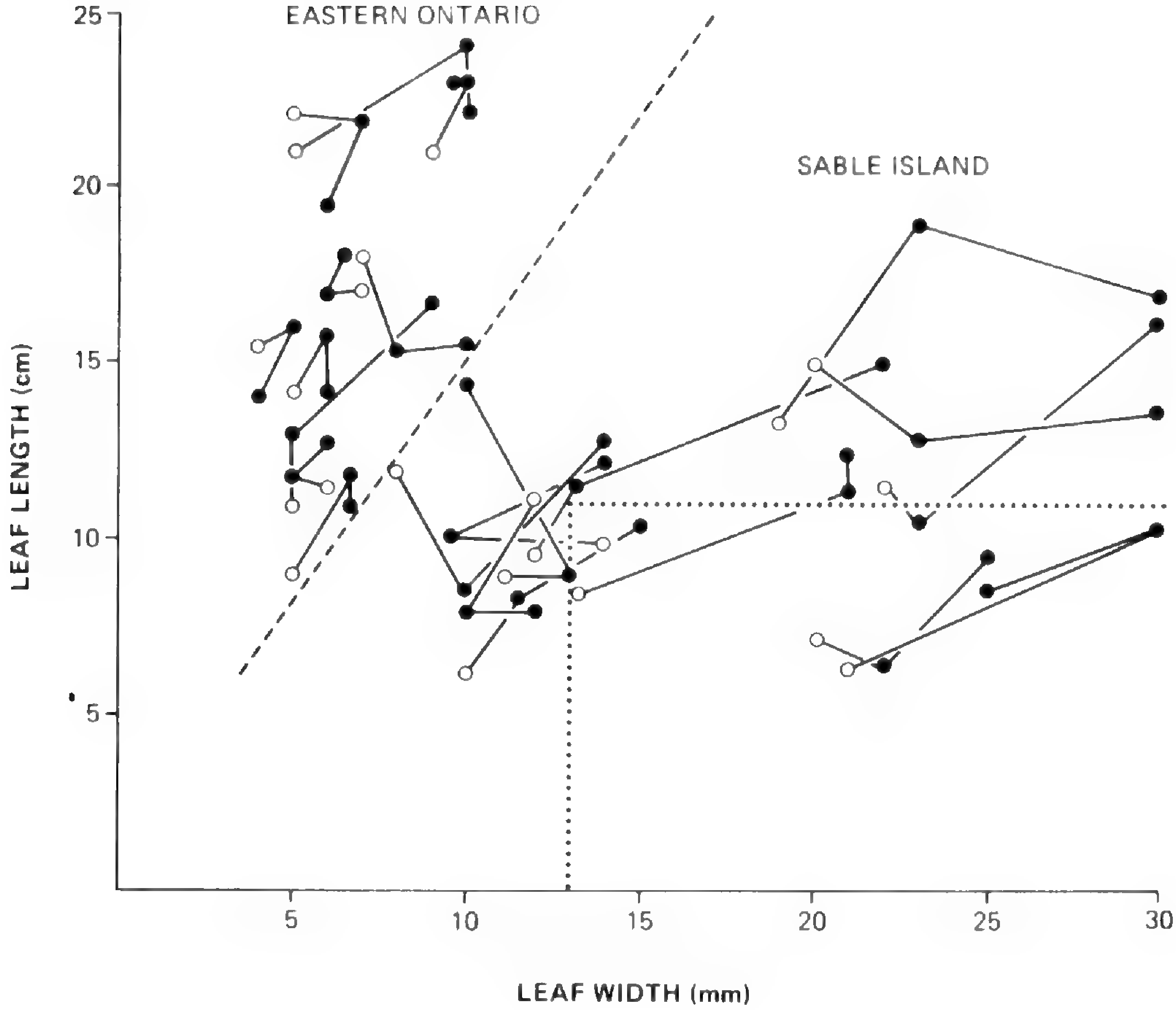

Figure 6. Position of 4 plants of *Calopogon tuberosus* var. *latifolius* from Sable Island, 8 plants close to *C. tuberosus* var. *latifolius* from Sable Island (but referable to *C. tuberosus* var. *tuberosus*), and 10 plants of *Calopogon tuberosus* var. *tuberosus* from eastern Ontario, with regard to leaf length and leaf width at the time of collection in their natural habitat (open circles) and one and two years subsequently in uniform cultivation (joined solid dots).

arbitrary nature of the limits of var. *latifolius*. This observation, and more significantly the fact of a continuum of variation in the most important morphological characters, make formal taxonomic recognition of the short, wide-leaved plants altogether inappropriate. Consequently both f. *latifolius* St. John and var. *latifolius* (St. John) Boivin are reduced to synonymy with *Calopogon tuberosus* (L.) BSP.

The var. *latifolius* represents a case of what may be referred to as the "Fernaldian" application of varietal rank (Fernald, 1950). This application recognized varieties in any case where variation within a species was not expressed throughout the range. In fact, there is frequently a geographic component to the extremes of a morphological continuum. This component may have a genetic basis, as in the

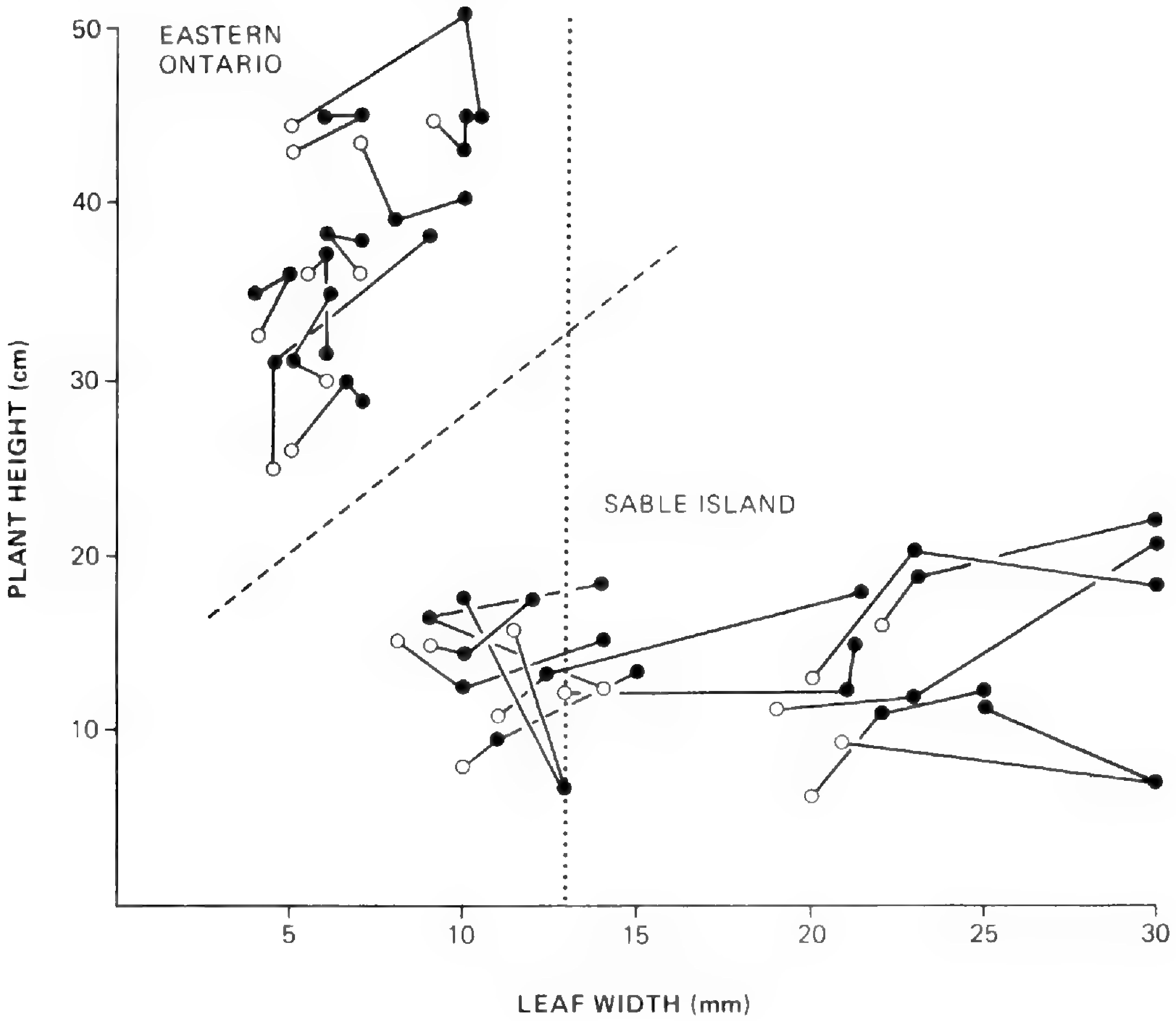

Figure 7. Position of 4 plants of *Calopogon tuberosus* var. *latifolius* from Sable Island, 8 plants close to *C. tuberosus* var. *latifolius* from Sable Island (but referable to *C. tuberosus* var. *tuberosus*), and 10 plants of *Calopogon tuberosus* var. *tuberosus* from eastern Ontario, with regard to plant height and leaf width at the time of collection in their natural habitat (open circles) and one and two years subsequently in uniform cultivation (joined solid dots.)

case of var. *latifolius,* but its arbitrary delimitation results in taxa that do not exist as discrete entities in nature, and in high frequencies of individuals that cannot be satisfactorily identified. The concept of *varietas* is useful only in the sense of morphological discontinuity involving one or a few differences that have a geographic basis. Completing the appropriate application of the concept, varieties within a species of a particular genus should be more closely related to each other than to any other species (including infraspecific taxa) in that genus.

Although we recommend against formal taxonomic recognition of this observed variation, this stance does not lessen interest in a unique and genetically-based pattern of variation on Sable Island. Unique variation has been reported in other plants on the island;

there are also endemic animals (Catling et al., 1984). There is a tendency to associate the unique variation in the plants and animals of Sable Island with the concept of their having escaped the Wisconsin glaciation (see Catling et al., 1984). However, it should be noted that there are a number of cases of distinctive patterns of variation in plants that presently exist in areas that were totally glaciated during the Wisconsin. The endemics of the Great Lakes shores provide a good example (Guire & Voss, 1963). Consequently, there is little reason to evoke more than isolation and an unusual climate to explain the unique variation.

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COMMUNITY CLASSIFICATION OF THE VASCULAR VEGETATION OF A NEW HAMPSHIRE PEATLAND[1]

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ABSTRACT

One hundred and one species of vascular plants were documented for the flora of Mud Pond Bog, a southern New Hampshire level bog in Hillsborough County. Percent cover data for 77 species in 99 quadrats were analyzed using the classification program TWINSPAN. Vegetation was classified into five community types and seven subtypes based on dominant vascular species. The *Nymphaea–Brasenia* community, an association of floating-leaved aquatics, formed in the open water adjacent to a minerotrophic edge association, the *Chamaedaphne–Decodon–Peltandra* community. A more ombrotrophic consolidated mat contained three subtypes of the *Chamaedaphne* community. The wooded areas of the bog were characterized by the *Acer–Nemopanthus* and *Ilex verticillata–Acer–Carex canescens* communities. The floristic composition, structure and distribution of these plant communities at Mud Pond Bog have strong similarities to other level peatlands in eastern North America.

Key Words: bog, peatland, plant community, plant classification, New Hampshire

INTRODUCTION

Although there are numerous studies on the vegetation of North American peatlands (Transeau, 1903; Gates, 1942; Conway, 1949; Dansereau and Segadas-Vianna, 1952; Sjors, 1959, 1963; Montgomery and Fairbrothers, 1963; Brewer, 1966; Crow, 1969; Heinselman, 1970; Jeglum et al., 1974; Vitt and Slack, 1975; Damman, 1979; Keough and Pippen, 1981), few have focused on the level or basin-type peatlands of New England. Level bogs are wetlands underlain by peat, having a *Sphagnum* mat surrounding a glacial depression (Vitt and Slack, 1975). In New England this type of

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peatland is distinguished from the ombrotrophic raised or plateau bogs of coastal Maine and other more minerotrophic peatlands known as fens (Worley, 1981).

In Vermont peatlands have been investigated from the standpoint of primary production (Osheyack and Worley, 1981) and preservation, whereas in Maine significant contributions have focused on peatland classification and preservation (Worley, 1981; Worley and Sullivan, 1980). In Massachusetts Swan and Gill (1970) examined the processes of bog mat formation and consolidation while Hemond (1980) focused on peatland water chemistry. Surprisingly, little is published about peatlands in New Hampshire. Krauss and Kent (1944) included four New Hampshire bogs in a palynological study. Belling (1977 Ph.D. thesis, N.Y. Univ., New York) found pollen in New Hampshire bogs helpful in interpreting the postglacial migrations of *Chamaecyparis thyoides,* while other New Hampshire bogs have been the subject of a mineral resource survey (White, 1941), a successional study (Barrett, 1966 M.S. thesis, Univ. of New Hampshire, Durham) and have been identified as important natural habitats (Johnson, 1985).

This study documents the vascular flora of Mud Pond Bog and describes the patterns and distribution of the vascular vegetation and compares it with other level bogs described in the literature.

STUDY SITE

Mud Pond Bog, a 48 hectare peatland located in the Fox State Research Forest in the Town of Hillsborough, Hillsborough County, New Hampshire (43°08″ N. Lat., 71°51″ W. Long.) has an extensive *Sphagnum* and heath mat surrounding an open lake (Figure 1). The study site included all areas of the basin underlain by peat except a *Typha* swamp to the south. The southern boundary was the transition zone between stands of *Larix laricina* and *Typha latifolia.* Within the study area, vegetation types included floating-leaved aquatics, a consolidated *Sphagnum* and heath mat, a bog forest and a marginal moat located at the base of the upland. Although there was no distinct inlet, water drained from the peatland through an outlet at the south end of the bog. Adjacent upland vegetation was dominated by a mixed broadleaf-conifer forest similar to the Hemlock–White Pine–Northern Hardwood forests described by Braun (1950). Mud Pond Bog lies within the Contoocook Valley, a glacial valley (Goldthwait et al., 1951) underlain by a Kinsman Quartz Monzonite (Nielson, 1981). Well-drained soils of

Figure 1. Aerial photograph of Mud Pond Bog taken from the northern end on August 16, 1983. (Photo by D. Dunlop)

the Canton and Paxton series and excessively drained soils of the Adams series are present on the adjacent slopes. In 1982, peat depths in the basin ranged from approximately 10 meters at the water's edge to 2.5 meters at the base of the upland. Material brought up in cores revealed that peat formed over a layer of fine gray clay. Local weather records from 1941 to 1980 (NOAA, 1981) document a mean annual daily temperature of 7.7° C (45.9° F). The mean normal January daily maximum is -0.4° C (31.3° F) and minimum is -11.8°C (10.7° F). The mean July maximum is 27.8° C (82.1° F) and the minimum is 14.4° C (57.9° F). Generally the period between May 17 and September 24 is frost free. Total precipitation averages 96.6 cm (38 inches) per year.

VEGETATION ANALYSIS

Quantitative data on species abundance were obtained in July and August 1982 by estimating percent cover of all vascular plant species and *Sphagnum* in 154 quadrats. Cover was defined as "the vertical projection of the crown or shoot area of a species to the ground surface expressed as a fraction or percent of a reference area" (Mueller-Dombois and Ellenberg, 1974 p. 80). Quadrats were placed randomly along seven transects and in two additional areas (Figure 2). Transects were located in areas that appeared to characterize the overall vegetation of the peatland and placed perpendicular to the observed pattern of zonation. On each transect a stratified random sample was taken (approximately 3 random quadrats every 10 meters). In addition, a 9 × 14 m wet depression on the mat and the peatland's outlet were sampled because they appeared floristically unique and did not conform to the zonal pattern evident in the rest of the bog. Each of the latter two areas was measured and gridded; quadrat location was determined by random numbers.

One-meter-square (1 × 1 m) quadrats were used to sample the low (less than 1.5 m in height) heath and herbaceous vegetation, whereas 4 × 4 m quadrats were employed to sample the tall (greater than 1.5 m in height) vegetation in the wooded zones (Oosting, 1956). In these 4 × 4 m quadrats, two 1 × 1 m subplots were placed in diagonal corners where percent cover was estimated for the low vegetation. Mean percent cover for the low vegetation in the two subplots and the percent cover for the tall vegetation from the 4 × 4 m plots were then combined for total 4 × 4 m plot data resulting in a final data matrix of absolute percent cover for 77 species in 99 samples.

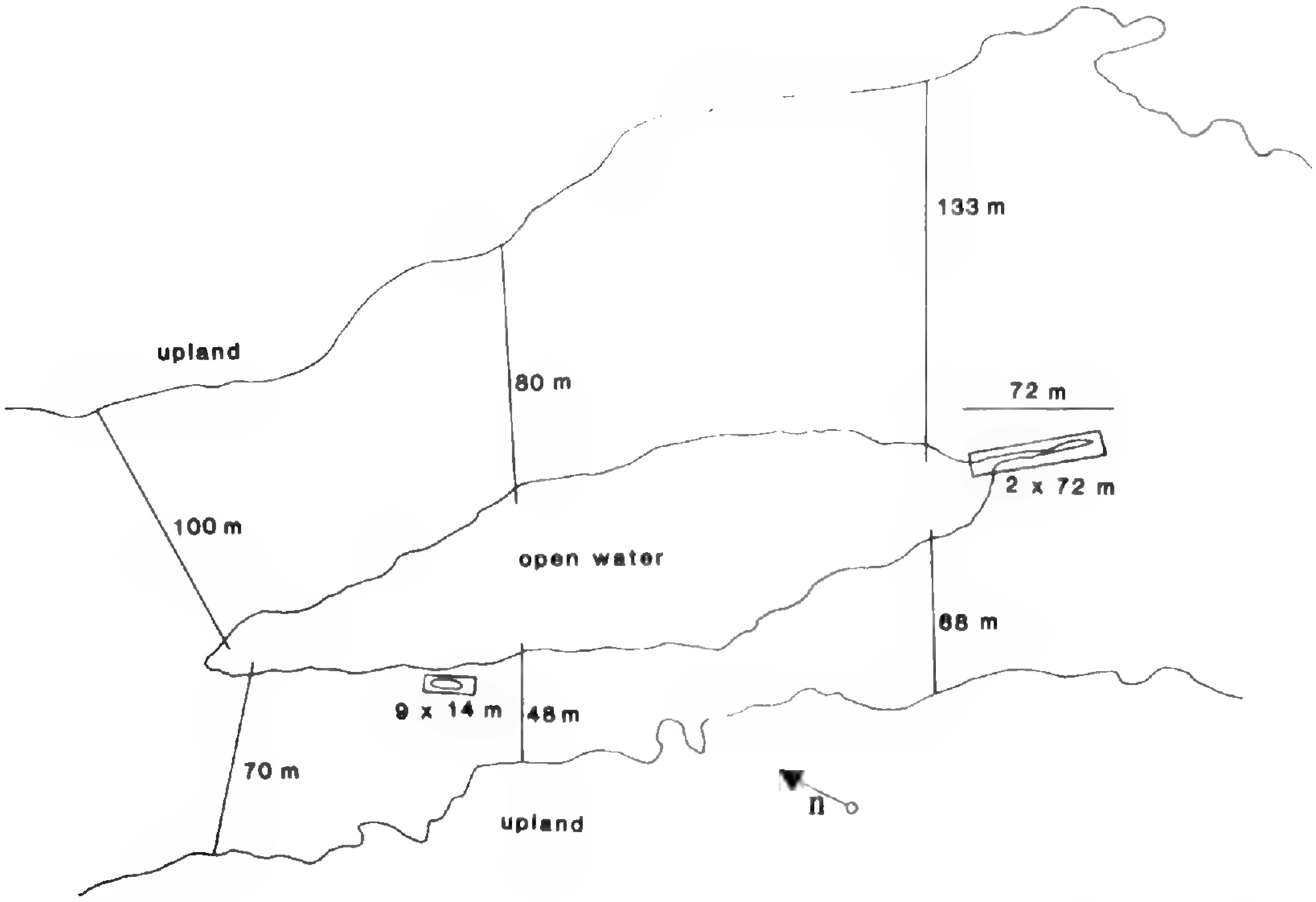

Figure 2. Locations of seven transects and the two additional sampling locations.

Quadrats were classified into communities by a divisive polythetic method known as TWINSPAN (Two Way Indicator Species Analysis; Hill, 1979), and a polar ordination (ORDIFLEX; Gauch, 1977). TWINSPAN is a hierarchical classification technique (Gauch, 1982) based on the reciprocal averaging method of ordination. Beginning with a single large cluster of samples and information on all species, this program successively divides the samples into smaller clusters, based on floristic similarity. The result is a hierarchy of sample clusters. Defaults used in the operation of this program are described elsewhere (Dunlop, 1983, M.S. thesis, Univ. of New Hampshire, Durham).

The 99 samples analyzed by TWINSPAN were dichotomized into clusters on six hierarchical levels (Figure 3 shows five levels). On the first level a cluster of 4 floristically distinct samples was distinguished. These open-water samples contained only floating-leaved aquatics in contrast to the other quadrats where *Sphagnum* was dominant. Subsequently, the remaining 95 samples were divided into two groups of 72 and 23 samples. These two groups were further separated on the third hierarchical level into four clusters of 56, 16, 15 and 8 samples. Community types were recognized at the third level and subtypes at the fourth and fifth levels (Figure 3). The

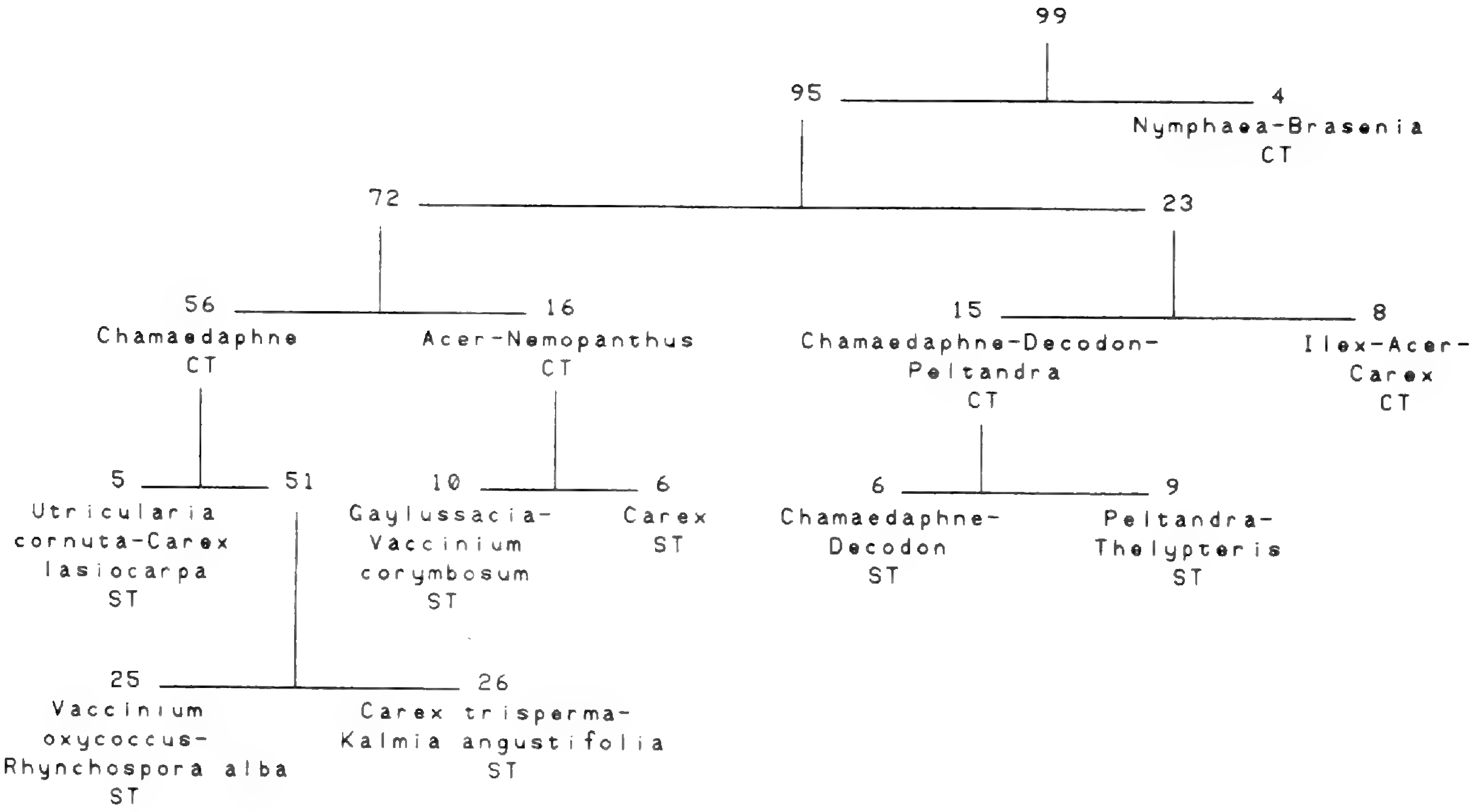

Figure 3. TWINSPAN Divisions: Separation of 99 samples into 5 community types and 7 subtypes based on five hierarchial levels made in the TWINSPAN analysis. (CT = community type, ST = subtype).

sixth hierarchical level (not shown) further divided the subtypes of the *Chamaedaphne* community into smaller units not recognized here. The continued dichotomization resulted in the recognition of five community types and seven subtypes (Figure 3).

Community types were named on the dominant vascular species using mean percent cover (Table 1). Likewise, subtypes were named using the subordinate dominant species. The number of species used in each community name depended on the composition of the subtypes. In the *Acer-Nemopanthus* community both subtypes were dominated by *Acer rubrum* and *Nemopanthus mucronata* whereas in the *Chamaedaphne* community, the three subtypes shared only one dominant species, *Chamaedaphne calyculata.*

TWINSPAN clusters corresponded with natural groupings of quadrats observed in the field. For example, the quadrats in the 8-sample cluster (Figure 3) came from the upland end of each transect. Likewise the quadrats in the 56-sample cluster were from the middle of each transect.

A Wisconsin polar ordination (ORDIFLEX) was utilized to further analyze the data and serve as a check on TWINSPAN (Gauch and Whittaker, 1972; Gauch et al., 1977). Groups of samples clustered using TWINSPAN were similarly grouped on the ordinations, thus substantiating the TWINSPAN results (Dunlop, 1983, M.S. thesis, U.N.H., Durham).

In an attempt to characterize the acidity of the substrate in each community, twenty-two water samples were taken from the sphagnum mat and open water on September 1, 1982 and analyzed on-site for pH using a Corning Portable pH meter (Model 6).

COMMUNITY TYPES

The *Nymphaea-Brasenia* community (NB) occurred in the open water adjacent to the *Sphagnum* mat and was dominated by aquatic plants. Bordering the open water, the mat edge community was dominated by *Chamaedaphne calyculata, Decodon verticillatus* and *Peltandra virginica* (CDP). Toward the upland on the consolidated mat, the *Chamaedaphne* community (C) formed, consisting of three distinct subtypes. Adjacent to the *Chamaedaphne* community, the *Acer-Nemopanthus* community (AN) represented a heterogeneous wooded zone with two subtypes. The fifth community type, the *Ilex verticillata-Acer-Carex canescens* community (IAC), occurred closest to the base of the upland and contained a moat with minerotrophic species.

Three general environmental gradients can be correlated with the distribution of the five community types. Along each transect from the open water over the consolidated mat, the substrate becomes noticeably drier (except for a moat at the base of the upland) and light intensity at ground level decreases as the tree canopy becomes more dense. The pH was highest in the open water and in the edge community and lowest on the consolidated mat. The distribution and abundance of individual taxa can be correlated with the observed gradients. For example, *Chamaedaphne calyculata* was ubiquitous in Mud Pond Bog (Table 1), whereas *Decodon verticillatus* was important only at the open wet edge of the mat. *Carex stricta* was important in the wooded zones, whereas *C. canescens* was abundant at the wet edge and near the moat in the wooded zones. *Rhynchospora alba* was present only in the drier, open center of the *Sphagnum* mat.

Nymphaea-Brasenia Community Type (NB)

Bordering the sphagnum mat on all sides except the east, floating-leaved and emergent aquatics formed a distinct zone in the open water (Figure 4). Development of this zone was highly variable and seasonal. At its maximum it extended out 2-3 meters from the mat. Quantitative data from the four samples representing this zone indicated that *Nymphaea odorata, Brasenia schreberi* and *Peltandra virginica* were dominant (Table 1). This zone probably was not sampled adequately (n = 4 quadrats), therefore the quantitative data may be somewhat misleading. My qualitative observations indicate that *Peltandra virginica* was associated more with the adjacent edge community where, as an emergent, it required a more solid substrate. The cover value for *Peltandra virginica* may reflect sampling overlap with the adjacent community where it was the third most abundant species. In contrast, *Nuphar variegata* was observed as an important component in a portion of the aquatic zone that was not sampled. Furthermore, *Pontederia cordata,* another species absent from the quantitative data, was observed to be abundant in the open water at the north and south ends of the peatland. The submerged aquatic *Utricularia vulgaris* was a minor component of this community as was *Potamogeton oakesianus.* The mean pH for the water in this community was 4.7 (n= 4).

Chamaedaphne-Decodon-Peltandra Community Type (CDP)

Fifteen samples, clustered by the TWINSPAN analysis, represent a community at the edge of the consolidated mat bordering the open water (Figure 4). This community was dominated by *Chamaedaphne calyculata, Decodon verticillatus* and *Peltandra virginica* (Table 1). *Carex canescens, Thelypteris palustris* and *Triadenum virginicum* were other important herbaceous species. In comparison to other communities, the *Sphagnum* layer was relatively unimportant (only 32% cover). This community was further divided into two subtypes that correspond to location in the peatland.

Chamaedaphne-Decodon Subtype (CD1)

Six samples represent a zone at the edge of the sphagnum mat bordering the open water (Figure 4). *Chamaedaphne calyculata,* the dominant species, had 63% cover (Table 1) while *Decodon verticillatus,* with its ability to root freely where arching branch tips touch the water, had a cover value of 50%. *Carex canescens, Peltandra virginica* and *Thelypteris palustris* were also important (Table 1). This community was most highly developed on the east side of the bog where it reached a maximum width of about 2 meters. The mean pH for water in this community was 4.4 (n = 4).

Peltandra-Thelypteris Subtype (PT2)

At the bog's south end, a 1-2 meter wide outlet drained the peatland where *Peltandra virginica* was dominant in the shallow water (Table 1). *Thelypteris palustris, Chamaedaphne calyculata* and *Decodon verticillatus* were co-dominant species with cover values ranging from 20-26%. The presence of *Carex atlantica, Carex lasiocarpa, Aster nemoralis, Acer rubrum* and *Lycopus uniflorus* floristically distinguished this subtype from the *Chamaedaphne-Decodon* subtype of the mat edge. The mean pH from this subtype was 4.4 (n = 3).

Chamaedaphne Community Type (C)

Adjacent to the edge community was a larger, homogeneous zone of *Sphagnum,* ericaceous shrubs and sedges. *Sphagnum* was clearly the dominant cover in this zone, forming a relatively level mat (Figure 4). This sphagnum-heath-sedge community was dominated by *Chamaedaphne calyculata, Vaccinium oxycoccus, Kalmia angustifolia, Rhynchospora alba* and *Carex trisperma* (Table 1). The vegetation was characterized by dwarf heaths (less that 45 cm.) and a few isolated individuals of *Larix laricina, Picea mariana* and *Acer rubrum.* Occasionally, *Vaccinium corymbosum* and *Alnus incana* ssp. *rugosa* were established on the mat. This zone reached a maximum width of 80 meters on the east side, whereas on the west it

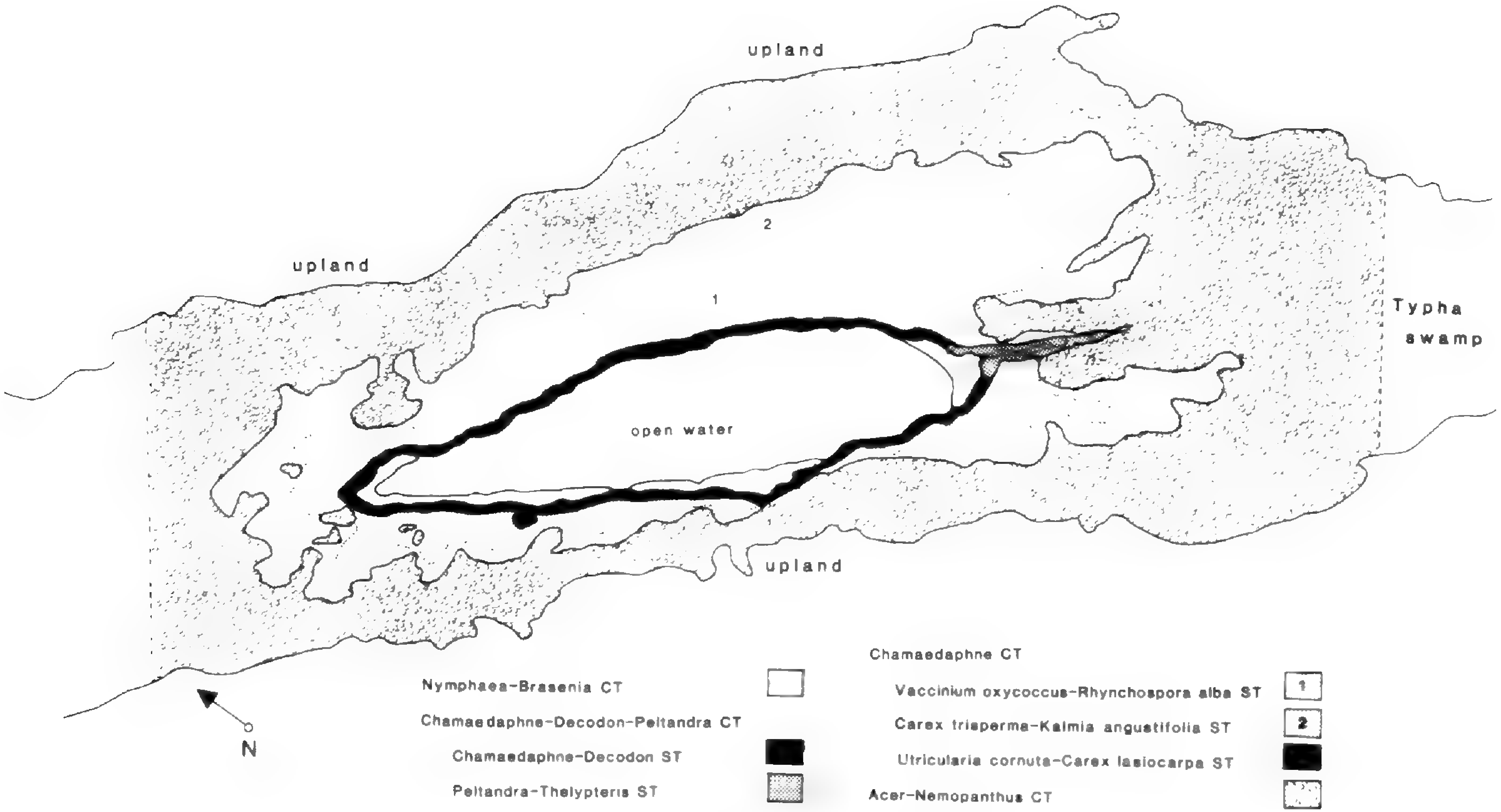

Figure 4. Vegetation map of Mud Pond Bog. Dashed lines represent approximate boundary between two *Chamaedaphne* community subtypes. Subtypes were not distinguished on this map for the *Acer-Nemopanthus* community; *Ilex verticillata Acer-Carex* community is not shown (see text). (CT = community type, ST = subtype).

narrowed to 25 meters. This community was further divided into three subtypes, all dominated by *Sphagnum* and *Chamaedaphne calyculata*. The distribution of two subtypes seemed to correspond to the observed moisture gradient across the mat. The mean pH for the entire mat community was 3.8 (n = 7). Subtypes were not distinguished for pH measurements.

Vaccinium oxycoccus-Rhynchospora alba Subtype (VR1)

Adjacent to the *Chamaedaphne-Decodon-Peltandra* community, the *Vaccinium oxycoccus-Rhynchospora alba* subtype dominated the wetter parts of the *Chamaedaphne* community. The general aspect of this subtype was one of an open mat dominated by dwarf heaths where *Vaccinium oxycoccus* and *Rhynchospora alba* were important. *Kalmia angustifolia, Sarracenia purpurea, Drosera rotundifolia* and *Eriophorum spissum* were present.

Carex trisperma-Kalmia angustifolia Subtype (CK2)

This group of samples occupied the drier sites of the *Chamaedaphne* community and in general had a taller, more woody aspect than the previous subtype. *Carex trisperma* and *Kalmia angustifolia* characterized this subtype. Patches of *Kalmia polifolia* and *Andromeda glaucophylla* added to the shrubby nature of the community. Other important woody species were *Vaccinium corymbosum, Acer rubrum, Larix laricina* and *Picea mariana* with the three tree species represented as dwarfed isolated individuals. Two orchids, *Calopogon tuberosus* and *Platanthera blephariglottis* were also present.

Utricularia cornuta-Carex lasiocarpa Subtype (UC3)

The third subtype occupied a 9 × 14 m floristically distinct, shallow pool on the northwest side of the bog on the *Sphagnum* mat. The moss layer of light green, partially submerged *Sphagnum* formed a continuous mat which did not support the weight of a person. *Chamaedaphne calyculata* had a lower cover value than in the other two subtypes (Table 1). The next most abundant species, *Utricularia cornuta* and *Carex lasiocarpa,* occurred in the wettest depressions with *Menyanthes trifoliata, Vaccinium macrocarpon* and *Cladium mariscoides.* These five species were all floristically unique to this wet pool.

Acer-Nemopanthus Community Type (AN)

Adjacent to the *Chamaedaphne* community was a zone of tall woody vegetation (Figure 4) dominated by an open canopy of *Acer*

Table 1. Mean absolute percent cover of 41 species in the community types and subtypes at Mud Pond Bog. See text for community and subtype abbreviations.

	Community Types and Subtypes											
	NB	**CDP**	CD1	PT2	**C**	VR1	CK2	UC3	**AN**	GV1	CX2	**IAC**
Number of plots:	4	15	6	9	56	25	26	5	16	10	6	8
Species												
Nuphar variegatum	–	1	1	1	1	–	–	–	–	–	–	–
Nymphaea odorata	33	1	–	1	–	–	–	–	–	–	–	–
Brasenia schreberi	26	4	11	–	–	–	–	–	–	–	–	–
Peltandra virginica	30	26	18	32	1	1	1	7	–	–	–	–
Decodon verticillatus	3	32	50	20	3	4	1	5	–	–	–	–
Carex canescens	–	19	26	14	1	1	–	1	6	5	8	34
Triadenum virginicum	–	12	10	13	1	1	–	1	–	–	–	2
Thelypteris palustris	–	21	13	26	–	–	–	1	1	–	–	–
Aster nemoralis	–	7	–	12	1	1	1	–	–	–	–	–
Carex atlantica	–	6	–	11	–	–	–	–	1	1	1	5
Chamaedaphne calyculata	1	39	63	23	44	56	36	24	6	8	–	–
Sphagnum species	–	32	32	32	88	92	83	100	59	59	46	46
Carex lasiocarpa	–	8	–	13	2	–	–	18	–	–	–	–
Menyanthes trifoliata	–	–	–	–	1	–	–	8	–	–	–	–
Utricularia cornuta	–	–	–	–	2	1	–	23	–	–	–	–
Drosera intermedia	–	1	1	1	1	1	–	13	–	–	–	–
Drosera rotundifolia	–	2	3	1	1	1	–	13	–	–	–	–
Sarracenia purpurea	–	–	–	–	3	2	2	9	–	–	–	–
Vaccinium macrocarpon	–	2	–	3	2	2	–	–	7	–	–	–
Galium trifidum	–	7	9	6	3	5	2	4	1	1	–	3
Aster simplex	–	3	–	4	–	–	–	–	–	–	–	–

Kalmia angustifolia	–	–	–	–	23	19	32	1	14	22	2	–
Rhynchospora alba	–	2	–	3	27	33	24	4	1	1	–	–
Vaccinium oxycoccos	–	2	5	–	32	39	32	–	1	2	–	
Kalmia polifolia	–	–	–	–	9	4	14	1	2	3	–	–
Larix laricina	–	–	–	–	2	1	4	–	14	22	–	–
Carex trisperma	–	–	–	–	16	1	35	–	21	21	22	2
Andromeda glaucophylla	–	1	1	–	4	1	6	6	1	1	1	–
Acer rubrum	–	7	2	11	2	1	3	2	48	42	60	34
Nemopanthus mucronata	–	–	–			–	–	–	29	26	36	3
Vaccinium corymbosum	–	1	–	1	2	1	3	–	21	24	15	6
Woodwardia virginica	–	–	–	–	1	–	2	–	11	8	15	–
Gaylussacia baccata	–	–	–	–		–	–	–	16	25	1	–
Ilex laevigata	–	–	–	–	–		–	–	8	5	13	4
Ilex verticillata	–	–	–	–	–	–	–	–	4	–	12	39
Lycopus uniflorus	–	4	–	6		–	–	–	1	–	3	10
Lysimachia terrestris	–	1	1	1		–	–	–	3	1	8	31
Aronia arbutifolia	–	–	–	–	1	–	2	–	2	3	–	1
Carex stricta	–			–		–	–	–	13	5	25	13
Osmunda cinnamomea	–						–	–	3	1	7	3
Picea mariana	–	–	–		1		2	–	8	4	–	1

rubrum. Tall shrubs formed a secondary stratum dominated by *Nemopanthus mucronata,* and a third layer was well represented by sedges and mosses (Table 1).

The sixteen plots representing this wooded community were further divided into two subtypes, both of which were dominated by *Sphagnum, Acer rubrum* and *Nemopanthus mucronata* (Table 1). The *Gaylussacia–Vaccinium corymbosum* subtype, represented by 6 plots, was transitional between the *Chamaedaphne* community and the *Carex* subtype of the AN community. Water samples were not collected in this community for pH analysis since the substrate was too dry when other samples were taken.

Gaylussacia–Vaccinium corymbosum Subtype (GV1)

The *Gaylussacia–Vaccinium corymbosum* subtype was characterized by a canopy of *Acer rubrum* and *Larix laricina* (Table 1). *Picea mariana* and *Pinus strobus* occurred infrequently. The shrub layer was well represented by the co-dominant species *Nemopanthus mucronata, Gaylussacia baccata, Vaccinium corymbosum* and *Kalmia angustifolia,* each with cover values ranging from 22%–26%. *Chamaedaphne calyculata* was also present. *Carex trisperma* was important in the ground cover.

Carex Subtype (CX2)

This second subtype was similarly dominated by *Acer rubrum* and *Nemopanthus mucronata.* However, *Larix laricina* was absent from the canopy. The subtype was named for *Carex trisperma* and *Carex stricta,* two secondary dominants. In comparison to the other subtype, *Ilex verticillata* and *I. laevigata* replace *Gaylussacia baccata* and *Vaccinium corymbosum* as important shrubs. In addition, *Chamaedaphne calyculata* and *Kalmia angustifolia* had low cover values. *Woodwardia virginica, Lysimachia terrestris, Lycopus uniflorus, Osmunda cinnamomea* and *Carex canescens* occurred frequently in this association.

Ilex verticillata–Acer–Carex canescens Community Type (IAC)

The eight samples representing this community were generally the last 1–3 quadrats on each transect, closest to the base of the upland. Probing in this area with a peat sampler revealed that peat was only 2.5 meters deep overlying glacial till. Runoff from the slopes accumulated forming a shallow moat or marginal channel 1–2 meters wide. Water levels fluctuated greatly in this channel during the summer of 1982.

This community was similar in physiognomy to the *Acer–Nemopanthus* community but contained numerous minerotrophic species (Jeglum, 1971). The *Acer rubrum* canopy was less dense, with a cover value of only 34%. The shrub layer was dominated by *Ilex verticillata;* other shrubs occurred less frequently. *Carex canescens, Carex stricta, Lysimachia terrestris, Lycopus uniflorus* and *Galium trifidum* (Table 1) were common herbs. *Bidens cernua* was observed to be more abundant than represented in the quantitative data. In addition, *Calamagrostis canadensis* and *Sparganium americanum,* other indicators of minerotrophic waters, were observed. The mean pH was 4.2 (n = 3).

Unlike the other communities that generally formed large continuous zones, this community had a patchy distribution which was difficult to differentiate in aerial photos; it is not represented in Figure 4.

DISCUSSION

In the absence of hydrological and water chemistry information, pH data and inferences made from the vegetation can be used to classify Mud Pond Bog. In the wetland system proposed by Jeglum et al. (1974), Mud Pond Bog might best be described as a low shrub bog with some treed areas. In contrast, Mud Pond Bog can be classified as a very poor fen with some richer fen areas using the classification of Worley and Sullivan (1980). In this system the term "bog" is restricted to ombrotrophic peatlands where nutrient input is primarily from precipitation, whereas a "fen" receives input from runoff and other ground water sources. At Mud Pond Bog, the presence of *Juncus effusus, Larix laricina, Calamagrostis canadensis, Carex canescens, Bidens cernua, Galium triflorum,* and *Trientalis borealis* at the edges of the mat adjacent to the open water and at the base of the upland reflect weak minerotrophic conditions (Jeglum, 1971). The species composition in the center of the *Sphagnum* mat suggests ombrotrophic conditions (Worley and Sullivan, 1980). In other vegetation classifications, Mud Pond would be classified as a Northern New England Level bog (Rawinski, 1984, unpubl. report, Nature Conservancy, Boston, MA) or as a moss wetland (Cowardin et al., 1977). Here, I do not restrict the term "bog" to strictly ombrotrophic peatlands; rather, I describe Mud Pond Bog as a level bog.

In the following discussion the structure, composition and pattern of vegetation at Mud Pond Bog are compared with other level bogs described in the literature.

Only a few authors (Gates, 1942; Dansereau and Segadas-Vianna, 1952; Crow, 1969) have described a floating-leaved aquatic zone floristically or physiognomically similar to the *Nymphaea–Brasenia* community at Mud Pond. The paucity of such descriptions is probably attributable to this zone being a variable unit limited to bogs with open water. In addition, this type of vegetation is not unique to bogs; similar zones typically form along many pond and lake margins, hence its exclusion from some peatland literature. Gates (1942) found *Nymphaea, Nuphar* and *Potamogeton* important in some Michigan bogs with open water; Conway (1949) also mentioned a zone of hydrophytes in some Minnesota bogs.

The *Nupharetum variegati* association described by Dansereau and Segadas-Vianna (1952) from bogs in the Laurentian Shield, formed an assemblage of floating-leaved aquatics and was viewed as an initial stage in the pioneer phase of peatland succession. Crow (1969) reported a similar floating-leaved aquatic zone in the open water of Pennfield Bog in southern Michigan, having a species composition similar to the *Nymphaea–Brasenia* community at Mud Pond. Unlike Mud Pond Bog, this bog had many more submerged species.

Conway (1949) and Crow (1969) described communities from Minnesota and Michigan bogs similar in composition and position to the *Chamaedaphne–Decodon–Peltandra* community recognized at Mud Pond Bog. Both found edge communities in which *Decodon verticillatus* is an important species. In the *Decodon* zone at Pennfield Bog (Crow, 1969), *Chamaedaphne calyculata* and *Thelypteris palustris* were also important species.

On the other hand, Dansereau and Segadas-Vianna (1952) found other species important at the edge of the mat. Their *Menyanthes trifoliata* association formed a narrow zone at the edge of some bog mats.

At Mud Pond Bog it is clear from aerial photos, field observations and analysis of the quantitative data that floristic similarities exist between the vegetation at the edge of the mat and at the outlet. Species composition at both locations is probably greatly influenced by water chemistry. In other peatland edge communities where the vegetation is in contact with bog lake water, Vitt and Slack (1975) found pH and/or cation content of the lake water were important environmental factors that correlated with the vegetation composition.

In some Michigan alkaline bog lakes Vitt and Slack (1975) found species at the mat edge typical of alkaline conditions, however vegetation in the contiguous mat community was typical of acidic conditions. The authors suggested that the alkaline edge community "acts as a buffer zone to the acidophilous community farther from the water's edge" (Vitt and Slack, 1975, p. 357). Conway (1949) described a similar situation and suggested that an extensive acidic moss-heath community may develop rapidly in areas where the pioneer mat is wide and acts as a shield from the direct influence of lake water. In a similar way at Mud Pond Bog, pH data and floristic composition at the edge of the mat suggest that more minerotrophic conditions exist in the open water and at the edge of the mat than in the interior of the mat. The edge community may buffer or isolate the vegetation of the bog mat from these more minerotrophic waters.

Probably the most characteristic vegetation type in flat bog peatlands is a *Sphagnum* mat dominated by sedges and low ericaceous shrubs. At Mud Pond Bog, this type is exemplified by the *Chamaedaphne* community. Floristically and physiognomically similar communities have been described in Michigan (Gates, 1942; Crow, 1969; Vitt and Slack, 1975), in Ontario (Dansereau and Segadas-Vianna, 1952; Segadas-Vianna, 1955), and in Minnesota (Conway, 1949; Heinselman, 1970). In Michigan, Gates (1942) found a *Chamaedaphne* association where *Chamaedaphne calyculata* was dominant with *Andromeda glaucophylla, Kalmia polifolia, Ledum groenlandicum* and *Vaccinium oxycoccus.* Vitt and Slack (1975) described a similar zone dominated by *Sphagnum, Chamaedaphne calyculata, Vaccinium oxycoccus* and *Rhynchospora alba.* This community formed on the mat edge adjacent to open water and was characterized by a low pH and slightly minerotrophic conditions. In addition, Vitt and Slack (1975) found an Acidic Lake Edge Zone where *Sphagnum* species, *Chamaedaphne calyculata, Rhynchospora alba, Vaccinium oxycoccus* and *Vaccinium macrocarpon* were important species. Vitt and Slack stated that these two zones, the Open Mat Zone and the Acidic Lake Edge Zone, were very similar floristically, but differed in chemical properties. Their Acidic Lake Edge Zone was not comparable to the edge community (*Chamaedaphne-Decodon-Peltandra* community) at Mud Pond Bog.

The heterogeneity in the wooded zones at Mud Pond Bog makes it difficult to compare with wooded communities in other bogs. Crow (1969) found a *Larix* zone encircling Pennfield Bog which was encircled by an *Acer rubrum* zone. Both zones shared species in common with the wooded communities at Mud Pond. *Ilex verticillata, Nemopanthus mucronata* and *Vaccinium corymbosum* were similarly dominant shrubs. Vitt and Slack (1975) described a Closed Mat Zone, typical of all bogs they studied, where *Picea mariana* and *Larix laricina* were dominant. Ericaceous shrubs were important in the understory, as they were in parts of the wooded community at Mud Pond Bog. At Mud Pond Bog *Larix laricina* and *Picea mariana* were subordinate to *Acer rubrum* in the wooded communities. In contrast, *L. laricina* formed park-like stands in other bogs (Conway, 1949). *Larix* and *Picea* were thought to be associated with more minerotrophic environments (Sjors, 1963). Conway (1949) suggested that *Larix* is more successful at invading open bog communities than *Picea mariana* because it can tolerate greater fluctuations in water level, is more shade tolerant, and has a more rapid growth rate.

At Mud Pond Bog, a moat has formed at the base of the upland slopes. Based on other descriptions this marginal moat is a common feature in level bogs, but is often variable in size and distribution. Moat characteristics are dependent on numerous factors that vary in individual peatlands such as shape of basin, depth of peat, and drainage of surrounding upland. Vitt and Slack (1975) described a marginal moat dominated by *Nemopanthus mucronata* and *Ilex verticillata.* Others report very deep moats with floating-leaved aquatics; for example, Crow (1969) described breaks in the *Acer rubrum* zone at Pennfield Bog that tended to have species typical of swampy sites, similar to the species found in the shallow moat at Mud Pond.

In summary, Mud Pond Bog is best classified as a level bog. The bog lake contains the *Nymphaea–Brasenia* community of floating-leaved aquatics and the bog mat is characterized by a minerotrophic edge community (the *Chamaedaphne–Decodon–Peltandra* community) and a more ombrotrophic consolidated mat represented by the *Chamaedaphne* community. The wooded areas of the bog are characterized by the *Acer–Nemopanthus* community, consisting of a dense tree and shrub layer, whereas the *Ilex verticillata–Acer–Carex canescens* community contains more herbaceous minerotrophic species which characterize the moat. The five community types at Mud Pond Bog reflect general floristic and vegetational similarities with other flat (level) bogs in northeastern North America whereas the subtypes are rather specific to the physical and environmental conditions at Mud Pond Bog.

THE VASCULAR FLORA OF MUD POND BOG

In order to document the flora, voucher specimens for all vascular plants were made between May 1982 and October 1983, deposited in NHA and cited in the floristic list. Nomenclature follows that of Fernald (1950) or Gleason and Cronquist (1963); the sequence of angiosperm families follows Cronquist (1981).

The flora of Mud Pond Bog is composed of 101 species in 80 genera distributed among 44 families. The dominant families are the Cyperaceae and Ericaceae, comprising 21% and 15% of the flora, respectively. None of the taxa found at Mud Pond Bog is listed on the New Hampshire rare and endangered list (Storks and Crow, 1978).

Although a flora of the Fox State Forest was compiled in 1938 (Beetle, 1938; Weatherby and Blake, 1939), little attention was given to Mud Pond Bog since at that time the bog had not been incorporated into the State Forest. However, Beetle notes that some collections were made on the adjoining land at that time. Taxa preceded by an asterisk were not included in Beetle's flora.

Pteriodphytes

OSMUNDACEAE

Osmunda cinnamomea L.—Common; in wooded zones and throughout outlet.

Osmunda regalis L.—Uncommon; in wooded zones and along the mat edges.

POLYPODIACEAE

Thelypteris palustris Schott. var. *pubescens* (Lawson) Fern.—Occasional; at edge of sphagnum mat bordering open water and the outlet.

* *Woodwardia virginica* (L.) Smith—Occasional; on the sphagnum mat.

Gymnosperms

PINACEAE

Abies balsamea (L.) Mill.—Uncommon; few trees scattered in wooded zone.

Larix laricina (DuRoi) K. Koch—Occasional; in wooded zone. Common; bordering outlet at the south end of the bog.

Picea mariana (Mill.) BSP.—Occasional; on mat and in wooded zone.

Pinus strobus L.—Uncommon; a few small trees on open mat.

Tsuga canadensis (L.) Carr.—Uncommon; in wooded zones.

Angiosperms

Dicotyledons

NYMPHAEACEAE

Nuphar variegatum Engelm.—Occasional; in open water.

Nymphaea odorata Ait.—Common; in open water.

CABOMBACEAE

**Brasenia schreberi* Gmel.—Frequent; in open water.

RANUNCULACEAE

Coptis trifolia (L.) Salisb.—Uncommon; in wooded zones.

HAMAMELIDACEAE

Hamamelis virginiana L.—Uncommon; at border of upland.

MYRICACEAE

Myrica gale L.—Uncommon; few plants on sphagnum mat.

BETULACEAE

Alnus incana ssp. *rugosa* (DuRoi) Clausen—Occasional; in wooded zone.

Betula lenta L.—Uncommon; in wooded zone.

Betula populifolia Marsh.—Uncommon; in wooded zone.

CLUSIACEAE

**Triadenum virginicum* (L.) Raf.—Common; at edge of sphagnum mat.

SARRACENIACEAE

Sarracenia purpurea L.—Frequent; on open sphagnum mat.

DROSERACEAE

**Drosera intermedia* Hayne—Locally abundant; in shallow sphagnous pool on west side of bog with *Menyanthes.*

Drosera rotundifolia L.—Abundant; in wet areas of sphagnum mat. Occasional; in wooded zone.

VIOLACEAE

Viola blanda Willd.—Occasional; in sphagnum in wooded zone.

SALICACEAE

Salix discolor Muhl.—Uncommon; in wooded zone and upland.

ERICACEAE

Andromeda glaucophylla Link—Frequent; on sphagnum mat.

Chamaedaphne calyculata (L.) Moench—Abundant; bordering open water, on sphagnum mat and through all zones to base of upland.

Gaultheria procumbens L.—Occasional; on dry hummocks in wooded areas.

Gaylussacia baccata (Wang.) K. Koch—Abundant; in wooded zones.

**Kalmia angustifolia* L.—Abundant; on sphagnum mat and at edge of wooded zones.

Kalmia polifolia Wang.—Frequent; on sphagnum mat and occasional in wooded zone.

Lyonia ligustrina (L.) DC.—Occasional; in wooded zone.

**Rhododendron canadense* (L.) BSP.—Rare; one plant under *Acer rubrum* in wooded zone on northeast side.

**Rhododendron prinophyllum* (Small) Millais—Rare; one plant in wooded zone on southwest side.

Vaccinium corymbosum L.—Occasional; on sphagnum mat. Abundant; in wooded zones.

**Vaccinium macrocarpon* Ait.—Occasional; in wet sphagnous area on west of bog with *Menyanthes*.

Vaccinium oxycoccos L.—Abundant; on sphagnum mat from edge with open water to border of wooded zone.

PRIMULACEAE

Lysimachia terrestris (L.) BSP.—Common; in wooded zones.

Trientalis borealis Raf.—Occasional; in wooded zones.

ROSACEAE

Amelanchier canadensis (L.) Medic.—Occasional; in wooded zone.

Aronia arbutifolia (L.) Ell.—Occasional; on sphagnum mat and in wooded zone.

Aronia melanocarpa (Michx.) Ell.—Occasional; in wooded zone.

Rubus hispidus L.—Occasional; in sphagnum in wooded zones.

Spiraea latifolia (Ait.) Borkh.—Uncommon; in wooded zone.

FABACEAE

Apios americana Medic.—Uncommon; climbing on shrubs in wooded zone.

LYTHRACEAE

Decodon verticillatus (L.) Ell.—Abundant; on edge of sphagnum mat.

CORNACEAE

Cornus canadensis L.—Occasional; on dry hummocks in wooded areas.

VISCACEAE

Arceuthobium pusillum Peck—Occasional; parasitic on *Picea mariana* in wooded zone on east side of bog.

AQUIFOLIACEAE

**Ilex laevigata* (Pursh) Gray—Common; in wooded zone near base of upland.

Ilex verticillata (L.) Gray—Common; in wooded zone.

Nemopanthus mucronata (L.) Trel.—Abundant; in wooded zone.

ACERACEAE

Acer rubrum L.—Frequent; dominant in wooded zones.

ANACARDIACEAE

Toxicodendron vernix L.—Abundant; at north end of bog in wooded zone. Occasional; in wooded zones on east and west side.

ARALIACEAE

Aralia nudicalis L.—Occasional; in wooded zone.

APIACEAE

Cicuta bulbifera L.—Occasional; on sphagnum mat bordering open water.

MENYANTHACEAE

Menyanthes trifoliata L.—Uncommon; in pool on spagnum mat.

LAMIACEAE

Lycopus uniflorus Michx.—Common; in wooded areas and at base of upland.

OLEACEAE

Fraxinus nigra Marsh.—Uncommon; in wooded area on east.

LENTIBULARIACEAE

**Utricularia cornuta* Michx.—Frequent; on mat in wet hollows.

**Utricularia vulgaris* L.—Uncommon; in open water at edge of bog mat.

RUBIACEAE

Galium trifidum L.—Common; at edge of sphagnum mat bordering open water.

Cephalanthus occidentalis L.—Uncommon; in wet parts of moat.

CAPRIFOLIACEAE

Sambucus canadensis L.—Uncommon; in wooded zone.

Viburnum cassinoides L.—Occasional; in wooded zone.

ASTERACEAE

**Aster nemoralis* Ait.—Occasional; at edge of sphagnum mat.

**Aster simplex* Willd.—Occasional; at outlet.

**Bidens cernua* L.—Common; in wet channel-like moat.

**Solidago uliginosa* Nutt.—Occasional; on mat.

Monocotyledons

POTAMOGETONACEAE

**Potamogeton oakesianus* Robbins—Uncommon; in open water.

ARACEAE

**Calla palustris* L.—Uncommon; few plants in wooded zone.

Peltandra virginica (L.) Kunth—Frequent; in sphagnum at water's edge.

JUNCACEAE

Juncus canadensis J. Gay—Occasional; at outlet.

Juncus effusus L. var. *solutus* Fern. and Wieg.—Uncommon; at outlet.

**Juncus pelocarpus* E. Meyer—Occasional; in wet sphagnous pool with *Menyanthes.*

CYPERACEAE

**Carex atlantica* subsp. *capillacea* (L. H. Bailey) Reznicek—Abundant; on sphagnum mat in all zones.

Carex canescens L.—Abundant; at edge of sphagnum mat and in wooded zone.

**Carex crinita* Lam. var. *crinita*—Uncommon; in wooded zone.

Carex intumescens Rudge—Occasional; in wet areas of the wooded zone.

**Carex lasiocarpa* Ehrh. var. *americana* Fern.—Common; at edge of sphagnum mat.

Carex limosa L.—Rare; on sphagnum mat.

**Carex lurida* Wahl.—Uncommon; in wooded zone.

Carex stricta Lam.—Common; in wooded zones near or in moat.

**Carex trisperma* Dew. var. *trisperma*—Abundant; on sphagnum mat in all zones.

Cladium mariscoides (Muhl.) Torr.—Occasional; in shallow sphagnous pool on west side with *Menyanthes.*

Dulichium arundinaceum (L.) Britt.—Frequent; in wooded zones.

**Eleocharis smallii* Britt.—Uncommon; in water at outlet.

Eriophorum spissum Fern.—Occasional; on mat.

Eriophorum virginicum L.—Common; on sphagnum mat.

Rhynchospora alba (L.) Vahl—Abundant; on sphagnum mat.

**Scirpus cyperinus* (L.) Kunth.—Uncommon; in wooded zone.

POACEAE

Calamagrostis canadensis (Michx.) Nutt.—Occasional; near moat.

Glyceria canadensis (Michx.) Hubbard.—Occasional; in moat.

Leersia oryzoides (L.) Swartz—Uncommon; wooded zone on east.

Oryzopsis asperifolia Michx.—Uncommon; in wooded zone on southwest side.

SPARGANIACEAE

**Sparganium americanum* Nutt.—Infrequent; large patch in moat.

TYPHACEAE

Typha latifolia L.—Uncommon; in shallow moat-pool and in outlet.

PONTEDERIACEAE

Pontederia cordata L.—Occasional; at edge of sphagum mat.

LILIACEAE

Maianthemum canadense Desf.—Occasional; on dry hummocks in wooded areas.

IRIDACEAE

Iris versicolor L.—Occasional; in moat-pool.

ORCHIDACEAE

Calopogon tuberosus (L.) BSP.—Occasional; on sphagnum mat around bog.

**Platanthera blephariglottis* (Willd.) Lindl.—Frequent; on sphagnum mat.

**Pogonia ophioglossoides* (L.) Ker.—Rare; few plants on sphagnum mat.

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NEW ENGLAND NOTE

RANGE EXTENSION FOR *CARYA CORDIFORMIS* IN NEW ENGLAND

CHARLES RAYMOND CORMIER

The previously known northeastern limit for *Carya cordiformis* (Wang.) K. Koch was recorded by A. R. Hodgdon (1946) in Durham, N.H. near the Newmarket town line. I first noted a station consisting of two trees located in a wet, wooded area within the city of Portsmouth, N.H. about 5 miles east from the Durham station. A second and more northeasterly station is located across the Piscataqua River in the town of Kittery, Maine. This station is more noteworthy owing to the fact that the species has never been recorded as occurring naturally in Maine.

On December 15, 1986, a field trip was made to collect winter twigs from a known single specimen at this second location. At this time a search of an adjacent five-acre wooded lot revealed a well-established colony of at least fifty-five individuals. The three largest measured 19.4, 18, and 17.6 inches in diameter at four feet above ground level. This colony is located on a northwesterly-facing rocky slope bordering Spinney Creek in Kittery. The area also supports *Quercus alba, Quercus rubra, Fraxinus americana* and *Pinus strobus* (Richards et al., 1983). Voucher specimens have been deposited at NHA, MAINE, and NEBC.

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BOOK REVIEW

ANDRE F. CLEWELL. *Guide to the Vascular Plants of the Florida Panhandle.* 605 pp. University Presses of Florida, Gainesville. (Price $30.00)

The panhandle of Florida is an exciting area in which to botanize. The flora of this diverse region is now much more accessible thanks to this fine effort by Dr. Andre F. Clewell. Clewell's guide was made possible by the years of astute collecting and botanical insight of Dr. Robert K. Godfrey, to whom the book is most deservedly dedicated. Prior to this guide, one's recourses for panhandle botany were Small's manuals; Radford, Ahles and Bell's manual of the Carolinas; and the invaluable collections of Godfrey and others at the Florida State University Herbarium (FSU). There was no other single source that treated the surprising number of narrow endemics to the bogs and flatwoods of the lower Apalachicola River basin, to the ravine and slope forests along the upper Apalachicola River, and to the dunes along the Gulf Coast, as well as the many disjunct and peripheral species found throughout the panhandle. Clewell's guide for the panhandle coordinates to considerable extent in nomenclature, coverage, and style with the guide by R. P. Wunderlin (1982. *Guide to the Vascular Plants of Central Florida*) but offers several useful improvements in style. Both guides are from the same publisher. Along with the earlier manual by R. W. Long and O. Lakela (1976. *A Flora of Tropical Florida*), all but the northeastern corner of Florida is specifically covered by a recent guide or manual.

Although specific to the Florida panhandle, that portion of Florida from the Suwannee River west to the Perdido River, Clewell's guide will be useful as far west as Mississippi and north into adjacent southern Alabama and Georgia. The guide includes 2359 species in 810 genera and 181 families; however, even a section on "Additional Taxa" added between preparation and publication, does not allow the book to keep pace with the rate of botanical discovery in the Florida panhandle. Since publication, several species new to the panhandle, including at least one endemic, have been noted.

The book is of good quality and convenient size, and has survived a fair amount of field work. A county map is given inside the front cover and an index to families inside the back cover. The glossary, with terms in bold type, is fairly complete. Melanie Darst's well-executed and accurate illustrations of general foliar, floral and fruit morphology, and of flower morphology in Gramineae, *Andropogon, Xyris, Asclepias,* Compositae, Leguminosae, and Polygalaceae are most useful. A brief section on Physiography and Habitats is a helpful introduction to the distinctive habitat diversity of the region. The book arranges families in alphabetical order in four sections, pteridophytes, gymnosperms, monocots, and dicots, with genera and species arranged alphabetically within respective families and genera. Brief descriptions are given for families and for the genera of grasses. Species descriptions are not included, but Clewell has attempted to make the indented keys themselves somewhat descriptive. The guide also gives pertinent synonyms and habitat "preferences," distribution in Florida counties, and reproductive season based on FSU specimens; the status given for protected species is somewhat out-of-date.

The keys that I have used worked well. The author has adopted the admirable practice, under many family and generic names, of providing references that are often the source of keys and of further detail not usually included in a field key. The references are extremely useful when working with difficult groups and in obtaining useful ecological and biogeographical information not in the guide.

To have added detailed species descriptions and drawings, notes on range outside the state, and more lengthy keys, would have defeated the stated goal of this volume—to provide a handy field key in a timely fashion. Dr. Clewell's guide succeeds in this goal and is a welcome and long-awaited addition to the coverage of the flora of Florida; it is worth acquiring for botanical work or pleasure in the Florida panhandle.

E. DENNIS HARDIN
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BOOK REVIEW

Ralph W. Tiner, Jr. *A Field Guide to Coastal Wetland Plants of the Northeastern United States.* 285 pp. University of Massachusetts Press, Amherst, MA 01004. 1987. ISBN 0-87023-538-9. (Price: $12.00)

This guide focuses on identification of herbaceous plants in the northeast coastal wetlands. It is organized into five sections: Coastal Wetlands Ecology: a General Overview; Identification of Coastal Wetland Plants; Wetland Plant Descriptions and Illustrations; Places to Observe Coastal Wetlands; and Sources of Other Information.

The first section gives examples of the forces active along the coasts, clearly states working definitions of major land forms, and discusses in some detail the coastal tidal wetlands, including marine, brackish and freshwater situations, their gradations one from another, and their dependence upon repeated tidal cycles for their continued existence.

The section on Identification of Coastal Wetland Plants provides seven keys, only one of which is based upon flowers, with the others on the more likely-encountered vegetative characters. Five pages of outline drawings (leaf types and arrangements, flower types and arrangements, grasses, sedges, rushes) as well as a glossary (prior to the index, but without a page reference where it is first mentioned) help the novice to find his or her way through the keys to reach the illustrations and descriptions. One criticism is that there are no subsequent page references to the seven keys given when they are first presented in a "Key to Subsidiary Keys." I tried the keys on a number of plants in the field; Items 15 and 16, which purport to separate plants with leaves in whorls from those with alternate leaves are not clear, referring to leaves arranged "singly in whorls around the stem," a condition difficult to find, or even to imagine. There is, moreover, no reference to whorled leaves in the detailed description (of *Suaeda*) to which the key leads. All other examples I tried were clearly and efficiently delineated.

The scientific nomenclature employed is not entirely that found in Fernald's 8th edition of Gray's Manual, but no other source of names or name updates is mentioned. However, it makes little difference to most prospective users of the book as to whether the scientific name attached to a particular plant is nomenclaturally up to date; the keys deliver the user consistently to the same recognizable plant and common names are regularly included. The individual plant drawings, done by Abigail Rorer, and each occupying a separate page, are excellent in proportion, technically correct, and carefully scaled. A much-appreciated feature is mention of closely-related species with salient features which distinguish them from the one being described.

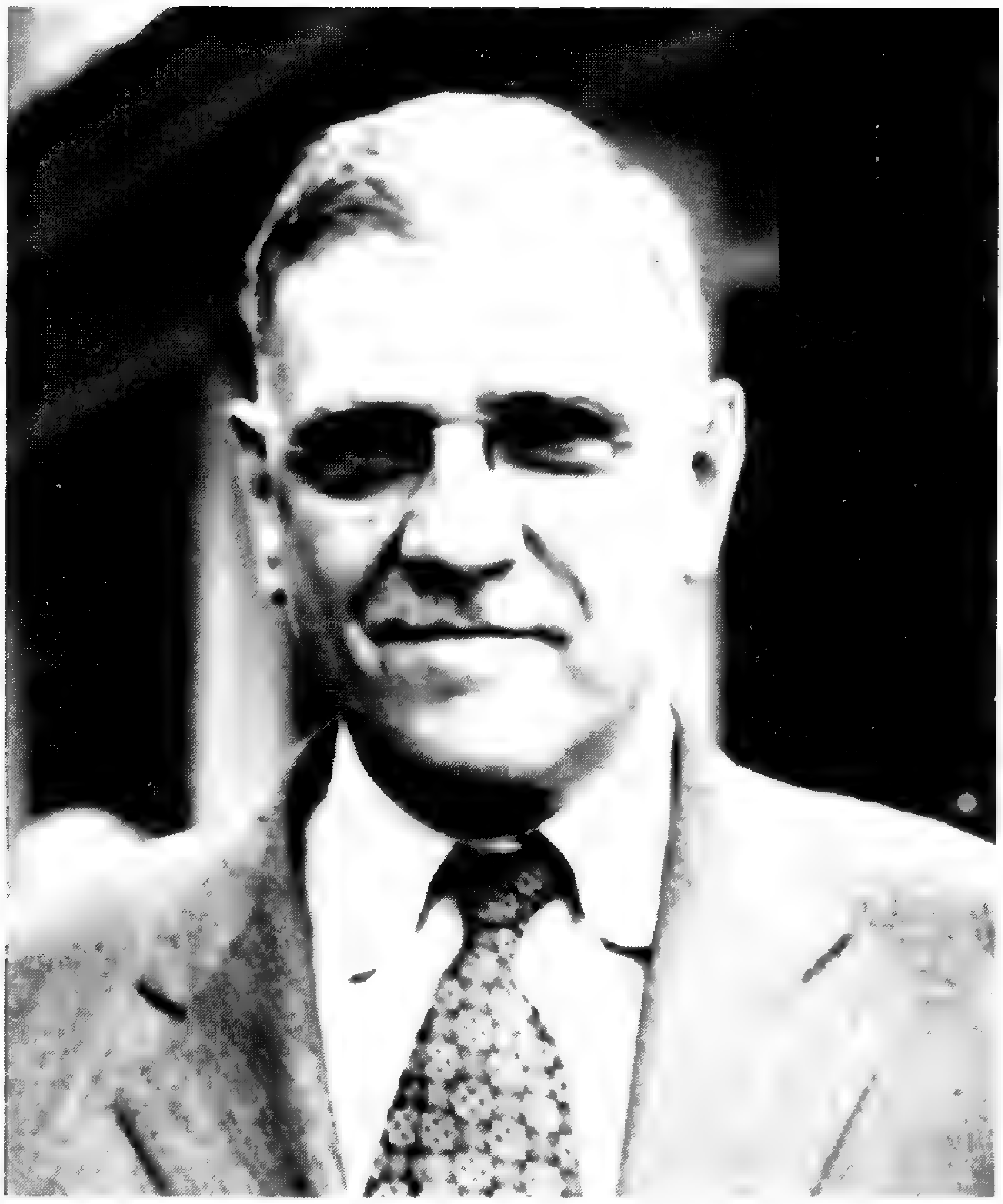
The section on Places to Observe Coastal Wetlands is organized with illustrated maps by states, from north to south, and is an excellent general scheme of how intricate and related a pattern our coastal wetlands form. It includes public access points to representative wetland areas. A small objection I find to this section is that it is written in quite an optimistic tone, without mention of the fact that recently-destroyed wetland areas in many instances rival the wetlands acreages now present. One of the major points of the book is to help identify wetlands, which are generally protected from destruction by both state and federal laws, for genuine preservational action at all three levels of government. Figures of total wetlands areas are often interpreted as minimizing the importance of leaving specific, small acreages in their natural state, when such an assumption is totally unwarranted.

A section of Sources of Other Information completes the book, and offers the reader a wide variety of literature citations and organizational names (with addresses) of public and private groups concerned with wetlands preservation and management over the total geographic area covered.

Overall, this guide is an excellent and welcome addition to the library of anyone dealing with coastal wetlands plants from Maine through Maryland; it is also applicable in the general region from Canada to northern Florida. Found printed on its back cover is an assessment of the author's intention for this field guide, with which I can readily agree: "This book is . . . useful to biologists, planners and landscape architects, conservation commissioners, consulting engineers, naturalists, environmental scientists, and other people interested in coastal wetlands."

NORTON H. NICKERSON
PHIPPEN-LACROIX HERBARIUM
TUFTS UNIVERSITY
MEDFORD, MA 02155

IN MEMORIAM



RALPH C. BEAN
1881–1977

[Diligent search of past issues of RHODORA failed to bring to light any earlier tribute to Ralph Bean. Mr. Bean was a member of the New England Botanical Club for 68 years, a record no one else has matched. It seems appropriate therefore that in this year, the 10th anniversary of his death, we respectfully recognize his long devotion and commitment to the advancement of botanical study in New England. -Ed.]

Ralph Carleton Bean died January 31, 1977 at the age of 95. He had been a member of The New England Botanical Club since 1909, its president from 1941 to 1944 and its librarian from 1952 to 1971.

Mr. Bean was born in Clinton, Maine on April 23, 1881. He was graduated from Coburn Classical Institute in 1898 and from Colby

College in 1902. He subsequently received the degree of Master of Education from Harvard.

He married Florence Winchester Lowell of Auburn, Maine in 1911. Mrs. Bean died in 1959.

Mr. Bean was a teacher by profession. After a few years at Clinton and at Bridgton Academy in Maine and Wakefield High School in Massachusetts he went to the Girls' High School in Boston where he taught biology and became head of the Science Department. He retired to his home in Wakefield in June 1951.

In addition to his considerable activity in the New England Botanical Club, Mr. Bean was also a member of the Josselyn Botanical Society of Maine from 1907 until his death. He was made an honorary member of the Josselyn Society in 1961, and was one of the editors of its 1966 edition of the Revised Check-List of the Vascular Plants of Maine.

His genuine interest in botany began in his boyhood days and continued with enthusiasm through the years. A knowledgeable person, he won the admiration and respect of his colleagues not only as a competent botanist but also as an amiable, unselfish, and considerate individual of great understanding. His keen eye, scholarly approach, sound judgement, patience, persevering nature and broad interest in taxonomy have contributed much to the knowledge of New England plants. It is a pleasure and a great privilege to have had Ralph Bean as a friend and colleague in botany over a span of many memorable years. There should be more Ralph Beans to keep the discipline of botany alive and prosperous! [Fay Hyland]

NEBC AWARD
FOR THE SUPPORT OF BOTANICAL RESEARCH

Mr. Zack Murrell, Botany Department, Duke University, was selected to receive the 1987 New England Botanical Club award in support of botanical research for his proposal "Systematics of Cornus".

The New England Botanical Club will again offer an award of $1000 in support of botanical research to be conducted in relation to the New England flora during 1988. This award is made to stimulate and encourage botanical research on the New England flora and to make possible visits to the New England region by those who would not otherwise be able to do so. The award will be given to the graduate student submitting the best research proposal dealing with field studies in systematic botany, biosystematics, and plant ecology, but proposals for research in other areas of botany will also be considered. This award is not limited to graduate students at New England institutions, nor to members of the New England Botanical Club. Papers based on this research must acknowledge the NEBC's support, and it is encouraged that they be submitted to *Rhodora,* the Club's journal, for possible publication—subject to standard review processes.

Applicants should submit a proposal of no more than three double spaced pages, a budget (the budget will not affect the amount of the award), and a curriculum vitae. Two letters, one from the student's major professor, in support of the proposed research are also required. Proposals and supporting letters should be sent before 28 February 1988 to:

Awards Committee
The New England Botanical Club
22 Divinity Avenue
Cambridge, MA 02138

The recipient of the award will be notified by 30 April 1988.

MEETING ANNOUNCEMENT
NEW ENGLAND BOTANY GRADUATE STUDENTS

The third New England Botany Graduate Student Meeting will be hosted by the Botany Department at the University of Rhode Island, Kingston, RI, on Saturday 26 March 1988. Attendance is open to all. Paper presentations will be largely restricted to graduate student research (completed or in progress) representing all areas of botany (systematics, ecology, reproductive biology, anatomy, physiology, etc.). Time slots for paper presentations are limited and prior registration is required. Abstracts are due by 15 February 1988. For additional information and abstract forms, contact:

Julie A. Hambrook Botany Dept. University of Rhode Island Kingston, RI 02881 (401) 792-2620	or	Cathy A. Paris Dept. of Botany University of Vermont Burlington, VT 05405 (802) 656-3221

SEARCH FOR EDGAR T. WHERRY MEMORABILIA

Some members of the Delaware Valley Chapter of the American Rock Garden Society have volunteered to locate and catalog letters and other written material, slides and photographs and memorabilia relating to the life and work of our respected friend, the late Dr. Edgar T. Wherry.

Arrangements have been made to house and service the Wherry Collection in the library of the Academy of Natural Sciences of Philadelphia for the benefit of future students and researchers.

If you have such material in your files, or if you know someone or some institution that might have, please contact:

Milton Laden
334 Wellesley Road
Philadelphia, PA 19119
Tel. (215) 247-7616

REVIEWERS OF MANUSCRIPTS

JULY 31, 1986 — July 31, 1987

The editors of RHODORA are grateful to each of the following specialists for their participation in the review process.

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INDEX TO VOLUME 89

New scientific names are in **bold face.**

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INSTRUCTIONS TO CONTRIBUTORS TO RHODORA

Submission of a manuscript implies it is not being considered for publication simultaneously elsewhere, either in whole or in part.

Manuscripts should be submitted in **triplicate** (an original and two xerographic copies) and *must be double-spaced* (at least 3/8″) **throughout** including tables, figure legends, and literature citations. Please do not use corrasable bond. The list of legends for figures and maps should be provided on a separate page. Footnotes should be used sparingly. Do not indicate the style of type through the use of capitals or underscoring, particularly in the citation of specimens. Names of genera and species may be underlined to indicate italics in discussions. Specimen citations should be selected critically, especially for common species of broad distribution. Systematic revisions and similar papers should be prepared in the format of "A Monograph of the Genus Malvastrum", S. R. Hill, Rhodora 84: 1–83, 159–264, 317–409, 1982, particularly with reference to indentation of keys and synonyms. Designation of a new taxon should carry a **Latin diagnosis** (rather than a full Latin description), which sets forth succinctly just how the new taxon is distinguished from its congeners. Papers of a floristic nature should follow, as far as possible, the format of "Annotated list of the ferns and fern allies of Arkansas", W. Carl Taylor and Delzie Demaree, Rhodora 81: 503–548, 1979. For bibliographic citations, refer to the Botanico-Periodicum-Huntianum (B-P-H, 1968), which provides standardized abbreviations for journals originating before 1966. All abbreviations in the text should be followed by a period, except those for standard units of measure and direction (compass points). For standard abbreviations and for guidance in other matters of biological writing style, consult the *CBE Style Manual,* 5th ed. (original title: *Style Manual for Biological Journals*). In preparing figures (maps, charts, drawings, photos, etc.) please remember that the printed plate will be 4 × 6 inches; be sure that your illustrations are proportioned to reduce correctly, and indicate by blue pencil the intended limits of the figures. (Some "turn-page" figures with brief legends will be 3 1/2 × 6 in.) Magnification/reduction values given in text or figure legends should be calculated to reflect the actual printed size. An Abstract and a list of Key Words should be supplied at the beginning of each paper submitted, except for a very short article or note.

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