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Subscriptions: $2.00 per year. Single copies: $.50 (except the two numbers of Volume 1, $1.00 each).

Articles and notes relating to any phase of botany in the Upper Great Lakes region are welcomed; manuscripts should be sent to the editor in chief. Subscriptions and inquiries regarding them (from those not members of the Michigan Botanical Club) should be sent to the circulation manager, who will assume that subscriptions received prior to the last number of a volume are intended to begin with the first number of that volume unless specified to the contrary.

Manuscripts intended for publication should be neatly typed, double-spaced, carefully prepared and checked for accuracy before submission, as our method of printing does not include a proof which can be sent to authors. Follow the style of recent issues, especially in regard to references. In determining suitability of material for publication, the editors and reviewers must consider the wide diversity of botanical interests among our members and subscribers and seek appropriate clarity and precision. Authors of more than two pages of print in an issue will receive, if requested in advance, five copies of that issue. Reprints may be ordered at cost.

THE MICHIGAN BOTANICAL CLUB

Membership in the Michigan Botanical Club is open to anyone interested in its aims: conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on the plant life of the State; sponsorship of legislation to promote the preservation of Michigan native flora and to establish suitable sanctuaries and natural areas; and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

Inquiries regarding membership may be directed to the state secretary or, from those residing where there is a chapter, to the appropriate chapter secretary. (The Southeastern Chapter is centered in the Detroit metropolitan area; the Huron Valley Chapter, in Washtenaw County; and the Northwestern Chapter, in the northwestern Lower Peninsula.) Dues are modest, but vary slightly among the chapters; in all cases, they include subscription to THE MICHIGAN BOTANIST.

HYBRID WOOD FERNS IN ONTARIO[1]

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For the past six summers the author has been collecting wood ferns *(Dryopteris)* in Ontario and studying them cytologically. The objectives of this study have been to discover which species are native to the province, their distribution, and the morphological variation shown by the different species and hybrids. Dr. Rolla Tryon of the Gray Herbarium has examined the collections and has been studying the morphological variation exhibited by the various taxa. His help in identification and his counsel on taxonomic matters has been greatly appreciated. Cytological study of the hybrids during meiosis allows one to observe chromosome pairing and thus the genetic relationship of the sets of chromosomes from different parents. This is called genome analysis. For example *D. intermedia* (2X) has 41 pairs of chromosomes and *D. cristata* (4X) has 82 pairs of chromosomes. The well known hybrid between these two *(D. × Boottii)* is a triploid (3X) because it is the result of a cross between a diploid and a tetraploid, and furthermore since there is little or no pairing of the chromosomes at meiosis, one observes 123 single chromosomes at diakinesis. Since *intermedia* contributed one set of 41 chromosomes this may be designated as I and the contribution of *cristata,* 82 chromosomes, consists of two unlike sets which can be designated as B and C. Accordingly, the genome formula for *D. × Boottii* (3X) is IBC, whereas if its formula had been IIC, ICC, or IBB, one would have observed ca. 41 pairs and 41 single chromosomes at meiosis.

In southern Ontario there are three basic diploid (2X) species, *D. intermedia* (II), *D. goldiana* (GG), and *D. marginalis* (MM). In northern Ontario there are two more diploids, *D. fragrans* (FF) and the controversial Lake Superior diploid which may be synonymous with diploid "*D. dilatata,*" called by Walker (1961), *D. assimilis.* There are three tetraploid (4X) species in the province, *D. spinulosa* (IIBB), *D. cristata* (BBCC) and *D. filix-mas.* The ninth and perhaps last species of true *Dryopteris* in the province is *D. clintoniana* (6X), which is considered to have the formula GGBBCC (Walker, 1962). In other words, as far as its origin is concerned, *D. clintoniana* is the result of a cross between *cristata* and *goldiana* and the resulting sterile triploid hybrid (GBC) has now become a fertile species through chromosome doubling. Meiosis is regular with 123 pairs of chromosomes, because each set has a partner, i.e., G pairs with G, B with B, and C with C.

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[1]This work was supported by Grants-in-aid from Sigma Xi RESA 1959-61.

Accordingly, there are nine species of *Dryopteris* in Ontario, five of which are basic diploids; the four others are polyploids which were originally of hybrid origin, but are now sexually reproducing species with a normal meiosis. These nine species are the parents or breeding lines which have crossed to yield such a wealth of hybrids as are found in nature.

Before an amateur attempts to collect and know hybrid wood ferns, he would be wise to become thoroughly familiar with these nine species and to observe closely several hundred of them in the field (Britton, 1961).

On the basis of our present knowledge, there are no genetic barriers to hybridization between species, so that theoretically these nine species could be crossed with each other to give 36 different hybrid combinations. One arrives at this number by considering a checkerboard of 9 × 9 giving 81 possible combinations, subtracting nine for selfs, e.g., *intermedia* × *intermedia*, *fragrans* × *fragrans*, etc. One then divides this number, 72, by two, in order to lump reciprocal crosses, e.g., *intermedia* × *cristata* vs. *cristata* × *intermedia*. If reciprocal crosses gave different end products it would be necessary to consider 72 combinations, but there is no evidence for this at the present time, so one is able to make this extrapolation from our knowledge of most higher plants.

How many of these theoretical combinations are known? Wherry (1961) has described 18 of them and Wagner and Hagenah (1962) have added two more. However, little information is available on which hybrids occur, where they are found, and their frequency. Some have been described on the basis of only one specimen, e.g., *goldiana* × *filix-mas*, whereas others are given a meaningless range because someone has taken the time to find them there, e.g., (1) *goldiana* × *spinulosa* "with parents in N.Y. and Penna." (Wherry, 1961). Why not Ontario and Michigan also? (2) *filix-mas* × *marginalis* "Vermont only." We now know that it is found in Michigan (Wagner and Hagenah, 1962), and this author has studied several in Ontario.

Herbarium records can be quite misleading unless the collections have been arranged and studied by an expert. There would seem to be a tendency to have more sheets of some large striking hybrids such as *goldiana* × *clintoniana* than is warranted. One suspects that one keen amateur shows another a specimen of a hybrid, and the second collector by diligent searching adds the same hybrid to his list. Another difficulty with herbarium records is that the basic species have only recently been recognized and hence hybrids such as *intermedia* × *spinulosa* and *clintoniana* × *cristata* will quite often be identified and filed under *spinulosa* (sens. lat.) and *cristata* (sens lat.) respectively.

There is only one hybrid described which involves *D. fragrans*. This is *fragrans* × *intermedia* described by Tryon (1942). When one

CHART I: DRYOPTERIS HYBRIDS IN SOUTHERN ONTARIO

	(2X) INTERMEDIA	(2X) GOLDIANA	(2X) MARGINALIS	(4X) SPINULOSA	(4X) CRISTATA	(4X) FILIX-MAS	(6X) CLINTONIANA
(2X) INTERMEDIA	(2X) INTERMEDIA						
(2X) GOLDIANA	DOWELL 1908 W. Rare	(2X) GOLDIANA					
(2X) MARGINALIS	BENEDICT 1909 W. Rare B. Rare	DOWELL 1908 B. Rare	(2X) MARGINALIS				
(4X) SPINULOSA	X TRIPLOIDEA WHERRY 1960 W. v. common B. v. common	X POYSERI WHERRY 1960 BENEDICT 1909 W. v. rare	X PITTSFORDENSIS SLOSSON 1904 W. v. rare	(4X) SPINULOSA			
(4X) CRISTATA	X BOOTTII UNDERWOOD 1893 DOWELL 1908 W. common B. common	BENEDICT 1909 W. 1 only	X SLOSSONAE WHERRY 1942 DAVENPORT 1894 W. Scattered B. rare	X ULIGINOSA DRUCE 1909 CHRISTENSEN 1905 W. rare B. occasional	(4X) CRISTATA		
(4X) FILIX-MAS	———	RUGG 1950 W. 1 only	WINSLOW 1910 W. Vermont B. Locally abundant	———	———	(4X) FILIX-MAS	
(6X) CLINTONIANA	X DOWELLII WHERRY 1961 DOWELL 1908 W. rare B. frequent	DOWELL 1908 W. rare B. occasional	SLOSSON 1910 W. rare B. rare	X BENEDICTII WHERRY 1961 BENEDICT 1909 W. occasional B. frequent	WHERRY 1961 W. common B. common	———	(6X) CLINTONIANA

considers that *D. fragrans* is usually ecologically isolated from other *Dryopteris* and certainly is geographically isolated in Ontario from *goldiana, filix-mas,* and *clintoniana,* the eight possible hybrid combinations with *fragrans* may be removed from consideration here.

The Lake Superior diploid may also be removed from consideration at this time, because this taxon is not yet well enough known (Britton, 1962; Wagner and Hagenah, 1962; Wagner, 1963) to consider its various hybrids. However, two have already been described by Wagner and Hagenah (1962). These are "*dilatata*" × *intermedia* (1 plant) and "*dilatata*" × *marginalis* (8 plants).

If one considers the seven southern Ontario species, then there are still 21 theoretical combinations of hybrids (Chart I). Wherry (1961) treats 17 of these, and the four undescribed hybrids all have one parent that is *D. filix-mas*. Is this because *filix-mas* hybridizes infrequently with other species, or is it only because *D. filix-mas* itself has a very restricted range and is not well known by most collectors? Only further work will decide.

On Chart I, the present names of the hybrids with their authors and the author of the original description is given. The W. refers to "The Fern Guide" (p. 126-132) (Wherry, 1961), from which information concerning abundance is given. If a hybrid has been collected by this author in southern Ontario it has a designation B. with an assessment of its frequency in this area.

Where are these hybrids found? The best rule of thumb to use is this: If both parents are growing well in a given locality then the hybrid will probably find a suitable niche to grow at the same locality. Although much can be made of the fact that spores are airborne and theoretically could be blown in from hundreds of miles away, I know of no *Dryopteris* hybrid in Ontario where the parents are not growing immediately adjacent. It would seem that in practice one needs large populations of gametophytes of the two parents for the chance occurrence of having two gametophytes of different parents growing side by side or overlapping, with subsequent cross fertilization occurring.

One type of locality which is most important is the edge of depressions or the foot of hillsides. Here one may find *marginalis* and *intermedia* growing on well drained but moist rocky slopes and *spinulosa, cristata* and *clintoniana* in the more moist locations on the level. Hybrids can be found where these two microenvironments meet. However, too much reliance on habitat can be misleading. On this basis, one would expect *spinulosa* × *cristata,* sharing a common habitat, to be a more common hybrid than *intermedia* × *cristata (D.* × *Boottii).* This is not the case.

Since hybridization occurs in the gametophytic stage, it is only reasonable to conclude that conditions must be right for the respective gametophytes to grow well in close proximity. Unfortunately, little is known of the requirements for the gametophytes of different species, although Walker (1955) states that artificial hybridization using *cristata* is difficult. It would, of course, be essential that the gametophytes of the two species be at the same stage of development for the cross to be successful. One could speculate that perhaps some gametophytes grow more slowly or produce eggs and sperm at a time when the gametophyte of another species is at a different stage of development, thus creating a barrier to crossing analogous to time of flowering in higher plants.

As far as the frequency of hybrids is concerned, it would appear that *intermedia* x *spinulosa* is by far the most common hybrid encountered. At some locations, it seems to outnumber the respective parents in numbers of individuals. In other localities, one may find approximately equal proportions of *spinulosa* and the hybrid and very few *intermedia*. On the basis of this author's experience, one should expect to find this hybrid wherever the two parent species are in close proximity. In fact, *D. intermedia* would appear to hybridize readily with other species. *D. intermedia* x *cristata* is of common occurrence and *intermedia* x *clintoniana* is not rare. The only combination undescribed is *intermedia* x *filix-mas*.

As a rough guide to the frequency of hybrids in southern Ontario, Table 1 has been prepared, showing the seven species and their respective hybrids in decreasing order of frequency. This is perhaps more meaningful than stating that *D. marginalis* crosses readily with *filix-mas* and rarely with the others. If one concentrates on only one parent of a cross and considers the respective hybrids it forms, then it is possible to rate the seven species in this order: *clintoniana* and *intermedia* (3 or 4 combinations commonly to occasionally), *spinulosa*,

TABLE 1

Occurrence of hybrids in decreasing order of frequency under one species

intermedia	goldiana	marginalis	spinulosa	filix-mas	cristata	clintoniana
x spin.*	x clint.*	xf.-mas*	x int.*	x marg.*	x clint.*	x crist.*
x crist.*	x marg.*	x gold.*	x crist.*	x gold.	x int.*	x int.*
x clint.*	x crist.	x crist.*	x clint.*	(x clint.)	x spin.*	x spin.*
x gold.	x int.	x clint.*	x marg.	(x int.)	x marg.*	x gold.*
x marg.*	x spin.	x int.*	x gold.	(x spin.)	x gold.	x marg.*
(xf.-mas)	xf.-mas	x spin.	(xf.-mas)	(x crist.)	(xf.-mas)	(xf.-mas)

Those above line, common to occasional, below line rare to very rare. Hybrids in parentheses are undescribed.

*Putative hybrid combinations collected in southern Ontario, which have been studied cytologically by this author.

cristata, and *goldiana* (2 or 3 combinations of more than rare occurrence) and *marginalis* and *filix-mas* hybridizing rarely except between each other. This is not the conclusion one would reach if one just considered the number of *marginalis* hybrids described. This is undoubtedly because of the distinctive morphology of *marginalis* which is still partly apparent in its hybrids.

There is one common misconception that should be clarified regarding hybridization. It has often been assumed that some of the variation seen in *Dryopteris* was due to segregating hybrids and to backcrosses to respective parents (Chandler 1948). The 21 hybrids considered here (Chart I) will all have a disturbed meiosis because of unpaired chromosomes, and the spores will abort. There is a very small chance of complete genomes ending in one spore e.g., IBC of *D.* × *Boottii,* so that each hybrid represents an evolutionary "end-point." At the same time, each of the 21 hybrids represents a potential new species if by chance the chromosome number should become doubled. Considering all the possible hybrid combinations and all the individuals, it is perhaps strange that there are not more fertile species that have evolved this way. On the basis of our limited knowledge, a hybrid such as *intermedia* × *spinulosa* with subsequent chromosome doubling would be a very successful species. Such a species is not known. However, we do think *D. cristata, spinulosa, filix-mas,* and *clintoniana* (i.e., four of nine species considered here) did arise in this way (i.e., by allopolyploidy), which is perhaps a suitably large percentage of our native species.

Future work will undoubtedly give a clearer picture of the variation shown by the parents and their hybrids. Not all hybrids are intermediate in morphology between their parents, for example. With more accurate descriptions of the hybrids, they will be identified with greater ease, while at the same time genome analysis will help to resolve the evolutionary relationships of the species.

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Michigan Botanical Club News

HORNER'S WOODS

Since its founding in 1941, the Michigan Botanical Club has been dedicated to the enjoyment, conservation, and preservation of our native plants. Programs to accomplish our aims have included meetings and field trips, sponsoring of plant protection legislation, meeting major conservation threats, and engaging in educational projects such as the big tree survey, poster campaign, and various publications.

Another important step was taken in 1964 with the purchase of our first plant sanctuary, a 22.4 acre tract known as Horner's Woods, not far from Ann Arbor. After a small loan from the Nature Conservancy is paid off, the land will be deeded to The University of Michigan as a permanent preserve (with reversion clause to the Nature Conservancy), guaranteeing continuing management of the tract as a sanctuary.

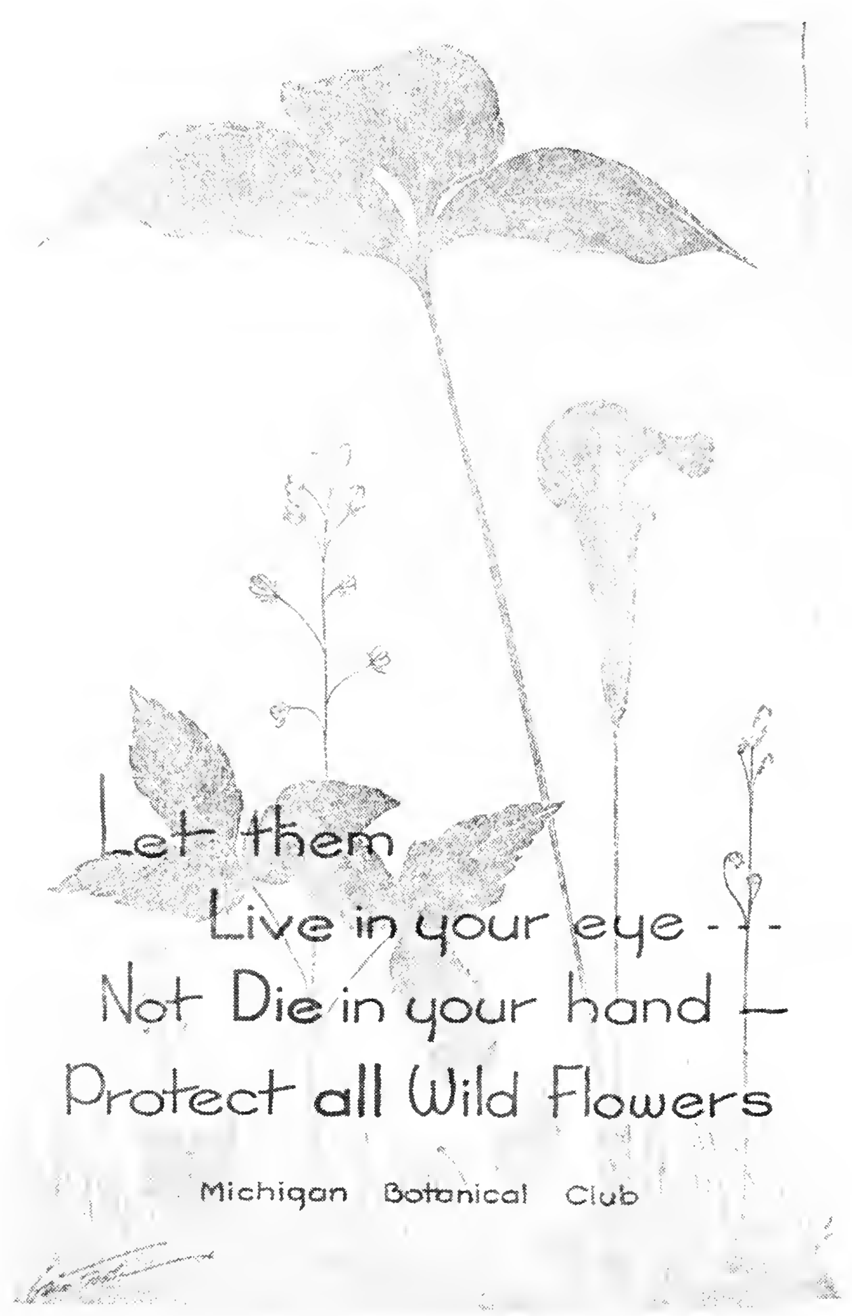
Members who have not yet seen this woods, including the rare twinleaf *(Jeffersonia diphylla)*, will have the opportunity to do so at the time of our Annual Meeting April 25.

Those who wish to help eliminate our indebtedness on this project may send contributions to the MBC treasurer, Charles Buswell, 19204 Plainview, Detroit, Michigan 48219. Checks payable to the Nature Conservancy are tax-deductible.

OUR NEW POSTER AND ITS DESIGNER

Pictured on the next page is the second poster sponsored by the Michigan Botanical Club to encourage good conservation habits in schools, camps, parks, and elsewhere. Even a good photograph (for which we are indebted to Doug Fulton) can hardly do justice to this delicately colored 13 × 16-1/2 inch poster. It was designed and printed, and the first printing donated to the Club, by Gwen Frostic, whose artistry is well known through her books and note papers that she produces at her studio on the River Road between Benzonia and Frankfort.

On Sunday, October 11, 1964, a number of Botanical Club members gathered at Miss Frostic's for a surprise presentation to her of an honorary membership in the Club (she had formerly been a member of the Northwestern Chapter). A highlight of the occasion was a tour of some of the nature trails on her property.



Single copies of this poster may be obtained for display by teachers and others from the secretary of the Botanical Club, Miss Barbara Bowen, 1003 Brooks St., Ann Arbor, Michigan 48103.

Editorial Note

A MATTER OF STYLE

With some exceptions, THE MICHIGAN BOTANIST tries to follow the "Style Manual for Biological Journals" (published by the American Institute of Biological Sciences, 1960) and the list of "Abbreviations of Titles of Serials Cited by Botanists" by Lazella Schwarten and H. W. Rickett (Bull. Torrey Bot. Club 85: 277-300. 1958).

Authors are urged to follow the style of current issues when preparing manuscripts (see also page 38), especially in regard to the citation of literature. All principal words in titles of books and serials are capitalized; only proper nouns in the titles of articles in a serial. Starting with the current issue (except for a few "New Literature" titles previously set up and held over), scientific names in titles cited are *not* italicized; past practice (which caused some confusion and inconsistency) was to italicize if (and only if) italics were used in the original title. The new practice will promote uniformity (and ease certain composition problems involving italics in the smaller type used for literature lists). Scientific names (at the level of genus and lower) will continue to be italicized in text material (except usually long lists and tables).

SOME RARE AND INTERESTING AQUATIC VASCULAR PLANTS OF NORTHERN MICHIGAN, WITH SPECIAL REFERENCE TO CUSINO LAKE (SCHOOLCRAFT CO.)[1]

Edward G. Voss
Herbarium, The University of Michigan, Ann Arbor

Michigan, which modestly advertises itself as the "Water Wonderland," does have an exceptional richness and diversity of aquatic plants in its numerous rivers, lakes, and streams. Among the pondweeds, for example, we have in this state 31 of the 37 species of *Potamogeton* recognized in Gray's Manual, and 5 of the 6 species of *Naias*, plus the related *Ruppia* and *Zannichellia*.

The richest pondweed locality which I know is in the Black River, Cheboygan County; here, in a distance of about two miles, midway between Alverno and the mouth of the river, 17 species of *Potamogeton* may be found: *P. amplifolius, P. berchtoldii, P. epihydrus, P. filiformis, P. friesii, P. foliosus, P. gramineus, P. illinoensis, P. longiligulatus, P. natans, P. nodosus, P. pectinatus, P. richardsonii, P. robbinsii, P. strictifolius, P. vaginatus,* and *P. zosteriformis*. Two additional species, *P. alpinus* and *P. praelongus*, occur not far from the source of the Black River, in Black Lake itself or *(P. alpinus)* near the mouth of Mud Creek. *P. praelongus* is caught by the dam at Alverno, and possibly both of these species will some day be collected in the relatively unexplored river system between Alverno and Black Lake.

The Black River is the only locality of record in the northern half of the Lower Peninsula for *Potamogeton nodosus* Poir. *(11240)*. The only Upper Peninsula collection of this species is from Torch Lake, Houghton Co. *(Farwell 9230,* BLH; det. Ogden in 1959). (See Map 2 for distribution in Michigan and adjacent area.[2])

THE PROBLEM OF *POTAMOGETON LONGILIGULATUS*

Probably the most interesting species in the Black River is *Potamogeton longiligulatus*, which was originally described by Fernald (1932, pp. 66-68) from Newfoundland (type locality), Connecticut, New York, Ontario, Michigan, and Minnesota. Mature fruit is unknown in this species (notwithstanding the dates "Aug., Sept." given for it in Gray's Manual (Fernald, 1950, p. 72), where the months are said (p. 65) to indicate "the time of ripening of the fruit.") Hence, its

[1]Contribution from the Biological Station of The University of Michigan; Paper from the Herbarium and Department of Botany, The University of Michigan. The cost of printing additional pages in this article has been shared by these three departments.

[2]On all maps showing distributions in Michigan and neighboring regions, solid symbols represent specimens examined (see Acknowledgments); open symbols represent additional published records; and half-solid symbols represent published county records (no exact locality given).

relationships have been problematic, and a hybrid origin was suggested by Gleason (1952, i: 74) and Ogden (1957, p. 366, and personal correspondence, 1953 and subsequent years).

Altogether, specimens referred to *P. longiligulatus* probably include a number of things—e.g., hybrids of various parentages and coarse *P. strictifolius*. However, plants from the Black River and from a bay in Black Lake just west of the mouth of the Upper Black River, conforming to the description of *P. longiligulatus*, have every appearance of being hybrids between *P. zosteriformis* and *P. strictifolius*. *P. longiligulatus* was described as differing from *P. strictifolius* in having more veins in the leaves, convolute (not connate) stipules,[3] and larger winter buds. Some specimens otherwise resembling *P. longiligulatus* have definitely connate stipules. Therefore, one must conclude that this plant may have stipules either connate or convolute or that some specimens referred to it are merely larger and coarser *P. strictifolius* with more veins than usual.

Michigan specimens fully referable to *P. longiligulatus*, with convolute (overlapping) stipule margins, have been seen from Schoolcraft Co. (McDonald Lake, *Uhler 96*, the specimen figured on plate 15 in Martin & Uhler, USDA Tech. Bull. 634; 1939); Van Buren Co. (Magician Lake, *Pepoon 155*, MSC; Lake of the Woods, *Roelofs 236)*; and Washtenaw Co. (Pleasant Lake, *Robertson 638)*; in addition to the Cheboygan Co. plants from Black Lake *(11745, 11760)* and Black River *(11118*, GH, *11359)*.

In the Black River, there is at least one colony of *P. longiligulatus* in water about 0.5-1 m deep in a large bay along the east bank about 3-1/2 miles northwest of Alverno. *P. zosteriformis* and *P. strictifolius* also occur here, as does a long-internode form of *P. robbinsii*—all four of these looking superficially similar when viewed from above the surface of the water. *P. friesii* and *P. berchtoldii*, both producing characteristic winter buds, are other linear-leaved species in this same large Chara-filled bay. In the bay of Black Lake west of the mouth of the Upper Black River, at similar depths, there are large beds of *P. longiligulatus*. The putative parents and *P. robbinsii* are likewise here.

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[3]Several linear-leaved pondweeds are characterized by having the stipule margins connate. The only sure way to determine this point is to cut one or more sections about 1 - 1.5 mm long with a sharp razor blade cleanly across a young branch tip (moistened, if the specimen is dry, with a drop or two of detergent solution). Examine the sections in water or detergent solution under 10x to 20x magnification. If the sections have been made where the internodes are short and the stipules overlap, at least the inner ones in those species with connate margins *(P. foliosus, P. friesii, P. strictifolius,* and *P. pusillus)* will form cylinders or tubes which will be evident when the sections are carefully sorted out with dissecting needles. Older stipules tend to split, so that this characteristic must be determined with caution from the youngest stipules possible. The margins may overlap strongly in species in which they are not connate.

P. longiligulatus grows from winter buds quite similar to those of *P. zosteriformis*, which it also often resembles in having several finer veins in addition to the usually 7-9 prominent veins, and in a more or less compressed or flattened stem. Except for the fine nerves, the leaves resemble large ones of *P. strictifolius* in general stiff aspect, dark green color, very acute apex, and tendency to dry more or less revolute. Basal glands are usually present at the nodes, as in *P. strictifolius*. Fresh material in Black Lake September 7, 1964, showed well that the winter buds are intermediate in size and appearance between those of the putative parents on the same date. Sometimes plants of *P. longiligulatus* resemble one of the putative parents rather closely, sometimes the other; they are not always strictly intermediate. In short, the circumstantial evidence for a hybrid origin is considerable, the chief differences from *P. strictifolius* being the non-connate stipules and extra nerves, and from *P. zosteriformis* the smaller size of stem and of the fewer-nerved leaves and hence the overall aspect.

POTAMOGETON HILLII IN MICHIGAN

Potamogeton hillii is a rare and local but very distinctive species, of uncertain position in the genus. It is named for the veteran Illinois collector, Rev. E. J. Hill (1833-1917), who often spent his summers botanizing in northern Michigan. He first collected this species near Manistee in 1880. Thomas Morong, then the leading student of American pondweeds, named the species for Hill (Bot. Gaz. 6: 290. 1881) and visited the locality himself in 1882. It was later found at a few places in northeastern Ohio and western Pennsylvania, Vermont, and New York.

Rediscovery of the type locality of a plant so full of local interest was a challenge. The only help was a footnote in Fernald's classic monograph of the linear-leaved pondweeds (1932, p. 72): "*P. hillii* is so extremely local that any clues to the stations are important. Most of the Manistee specimens are without detail as to habitat or exact station. One of Morong's labels at the New York Botanical Garden, however, gives an important clue: 'pool on Canfield's farm, near Manistee, . . .Aug. 14, 1882.'" The name of Canfield is one of the most prominent in the history of lumbering in the region. Old plat books show hundreds of acres of Canfield ownership, widely dispersed, in Manistee County. Where was "Canfield's Farm"?

A small lake just south of Manistee is called Canfield Lake, but is a little large to be called a "pool." In September, 1959, with the aid of Raymond McAdams and Stephen Koch, I threw grappling hooks into Canfield Lake, finding no *P. hillii*. Also without success we investigated what were shown on detailed maps as some smaller ponds in the vicinity (on land once owned by Canfield). Inquiries in the county courthouse in Manistee produced only the advice that if anyone could help us it would be Mr. C. N. Russell, president of the Manistee County Historical Society. Mr. Russell was not to be found that day, so I later wrote to him, expressing the hope that in 1882 Canfield had some farm which was well known and might have been the farm referred to on the 1882 labels. The reply from Mr. Russell was wonderfully brief and explicit, even if disappointing: "I enclose a map with Canfield's Farm outlined on it. The farm was at the extreme SW edge of the city limit. There were two pools on it. I have marked their location also. The Manistee Country Club took over the site in the late 1880's. The pools both were drained and no longer exist. I hope this gives you the information you needed." So much for the type locality of *Potamogeton hillii!* It appears to have been drained only a few years after the discovery of the species.

Fortunately, however, two new Michigan localities have been found.[4] (Map 1) The specimens from both were originally determined as *P. foliosus*. One is from Kalkaska Co., Little Blue Lake, July 26, 1930 *(Ashley 92);* I have not yet tried to revisit this locality. The other collection is from the outlet of Grass Lake, Otsego Co., August 3, 1932 *(Ashley 64*, det. as *P. hillii* confirmed by Ogden in 1959). Almost exactly 30 years later, on July 31, 1962, this site was revisited by Ronald L. Stuckey, who found *P. hillii* to be common *(Stuckey 1300)*. I made several visits in 1963 and 1964, finding many plants both rooted and drifting in a few inches of water where the outlet of Grass Lake has been dammed by a sand road near the center of the east edge of sec. 5, T 32 N, R 1 W, only about two miles northwest of the headquarters of the Pigeon River Trout Research Area. Prevailing westerly winds probably have aided the concentration of plants at this east end of the lake.

P. hillii has fruited abundantly here for the past three years; the shore is covered with fruit in August. These are distinctive in their large size (3-4 mm long, including a short beak, scarcely keeled). As in *P. foliosus*, they are borne in few-flowered, subglobose heads on short peduncles. The fruit of *P. foliosus*, however, is distinctly less than 3 mm long and has a sharp keel. The stems of *P. foliosus* lack glands at the nodes, while in *P. hillii* these glands are usually present. *P. foliosus* has the stipules very thin and membranous, with connate margins; in *P. hillii* the stipules are more coarsely fibrous (though not always so much so as in *P. friesii* and *P. strictifolius*, to which it has been assumed to be most closely related), and the margins are overlapping, not connate. Winter buds of *P. hillii* were unknown to Fernald, but it was expected that they would resemble those of the presumably related species. However, young winter buds on plants at Grass Lake *(11349)* have quite a different shape, more fusiform than fanlike,

[4]Of the records cited by Oosting (Pap. Mich. Acad. 15: 166. 1932), only the Manistee Co. one can be verified (ex herb. E. J. Hill, ex herb. D. A. Pelton, MSC).

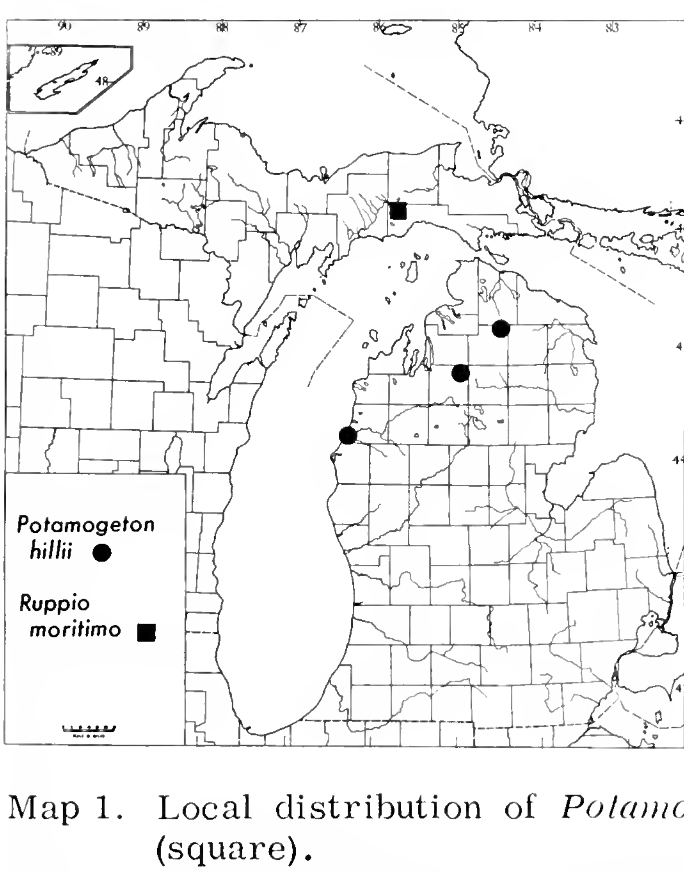
without such conspicuous white stipules and indurated bases as develop in *P. friesii* and *P. strictifolius*. They are borne at the ends of branches, and are similar in general aspect to large ones of *P. berchtoldii*.

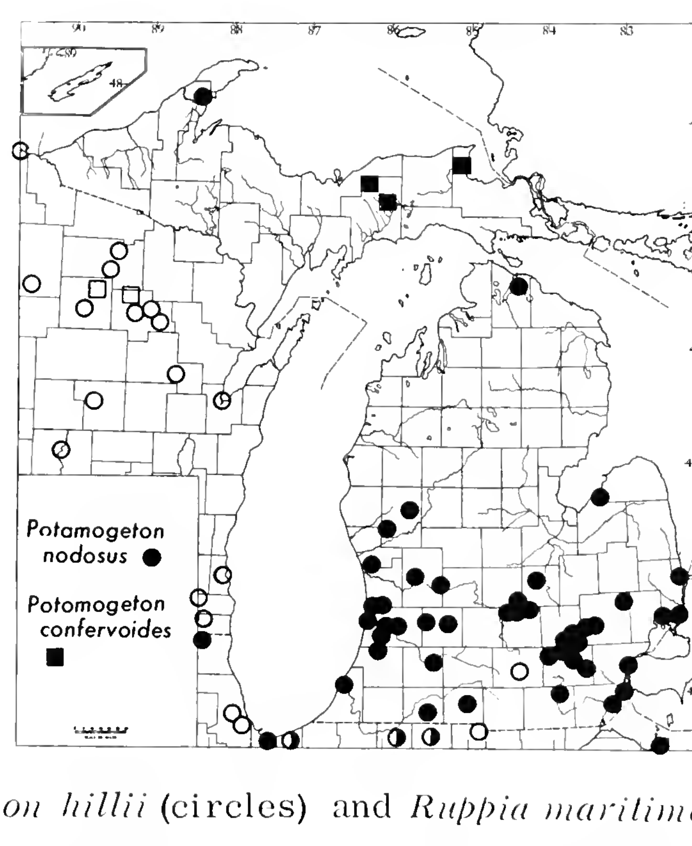
P. hillii is evidently a very local but distinctive species, which when fruiting should hardly be confused with any other.

RUPPIA MARITIMA IN MICHIGAN

Although not previously reported from Michigan in any manual, the widgeon-grass, *Ruppia maritima* var. *occidentalis* (S. Wats.) Graebn., was collected in Manistique Lake, Mackinac County, on August 13, 1936, by D. E. Miller, of the Institute for Fisheries Research *(Miller 157 & 161)*. (Map 1) Two beds, each over 1 mile long, were reported in water 5-8 feet deep near the Cedar Springs Resort. This species has recently been found in east-central Illinois (G. S. Winterringer, personal communication). Predominantly a species of marine, brackish, or alkaline waters, the nearest additional inland localities for it are apparently isolated ones in Minnesota and New York.

Chester W. Laskowski, John S. Russell, and I successfully located *Ruppia* once again in Manistique Lake on June 28, 1964. *(11538)* This was rather early in the season, and the plants were not large, but they were apparently frequent associated with abundant *Chara* along the dropoff in about 6 feet of water opposite the Cedar Springs Resort, sec. 12-13, T 44 N, R 12 W. The total area of this large lake is nearly 16 square miles; one can only wonder how many other beds of this (or other) species may yet await discovery there. All we did was to





Map 1. Local distribution of *Potamogeton hillii* (circles) and *Ruppia maritima* (square).

Map 2. Local distribution of *Potamogeton nodosus* (circles) and *P. confervoides* (squares).[2]

confirm the presence of *Ruppia* in the southeast part of the lake, in a narrow zone. Superficially, the plants bear some resemblance to *Potamogeton pectinatus*, but the sheathing leaf-base has no free stipule or ligule, whereas in *P. pectinatus* the sheath (formed by adnation of blade and stipule) is terminated by a short portion of free stipule. The general aspect of *Ruppia* is stiffer and more coarse. There is a Public Fishing Site where one may launch a boat less than a mile from the *Ruppia*.

CUSINO LAKE—A REMARKABLE LOCALITY FOR RARE AQUATICS

Having noted that at least two northern aquatics *(Sparganium fluctuans* and *Potamogeton confervoides),* not known as far south in Michigan as the Lower Peninsula, had been collected in Cusino Lake, in the upper reaches of the Manistique River system, Schoolcraft County, I planned a trip to collect demonstration specimens for the class in Aquatic Flowering Plants at the University of Michigan Biological Station and to seek for possible additional rarities. So remarkable a site did this prove to be when first examined with C. W. Laskowski and J. S. Russell on June 28 and 29, 1964, that a return visit was made August 2 with R. L. Stuckey and five students from the class.

Many years ago (perhaps 30) the name of Cusino Lake was changed from the less distinctive "Round Lake" by the U.S. Geographic Board, with approval of the County Board of Supervisors and the Michigan State Committee on Geographic Names; however, the old name still appears on some highway maps and vestigial signs in the region. A State Forest campground and the geography camp of Western Michigan University (formerly of The University of Michigan) at the north end are the only marks of habitation about this wilderness lake, where loons laughed at our search for aquatics for half a morning.

Cusino Lake is only a trifle more than half a mile at its greatest width. It is about 8 miles east of the town of Melstrand, and shows well on the U. S. Geological Survey topographic map for the Shingleton Quadrangle. The lake has been included in the lake and stream improvement program of the Michigan Department of Conservation; the Institute for Fisheries Research has made available to me their management records and surveys, upon which the remainder of this paragraph is based. When surveyed July 16, 1964, the lake occupied 145.2 acres; the maximum depth was 35 feet, but 40% of the lake was less than 5 feet deep. Various species of fish were planted from 1935 through 1941. In the fall of 1949, 64 brush shelters were installed. Only a few days after our August 2 visit, on August 11, 1964, the lake was treated with emulsified rotenone to obtain complete eradication of all fish, prior to management for large-mouth bass and bluegills. In 1942, the lake was described as "slightly acid and extremely soft" (pH 6.8 and methyl orange alkalinity of 2.0 to 4.0 ppm.). In 1949, a lower pH was reported (5.2-5.4, but below range of measuring technique) and it was also stated that people in the vicinity used the water in batteries. On July 9, 1964, water temperature ranged from 61° F. at 34 feet to 72° at 5 feet; on August 11, 1964, from 73° at 20 feet to 79° at the surface. The inlet and outlet have both apparently been inactive for some time. The dominant bottom type in shallow water is mostly sand, except for fibrous peat in protected bays; at about 11 feet the bottom changes from sand to pulpy peat, although sand was found in the deepest depression (which is about 100 yards northwest of a narrow peninsula on the east shore toward the south end of the lake).

The shore of Cusino Lake varies from sand to muck, at least in such a year of generally low water levels as 1964. The moist sandy or sandy-mucky shores have the assemblage of species characteristic of soft-water lakes of the region (which probably represent old bogs thoroughly burned out after lumbering). Among the conspicuous species are several rushes (especially *Juncus pelocarpus*, but also including *J. alpinus*, *J. canadensis*, and *J. effusus)*, several St. John's-worts (including *Hypericum boreale*, *H. canadense*, and *H. virginicum)*, pipewort *(Eriocaulon septangulare)*, horned bladderwort *(Utricularia cornuta)*, and several sedges--plus numerous other shore and marsh species as well as some of the marginal aquatic species noted below.

It is the true submersed aquatics themselves, and some species of the very edge of the water, which are unusual. The following list includes all which we collected in the course of reasonably extensive search. The number of species in the lake is not large, but with very few exceptions they are rare and local ones. Undoubtedly we were favored by the low water levels of 1964; yet further search may well turn up additional rarities. We had hoped, for example, to find here the awlwort, *Subularia aquatica*, known from only two localities in Michigan;[5] failure to find it was the only disappointment and was more than compensated by other discoveries.

Isoetës macrospora Dur. Quillwort

Apparently quite common in about 2-3 feet of water, where associated with *Utricularia purpurea*, *Myriophyllum farwellii*, and vegetative *M. tenellum*. *(11546)* Not recorded from Schoolcraft Co. on the map in Billington's "Ferns of Michigan" (Cranbrook Inst. Sci. Bull. 32: 119. 1952), but occurring locally throughout the state, especially northward.

Sparganium angustifolium Michx. Bur-reed

Local, a small colony near the larger ones of *S. fluctuans*. *(11548)* This opportunity to compare these two northern species, both

[5]Isle Royale and Sugar Island (see Mich. Bot. 1: 24. 1962), neither shown on map by Mulligan & Calder in Rhodora 66: 128 (1964).

with elongate floating leaves, readily showed the distinctions between them even when fruit is immature: The leaves of *S. angustifolium* are narrower (mostly 2-3 mm wide), and the inflorescence is unbranched, the lowermost pistillate heads supra-axillary (whether sessile or peduncled)—i.e., the bract apparently inserted several mm below the head (or peduncle) rather than closely subtending it.

Sparganium fluctuans (Morong) Robins. Bur-reed

Map. 3. Locally frequent, forming large beds in about 1-2 feet of water. *(11549)* The floating leaves are broader (mostly 5-9 mm wide) than in the preceding species, and the inflorescence is branched; all of the heads or branches are axillary.

Potamogeton confervoides Reichenb. Alga Pondweed

Map 2. Evidently widespread in the lake. *(11547)* This rare species has been known from only one other locality in Michigan: the Cabin—Water Tank lakes group about 1-1/2 miles east of the Lower Falls of the Tahquamenon River, Chippewa Co. *(Wood 8148; Voss 11341)*. The distinctive, extremely delicate foliage has presumably suggested the name translated as "Alga Pondweed." First collected in Cusino Lake July 21, 1942 *(B. M. Robertson 916)*.

At the time of Fernald's monograph of linear-leaved pondweeds (1932, pp. 32-36), *P. confervoides* was known to him from Newfoundland to New Jersey, but not west of the mountains of eastern New York and Pennsylvania; he suggested, however, that it was "to be looked for in the acid region from southern Labrador to the Great Lakes." The validity of this prediction has been borne out by discovery of the species in Michigan and northern Wisconsin (Greater Bass Lake, Langlade Co. [Fassett, 1934, p. 349] and Bass Lake, Lincoln Co. [Seymour, 1960, p. 55]). A new Schoolcraft County location was found in 1964 by C. W. Laskowski *(1129A)*, at the B-1 Pool in the Seney National Wildlife Refuge; two fragments of *P. confervoides* were discovered adhering to a mat of *Utricularia gibba* brought from this pool (not recognized in the field).

Potamogeton oakesianus Robbins Oakes' Pondweed

Locally common in shallow water, where fruiting August 2. *(11550, 11729)* The fruit is smaller than that of *P. natans* (less than 3.5 mm long) and rather prominently keeled; the floating leaves are rounded but not subcordate at the base. Otherwise, *P. oakesianus* closely resembles a small version of the common and widespread *P. natans*—which was the only other *Potamogeton* observed in Cusino Lake.

Xyris montana Ries Yellow-eyed-grass

Occasional on low mucky-sandy shores and a small barely exposed "island." *(11730)*

Brasenia schreberi Gmel. Water-shield

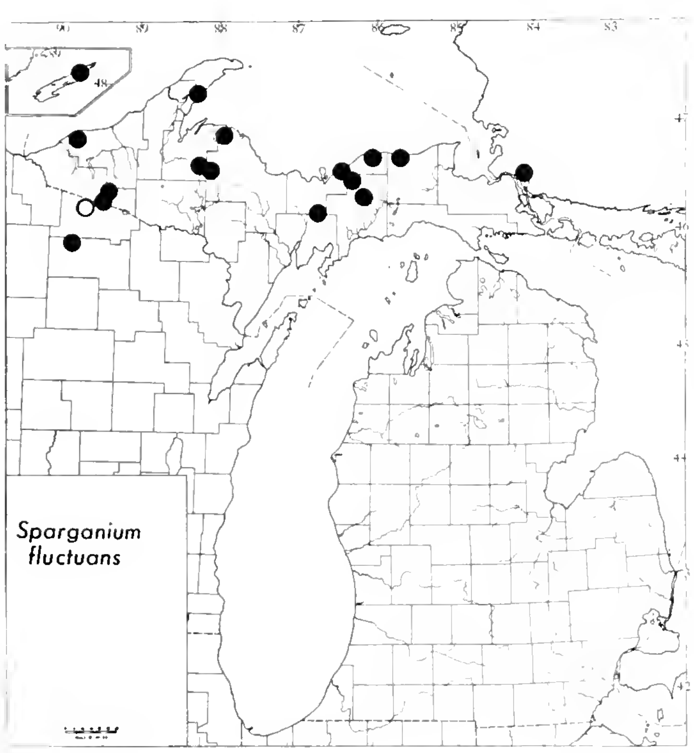
Locally common (several large colonies). *(11728)* Flowering on August 2. The thick gelatinous layer characteristic of this plant, especially the younger parts, presents problems in making specimens, which tend to glue themselves to the paper. A satisfactory method is to lay out the specimen on a sheet of herbarium mounting paper, and then to place a sheet of ordinary waxed paper over the entire surface. This "sandwich," with specimen between mounting paper on one side and waxed paper on the other, can then be placed in the usual newspaper folder and dried in press. The waxed paper peels off easily after drying.

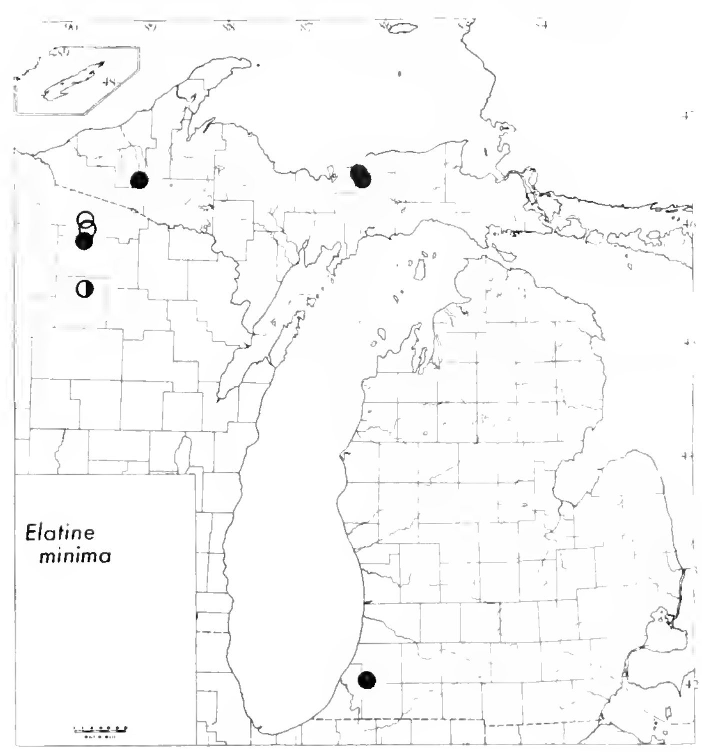
Nymphaea odorata Ait. Fragrant White Water-lily

Small-flowered plants, the leaf blades maroon beneath and the petioles not striped; presumably this species, although the rhizomes (exhumed by Gary R. Williams) have tuber-like branches. *(11727)* Our Nymphaeas are in need of thorough study.

Elatine minima (Nutt.) Fisch. & Mey. Waterwort

Map 4. Abundant in shallow water near the shore. *(11732)* Tiny plants, only a few centimeters long at most, and nearly overlooked although bearing fruit. The seeds are thick-cylindric, slightly curved, with definitely straight longitudinal rows of about 15 round-ended pits. The North American distribution is mapped by Fassett (1939, p. 372) with a single Michigan record (Van Buren Co.). The Cusino Lake station is closer to the numerous localities known in northern and





Map. 3. Local distribution of *Sparganium fluctuans*.
Map 4. Local distribution of *Elatine minima*.[2]

northwestern Wisconsin. Also found at the south end of Gemini Lake *(11739)*, about 3 miles northwest of Cusino Lake.

The only previous Michigan collections I have seen are from Round Lake in southwestern Van Buren Co. *(F. C. Gates 1740,* MICH; *H. S. Pepoon 639,* MSC; both in 1906) and Moll Lake in southeastern Ontonagon Co. *(A. S. Hazzard 2,* in 1941).

Myriophyllum farwellii Morong Farwell's Water-milfoil

Map 5. Apparently local in 2-3 feet of water. *(11551)* This is the only one of the seven species of *Myriophyllum* in Michigan which bears its flowers in the axils of normal submersed leaves rather than in a terminal emersed spike. (The Cusino Lake material, however, seemed to be sterile.) It can generally be identified vegetatively by its extremely delicate and lax foliage (the plants completely limp when removed from the water) with the leaves more or less alternate rather than strictly whorled on some portions of the stem (especially the older); many of the leaves bear minute dark tubercles or spicules where the lateral segments join the rachis, but these are lacking in the only other species which we have that might be confused with *M. farwellii* in sterile condition because of the normal presence of alternate leaves, *M. pinnatum*.[6] The type locality is a "small pond" in Keweenaw County (Bull. Torrey Bot. Club 18: 146-147. 1891); according to his notes, Farwell collected this plant August 22, 1884, "In a small pond near North Cliff. The only place found." The only fruiting material I have seen from Michigan is Farwell's (*191,* BLH; *s. n.,* MSC) and one other collection from Keweenaw Co., from Medora Lake *(Beckman 17)*; the fruit is large, 2-2.5 mm long, with ridges of tubercles on the back.[7]

[6] *Myriophyllum pinnatum* (Walt.) BSP. has apparently not been previously reported north of southern Iowa, western Illinois, and northwestern Indiana. Three Michigan collections in the University of Michigan Herbarium would seem to belong here; all are flowering, with perianth a full 2 mm long, thus ruling out the small-flowered *M. humile* as an identification. One is from Houghton Co., Sturgeon Slough east of Chassell *(Richards 1154,* June 27, 1948, as *M. verticillatum* var. *pectinatum)*. The other two are from Marquette Co., shallow water of Dead River *(A. Dachnowski* in July & Aug., 1906, as *M. heterophyllum)*. The submersed leaves are rather similar to those of *M. farwellii*, but part (if not all) of the plant is emersed, the flowers then borne in axils of pectinate bracts (not submersed leaves) rather similar to those of *M. verticillatum*. The leaves all lack the dark spicules of *M. farwellii*. (Map 5)

[7] Sterile material from Chapel Lake in Alger Co. *(7616)* is tentatively referred here, although somewhat more robust than usual. Also tentatively placed here is a very interesting collection *(Hiltunen 222,* WUD) from a shallow marl-bottom pool on Sugar Island, Chippewa Co. The plant has many alternate leaves, which are like those of *M. farwellii*, including prominent black spicules; but the tips of two of the four branches have smaller, stiffer, deeply dissected bracts (with slender rachis), bearing flowers in their axils. The flowers are too small for *M. pinnatum*, too large for *M. humile*, and the black spicules at the axils of the segments are even more prominent than on the submersed leaves. Perhaps *M. farwellii* can rarely have emersed bracts.

Myriophyllum tenellum Bigel. Slender Water-milfoil

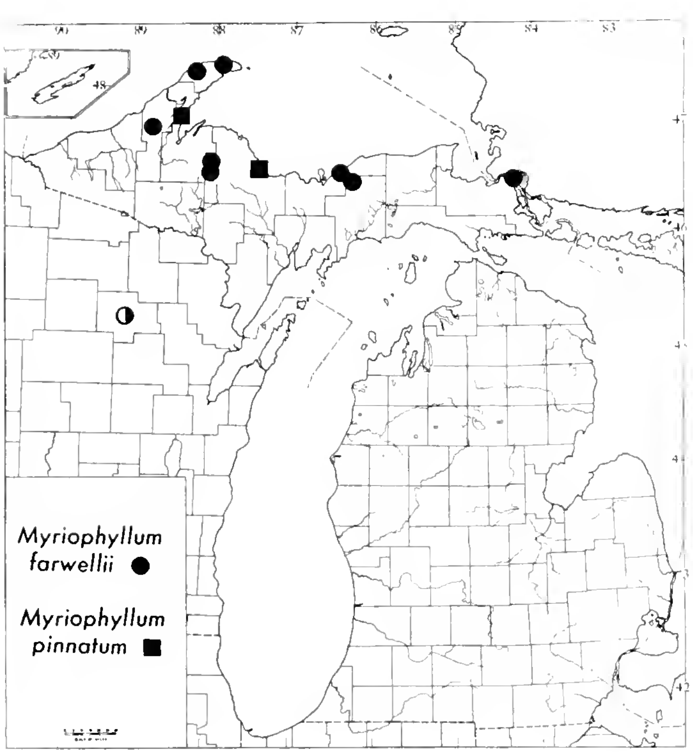
Map 6. Common to abundant, flowering August 2 on wet sandy-mucky shores and in shallow water; vegetative plants dredged from deeper water. *(11726)* Also found locally common in shallow water at the south end of Gemini Lake *(11740)*. A much more common and wide-spread species in Michigan than generally supposed; doubtless over-looked for its unimpressive appearance, the delicate yellowish-green stems bearing minute alternate bumps instead of leaves. The first definite record for the state was in Emma J. Cole's "Grand Rapids Flora" of 1901; in 1947 (Pap. Mich. Acad. 31: 30) C. R. Hanes observed that the species was at one time considered rare in the state, but was known from 10 counties. The number of counties is now doubled, and doubtless more will be added by observant botanists.

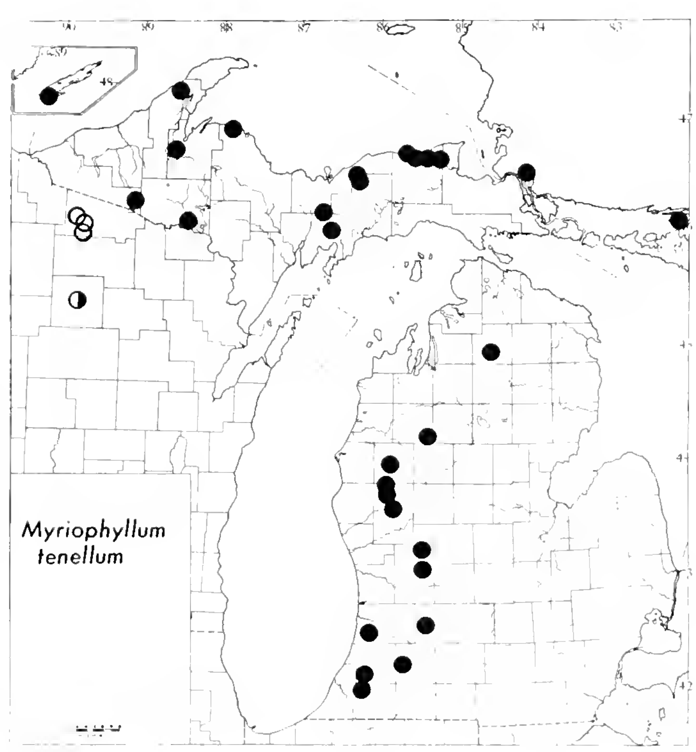
Utricularia geminiscapa Benj. Bladderwort

Apparently uncommon in shallow water. One fragmentary specimen collected near *Potamogeton oakesianus* and *Xyris montana* seems to be this species. *(11731)*

Utricularia purpurea Walt. Bladderwort

Map 7. Sterile plants abundant in about 2-3 feet of water. *(11545)* This is evidently the only known station in the Upper Peninsula; the species (our only one with whorled leaves or branches) is local in the southern Lower Peninsula.





Map 5. Local distribution of *Myriophyllum farwellii* (circles) and *M. pinnatum* (squares).

Map 6. Local distribution of *Myriophyllum tenellum*.

Utricularia resupinata B. D. Greene Bladderwort

Common flowering at or near the water's edge, on sandy-mucky shores. *(11725)* Sterile plants in deeper water (and easily confused at first glance with what is presumably *Juncus pelocarpus* f. *submersus* Fassett). Occurs more or less throughout the state, but is not often recognized, as it flowers only under conditions of both high average temperature and low water level (cf. Gates, Lilloa 5: 159-162. 1939).

Littorella americana Fern.

Locally abundant on sandy-mucky shore (where exposed within the previous few weeks, as near the edge of water August 2), forming a dense carpet. *(11733)* This species has never before been reported from Michigan, and is so seldom seen that it apparently lacks a satisfactory "common name." The finding of a carpet of diminutive flowering plants of *Littorella* was unquestionably the highlight of Cusino Lake. Fassett's Manual of Aquatic Plants observes: "Thought to be rare, but perhaps more abundant in the submersed sterile state than is supposed. The flowers appear only as the water recedes and are certainly very rare." (Fassett, 1957, p. 316) In describing the American plant as distinct from the European *L. uniflora*, Fernald (1918, p. 61) referred to it as "one of the rarest plants of the North American flora. . .known from only a few sandy or muddy shores from Newfoundland to Minnesota." Subsequently, Fassett (1939, p. 350), after observing that *Littorella* "enjoys a reputation for great rarity," reported that "it is a characteristic and abundant plant in many lakes of northern Wisconsin." Only once, however, did he find it flowering.

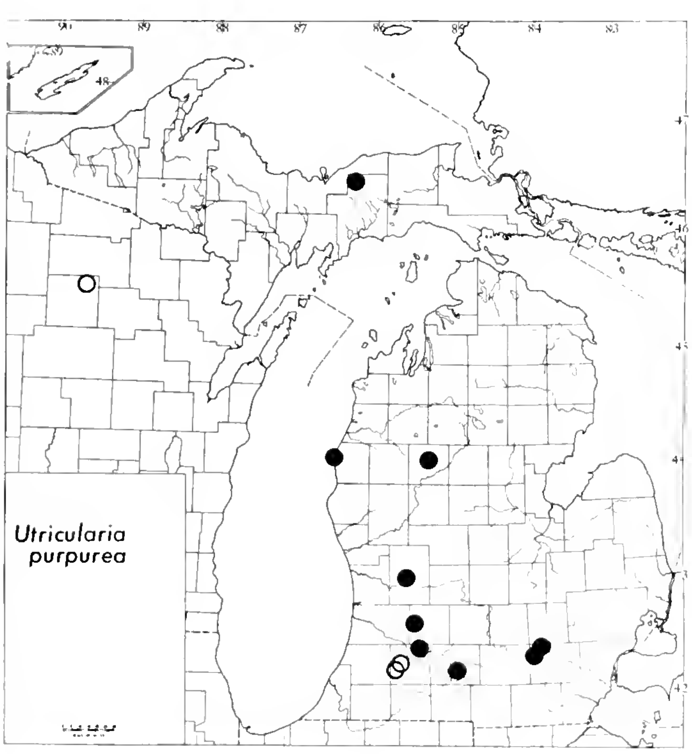
Many authors have followed Fernald in treating American plants as distinct from the European; Gleason (1952, iii: 273) has recognized ours as only a smaller variety of *L. uniflora*, and there is some merit in this opinion. In reporting the occurrence of *Littorella* in New York, Muenscher (1934) observed leaves longer than stated by Fernald. American plants supposedly differ in having the leaves flattish, as well as shorter than the European; the Cusino Lake plants, however, have the leaves quite terete. Living plants were brought back to the University of Michigan Botanical Gardens by Ronald L. Stuckey. These have thrived under care by Louis K. Ludwig, spreading by means of slender rhizomes just beneath the surface of the moist sand. Leaves of the cultivated plants are not noticeably flattened.

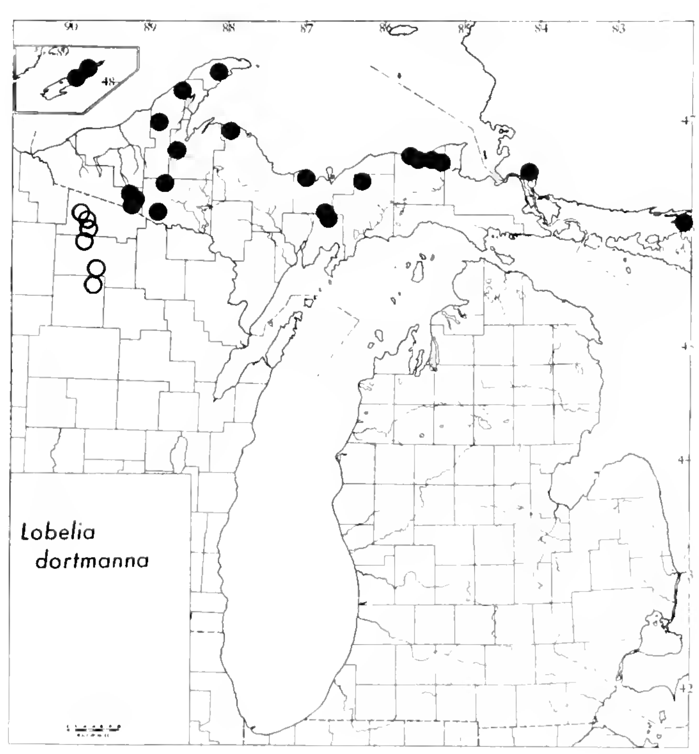
In view of the rarity of flowering material, the following description of average fresh specimens from Cusino Lake is recorded: Leaves subulate, terete, 2-3 cm long or shorter, crowded and ± sheathing at base of plant, often slightly curved outward and superficially resembling rosettes of *Isoëtes macrospora* or *Eriocaulon septangulare* (but without the septate aspect of leaves and roots of the latter, and paler green than the former). Staminate flower on peduncle usually not much over 5 mm long but as long as 15 mm; calyx 3-4-lobed, ca. 3-3.5 mm long, the sepals green with ± translucent, somewhat pinkish borders nearly as broad as the central green portion; corolla 3-4-lobed, protruding ca. 1.5 mm beyond calyx, the lobes brown and tube pinkish; filaments at maturity ca. 11 mm long, long-exserted, but bent back double (as in letter 'N') in bud; anthers sagittate, ca. 2.5 mm long, reddened at very acute to acuminute tip, tending to cohere in pairs. Pistillate flower similar, sessile at base of plant, the pistil with slender elongate style ca. 3.5-8 mm long, pink, with stigmatic stripe on one side.

Fassett's one station for flowering specimens was Muskellunge Lake, in Vilas Co., Wisconsin (1934, p. 350). From this same lake he had earlier (1930, p. 167) reported several of the interesting species which we also have in Cusino Lake: *Isoëtes macrospora, Eriocaulon septangulare, Elatine minima, Myriophyllum tenellum, Lobelia dortmanna, Sparganium angustifolium, S. fluctuans.* Muenscher (1934) reported *Subularia aquatica* and *Gratiola aurea* with *Littorella,* and *Gratiola* has been found at several northern Wisconsin Lakes (Fassett, 1930). Lakes, such as Cusino Lake, known for concentrations of rare and unusual species, which often depend upon fluctuations in water level for best development, will certainly bear watching annually for additional discoveries.

Lobelia dortmanna L. Water Lobelia

Map 8. Frequent on very wet sandy shore (rosettes seen in shallow water also). *(11544)* Flowers (white or very pale blue) were





Map 7. Local distribution of *Utricularia purpurea.*
Map 8. Local distribution of *Lobelia dortmanna.*

seen both June 28 and August 2; there is evidently a long flowering season. Local throughout the Upper Peninsula in Michigan, where usually associated with *Myriophyllum tenellum*, although never yet found with this species in the Lower Peninsula.

On August 2, several other lakes in the vicinity of Cusino were given a cursory examination (a single stop at one place along each shore), but only the south end of Gemini Lake held much promise of rivalling Cusino Lake. Here, near the State Forest campground, were *Elatine minima*, *Myriophyllum tenellum*, and *Sparganium fluctuans* (also *Ranunculus reptans*, rather surprisingly missing from Cusino Lake).[8] In Canoe Lake, near the campground, were fine fruiting plants of *Potamogeton epihydrus* and *P. obtusifolius*. Ross Lake and Worchester Lake produced nothing exciting, but further exploration in this area is surely indicated.

ACKNOWLEDGMENTS

Several students, whether by sharp eyes or strong backs, or both, have aided in field work and are mentioned above. Dr. Frank F. Hooper has made available the extensive records on Cusino Lake in the files of the Institute for Fisheries Research. Dr. E. C. Ogden kindly examined many especially difficult specimens of *Potamogeton* when I was preparing a treatment of local species of that genus several years ago: his annotations and correspondence have been most helpful. The rich representation of aquatics in the University of Michigan Herbarium results in large part from a survey of aquatic plants conducted in the 1930's and early 1940's by staff of the Institute for Fisheries Research of the Michigan Department of Conservation, in collaboration with the Botanical Gardens of the University of Michigan: the botanical work of this survey was coordinated by Betty Robertson Clarke, and a number of Mrs. Clarke's annotations have been of aid. Through the kindness of Dr. G. N. Jones, I have examined all of the Michigan *Potamogeton* in the herbarium of the University of Illinois, where E. J. Hill's collections (including a nice series of *P. hillii*) now rest. Other herbaria on which the maps are based are Michigan State University (MSC), Cranbrook Institute of Science (BLH), and Wayne State University (WUD). Collection numbers cited (in italics) are mine unless otherwise attributed, and all cited collections are represented in the University of Michigan Herbarium (MICH) except when others are indicated. (Many duplicates are, or will be, distributed elsewhere.)

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[8]*Aster nemoralis*, although hardly an aquatic, in boggy ground on the shore of Gemini Lake (*11711*) is a western extension of this species, previously known in the state only from several localities in Chippewa and Luce counties.

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Seymour, Frank Conkling. 1960. Flora of Lincoln County Wisconsin. 363 pp.

Review

THE MOSSES OF MICHIGAN. By Henry T. Darlington. Cranbrook Institute of Science (Bulletin 47), Bloomfield Hills, Mich., 1964. 212 pp. + 147 fig. $12.00

It is a satisfaction to report that Dr. Darlington's failing health allowed him to live long enough (though by only a few days) to see this handsome publication of the work on which he had labored so long in recent years. Thoroughly edited and checked by Dr. Howard Crum, the text can be relied upon as the definitive treatment of the 43 families, 125 genera, and 377 species of mosses known from Michigan.

The introduction includes a history of bryological exploration of Michigan—a commendable feature!—and is followed by keys to and descriptions of all species. While there are no distribution maps, county records (with collectors of voucher specimens) are listed for both Upper and Lower Peninsulas. References are given to illustrations in standard works by Conard, Grout, Jennings, and Welch. In addition, there are elegant drawings reproduced from some of the great works (chiefly 19th century) by Braithwaite, Limpricht, Sullivant, and others. The keys, descriptions, and illustrations for *Sphagnum* are the work of Dr. Irma Schnooberger. A glossary, list of references, and index conclude the work.

Anyone interested in the mosses of the upper Great Lakes region should be proud to own so attractively printed and illustrated a volume, authoritatively edited and painstakingly documented.

E. G. V.

ADDITIONS TO THE DOUGLAS LAKE BRYOFLORA

Howard Crum
National Museum of Canada, Ottawa

Since the publication of my catalogue of the mosses of the vicinity of the University of Michigan Biological Station at Douglas Lake, including Cheboygan, Emmet, Mackinac, and Presque Isle counties (Mich. Bot. 3: 3-12; 48-64. 1964), I have examined a number of additional specimens from the area and have found two species *(Sphagnum compactum* and *S. fimbriatum)* new to the flora as well as eight new county records.

I am grateful to Dr. A. J. Sharp and Mr. Clem Bur for making it possible for me to study all the Sphagna in the Biological Station herbarium. (All specimens cited below are represented in that herbarium.)

SPHAGNACEAE

Sphagnum capillaceum (Weiss) Schrank var. *tenellum* (Schimp.) Andr. Emmet Co.: Stutsmanville (Robinson & Sharp, June 19, 1955).

Sphagnum compactum Lam. & DC. Cheboygan Co.: Douglas L. (Nichols, Aug. 1924).

Sphagnum fimbriatum Wils. ex Hook. Cheboygan Co.: Reese's Bog (Robinson, June 25, 1955).

Sphagnum magellanicum Brid. Presque Isle Co.: Hammond Bay (Hatcher, July 17, 1952).

Sphagnum recurvum P.-Beauv. Mackinac Co.: Bois Blanc I. (B. Lange 518).

Sphagnum robustum (Russ.) Röll. Emmet Co.: Stutsmanville (Robinson & Sharp, June 19, 1955; Robinson & Crum, July 8, 1958).

Sphagnum squarrosum Sw. ex Crome. Emmet Co.: Cecil Bay (Wynne 2737).

Sphagnum warnstorfianum DuRietz. Presque Isle Co.: Hammond Bay (Hatcher, July 18, 1952).

POTTIACEAE

Tortella humilis (Hedw.) Jenn. Emmet Co.: Cross Village (Kubsch). (This collection was erroneously referred to *T. inclinata* in my previous paper on the flora of the Douglas Lake region.)

Barbula convoluta Hedw. Presque Isle Co.: Ocqueoc Falls (Crum, July, 1958).

A NEW SPECIES OF THE BOLETACEAE

Alexander H. Smith and Robert L. Shaffer
Herbarium, The University of Michigan, Ann Arbor

Mrs. Paul H. Weaver, of Faribault, Minnesota, has sent us a collection of an undescribed species of *Fuscoboletinus* Pomerleau & A. H. Sm.:

Fuscoboletinus weaverae A. H. Sm. & Shaffer, sp. nov.

Pileus 3.5-7 cm latus, viscidulus, glaber, ad marginem appendiculatus, avellaneus vel cinnamomeus; stratum tuborum 1.5-4 mm crassum, adnatum, glandulosum, cremeum vel ochraceum; stipes 4-8.2 cm longus, 9-25 mm latus, peronatus, glandulosus; sporae in cumulo sicco brunneo-purpureae, 6.7-8.0 × 2.7-3.2 μ.

Pileus 3.5-7 cm broad; convex, expanding to broadly convex; viscid; glabrous; when young near (but pinker than) "avellaneous"[1] centrally and "orange-cinnamon" marginally, later mottled with "pinkish cinnamon" to "light pinkish cinnamon" centrally and "mikado brown" to "verona brown" marginally. Trama 9-19 mm thick above the edge of the stipe; yellow to orange around larval channels, unchanging when cut; with a nondistinct odor and a pleasant taste.

Hymenophore adnate. Tubes 1.5-4 mm long; white at first, becoming yellowish, unchanging when cut. Tube mouths angular and irregular in shape; sometimes compound; ± radially arranged, but not elongated radially; when young lighter than "light buff" to "cream color," becoming more ochraceous in age, unchanging when injured; with prominent "mikado brown" to "verona brown" glandular dots.

Stipe 4-8.2 cm long, 9-15 mm thick at the apex; usually tapering downward, but sometimes swollen (and up to 25 mm thick) just above the middle; with "mikado brown" to "verona brown" glandular dots; tan, sometimes staining "cream-buff" to "straw yellow" at the base where bruised; with white to bright yellow mycelium at the base and in the surrounding soil. Trama like that of the pileus except sometimes "maize yellow" to "honey yellow" at the base.

Veil fibrillose to cottony; white to pale cream color; in young basidiocarps sheathing the lower portion of the stipe and covering the hymenophore; remaining as a sheath on the lower portion of the stipe and at least for a time as patches on the pileus margin; not forming an annulus.

Spore deposit when moist near "avellaneous" to near "cacao brown," when dry "deep brownish drab."

Spores 6.7-8.0 × 2.7-3.2 μ; usually narrowly oblong to narrowly ovate in profile, occasionally narrowly obovate; smooth; pale yellowish (in water and KOH); nonamyloid to strongly dextrinoid, usually weakly

[1]Quoted color names are from Ridgway (1912).

to moderately dextrinoid. Basidia 20-29 × 4.1-6.9 μ; usually clavate, sometimes subcylindric; usually hyaline (in water and KOH), but in the vicinity of the clusters of cystidia sometimes bister; 4-spored. Pleurocystidia 20-60 × 3.3-9.6 μ, the shorter ones not projecting beyond the basidia, the longer ones projecting up to 40 μ; usually clavate, occasionally subfusiform or subcylindric; occurring usually in clusters of few-many, rarely singly; hyaline (in water and KOH) at first, usually becoming bister and then incrusted with bister, irregularly shaped, ± refractive crystals on the nonprojecting portions; thin-walled; abundant. Cheilocystidia like the pleurocystidia.

Hymenophoral trama bilateral; with a medial layer composed of vertical, parallel hyphae 1.5-5.3 (-8.0) μ broad, this layer approximately 10 μ thick and hyaline (in water and KOH) near the tube mouths, but becoming broader and reddish to brownish upward, merging directly into the pileus trama, and flanked by lateral layers, each approximately 150 μ broad, composed of hyaline, subgelatinous hyphae 2.7-13.3 μ broad which diverge downward from the medial layer and give rise to an indistinct prosenchymatous subhymenium. Pileus trama composed of interwoven, hyaline to brownish or reddish (in water and KOH), nongelatinous hyphae 1.6-12.0 μ broad. Pileus cuticle 400-470 μ thick; an ixotrichodermium composed of loosely interwoven, nongelatinous, septate, rarely branched, usually brownish (in water and KOH), round-tipped hyphae 2.7-7.3 μ broad which are densely incrusted with minute refractive particles. Stipe cuticle (on the upper portion of the stipe) a palisade composed mainly of clavate to subcylindric, hyaline (in water and KOH) cells 13-20 x 2.7-5.3 μ, but also containing basidia and cystidia like those of the hymenophore proper, except that the caulocystidia may be larger (up to 80 × 11.3 μ), project farther (up to 60 μ), and occur in greater numbers per cluster than the pleurocystidia. Clamp connections apparently absent on the hyphae of the basidiocarp.

Scattered to caespitose on humus in sandy soil of a mixed woods (*Quercus, Populus, Betula, Pinus resinosa, P. banksiana,* and *P. strobus);* between Pelican Lake and Lake Markee, Crow Wing Co., Minn.; 12 Sep 1964; Margaret G. Weaver 1086 (Holotype, MICH).

Notes on the macroscopic characters of the basidiocarps of the new species were recorded by Mrs. Weaver.

Fuscoboletinus weaverae combines the features of a brownish drab spore deposit and a stipe having glandular dots, which one sees microscopically as clusters of cystidia. Pomerleau and Smith (1962) originally described the stipe in *Fuscoboletinus* as not glandular-dotted because at that time no species in which the stipe was so ornamented had been studied. The discovery of *F. weaverae* adds to the similarities between *Fuscoboletinus* and *Suillus* S. F. Gray and strengthens the hypothesis that there is an evolutionary line, represented by *Fuscoboletinus*, leading to *Gomphidius* Fr. Caulocystidia in clusters are also known in some species of the latter genus.

Fuscoboletinus and *Suillus* are a pair of closely related genera much like *Lactarius* S. F. Gray and *Russula* S. F. Gray in that differences in a single character separate each member from its counterpart. In the case of *Lactarius* and *Russula,* the difference in the presence or absence of latex continues into or from the gastromycetes where the same difference separates members of other pairs of genera (e.g., *Macowanites* Kalchb. and *Arcangeliella* Cav.). In the case of *Fuscoboletinus* and *Suillus*, the difference is in spore color (Pomerleau and Smith, 1962). These two genera may be derived from *Rhizopogon* Fr. or its relatives, and Smith has observed that a similar difference in spore color is evident in *Rhizopogon.*

We consider it likely that *Fuscoboletinus* and *Suillus* have evolved, beginning from a common ancestor, along parallel lines. The spore colors in *Fuscoboletinus* form a sequence leading through various shades of vinaceous-brown and brownish drab toward the colors found in *Gomphidius*. However, it would be premature to insist upon the significance of this sequence. It may be that the sections of *Fuscoboletinus* (see the following infrageneric classification) have been derived from the corresponding sections of *Suillus* (Smith and Thiers, 1964). It seems unlikely that the change to vinaceous-brown or brownish drab spores occurred this many times, but if it did, then *Fuscoboletinus* as presently constituted is not a natural genus.

Assuming, as we do, that *Fuscoboletinus* is a natural group of species, some may still argue whether the group deserves recognition as a genus or whether it should be assigned some infrageneric status. This question can best be settled after a critical study of the other subfamilies of the Boletaceae where some genera based on spore deposit color have been accepted by many authors who divide *Boletus* sensu latissimo into smaller genera. The important point to keep in mind is that *Fuscoboletinus*, or part of it, probably represents the ancestors of *Gomphidius,* and perhaps *Suillus* occupies a similar position in relation to *Phylloporus* Quél.

Fuscoboletinus sect. *Fuscoboletinus*

Type: *F. sinuspaulianus* Pomerleau & A. H. Sm.

Synonyms: *Boletinus* sect. *Spectabiles* Sing., Revue Mycol. Paris 3: 157. 1938

Suillus sect. *Glandulosi* Sing. in Sing., Snell, & Dick, Mycologia 55: 356. 1963

Pileus viscid, glabrous or at first squamulose from the remains of a veil; tubes yellow at maturity; stipe lacking glandular dots.

F. glandulosus (Pk.) Pomerleau & A. H. Sm., *F. sinuspaulianus*, and *F. spectabilis* (Pk.) Pomerleau & A. H. Sm.

Fuscoboletinus sect. *Griselli* A. H. Sm., sect. nov.

Type: *F. aeruginascens* (Secr.) Pomerleau & A. H. Sm.

Pileus viscidus vel subviscidus, glaber, fibrillosus, vel squamosus; tubi maturitate grisei vel brunnei; stipes non glandulosus.

F. aeruginascens, F. grisellus (Pk.) Pomerleau & A. H. Sm., and possibly *Botelinus solidipes* Pk. (see Smith and Thiers, 1964).

Fuscoboletinus sect. *Palustres* (Sing.) A. H. Sm., comb. nov.

Type: *F. paluster* (Pk.) Pomerleau

Basionym: *Boletinus* sect. *Palustres* Sing., Revue Mycol. Paris 3: 162. 1938

Pileus dry, fibrillose to squamulose; tubes yellow at maturity; stipe lacking glandular dots.

F. ochraceoroseus (Snell) Pomerleau & A.H.Sm. and *F. paluster.*

Fuscoboletinus sect. *Pseudosuillus* A. H. Sm., sect. nov.

Type: *F. weaverae.*

Pileus viscidus; glaber; tubi maturitate lutei; stripes glandulosus.

F. weaverae.

LITERATURE CITED

Pomerleau, R., & A. H. Smith. 1962. Fuscoboletinus, a new genus of the Boletales. Brittonia 14: 156-172, 6 pl.

Ridgway, R. 1912. Color standards and color nomenclature. iii + 43 p., 53 pl. Washington, published by the author.

Smith, A. H., & H. D. Thiers. 1964. A Contribution Toward a Monograph of North American Species of Suillus. 116 pp., 46 pl. Ann Arbor, published by the authors.

News of Botanists

On October 23, 1964, Dr. Henry T. Darlington, whose botanical interests in Michigan spanned half a century, died in Lansing. He was 89 years old. A biographical sketch of Dr. Darlington, with bibliography, will appear in the next number of THE MICHIGAN BOTANIST.

Robert R. Dreisbach, chemist, entomologist, and botanist, died on June 24, 1964, at the age of 75. Since 1912 (except for a 7-year period beginning in 1920), he was associated with the Dow Chemical Company as a research chemist. After his retirement (as director of the Basic Research Laboratory) in 1953, he continued as a consultant to the company—and spent increasing amounts of time on his entomological research, for which he was widely known. His insect collection of about 250,000 specimens was left to Michigan State University. By the early 1930's, his interest in insects was leaving little time for active botanical work. As the pinch for space for his collections became acute, in 1954 he began to present his private herbarium to The University of Michigan, where the herbarium has accessioned altogether nearly 10,000 specimens from Dreisbach, about 10% of them his own collections from Michigan, the remainder acquired by him through exchange or collected by him elsewhere. In addition, a number of duplicates were included and are being distributed in exchange by the University Herbarium.

An author of technical papers and five books on physical chemistry, Mr. Dreisbach held 65 patents and played a leading role in the development of aspirin and styrene. Fellow Botanical Club members who remember him on some of our field trips will appreciate this statement by the Dow Chemical Co., for it could apply equally well to his biological interests: "His enthusiasm and boundless energy were his trademarks, and his technical competence and versatility won him the deep respect of professional colleagues both within and without the company."

The 10th award of the Mary Soper Pope Medal of Cranbrook Institute of Science was given to Professor Edgar T. Wherry at a reception in the Academy of Natural Sciences, Philadelphia. The occasion chosen, September 10, 1964, was Professor Wherry's 79th birthday, which was recognized by the presence of a large and handsome cake elaborately sculptured in colored icings in the form of ferns, flowers, and rocks, symbolizing some of his special interests. About 150 of Professor Wherry's colleagues, students, and friends were present for the occasion, and as the medal was presented to him by Dr. Robert T. Hatt, Director of Cranbrook Institute of Science, a standing ovation was given to the recipient.

The Mary Soper Pope Medal was founded at Cranbrook Institute of Science as a memorial to the women whose name it bears. It is given from time to time to persons who have given noteworthy and distinguished service to the field of the plant sciences.

Last May the Henry Russel Lecture was delivered at The University of Michigan by William Randolph Taylor, who has been professor of botany at the University since 1930. Considered to be the University's highest recognition of academic research, the lecturer is chosen annually by the Regents on the recommendation of the Research Club and former Russel lecturers. Dr. Taylor is the author of numerous scientific papers and six books dealing with marine algae of various parts of the world.

Publications of Interest

The account of new maps, books, bulletins, etc., in the New Literature section this month (beginning on the next page) includes an unusually interesting selection of publications. Members, readers, and librarians will, we hope, find the listings useful as a guide to further reading.

In addition we note here some other recent publications which, because of concern with economic botany and/or lack of any direct reference to Michigan do not qualify for regular listing although they may well be of interest:

TRILLIA. Proceedings of the Botanical Society of Western Pennsylvania. No. 12 (1946-1963). 1964. 167 pp. $2.25. This first issue of "Trillia" in nearly 20 years is dedicated to the memory of Dr. O. E. Jennings (1877-1964), of whom a biographical sketch by L. K. Henry appears. Other articles include additions to the check list of vascular plants of Allegheny Co., Pennsylvania, "Rare or otherwise noteworthy plants in western Pennsylvania" (the major article), notes on bogs in Erie Co., Pennsylvania, and various brief biographical sketches, and accounts of meetings and field trips. This and previous publications may be obtained from the Botanical Society of Western Pennsylvania, c/o The Herbarium, Carnegie Museum, 4400 Forbes Ave., Pittsburgh, Pennsylvania 15213.

FARMER'S WORLD. The Yearbook of Agriculture 1964. Government Printing Office, Washington, 1964. 592 pp. This year's volume of a well known series is devoted to a general survey of agriculture, primarily but not exclusively American. The volume may be purchased for $3.00 from the Superintendent of Documents, Washington 20402, or (as most readers know) obtained without charge from one's Congressmen.

M N G A NEWS-LETTER. The newsletter of the Michigan Nut Growers Association (a chapter of the Northern Nut Growers Association, Inc.) appears only irregularly. The October, 1964, number includes many short notes on nut trees, several recipes (using nuts, of course), and accounts of the Association's activities. Annual membership in the MNGA is $2.00, and the treasurer is Hugh W. Glover, 124 Ashman St., Midland, Michigan.

THE SECRET LIFE OF FLOWERS. By Anne Ophelia Dowden. Odyssey Press, New York, 1964. 45 pp. $.95. The author (and artist) has produced a well written and well illustrated, colorful pocket-size account of flowers, especially the subject of pollination in its diverse expressions. Mrs. Dowden (Anne Ophelia Todd) was formerly chairman of the art department at Manhattanville College and is now a free lance textile designer and botanical illustrator, specializing in water colors. Her work has appeared in Life Magazine, House Beautiful, and Natural History Magazine. This very attractive and non-technical book should appeal to all readers.

NATIVE WILD PLANTS OF EASTERN CANADA and the Adjacent Northeastern United States. By F. H. Montgomery. Ryerson Press, Toronto, 1962. 193 pp. $4.95. An attractive small book intended for amateur botanists, with simple keys, numerous line drawings, and colored plates with 24 very handsome color photos.

MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

The aim of this section is to list all significant literature relating to Michigan botany published since the beginning of 1960, without attempting much coverage of related fields such as agriculture, conservation, and forestry. When the subject matter or relation to Michigan is not clear from the title, annotations are added in brackets.

A. MAPS, SOILS, GEOGRAPHY, GEOLOGY

Under this heading we periodically list new maps of use to field naturalists, as well as selected bulletins and articles on soils and geology of the region, as these may be of value in interpreting plant distribution ecologically or historically.

The following topographic maps for Michigan have been published by the U. S. Geological Survey, Washington, D. C. 20242, since the previous listing in the January, 1964, issue. Those marked with an asterisk are 7-1/2-minute quadrangles (scale of 1:24,000 or about 2-1/2 inches to a mile); the others are 15-minute quadrangles (scale of 1:62,500 or about 1 inch to a mile). Maps are supplied with green overprint showing woodland areas unless request is made to the contrary. Maps may be ordered from the survey at $.30 each (20% discount on orders for $10.00 or more). Following the name of the quadrangle, the county or counties in which it primarily lies are added in brackets in the list below:

Addison* [Lenawee]
Adrian* [Lenawee]
Applegate* [Sanilac]
Argyle* [Sanilac]
Attica* [Lapeer]
Auburn* [Bay, Saginaw]
Birch Creek* [Menominee]
Boyne City [Charlevoix, Antrim]
Boyne Falls [Charlevoix, Antrim, Otsego]
Carsonville* [Sanilac]
Cass City* [Tuscola]
Cedar River [Menominee]
Chappee Rapids* [Menominee, + Wisc.]
Clifford* [Lapeer, Tuscola]
Croswell* [Sanilac]
Decker* [Sanilac]
El Dorado* [Crawford]
Ellington* [Tuscola]
Fairgrove* [Tuscola]
Florence East* [Iron, + Wisc.]
Florence West* [Iron, + Wisc.]
Forestville* [Huron, Sanilac]
Frankenmuth* [Tuscola, Saginaw]
Gagetown* [Huron, Sanilac]
Gilford* [Tuscola]
Hudson* [Lenawee]
Imlay City* [Lapeer]
Iron Mountain SW* [Dickinson, + mostly Wisconsin]
Jasper* [Lenawee]
Kingston* [Tuscola]
Lapeer* [Lapeer]
Luzerne* [Oscoda]
Luzerne NW* [Crawford]
Marinette East* [Menominee, + mostly Wisconsin]
Marinette West* [Menominee, + mostly Wisconsin]
Marlette* [Sanilac]
Midland North* [Midland]
Midland South* [Midland]
Minden City* [Huron, Sanilac]
Naults* [Iron, + mostly Wisconsin]
New Greenleaf* [Huron, Sanilac]
Owendale* [Huron, Sanilac]
Palms* [Sanilac]
Peck* [Sanilac]
Pittsford* [Hillsdale]
Port Sanilac* [Sanilac]
Quanicassee* [Tuscola, Bay]
Red Oak* [Oscoda]
Reese* [Tuscola, Saginaw]
Richmondville* [Sanilac]
Rome Center* [Lenawee]
Ruth* [Huron, Sanilac]

Sandusky* [Sanilac]
Shabbona* [Sanilac]
Ubly* [Huron, Sanilac]
Vassar* [Tuscola]
Wheatland* [Hillsdale]
Willard* [Bay]

The United States Series of topographic maps, at a scale of 1:250,000, was described in Vol. 2, p. 59-60 (March, 1963), where those covering Michigan were listed. Limited revisions have now been published for the following sheets: Cheboygan (NL 16-9), Sault Ste. Marie (NL 16-6), and Ashland (NL 15-6). [The "limited revision" of the Cheboygan sheet is just that; at least, the Mackinac Bridge has been moved two miles east to its correct location. However, errors in spelling (e.g., "Petosky," "Menonagua") have not been corrected, non-existent roads southwest of French Lake in Emmet Co. and north of Whiskey Creek in Charlevoix Co. still appear; the lighthouse at Mackinaw City, abandoned upon completion of the bridge, is labeled as "Light"—as are the lighthouse abandoned at McGulpin Point decades ago and the Round Island lighthouse. "Nigger Creek" flowing into Mullett Lake has been dignified as "Negro Creek." U. S. 27 is still shown between Gaylord and Indian River (although the route now ends at Grayling), the new route of M-68 is not shown even though a few recently paved county roads as well as U. S. 23 show in an improved style, and interstate 75 is superimposed. There is no indication nor road to mark the big nuclear reactor at Big Rock Point. And new error has been introduced in marking the road on the north side of Carp Lake as M-108 (it remained as U. S. 31 until very recent re-routing.) While every one-room country school, even if abandoned, is shown by a symbol for school, the University of Michigan Biological Station, with nearly 9,000 acres of land and almost 150 buildings, does not even rate a school symbol or identification of any kind.]

A new index map to topographic mapping in Michigan was announced in March.

COUNTY MAPS. Region II (Northern Lower Peninsula). Michigan Department of Conservation, 1964. $1.00. [The long awaited appearance of this book completes the coverage for the state with new, up-to-date maps, all to the same scale, showing not only the usual features of roads, trails, lakes, and streams, but also (by gray shades) state and federal ownership and (by red overprint) conservation project boundaries and recreational facilities such as water access ("public fishing") sites, roadside parks, etc. In the first issue of this journal (1:46) we praised the books for Region I (Upper Peninsula) and Region III (southern Lower Peninsula), and attention was later called to advance sheets for Region II (2: 29 & 3: 103). All three books are now available (when not temporarily out of print) at $1.00 each; individual sheets (more than one required for some large U. P. counties) are 10¢ each (a single sheet only free). Orders, including 4% Michigan Sales Tax, should be sent to Maps and Publications, Department of Conservation, Lansing, Michigan 48926.

The accuracy, thoroughness, and clarity of these maps is remarkable. They are absolutely essential to anyone who wants to locate himself accurately in the field, wander on back roads, find a campsite on public land, or engage in any number of outdoor activities. Of course, no map is perfect nor does one remain automatically up to date. Individual users will note inconsistencies in treatment of road and trail types, etc. The old county map series is still useful for its greater percentage of railroad grades and trails (such as abandoned logging roads) which may yet be visible. In the counties most familiar to the editor, Emmet and Cheboygan, the new maps are astonishingly accurate (apart from erroneous location of McGulpin Point, noted previously). This is hardly the place for nit-picking on details, but I did find some minor discrepancies on two 1964 field trips: In Otsego Co., T29N, R1W, the Consumers Power Line is accompanied by a dirt road for at least six miles, and in sec. 15 the abandoned railroad grade is a dirt road of apparently long standing. In Lake Co., the new map evidently relies too much on an equally erroneous U. S. Geological Survey map of the Custer Quadrangle, for both show a road leading from the north to Roby Lake (sec. 29-32, T17N, R14W), where there is in fact no evidence that a road ever existed—while good dirt roads do lead to the west end of the lake, where none are shown on either map. But even though not perfect, the new maps are so vastly superior to anything else available that the Conservation Department must be warmly commended for the enormous effort in compiling them and for making them available at so reasonable a cost.]

B. BOOKS, BULLETINS, SPECIAL REPORTS, AND MISCELLANEOUS

Blasdell, Robert F. 1963. A Monographic Study of the Fern Genus Cystopteris. Mem. Torrey Bot. Club 21(4). 102 pp. $3.00 [Some cytological and ecological data from Michigan, and selected specimens cited from the state for *C. fragilis, C. protrusa, C. bulbifera, C. diaphana* x *fragilis* complex, & *C. diaphana* x *protrusa* complex (but *C. diaphana* not known north of Mexico); several of the drawings are based on Michigan material.]

Darlington, Henry T. 1964. The Mosses of Michigan. Cranbrook Inst. Sci. (Bull. 47), Bloomfield Hills, Mich. 212 pp. + 147 fig. $12.00 [See review on page 25 of this issue.]

Gleason, Henry A., & Arthur Cronquist. 1964. The Natural Geography of Plants. Columbia Univ. Press, New York. 420 pp. $10.00 [Distribution maps of 12 tree species include Michigan, a few of the numerous photographs were taken in the state, and there are several Michigan references in the text. A copiously illustrated book designed more for the lay reader than as a text, describing the principles of plant geography and the vegetational regions of North America in non-technical language.]

Great Lakes Research Division. 1964. Proceedings Seventh Conference on Great Lakes Research. Institute of Science & Technology, Univ. of Mich., Ann Arbor. 390 pp. [Publ. 11 of GLRD, includes many papers on chemistry, geology, meteorology and hydrology, and physical studies, as well as basic biological topics (e.g., photosynthesis, yeasts, bacteria) relating to the various Great Lakes.]

National Park Service. 1964. Isle Royale National Park (revised). U. S. Government Printing Office, Washington. 24 pp. $0.15 [Revision of general circular introducing the background of this Lake Superior wilderness, with advice for the potential visitor.]

Rominger, James M. 1962. Taxonomy of Setaria (Gramineae) in North America. Ill. Biol. Monogr. 29. Univ. Ill. Press, Urbana. 132 pp. $3.00 [Includes keys and descriptions. Citations of specimens from Michigan include one each of *S. verticillata* and *S. lutescens*.]

Singer, Rolf, & Alexander H. Smith. 1960. Studies on Secotiaceous Fungi IX The Astrogastraceous Series. Mem. Torrey Bot. Club 21(3). 112 pp. $2.00 [*Octavianina asterosperma* var. *potteri* is described as new from Ithaca, Mich.]

Smith, Alexander H., & Robert L. Shaffer. 1964. Keys to Genera of Higher Fungi. Univ. of Mich. Biological Station. 120 pp. $3.00 [Includes brief descriptions of genera as well as keys to them (and occasionally to subgenera and sections). While no distributional data are given, the keys have been developed primarily for students in Michigan. The book may be ordered by mail from the U. of M. Biological Station, Ann Arbor.]

Smith, Alexander H., & Harry D. Thiers. 1964. A Contribution Toward a Monograph of North American Species of Suillus. 116 pp. + 46 pl. $4.00 [A number of the species of this bolete genus are recorded from Michigan, usually without further locality data except for types of some of the new taxa: *S.*

proximus, S. lutescens, S. acidus var. *subalutaceus*, & *S. brevipes* var. *subgracilis*. Privately printed, and available from A. H. Smith, Herbarium, University of Michigan, Ann Arbor.]

Yarnell, Richard Asa. 1964. Aboriginal Relationships Between Culture and Plant Life in the Upper Great Lakes Region. Museum of Anthropology, Univ. of Mich., Anthro. Pap. 23. 218 pp. $2.50. [A major assemblage of data on utilization of native plant products and aboriginal agriculture, with special reference to archeological sites on Bois Blanc Island (Mackinac Co.) and in the Saginaw area. Plant geographers and ecologists will get many ideas on possible relationships between Indians and plant distribution. References to the appendixes are all erroneously cited on pp. 83-88 (I should be A; IIA = B, B = C, III = D, IV = E, V = F, & F = G); since there are several lists based on season and use made of plants, it is frustrating to the botanist that there is no index.]

C. JOURNAL ARTICLES

Alex, J. F. 1962. The taxonomy, history, and distribution of Linaria dalmatica. Canad. Jour. Bot. 40: 295-307. [Map includes one Michigan location.]

Arend, John L., et al. 1961. Jack pine geographic variation—five-year results from Lower Michigan tests. Pap. Mich. Acad. 46: 219-238.

Baxter, Dow V. 1964. Fungus development from field to forest in spruce plantings of 1904 and later. Pap. Mich. Acad. 49: 3-13. [Long-term records of fungus development in the experimental Saginaw Forest, Washtenaw Co.]

Beaudry, Jean R. 1963. Studies on Solidago L. VI. Additional chromosome numbers of taxa of the genus Solidago. Canad. Jour. Genet. & Cytol. 5: 150-174. [Includes report of 2n = 36 for *S. randii* from Mackinaw City [Emmet Co.] and repeats report of 2n = 36 for *S. rigida* from Bloomfield Hills.]

Bigelow, Howard E., & Margaret E. Barr. 1963. Contribution to the fungus flora of northeastern North America. III. Rhodora 65: 289-309. [*Nectria atrofusca* & *Niesslia barbicincta* cited from Michigan.]

Cantlon, J. E., E. J. C. Curtis, & W. M. Malcolm. 1963. Studies of *Melampyrum lineare*. Ecology 44: 466-474. [Studies related to parasitism, the material from Crawford Co.]

Case, Frederick W., jr. 1962. Growing native orchids of the Great Lakes region. Am. Orchid Soc. Bull. 31: 437-445. [Some references to Michigan habitats in relation to garden culture.]

Cooper, Arthur W. 1961. Relationships between plant life-forms and microclimate in southeastern Michigan. Ecol. Monogr. 31: 31-59. [Study done on the George Reserve, Livingston Co.]

Culbertson, William L. 1961. The Parmelia quercina group in North America. Am. Jour. Bot. 48: 168-174. [Map indicates distribution of *P. galbina* in Michigan.]

Darlington, H. T., & G. P. Steinbauer. 1961. The eighty-year period for Dr. Beal's seed viability experiment. Am. Jour. Bot. 48: 321-325. [Report on the famous seed experiments at East Lansing; 3 of the original 20 week species still have viable seed for 80 years.]

Dore, William G. 1964. Two kinds of Blue Cohosh. Ontario Naturalist 2 (1): 5 pp. (March). [Further data will considerably alter the generalized distribution maps showing the yellow-flowered variety of *Caulophyllum thalictroides* in Michigan only in the Upper Peninsula and southernmost Lower Peninsula, and the purple-flowered variety, originally described by Farwell, only in the southeastern L. P.]

Evans, A. Murray, & W. H. Wagner, Jr. 1964. Dryopteris goldiana x intermedia —a natural woodfern cross of noteworthy morphology. Rhodora 66: 255-266. [One locality for the hybrid is cited in Antrim Co.]

Evans, Francis C. 1964. The food of vesper, field, and chipping sparrows nesting in an abandoned field in southeastern Michigan. Am. Midl. Nat. 72: 57-75. [Tables include plant materials, usually determined only to genus—even if there is only one species possible in the region.]

Forman, Richard T. T. 1964. Growth under controlled conditions to explain the hierarchical distributions of a moss, Tetraphis pellucida. Ecol. Monogr. 34: 1-25. [Distribution map includes Michigan and basis of some data includes Michigan material.]

Gillett, J. M., & H. A. Senn. 1960. Cytotaxonomy and infraspecific variation of Agropyron smithii Rydb. Canad. Jour. Bot. 38: 747-760. [Map of distribution in North America includes 3 or 4 Michigan locations.]

Glassman, S. F. 1963. New records of grasses from the Chicago region and lower Michigan. Rhodora 65: 284-285. [First report of true European *Elymus arenarius* (not *E. mollis*) from Michigan: Berrien Co.]

Hauke, Richard L. 1962. A resume of the taxonomic reorganization of Equisetum, subgenus Hippochaete, IV. Am. Fern Jour. 52: 123-130. [Hybrids said to occur in Michigan: *E.* x *ferrissii* & *E.* x *nelsonii.*]

Heatwole, Harold. 1961. Analysis of the forest floor habitat with a structural classification of the litter or L layer. Ecol. Monogr. 31: 267-283. [Includes ecological data from various habitats in Emmet, Cheboygan, and Washtenaw counties.]

Koyama, Tetsuo. 1962. The genus Scirpus Linn. Some North American aphylloid species. Canad. Jour. Bot. 40: 913-937. [Specimens from Michigan are cited of *S. smithii, S. supinus* var. *hallii, S. subterminalis* var. *subterminalis* and var. *cylindricus* (= *S. torreyi*).]

Longcore, Jerry R., & George W. Cornwell, 1964. Consumption of natural foods by captive canvasback and lesser scaup. Pap. Mich. Acad. 49: 207-215. [Observations on the lower Detroit River include various plants.]

Lõve, Áskell. 1963. Sverdmosinn. Nátturúfraedingurinn 33: 113-122. [Map of distribution of swordmoss, *Bryoxiphium norvegicum*, apparently includes southwestern Michigan. (In Icelandic, with English summary.)]

Lõve, Áskell, & Otto T. Solbrig. 1964. IOPB chromosome number reports. I. Taxon 13: 99-110. [Includes several counts on Michigan ferns by Wagner & Chen.]

Myers, Oval, jr., & F. H. Bormann. 1963. Phenotypic variation in *Abies balsamea* in response to altitudinal and geographic gradients. Ecology 44: 429-436. [Map indicates occurrence in Michigan of var. *phanerolepis* and var. *balsamea.*]

Soper, James H. 1963. Ferns of Manitoulin Island, Ontario. Am. Fern Jour. 53: 28-40; 71-81; 109-123. [Maps for several of the species include northern Michigan.]

Thompson, Paul W. 1962. An unusual fern station on South Manitou Island, Michigan. Am. Fern Jour. 52: 157-159. [The map with this report of rarities is misleading: it does not show "nearest known localities" for the species, as the symbols are evidently intended only to indicate *county* records, not localities (they are not at known localities for the ferns); and furthermore it omits some nearest records which happen to be in Wisconsin rather than Michigan.]

Uyenco, Flordeliz R. 1963. The species of *Coenogonium* in the United States. Bryologist 66: 217-224. [*C. interplexum* cited from Washtenaw Co.]

Wagner, W. H., jr. 1962. Plant compactness and leaf production in Botrychium multifidum "ssp. typicum" and "forma dentatum." Am. Fern Jour. 52: 1-18. [Data from several Michigan localities.]

Wiegert, Richard G., & Francis C. Evans. 1964. Primary production and the disappearance of dead vegetation on an old field in southeastern Michigan. Ecology 45: 49-63. [Study on George Reserve, Livingston Co.]

Information for Authors **The Michigan Botanist**

THE MICHIGAN BOTANIST is distributed not only to a considerable number of individual and institutional subscribers domestically and abroad, but also to all members of the Michigan Botanical Club, an organization composed in large part of non-professionals with concerns for conservation and nature study as well as the local flora. (Total paid circulation is over 700 copies.)

Articles and notes may relate to any phase of botany in the Upper Great Lakes region. Considering the range of interests among members and subscribers, we seek to include (in each year if not each issue) the widest possible range of subject matter in regard both to the entire plant kingdom and to branches of the field of botany. Notes on techniques useful to the teacher and hobbyist are welcomed.

To promote clarity to non-technical readers (without sacrifice of accuracy and precision), such means are encouraged as illustrations, inclusion of a generally accepted "common name" (when such exists) at least once in the title or text of any article devoted to consideration of one or a few species, and introductory material placing the author's studies in perspective and briefly indicating their significance.

Manuscripts should (unless in the nature of a "review" article) include some new botanical information, and should pertain to the Upper Great Lakes region. Not acceptable are manuscripts of primarily literary nature (including all poetry and articles of an "editorial" orientation).

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—The Editorial Board

PROGRAM NOTES

IMPORTANT MICHIGAN BOTANICAL CLUB DATES:

February 27 - March 7: Flower and Garden Show. Once again there will be a Botanical Club exhibit and booth at the Flower Show, at the State Fairgrounds, Detroit.

April 25: Annual Meeting. University of Michigan Botanical Gardens, and Horner's Woods.

May 28-31: Campout. In the Upper Peninsula this year.

Watch our newsletters and announcements for details on these and other forthcoming events.

MICHIGAN ACADEMY OF SCIENCE, ARTS, AND LETTERS:

March 19-20: 69th Annual Meeting of the Academy, University of Michigan, Ann Arbor. The Botany Section will meet Friday morning and afternoon (March 19) in Rackham Amphitheater; Saturday, in the Natural Science Building.

Editorial Notes

For a limited time, we are making a special offer to new subscribers to THE MICHIGAN BOTANIST. A complete set of Volumes 1-3, including the 3-year index, will be supplied for $4.00 postpaid to all new subscribers to Volume 4. The total price, therefore, for the four volumes will be $6.00, only on orders received by the Business & Circulation Manager prior to March 15, 1965. Tell your friends!

The October number (Vol. 3, No. 4) was mailed October 30, 1964.

THANKS TO REVIEWERS

One of the chief functions of the members of the Editorial Board is to review manuscripts submitted for publication, considering them from the standpoints of botanical content, clarity of presentation, and suitability for this journal. Reviewers are traditionally anonymous, but the editor trusts that the freedom of anonymity will not be impinged upon if he takes this opportunity to thank not only the members of the Editorial Board (named on the inside front cover) for their prompt and faithful services in this regard, but also several botanists not on the board, who have served as reviewers for one or more articles in volumes 1-3: Drs. C. B. Beck, W. S. Benninghoff, Margaret B. Davis, C. H. Dodson, M. T. Hall, P. B. Kaufman, M. A. Piehl, Rainer Scora, Helen V. Smith, and F. K. Sparrow.

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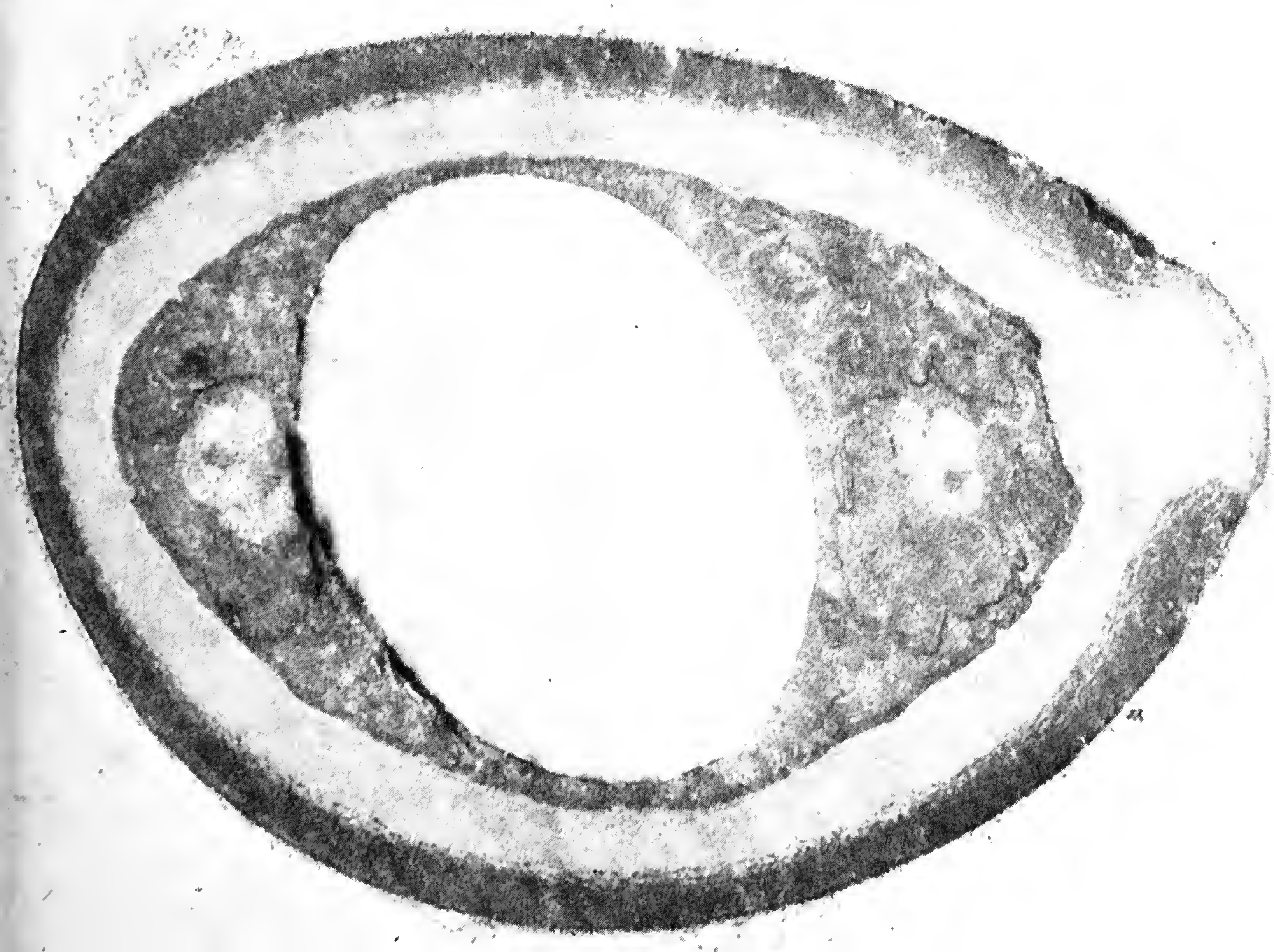
(On the cover: Capsules of the yellow Lady's-Slipper, Cypripedium calceolus, *above the snow at Ipperwash Beach, Ontario. From a color transparency by Warren P. Stoutamire, March 2, 1963.)*

Vol. 4, No. 2

THE MICHIGAN BOTANIST

March, 1965



THE MICHIGAN BOTANIST—Published by the Michigan Botanical Club four times per year: January, March, May, and October. Second-class postage paid at Ann Arbor, Michigan.

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Articles and notes dealing with any phase of botany in the Upper Great Lakes Region may be sent to the editor in chief. The attention of authors preparing manuscripts is called to "Information for Authors" (Vol. 4, p. 38, and also available from the editor).

THE MICHIGAN BOTANICAL CLUB

Membership in the Michigan Botanical Club is open to anyone interested in its aims: conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on the plant life of the State; sponsorship of legislation to promote the preservation of Michigan native flora and to establish suitable sanctuaries and natural areas; and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

Dues are modest, but vary slightly among the chapters. In all cases, they include subscription to THE MICHIGAN BOTANIST.

THE WHITE GENTIAN OF THE PRAIRIES[1]

James S. Pringle
Royal Botanical Gardens, Hamilton, Ontario, Canada

The White, Pale, or Yellowish Gentian, *Gentiana alba* Muhl., is one of the coarsest and most robust of the gentians. Its stout, clustered stems are usually one to three feet in length, and often more or less decumbent. Its large, ovate leaves are distinctively yellowish-green and somewhat succulent. Its flowers are produced in large, dense clusters. The calyx lobes are ovate, with decurrent keels which cause them to spread horizontally (a useful character in identification, since in herbarium specimens the lobes are usually spread irregularly rather than pressed vertically). The fresh corollas are white, with a network of prominent green veins and faint traces of purple on the inner surface of the corolla tube and occasionally at the tips of the lobes. Like those of the other perennial gentians of Michigan, the tubular corolla of *G. alba* consists of five petals, which terminate in triangular lobes alternating with corolla appendages. In *G. alba,* the summits of the appendages are low, erose structures or small triangular projections between the corolla lobes and partly folded inside them. The corollas open at the summit, but only slightly. This species usually blooms about the first week in September in southern Michigan, somewhat earlier than the other two perennial gentians of this area, which are the familiar Closed Gentian, *G. andrewsii* Griseb., and the rare (in Michigan) and beautiful Prairie Gentian, *G. puberula* Michx.

Gentiana alba is essentially a species of the prairies, and, like a number of other prairie species, it is uncommon as far northeast as Michigan. In Washtenaw County, Michigan, near Ann Arbor, *Gentiana alba* grows in a community dominated by the Big Blue-stem Grass, *Andropogon gerardi* Vitman, in the company of other characteristic prairie species such as *Euphorbia corollata* L., *Solidago rigida* L., and *Silphium terebinthinaceum* Jacq. The prairies of Michigan are largely confined to the southern part of the state (see Veatch, 1928, Butler 1947-1949, and their references), and it is from this region only that Michigan specimens of *Gentiana alba* have been collected. It is evidently a calciphile. The associations of Gray-Brown Podzolic soil series (Fox - Oshtemo - Warsaw, Fox - McHenry - Spinks, Miami - Dodge - Conover, and St. Clair - Blount Pewamo) on which it is found in Michigan are derived largely from calcareous, glacially transported parent materials (Odell et al., 1960); elsewhere in its range it is usually associated with similar materials or with limestone deposits. In Michigan, *Gentiana alba* has been collected in Genesee, Jackson, Kalamazoo, Oakland, St. Joseph, and Washtenaw Counties. (Specimens examined in

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[1]Contribution No. 2 from the Royal Botanical Gardens, Hamilton, Ontario.

BLH, MICH, MSC, TENN, WMU, WUD.)[2] Reports of this species from more northerly localities in Michigan have resulted from the confusion of this species with *G. rubricaulis* Schwein., the Red-stemmed or Gray's Gentian. Hybrids between *G. alba* and *G. andrewsii* have been collected at Flint (*Clarke* in 1864, MSC *acc. no. 66257*) and Belle Isle, Detroit (*Cook*, Oct 1900, WUD *acc. no. 8008*). An old specimen of *G. puberula* from Michigan, without locality (*Cooley 5-2 partim*, MSC *acc. no. 66262*), suggests introgression of genetic material from *G. alba* into that species. These species have been known to hybridize elsewhere.

Gentiana alba has found little acceptance in horticulture. Because of its coarseness and sprawling habit some horticulturists consider it rather ugly, although others have valued it for its vigor and abundance of bloom. Steyermark (1963) reports that it does well in cultivation, producing whiter flowers in full sun. Since the gentians are remarkably interfertile, it may be that as a result of breeding the horticulturally desirable qualities of this species may someday appear in more attractive combinations.

Because of the confused nomenclatural history of this species, some comments on the use of the name *Gentiana alba* seem in order.

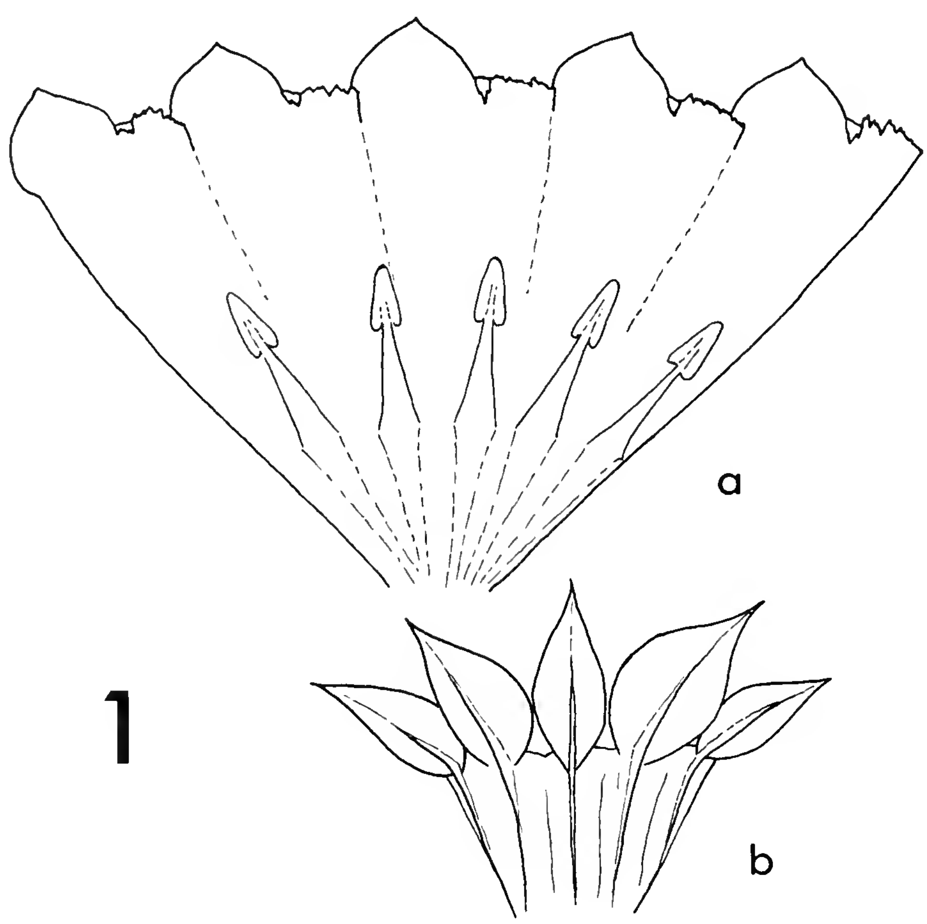

Fig. 1. Parts of flower of *Gentiana alba* from Ann Arbor, Michigan, x 1. (a) corolla, slit longitudinally and pressed, showing inner surface; connate anthers were separated in pressing. (b) calyx, showing outer surface.

[2]Herbaria are designated by abbreviations given in Lanjouw & Stafleu, *Index Herbariorum* (1964).

This combination was first formed by Young in 1783. Young's brief description does not make clear which species he designated "*Gentiana alba,*" but, since it bloomed earlier than the other perennial gentians he listed, it seems likely that it was this prairie species. However, since Young occasionally deviated from the binomial system of nomenclature, his "*Gentiana alba*" is to be regarded as a brief "descriptive phrase" and is not taken into account nomenclaturally, according to Article 23, Note 3, of the International Code of Botanical Nomenclature (1961).

The earliest valid publication of the name *Gentiana alba* was that by Muhlenberg in 1813. His description was also extremely brief, indicating only that the species was a perennial with a five-parted calyx and a five-parted, white corolla. The name *G. alba* Muhl. was shortly thereafter taken up by Nuttall (1818), but he described it only as having "flowers white."

The species considered here was described by Gray in 1846 as *G. flavida,* on the basis of specimens from the mountains of what is now West Virginia (*Gray* in 1843, GH, NY!). He noted at the time that he suspected his *G. flavida* was the same as Muhlenberg's *G. alba.* When the first edition of his Manual was published in 1848, Gray indicated his conviction that such was indeed the case, and this species was generally known as *G. alba* Muhl. during most of the remainder of the nineteenth century.

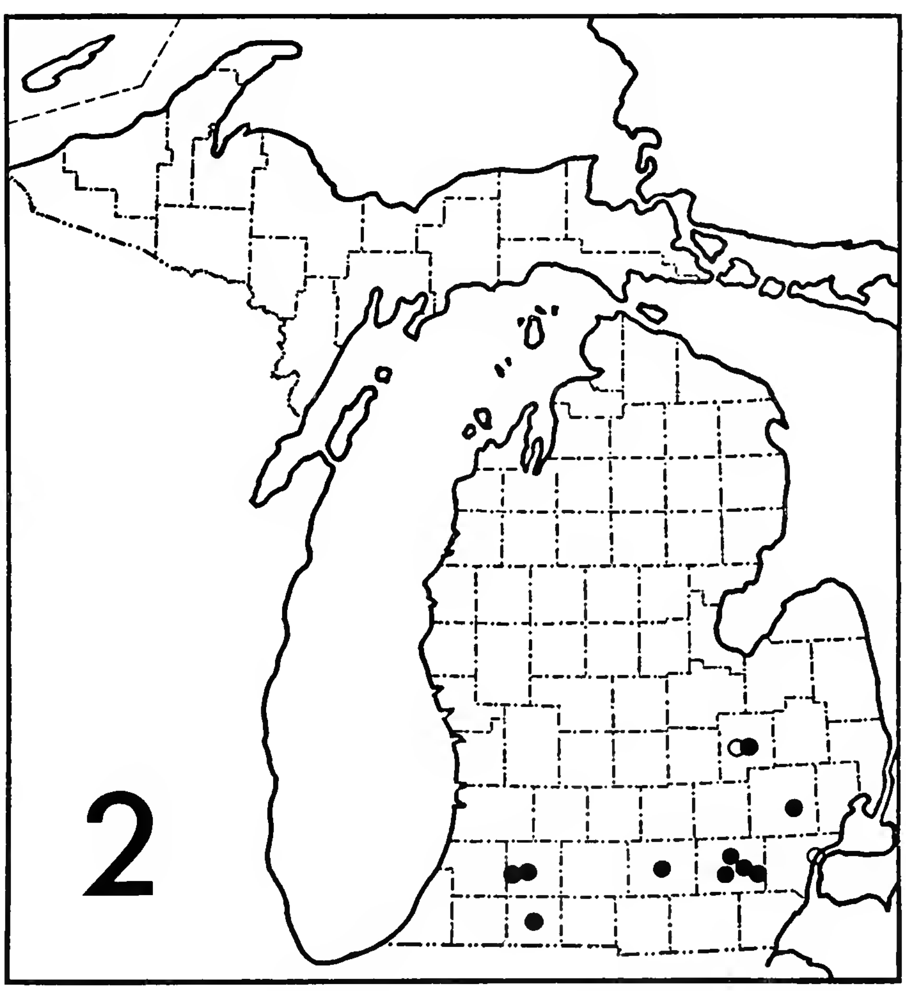

Fig. 2. Distribution of *G. alba* (solid dots) and hybrids between *G. alba* and *G. andrewsii* (open circles) in Michigan.

In 1889, Porter challenged Gray's treatment on the incorrect assumption that this species did not occur in eastern Pennsylvania and thus could not have been known to Muhlenberg, whose field work had been confined to that area. He suspected that a white-flowered form of "*G. andrewsii*" (a name then applied to *G. clausa* Raf. as well as to *G. andrewsii* Griseb.) had been the basis of Muhlenberg's cryptic description. Kusnezow (1896) rejected Porter's views and continued to use the name *G. alba* for this species, but most botanists followed Porter. As a result, this species has been called *G. flavida* Gray in most twentieth-century botanical works.

Farwell (1929) was sufficiently convinced that a white-flowered form of *G. andrewsii* was the basis of *G. alba* Muhl. that he adopted the older name *G. alba* for the Closed Gentian, designating the common blue-flowered form *G. alba* f. *andrewsii* (Griseb.) Farw. No other authors have followed this policy, but instead have usually rejected *G. alba* Muhl. as a *nomen dubium*.

Dr. J. M. Gillett of the Plant Research Institute, Canada Department of Agriculture, recently examined the gentianaceous material in Muhlenberg's herbarium (incl. in PH) and found a specimen of this species (*ex fold no. 336;* photo, DAO!). This specimen was labeled "*Gentiana alba,*" presumably by R. Eglesfield Griffith, an early curator of the herbarium of the American Philosophical Society (A. E. Schuyler, personal correspondence in 1964). It thus became obvious that this species was known to Muhlenberg, and since it was the only gentian among Muhlenberg's specimens which had white or pale flowers, it appeared evident to Dr. Gillett that it was this species which Muhlenberg had named *G. alba*. This specimen, selected and annotated *in herb.* as the lectotype by Dr. Gillett, is hereby officially designated the lectotype of *Gentiana alba* Muhl. Cat. 29. 1813.

Some early nineteenth-century authors (e.g., Sims, 1813) incorrectly applied the name *G. ochroleuca* Froel. to this species. Although presumably no type specimen is extant, Froelich's (1796) description indicated that his *G. ochroleuca* should be regarded as a synonym of *G. villosa* L., the name of a southern species.

The synonymy of this prairie species therefore is as follows:

Gentiana alba Muhl. Cat. 29. 1813

- *Gentiana alba* W. Young, Arbres, Arbustes & Pl. Herb. Am. 36. 1783. [not validly published because in contravention of Art. 23, Note 3].
- *Gentiana ochroleuca* sensu auctt., non Froel. Gent. 35. 1796.
- *Gentiana flavida* A. Gray, Am. Jour. Sci. II. 1:80. 1846.
- *Pneumonanthe flavida* (A. Gray) Greene, Leafl. Bot. Obs. & Crit. 1:71. 1904.
- *Dasystephana flavida* (A. Gray) Britton in Britton & Brown, Ill. Fl. ed. 2. 3:12. 1913.

Use of the name *Gentiana alba* Muhl. for this species conforms not only to the prevalent usage of the nineteenth century but also to that of Gillett (1963) and myself (Pringle, 1963a,b) in the works cited and in the annotation of herbarium specimens. It also corresponds to that found in some horticultural works in current use (e.g. Miller & Taylor, 1935, and Wilkie, 1956).

ACKNOWLEDGMENTS

I should like to express my appreciation to Dr. J. M. Gillett, for his informing me of the results of his study of the Muhlenberg collections; to Dr. R. Ross, for his comments on the application of the International Code of Botanical Nomenclature; to Dr. H. W. Rickett, for information on dates of publication; and to the many curators and librarians who have been most cooperative.

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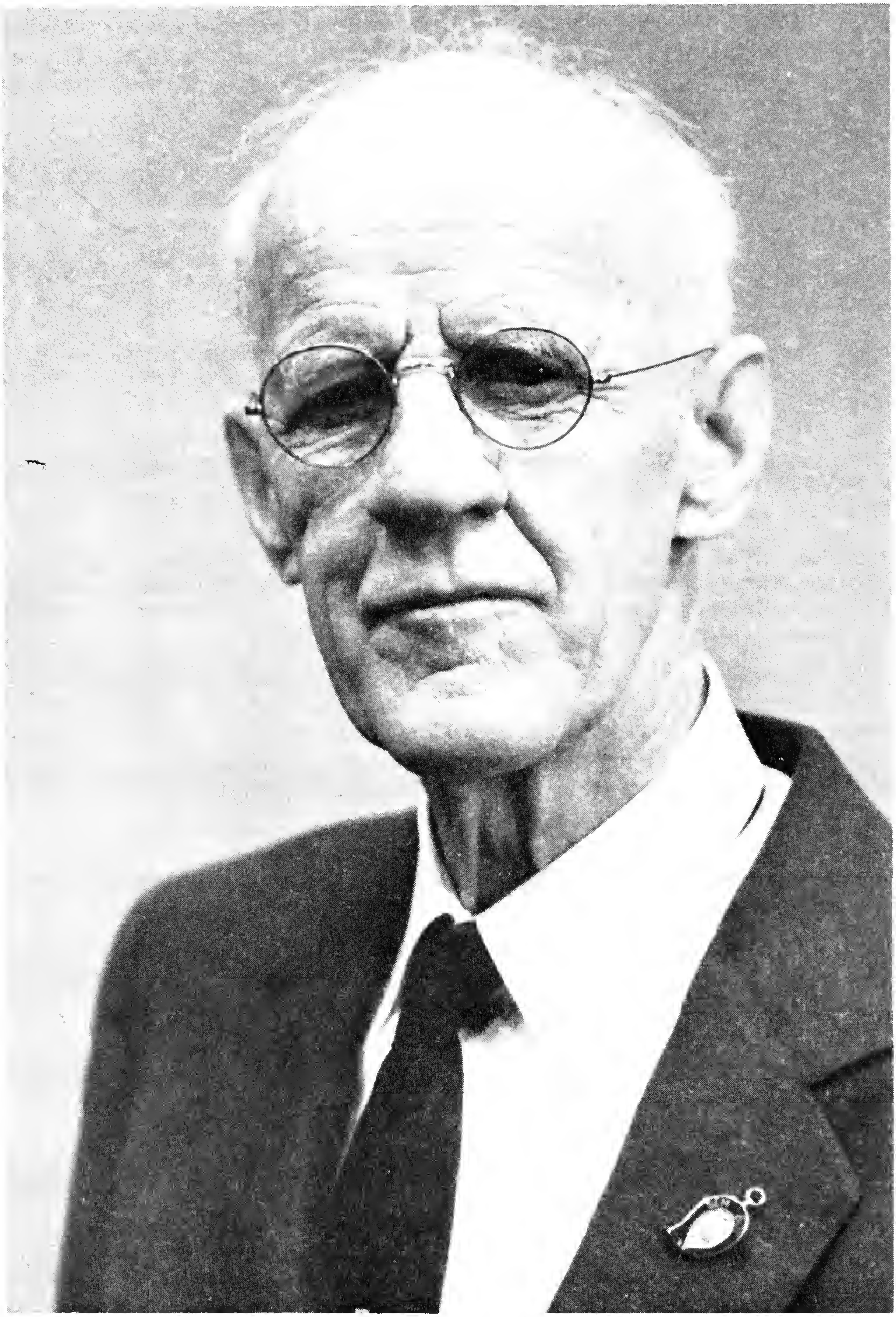

Henry Townsend Darlington, ca. 1956.

HENRY TOWNSEND DARLINGTON — 1875-1964

John H. Beaman
Department of Botany and Plant Pathology,
Michigan State University, East Lansing

A half-century career in Michigan botany ended with the death of Dr. Henry T. Darlington on October 23, 1964. Only three weeks earlier he had seen the first published copy of his book, *The Mosses of Michigan,* a study to which much of his eighth and ninth decades were dedicated.

Henry Townsend Darlington was born in West Chester, Pennsylvania on June 23, 1875, the son of Thomas Hillborn and Jane Sellers Paschall Darlington, and grand-nephew of William Darlington, noted botanist, statesman, and physician of West Chester. His parents and their family connections for many years back were of Quaker stock—a faith he followed throughout life. His secondary education was in Friends' School and the State Normal School (now West Chester State College). He was graduated from the latter in 1894 and received a post-graduate degree from the same institution in 1896. His higher education was at the University of Idaho (B. S., 1903) which he entered in 1900 as a sophomore, at Harvard University (M. S., 1911), and the University of Chicago (Ph. D., 1923). He was also enrolled for short periods at the Franklin Institute in Philadelphia and at Colorado College.

While a student at Harvard he met Beulah Clarke of Boston whom he married in 1912. She and their one daughter and three sons survive him. Mrs. Darlington and the children shared his love of nature and were frequent companions on local outings.

Upon completing undergraduate study with a major in mathematics and engineering, during which time he also served as an instructor in mathematics, Darlington spent two years in southern Idaho surveying for irrigation ditches and reservoirs (part of the time as Chief Engineer for the Idaho-Iowa Lateral and Reservoir Company). From 1905 to 1909 he was employed by the Great Western Sugar Company as a civil engineer in Fort Collins, Colorado, and helped construct sugar factories at Fort Morgan and Brush.

His interest in botany developed in youth when he devoted spare moments to identifying plants, using a copy of William Darlington's *Flora Cestrica* which had been handed down to him. But at that time the more "practical" fields of engineering and mathematics seemed to be the only means of earning a livelihood. In the plains of Colorado, however, his interests in natural history were intensified, and he resolved to make the study and teaching of plants his life's work. In 1910 he enrolled in graduate school at Harvard, serving also as an assistant at the Gray Herbarium and working for Professor Oakes Ames in his Botanical Garden. His studies at Harvard were climaxed by participation in the collecting expedition of 1911 to Newfoundland under the direction of Professor M. L. Fernald (see Rhodora 28:49. 1926).

After the expedition he left immediately for the West, taking a position in the Department of Botany at the State College of Washington. Among his friends there were Professor R. Kent Beattie, Dr. H. B. Humphrey, and Dr. and Mrs. Karl Sax. In the summer of 1913 he spent six weeks examining grazing conditions in the Blue Mountains of Washington and Oregon, a study which led to his first published paper.

Darlington's long career at Michigan State University (originally Michigan Agricultural College and later Michigan State College) began in 1914 when he was appointed Assistant Professor of Botany, Director of the Beal Botanical Garden, and Curator of the Herbarium. His academic duties were devoted about half to teaching and the remainder to the Botanical Garden and Herbarium. His courses were in freshman botany, systematics, ecology, phytogeography, trees and shrubs, poisonous plants, economic plants, and aquatic plants; during both world wars he also instructed mathematics. He served with the Botanical Garden until 1930 and continued as Curator of the Herbarium until retirement in 1945.

The three decades of Dr. Darlington's active service coincided with an especially difficult period in the history of the Botany Department and the University. Research support was negligible and his teaching load always heavy. The Herbarium was housed in overcrowded cases in a small basement room without working space. Rarely were funds allocated for herbarium operations and even mounting paper was a scarce commodity. To a man of less gentle and patient spirit, conditions would have been intolerable. In spite of the circumstances he contributed substantially to the academic community as a teacher, lecturer, and researcher. Well-known botanists who were his students include Drs. H. J. Oosting, E. C. Ogden, and J. R. Reeder. For special public lectures his favorite topics were conservation, wild flowers, and weeds. His research interests, principally along ecological and phytogeographic lines, are evident from the bibliography, but not listed there are a considerable number of unpublished papers including a 292-page manuscript on "Climatic patterns and their application to plant geography."

During his first ten years in Michigan, Darlington traveled widely in the State, sometimes on extended "walking trips," collecting and observing the vegetation. In the summer of 1915 he walked from Kalamazoo to Allegan and Holland to Muskegon where he was joined by Dr. E. A. Bessey. They continued by foot to Casnovia, Newaygo, Howard City, and part of the distance to Big Rapids. In August, 1916, they made another walking trip down the Muskegon valley in Roscommon, Missaukee, Clare, and Osceola counties. He spent two or three weeks in 1917 collecting with C. K. Dodge in Berrien County. In August, 1919, Darlington and Bessey botanized intensively in Gogebic County, and in

June, 1920, he spent two weeks in the vicinity of Ironwood. On this trip he was also in Baraga County for a short time. In the summers of 1922-23 he studied the vegetation and collected in the Porcupine Mountains. His field work between 1915 and 1923 netted approximately 3,000 collections which are deposited in the Michigan State University Herbarium. On the labels of many of these specimens the names of Darlington and Bessey are abbreviated "H. T. D." and "E. A. B."

Darlington's work in the Porcupine Mountains provided the basis for his Ph. D. thesis, "An ecological survey of the Porcupine Mountains, Michigan," done under the direction of Dr. H. C. Cowles. His graduate study at the University of Chicago was sandwiched between academic duties and summer field work, with a leave of absence in the winter of 1922 enabling him to complete requirements for the degree.

In addition to his study of Michigan's native vegetation and flora, Darlington was much interested in weed species. For 45 years, beginning in 1915, he continued the experiment started in 1879 by Professor W. J. Beal on germination of buried weed seeds. He was in charge of weed identification for the public and kept an extensive record of weed occurrence based upon this material. He also participated in "weed train" trips, reminiscent of political whistle stops, to consult with Michigan farmers about weed problems.

His interest in mosses began about 1920 (Darlington, 1964, p. 4) and for a number of years was a pleasant avocation during summers at his cottage on Glen Lake in Leelanau County. Upon retirement he was finally able to pursue the project in earnest. Most of his writing of the book on mosses was done between 1950 and 1958, but six more years were required for contracting the publisher, making revisions, and printing. Until about two years ago he came regularly to the Herbarium every morning, working quietly at his table in a corner of the room. His visits became less frequent only because he was weakened by cancer. I once offered him a new binocular dissecting microscope to replace the monocular instrument he had long used. He politely declined with the explanation that the binocular feature was unnecessary because he had lost the sight of one eye several years ago. Much of the work in revising the manuscript and reading proof was carried on with these handicaps.

Seeing *The Mosses of Michigan* to completion was perhaps the greatest honor to which this modest man aspired, and it is a fitting tribute to his perseverance. He was honored in other ways, however. In 1963 the portion of the Michigan State University Herbarium concerned with vascular plants was officially designated by the Board of Trustees as the Beal-Darlington Herbarium (the name was originated in the early 1950's by Dr. Charles L. Gilly, who was then Curator). At this time also he was given the title of Herbarium Associate in Bryophytes. Earlier honors included membership in Phi Beta Kappa and Sigma Xi. He was a fellow in the American Association for the

Advancement of Science, a member of several professional societies, and in 1922 was Vice-president (Botany) of the Michigan Academy of Science, Arts, and Letters.

ACKNOWLEDGMENT

I am indebted to Mrs. Darlington for supplying information and especially for making available an autobiographical essay "The First Forty Years," which Dr. Darlington wrote for his children.

PUBLICATIONS OF HENRY T. DARLINGTON

1915

A study of grazing conditions in the Wenaha National Forest. Wash. Agr. Exp. Sta. Bull. 122. 18 pp. + 7 fig., 1 map.

1917

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1919

Weed immigration into Michigan. Rep. Mich. Acad. 20 (for 1918): 261-267.

1921

Distribution of the Orchidaceae in Michigan. Rep. Mich. Acad. 21 (for 1919): 239-261, + 1 pl.

Contributions to the flora of Gogebic County, Michigan. Part I. Rep. Mich. Acad. 22 (for 1920): 147-176.

1922

Dr. W. J. Beal's seed-viability experiment. Am. Jour. Bot. 9: 266-269.

1923

The introduced weed flora of Illinois. Trans. Ill. Acad. 15: 171-184.

Contributions to the flora of Gogebic County, Michigan. Part II. Pap. Mich. Acad. 1: 74-82.

1927

Weeds and their seeds. Mich. Agriculturist 6 (5): 10, 20.

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Vegetation of the Porcupine Mountains, northern Michigan. Part I. Ecology. Pap. Mich. Acad. 13: 9-65 + 27 pl. [For abstract see Univ. Chicago, Abstr. of Theses, Science Series 2: 261-264].

The 50-year period for Dr. Beal's seed viability experiment. Am. Jour. Bot. 18: 262-265.

1933

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1937

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1938

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1939

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Some important Michigan weeds. Mich. Agr. Exp. Sta. Special Bull. 304. 216 pp. (with E. A. Bessey and C. R. Megee). [First revision, 1945; second revision, 1951].

Some vegetational aspects of Beaver Island, Lake Michigan. Pap. Mich. Acad. 25: 31-38 + 1 map, 3 pl.

1941

The sixty-year period for Dr. Beal's seed viability experiment. Am. Jour. Bot. 28: 271-273

1945

Taxonomic and ecological work on the higher plants of Michigan. Part I. A brief account of the Mcihigan flora and botanical survey. Part II. Bibliography. Mich. Agr. Exp. Sta. Tech. Bull. 201. 59 pp.

1946

Contributions to the botany of Michigan by Oliver Atkins Farwell. Ann. Rep. Mich. Acad. 48: 69-74 + 1 pl.

1951

The seventy-year period for Dr. Beal's seed viability experiment. Am. Jour. Bot. 38: 379-381.

1961

The eighty-year period for Dr. Beal's seed viability experiment. Am. Jour. Bot. 48: 321-325 (with G. P. Steinbauer).

1964

The mosses of Michigan. Cranbrook Inst. Sci., Bull. 47. xii + 212 pp. + 147 fig.

MUSHROOMS ON PARADE

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Two constantly recurring questions about mushrooms are how many there are, and how many kinds one can find in a day's collecting. The answer to the first question is that some 1500 or more species occur in Michigan and more than twice that many in the United States as a whole. The answer to the second question ranges from none up to an unknown figure, but the question was answered in part by the experience of a mushroom identification class conducted by Dr. Alexander H. Smith in the fall of 1963. During the fall collecting period when both rainfall and temperature are in the normal range, mushroom identification classes often bring in 100-150 kinds of fleshy fungi as a result of a half day's collecting. However, during the fall of 1963 two records were established for such classes, one for the largest number of species ever displayed in one day, and the other, two weeks later, for both the smallest number of species and the poorest specimens.

The previous record number of a collection made in Michigan in a single day's collecting was made in September, 1958, when the Michigan Botanical Club had a camp-out at the University of Michigan Biological Station at Douglas Lake near Pellston, Michigan. At that time 243 species were put on display; many of these were abundant, in prime condition, and excellent for eating.

In September, 1963, during the third weekend, members of the class in mushroom identification at the University Center for Adult Education in Detroit and the similar class at Delta College were joined by members of the NSF Teacher's Institute at Northern Michigan University, several mycologists from Michigan State University and the University of Michigan, and others interested in a marathon collecting trip. The headquarters were again at the University of Michigan Biological Station. Some 100 persons of various ages participated in the search.

The organized part of the collecting was Saturday afternoon and it was during that period that the bulk of the collections were made. The morning was rainy and unpleasant; in fact, two tornado funnels were sighted at a distance. In spite of this, a few intrepid collectors went out and found excellent material. The afternoon was one of those times one dreams about—clear blue skies, sunny crisp air with the fragrance of fall, and pleasantly warm—ideal for a collecting trip. The caravan of collectors went to Reese's Bog at the head of Burt Lake, where the hunters scattered in all directions. Others did not join the caravan but went their separate ways. Long before the scheduled three hours were up, people were streaming back to the laboratory with overflowing baskets. In addition to the material collected in that area a quantity of specimens were brought down from the Upper Peninsula by

Mrs. Ingrid Bartelli of the Michigan State Extension Service, and a number of class members brought small amounts of material from southeastern Michigan.

The total amount of material gathered was impressive, as was the total number of species of fleshy fungi represented. When the tabulation was completed, 320 species were listed. An additional 17 kinds were collected the following Monday morning near the Station grounds. It was evident that these additional species had been in good condition the previous Saturday, so it is clear that it would have been possible to see 337 species in the area that weekend.

In the laboratory, tables were assigned for various families and genera. As soon as the baskets were looked over and identifications checked, the collectors placed their material on the appropriate table. By late afternoon the laboratory presented a colorful and striking sight. Many species were present in great abundance, but several were represented by only a few specimens. There was a remarkable variety of form and color. By studying the material on the various tables one could see not only the wide range in variation within a single species, but also how the species of a genus differed from each other, and what characters united the genera into families. The table reserved for *Amanita* had contributions from nearly every collector since no one could resist the beauty of the destroying angel (*A. virosa*).

Seldom, if ever, in Michigan have so many species been displayed at one time. During the various spring mushroom festivals much greater amounts of mushrooms are collected but this large volume consists of only a few kinds of morel. Even in other states where mushrooms are usually more abundant than in Michigan such a large number of species is not commonly found at one time. The Oregon Mycological Society presented its 15th Mushroom Show in October, 1964, a poor collecting season for that area, and had 275 named species, a record number for that excellent annual exhibit.

The specimens at the Biological Station that September weekend represented more species than would be learned in the average course in mushroom identification. The finding of so many kinds in such a short period in an area that is so well collected during the summer presents a striking contrast when it is compared with the collections made by the Biological Station class in fleshy fungi during the 1963 summer session. That summer was dry and poor for fungi. During the eight-week period the students were required to learn spot recognition of only about 100 species, and about 175 more were seen too infrequently to learn. However, most summers a little over 300 species are readily found. Another contrast and big disappointment was in store for the members of the Detroit class when they had their last field trip of the season two weeks later in southeastern Michigan. Diligent searching in bone-dry woods yielded only some 30-35 mostly dessicated collections. This well illustrates the unpredictability of mushroom hunting.

The conditions responsible for this great difference in the abundance of mushrooms, of course, are attributable to the weather. During the summer of 1963 conditions were very dry and there was the smallest fruiting of fleshy fungi in the Biological Station area since the mushroom class was started in 1946. The drought was broken by numerous rains which started just after the session closed in mid-August, and it continued to be rainy for about a month, thus causing an exceptional mushroom break in September. These rains were confined to the northern part of the state. An interesting result of this unusual rain pattern was the peculiar aspect of the mushroom collections. The majority of species on display were those usually found in the summer in that area, and the typical fall kinds were either lacking or poorly represented. Apparently the summer fruiting was retarded by the drought and when conditions for fruiting became favorable later on the result was an abundance of fruiting bodies.

Of the 54 species of fungi included in the Michigan Botanical Club's publication *Some Common Mushrooms of Michigan's Parks and Recreation Areas* 35, or 64%, were on display, as were 82 species, or 42%, of the 188 species included in *The Mushroom Hunter's Field Guide* (Rev. Ed.). In addition to such well known and common species some 20-30 valuable scientific records were made of new, unusual, or interesting fungi. It is seen that anyone learning all the species found that weekend would have been well on the way to a good start on the study of the fleshy fungi of Michigan.

Of the total species included, 84 are rated as edible, several being considered choice. About twenty are known to be poisonous. The remaining species are in between, poor in flavor or texture, too small to be worthwhile as food, or their edibility is unknown. These figures make it appear that the mycophagist (mushroom eater) as well as the mycologist (mushroom student) had a field day, as indeed a few did. However, as often happens, figures are misleading, and of the edible species reported only about five were found in quantity. The honey mushroom, *Armillaria mellea,* was quite abundant, but many of the specimens were too old to eat. The much more robust *A. ponderosa* was found in sufficient quantity to eat by a single collector. *Boletus aurantiacus* (orange bolete) was in many baskets, but most specimens were riddled with worm holes. Some collectors found enough chanterelles for a meal or two, but most years these would be very abundant. The clublike *Clavaria truncata* was quite abundant and a number of other coral fungi were found in quantity sufficient to eat. A number of collectors had good amounts of the peculiar *Rhodophyllus abortivus* which in addition to normal caps produces odd irregular fleshy lumps of tissue. The clean-looking but generally characterless *Rozites caperata* was gathered in all stages of development by numerous collectors, most of whom were destined to disappointment on cleaning the specimens to find even the buttons riddled with worm holes. Delicious lactarius, *Lactarius deliciosa,* and the closely similar *L. thyinos* were represented by only a few old specimens though these species are usually quite abundant in September. Few puffballs were found in prime condition for eating (white clear through) and the single specimen of the giant puffball was an olive-yellowish brown throughout. The frustrated mycophagists had to console themselves with the thought that they had learned a lot of species, knowledge which could be used in the future but which did not net a meal at once. Those whose object was to learn to recognize mushrooms in general had more than they could assimilate at once!

The most beautiful and probably most collected genus was *Amanita.* Nine species were displayed. The fly agaric, *Amanita muscaria,* which is usually the commonest poisonous mushroom in Michigan, was present in less abundance than in most Septembers and was not as much collected as the destroying angel. Another genus which included a large number of poisonous species was *Lactarius.* There were five poisonous species of *Lactarius* but also four edible ones. Other poisonous species were distributed in various genera: *Tricholoma, Russula, Panus, Hebeloma,* and *Clavària.*

The identifications in the following list were made by Dr. Alexander H. Smith and represent field identifications. Those species which were not readily identified in the field are not enumerated. For this reason the total number of species listed is less than the total mentioned in the text. The asterisk (*) identifies species which are reputedly edible; the letter P designates those known to be poisonous. In this list, the sequence of genera is essentially the same as in *Keys to Genera of Higher Fungi* by Smith & Shaffer.

Elaphomyces cervinus
Cordyceps capitata
C. ophioglossoides
Hypomyces aurantiacus
H. hyalinus
H. lactifluorum
Leotia lubrica
L. stipitata
Helvella crispa
H. infula
H. lacunosa
H. mitra
Pseudohydnum helvelloides*
Phlogiotis gelatinosum*
Cantharellus cibarius*
C. infundibuliformis
C. lutescens*
C. tubaeformis
Craterellus cornucopioides*
C. lutescens
Clavaria aurea*
C. botryoides*
C. cinerea*
C. corniculata
C. flava*
C. flavescens*
C. formosa P
C. fumosa*
C. kunzei*
C. ligula*
C. pistillaris*
C. pulchra
C. stricta
C. truncata*
Dentinum repandum*
D. umbilicatum*
Hericium coralloides*
H. ramosum*
Hydnellum caeruleum
H. diabolis

Phellodon albonigricans
Steccherinum septentrionale
Laetiporus sulphureus*
Lentinellus omphalodes
Panus stipticus*
P. torulosus
Pleurotus geogineus
P. nidulans
P. ostreatus*
P. petaloides
P. porrigens*
P. serotinus
P. tremulus
Armillaria mellea*
A. ponderosa*
A. robusta
Leucopaxillus candidus
L. paradoxus
L. tricolor*
Laccaria amethystina*
L. laccata*
L. tortilis
L. trullisata*
Lepista cespitosa*
L. nuda*
L. truncata*
Lyophyllum decastes*
L. unifactum*
Collybia acervata
C. butyracea*
C. conigena
C. cookei
C. distorta
C. familea*
C. maculata
C. tuberosa
Clitocybe aurantiaca
C. adirondakensis
C. candicans
C. clavipes
C. cyathiformis
C. ectypoides
C. gibba
C. harperi
C. robusta
C. sinopica
C. striaepilea
Tricholoma albobrunneum
T. aurantium
T. flavobrunneum
T. flavovirens
T. fumosiluteum
T. michiganense
T. myomyces
T. pardinum P
T. sejunctum
T. sulphurescens
T. sulphureum
T. terreum
T. vaccinum
T. virgatum
Mycena atroalboides
M. delicatella
M. galericulata
M. haematopus
M. inclinata
M. maculata
M. olida
M. rosella
M. roseopallens
M. semivestipes
M. stannea
M. strobilinoides
Marasmius confluens
M. oreades*
M. rotula
Hygrophorus acuticonicus
H. acutoides
H. agathosmus
H. borealis
H. chrysaspsis
H. chrysodon*
H. camarophyllus*
H. cossus
H. cuspidatus
H. discoideus
H. erubescens*
H. flavescens
H. fuligineus
H. laetus
H. paludosus
H. perplexus
H. piceae
H. pratensis*
H. psittacinus
H. pudorinus*
H. puniceus
H. reaii
H. russula
H. sordidus
H. speciosus
H. tephroleucus
Amanita brunnescens P
A. citrina P
A. flavoconia P
A. fulva
A. magnivelerius P
A. muscaria P
A. porphyria P
A. vaginata
A. virosa P

Limacella illinita
Volvariella hypopithys
Pluteus cervinus var. scaber*
P. longistriatus
P. magnus*
P. tomentosulus
Lepiota americana
L. cristata
L. fuscosquamea
L. naucina*
Leucocoprinus cepastipes
Rhodophyllus abortivus*
R. albogriseus
R. griseoviolaceus
R. lividus
R. sinuatus
Agaricus haemorrhoidarius
A. sylvicola
Stropharia hornmanni
Hypholoma capnoides*
H. elongatum
H. sublateritium*
Coprinus atramentarius*
C. comatus*
C. lagopus
C. micaceus*
Psathyrella hydrophila
Naucoria limulatus
Inocybe decipiens
I. geophylla var. lilacina
I. subtomentosus
Hebeloma crustuliniforme P
H. sinapizans P
Cortinarius acutus
C. alboviolaceus
C. anomalus
C. armillatus
C. atkinsonianus
C. caninus
C. croceifolius
C. corrugatus
C. delibutis
C. laniger
C. leucorum
C. multiformis
C. obtusus
C. pholideus
C. rigidus
C. semisanguineus
C. spilomeus
C. splendidipes
C. trivialis
Galerina vexans
Rozites caperata
Pholiota curvipes
P. lenta
P. spumosa
Paxillus atrotomentosus
P. involutus*
Lactarius affinus
L. chrysorheus P
L. deceptivus
L. deliciosus*
L. fumosoides
L. griseus
L. helvus
L. hibbardae
L. maculatus
L. nigroviolascens
L. paradoxiformis*
L. parvulus P
L. representaneus P
L. resimus P
L. rufus
L. subpurpureus*
L. thyinos*
L. torminosus
L. trivialis P
L. uvidus P
Russula aeruginea*
R. delica*
R. dissimulans
R. emetica
R. foetens
R. fragilis
R. integra*
R. lepida*
R. paludosa*
R. palumbina
R. placita
R. simillima
R. subdepaulens
R. variata*
R. veternosa P
R. xerampelina
Chroogomphus rutilus*
C. vinicolor*
Boletus aurantiacus*
B. chromapes*
B. cyanescens*
B. edulis*
B. felleus
B. miniato-olivaceous
B. niveus*
B. piperatus
B. retipes
B. scaber*
B. subglabripes*
B. subtomentosus*
B. subvelutipes

B. variipes
Fuscoboletinus aeruginescens*
F. spectabilis*
Suillus acidus
S. albidipes*
S. americanus*
S. brevipes*
S. cavipes*
S. granulatus*
S. pictus*
S. punctipes*
S. subaureus
S. tomentosus*
Calvatia gigantea*
Cyathus striatus
Geastrum saccatum
Lycoperdon perlatum*
L. pyriforme*
L. umbrinum*
Scleroderma flavidum
S. macrorhizon
S. vulgare

A PREVIOUSLY UNDESCRIBED SPECIES OF *PLUTEUS* FROM MICHIGAN

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and Upper Peninsula Extension Center, Marquette

In connection with a detailed study of the mushrooms occurring on specialized habitats in the Upper Peninsula, considerable attention has been paid to the species occurring on sawdust piles both to study the variation presumed to be caused by the habitat and to inventory the species adjusting to it. The species described below is one of the more interesting finds made to date.

PLUTEUS ATROPUNGENS sp. nov.

Pileus 4-10 cm latus, subumbonatus, siccus, fibrillosus, ad marginem subrimosus, atrobrunneus, sapor distinctissimus; odor pungens; lamellae atro-marginatae; stipes 6-16 cm longus, 1-2 cm crassus, atrobrunneus; sporae 7-8 x 5-5.5 μ; pleurocystidia 50-80 x 10-20 μ; cheilocystidia 40-70 x 12-20 μ; hyphae fibulatae. Typus: Smith 62033; legit Ingrid Bartelli. (MICH).

Pileus 4-10 cm broad, convex to obtusely umbonate, surface dry and appressed fibrillose, near the margin tending to become rimose and showing the pale flesh, scurfy near and over the disc, color blackish to "mummy-brown" over all until the cuticle separates showing the pallid context; context pale dingy buff with a dark line near the cuticle and another just above the gills, rather punky in texture, odor strongly pungent on crushed context, taste very disagreeable.

Lamellae free, somewhat remote, close, broad, free, faces gray to dingy pallid when young, vinaceous in age, edges blackish brown.

Stipe 6-10 cm long, 1-2 cm thick at apex, solid, equal, dingy buff within drying pallid, surface colored like the pileus over all, or paler near the apex, dull and unpolished to scurfy.

Spores 7-8 x 5.5.5 μ varying to globose and 6-7 μ, at times obscurely angular, sterigmal appendage prominent on the globose to subglobose spores, pinkish in KOH, wall somewhat thickened. Basidia 23-27 x 6-8 μ, 2- and 4-spored, clavate when young, becoming fusoid and sterigmata developing at apex, hence at maturity broadest below the apex, hyaline and granular in KOH. Pleurocystidia abundant, 50-80 x 10-20 μ, variously shaped: clavate and thin-walled, variously fusoid-pedicellate with pointed apex and wall 0.2-2 μ thick near apex, fusoid-ventricose with thin to thickened walls or the apex truncate and with or without 1-3 weak projections, some misshapened thick-walled (2 μ) cystidia with irregularly ornamented apex also present but rare, all types hyaline in KOH; cheilocystidia 40-70 x 12-20 μ, clavate to fusoid-ventricose with broadly rounded to obtuse apex, smooth, content yellow-brown in KOH; cuticle of pileus of radially arranged hyphae with yellow-brown content (in KOH), the terminal cells tapered to obtuse at apex and measuring 80-200 x 9-23 μ; clamp connections readily demonstrated.

Gregarious on sawdust, Marquette, Michigan, Oct. 20, 1959, Mrs. Ingrid Bartelli (Smith 62033, type).

Pleuteus atromarginatus var. *atromarginatus* differs in the regularly thick-walled pleurocystidia many of which have apical ornamentation, the lack of a distinctive odor and taste, and more cheilocystidia intermediate in size and form between the typical thin-walled clavate cells and the "metuloids."

VARIATION IN *CHELONE GLABRA* IN WISCONSIN (SCROPHULARIACEAE)

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NOMENCLATURE

Salamun, in his study of Wisconsin Scrophulariaceae (1951), accepted the interpretation of *Chelone glabra* L. (Turtlehead) in the definitive treatment of the genus by Pennell (1935, pp. 177-196; 631-632), who recognized four subspecies and forms in the upper Great Lakes region:

1) *Chelone glabra typica*
2) *Chelone glabra typica* forma *tomentosa* (Raf.) Pennell
3) *Chelone glabra linifolia* Coleman
4) *Chelone glabra linifolia* forma *velutina* Pennell & Wherry

The same trinomials in Pennell and Wherry (1929) indicated the rank of variety; the taxa were keyed in a "Key to Species and Varieties." In addition, the terminology "var. *linifolia*" was used in the text. The later work of Pennell (1935) is the most recent comprehensive treatment of *Chelone* and must be reckoned with in detail in reinvestigations into the genus, as it represents many years of research by the greatest expert on Scrophulariaceae. Alas, the primary difference between this treatment and the former (as far as Wisconsin is concerned) is the avowed usage of the trinomial to indicate subspecies. "Names of subspecies are written as trinomials, but those of varieties and forms are preceded by abbreviations denoting their rank." (Pennell, 1935, p. 5). Therefore, using present-day terminology, the taxa should be written as follows:

1) *Chelone glabra* L. ssp. *glabra* forma *glabra*
2) *Chelone glabra* ssp. *glabra* forma *tomentosa* (Raf.) Pennell
3) *Chelone glabra* ssp. *linifolia* (Coleman) Pennell forma *linifolia*
4) *Chelone glabra* ssp. *linifolia*
   forma *velutina* (Pennell & Wherry) Pennell

However, in an obscure footnote (Pennell, 1935, p. 4) it is stated by Pennell that "I do not consider the trinomials appearing in this study to be new combinations." Whether legitimately or not, Pennell nevertheless treated *linifolia* as a subspecies, as he keyed the trinomial out in a "Key to Subspecies" and refers to it in the text as a subspecies. This has resulted in much confusion, the Gray Index listing the following names:

---

[1]Supported by the Research Committee of the University of Wisconsin on funds from the Wisconsin Alumni Research Foundation. Dr. Hugh H. Iltis encouraged the original study and is due special thanks, together with Dr. John Thomson for critically reading the manuscript.

1) *Chelone glabra* spp *typica* Pennell
   Chelone glabra var. *typica* [incorrectly attributed to Pennell by] Deam
2) *Chelone glabra* forma *timentosa* Pennell
3) *Chelone glabra* var. *linifolia* Coleman
   Chelone glabra ssp. *linifolia* [incorrectly attributed to Coleman by] Pennell
   Chelone linifolia Pennell ex Rydberg
4) *Chelone glabra* var. *linifolia* forma *velutina* Pennell & Wherry

In Salamun's Wisconsin treatment, cited above, the subspecies of Pennell are avoided, and the rank of variety is used, so that the nomenclatural question is more or less ignored. He incorrectly attributed forma *tomentosa* to Pennell [rather than to (Raf.) Pennell], but this error originated in the Gray Index, as indicated above.

VARIATION IN CHELONE

Not only has there been nomenclatural confusion as to the proper disposition of *Chelone* in Wisconsin, but, I believe, misinterpretation of the actual variation. I have recently concluded, in conjunction with preliminary studies of the flora of Wisconsin (published regularly in the *Transactions of the Wisconsin Academy of Sciences, Arts, and Letters),* that there is only one kind of *Chelone* in Wisconsin (Fig. 3) and venture to suggest the possibility that only one kind of *Chelone* may be present in the remaining upper Great Lakes region, also. I do not believe that the subspecies or varieties and forms mentioned above are at all well-taken as representations of the variation present in Wisconsin.

Chelone glabra often has leaf blades pubescent beneath, this character having no geographic or taxonomic integrity (rather being sporadic within populations). Wisconsin plants with such pubescence have been referred to forma *tomentosa* if they are thought to be a part of the typical subspecies, and to forma *velutina* if they are thought to fall within subspecies *linifolia*.

Victorian and post-Victorian botanists, as well as many of the Fernaldian school, have applied latin names to "forms" that have been later shown to rest on a simple genetic base, indeed, to be the result of a single allele. Upon reviewing many hundreds of herbarium specimens, it is my considered opinion that the "forms" *tomentosa* and *velutina* are indistinguishable from each other morphologically, while their joint sporadic occurrence suggests a simple genetic base. It seems quite probable that a single gene could be responsible for both of these named forms.

The primary purpose of this paper is not to refute the "forms" that have been named, but rather to question the presence of two subspecies (or varieties) of *Chelona glabra* in the area shown in Fig. 2.

Indeed, the parallel occurrence of the pubescent "forms" originally led to the re-evaluation of the subspecies.

Although Pennell (1935, p. 4) clearly meant his subspecies to be geographic facies of a species, it is clearly evident from the specimens that he cited (all mapped in Fig. 2, except two locations across the boundary line in Canada) that ssp. *linifolia* is entirely within the range of ssp. *glabra,* being no discrete geographic facies at all. If *linifolia* is to be interpreted as a variety in Pennell's 1935 sense (not nomenclaturally, of course, as he called it a subspecies), but certainly not as a variety in Pennell & Wherry's 1929 sense (since variety here was meant to have the geographic nature for which Pennell later used the term subspecies), then it must stand or fall on morphologic grounds.

In the original description (Coleman, 1874) the taxon (as a variety) is distinguished as having leaves 1/4 to 1/3 of an inch wide, with the leaves long, linear, and sparingly toothed. Pennell's delimination of *linifolia* was somewhat broader, allowing the leaves to be up to 20 mm wide. Pennell also added some cryptic corolla differences for separating *linifolia* from the typical subspecies. He stated that the corolla of *linifolia* was "greenish-yellow (at least distally), usually without trace of purple" and that the corolla of ssp. *glabra* was "externally white, internally dull purplish ('daphne pink') within [the] upper posterior lip and on lateral margins of lower lip."

This statement of corolla color of ssp. *linifolia* avoids mention of the 90% or more portion that is white as in ssp. *glabra,* but does at least, allow an occasional trace of purple. The color differences between "white" and "greenish-yellow" come and go among and within Pennell's seven subspecies of *Chelone glabra* to such an extent that their use at all in delimiting taxa might be questioned in the absence of evidence showing strict correlation with other morphological characters. It is unfortunate that the corolla color is always the same on dried specimens (a dirty yellow) regardless of geographic origin, and equally unfortunate that the "Chasing Chelones" trip (written up by Wherry, 1929) of Pennell & Wherry did not extend into the area with which we are concerned. Pennell's color observations were taken from the living plants he encountered in southern Indiana and Ohio in an area where some interbreeding with other subspecies would not be too surprising. I see no indication that Pennell actually used corolla color in determining specimens from Wisconsin and Michigan. He deplored the absence of color-notes on herbarium specimens.

The prime character upon which *linifolia* stands or falls is leaf breadth, and this alone must be used to determine dried material. Pennell's breaking point at 20 mm left something to be desired, and he recognized this, stating that the taxa "are difficult to distinguish sharply in the herbarium" and that "leaf-blades occur [in ssp. *glabra*]. . .as narrow as in *linifolia*." Indeed, Pennell is quite correct in the latter statement [cf. *Seymour 6065* (WIS), from the shrubby fringe of Wekepeke

Pond, Worcester County, Massachusetts, which has leaves distinctly less than 20 mm wide].

The present studies in Wisconsin were all made on the leaf breadth character. Fig. 1 shows the range of variation of leaf measurements of all *Chelone* specimens from Wisconsin in the Herbarium of the Milwaukee Public Museum and in the Herbarium of the University of Wisconsin. On the basis of this scatter-diagram, I can not recognize two distinct subspecies or varieties of *Chelone glabra* in Wisconsin.

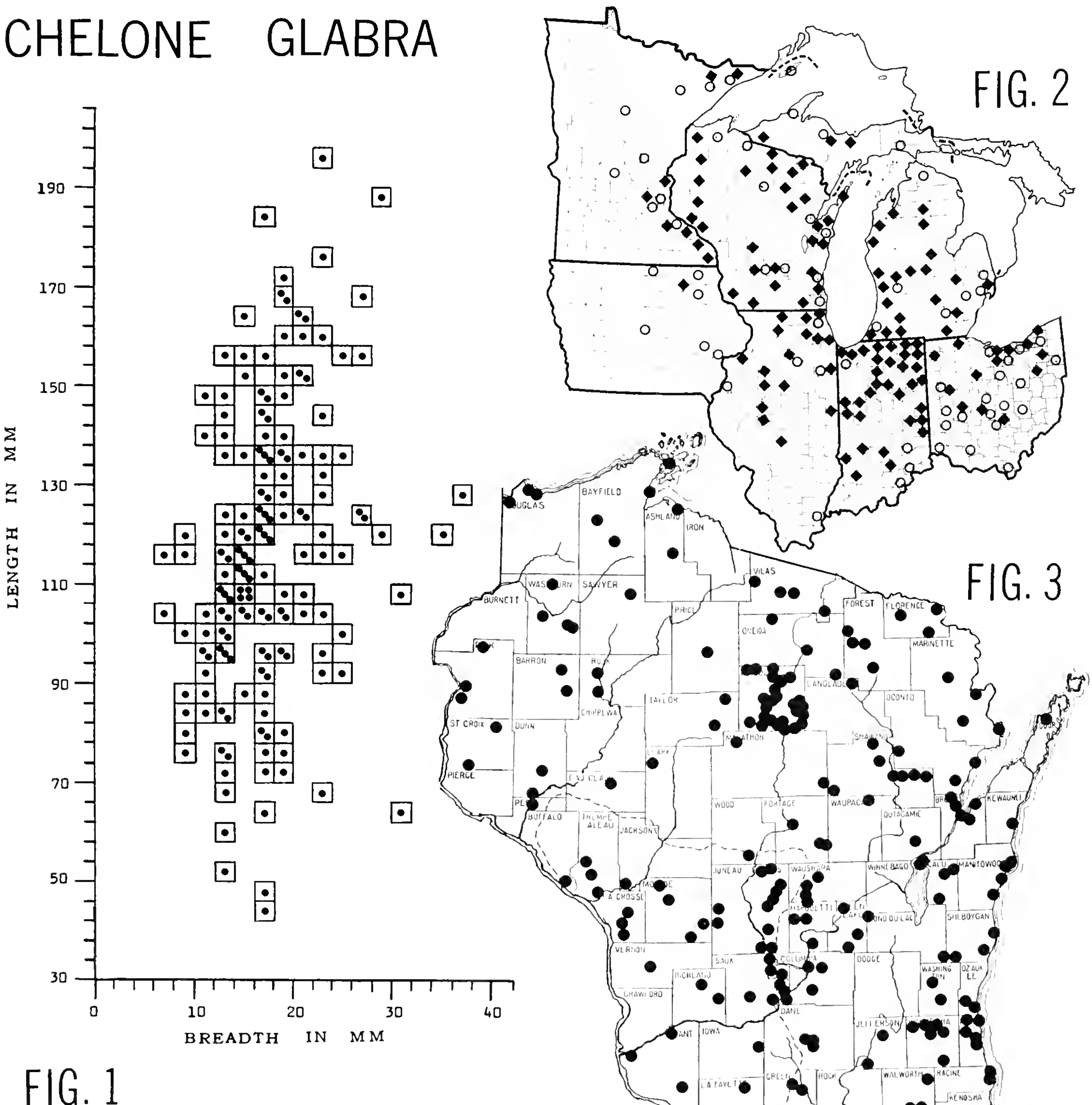

Fig. 1. Scatter-diagram of leaf measurements of *Chelone glabra* in Wisconsin.

Fig. 2. Distribution in the United States of *Chelone glabra* ssp. *glabra* sensu Pennell (diamonds), constructed by mapping the specimens by county only cited in Pennell (1935). Subspecies *glabra* sensu Pennell is mapped for the same area in the same fashion (circles).

Fig. 3. Distribution of *Chelone glabra* in Wisconsin.

I do not question the fact that leaves of *Chelone glabra* tend to be more narrow in the western part of its range, and perhaps the formal recognition of a narrow-leaved subspecies has impressed this on the minds of botanists, but I believe that it is fallacious to grant taxonomic rank when the "taxon" can not be delimited geographically or morphologically.

Without the recognition of formal "taxa" I believe it is easier to discuss the variation of *Chelone glabra* succinctly and more reasonably, at least as far as Wisconsin is concerned, as follows. *Chelone glabra* shows a higher incidence of narrow-leaved individuals in the areas north of the limit of Pleistocene glaciation, at least in the western part of its range. Since the plants, as they occur in such glaciated territory, are certainly immigrant to the territory after the retreat of the ice, and probably have come from regions that have presently a higher incidence of wide-leaved individuals, selection seems to have occurred. It is not unreasonable to believe that the somewhat drier climates in the western part of the range of *Chelone glabra* might confer a selective value to plants with narrow leaves.

LITERATURE CITED

Coleman, N. 1874. Catalogue of Flowering Plants of the Southern Peninsula of Michigan . . . Kent Sci. Inst. Misc. Publ. 2. 49 pp.

Pennell, Francis W. 1935. The Scrophulariaceae of Eastern Temperate North America. Acad. Nat. Sci. Phila. Monogr. 1. 650 pp.

Pennell, F. W., & E. T. Wherry. 1929. The genus Chelone of eastern North America. Bartonia 10: 12-23.

Salamun, Peter J. 1951. Preliminary reports on the flora of Wisconsin. XXXVI. Scrophulariaceae. Trans. Wis. Acad. 40: 111-138.

Wherry, Edgar T. 1929. Chasing Chelones. Bartonia 10: 1-11.

MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

The aim of this section is to list all significant literature relating to Michigan botany published since the beginning of 1960, without attempting much coverage of related fields such as agriculture, conservation, and forestry. When the subject matter or relation to Michigan is not clear from the title, annotations are added in brackets.

A. MAPS, SOILS, GEOGRAPHY, GEOLOGY

Guide to Fun in Michigan. Clarkson Map Co., Kaukauna, Wisconsin. 1965. 128 pp. $3.00. ["Available for just $3 from Michigan United Conservation Clubs, P.O. Box 2235, Lansing, Mich. 48911" according to a January MUCC news article, or for $3.00 plus tax plus 30¢ for postage and handling, according to a MUCC advertisement. At either price, this 11 1/2 x 16 inch book is a bargain. The major portion consists of county maps for the entire state; with a few updatings, these are largely the same as those distributed by the Conservation Department—with two major exceptions: They do not show section lines and section numbers, and they do not indicate public ownership (a note stating that such maps are available from Lansing might have been helpful). They do show conservation project boundaries, boundaries of dedicated natural areas on state lands (!), recreation facilities, and routes for "color tours" (an airplane is evidently required for the cross-country route mapped between Plymouth and Dearborn!). Helpfully associated with each map is an index to lakes for the county and a list of water access sites.

A list of "Michigan Campsites" is a bit erratic in use of "U.P." for only some Upper Peninsula sites and Wilderness State Park is erroneously listed in Cheboygan Co (and apparently as lacking swimming or boat launching sites and water). Much additional outdoor information is included on common trees, animals (admitting the ambiguities of "common names," the insect shown as a "lightning bug" [= firefly to most people] is an "electric-light bug"), beach stones (by no means "all Michigan's semi-precious stones," as claimed by MUCC), Great Lakes harbors, etc. While most of the material included has been available free or inexpensively from the Department of Conservation, it is handy to have it gathered together at a fair price.]

B. BOOKS, BULLETINS, SPECIAL REPORTS, AND MISCELLANEOUS

Case, Frederick W., Jr. 1964. Orchids of the Western Great Lakes Region. Cranbrook Inst. Sci. (Bull. 48), Bloomfield Hills, Mich. 148 pp. + 9 color & 24 halftone plates. $7.00 [See review on p. 70.]

Smith, Alexander H., & Rolf Singer. 1964. A Monograph on the Genus Galerina Earle. Hafner Publ. Co., New York. 384 pp. incl. 20 pl. $23.50 [A world monograph, with many species reported from Michigan localities, including types of some new taxa.]

Stapp, William B. 1965. Integrating Conservation and Outdoor Education into the Curriculum (K-12). Burgess Publ. Co., Minneapolis. 93 pp. $2.60 [A report on the outstanding program of the Ann Arbor Public School System, with many practical ideas outlined which would be adaptable elsewhere. Much botanical and zoological material is incorporated.]

C. JOURNAL ARTICLES

Ajello, L., & W. P. Cockshott. 1962. Occurrence of Microsporium cookei in Africa. Mycologia 54: 110-111. [This fungus first isolated from Michigan soil.]

Beaufait, William R. 1961. Crown temperatures during prescribed burning in jack pine. Pap. Mich. Acad. 46: 251-257. [Work chiefly near Grayling.]

Benninghoff, W. S., & K. J. Cramer. 1963. Phytosociological analysis of aspen communities on three site classes for Populus grandidentata in western Cheboygan County, Michigan. Vegetatio 11: 253-264.

Benninghoff, William S. 1964. The Prairie Penninsula as a filter barrier to post-glacial plant migration. Proc. Indiana Acad. 72: 116-124. [Includes observations on vegetational history in Michigan, with pollen data from several Lower Peninsula sites.]

Bowerman, Constance A. 1961. Lycoperdon in eastern Canada with special reference to the Ottawa district. Canad. Jour. Bot. 39: 353-383. [Citations of specimens examined include Michigan localities for several species, though counties are not given, even for obscure localities.]

Bulmer, Glenn S., & Everett S. Beneke. 1961. Studies on Calvatia gigantea. I. Germination of the basidiospores. Mycologia 53: 123-136.

Bulmer, Glenn S., & Everett S. Beneke. 1962. Studies on Calvatia gigantea. II. Factors affecting basidiospore germination. Mycologia 54: 34-43. [Material studied in this paper and the preceding came in part from Michigan.]

Cain, Roy F. 1961. Studies of coprophilous ascomycetes VIII. Preussia. Canad. Jour. Bot. 39: 1633-1666. [Type culture of *P. dispersa* cited from East Lansing.]

Clewell, Andre F. 1964. The biology of the common native Lespedezas in southern Indiana. Brittonia 16: 208-219. [Distribution maps include Michigan counties for *L. hirta* ssp. *hirta, L. intermedia,* & *L.* x *nuttallii*.]

Cook, Philip W. 1963. Host range studies of certain Phycomycetes parasitic on desmids. Am. Jour. Bot. 50: 580-588. [Much of the material studied was of Michigan origin.]

Cooke, Wm. Bridge. 1961. The genus Schizophyllum. Mycologia 53: 575-599. [*S. commune* in Michigan.]

Gilbertson, Robert L. 1962. Resupinate hydnaceous fungi of North America. I. Type studies of species described by Peck. Mycologia 54: 658-677. [Record of *Odontia separans* from New Richmond is questioned.]

Gilkey, Helen Margaret. 1961. New species and revisions in the order Tuberales. Mycologia 53: 215-220. [*Stephensia shanori* is cited from Ann Arbor.]

Golley, Frank B. 1960. Energy dynamics of a food chain of an old-field community. Ecol. Monogr. 30: 187-206. [Study in Ingham Co. includes analysis of plant species.]

Griffin, J. E., F. K. Sparrow, & R. M. Johns. 1961. A Physoderma on Agropyron repens. Am. Jour. Bot. 48: 539. [Abstract. Found in Michigan.]

Hall, Marion Trufant. 1961. Teratology in Trillium grandiflorum. Am. Jour. Bot. 48: 803-811. [Study of freaks in Oakland Co.]

Hodges, Charles S. 1962. Comparison of four similar fungi from Juniperus and related conifers. Mycologia 53: 62-69. [*Stigmina juniperina* cited from Ann Arbor.]

Jones, Robert L., L. J. McKenzie, & A. H. Beavers. 1964. Opaline microfossils in some Michigan soils. Ohio Jour. Sci. 64: 417-423. [Includes data from various sites on opaline phytoliths, taken as indicators of grass production.]

Kammeraad, Jack W., & Richard Brewer. 1963. Dispersal rate and elm density as factors in the occurrence of Dutch Elm Disease. Am. Midl. Nat. 70: 159-163. [A study in Ottawa Co.]

Maher, Louis J., Jr. 1964. Ephedra pollen in sediments in the Great Lakes region. Ecology 45: 391-395. [Includes 2 Michigan sites among the reports evaluated.]

Maycock, P. F., & J. T. Curtis. 1960. The phytosociology of boreal conifer—hardwood forests of the Great Lakes region. Ecol. Monogr. 30: 1-35. [Several of the stands sampled were in Michigan.]

Miller, Harvey A. 1964. Ohio liverworts. Ohio Jour. Sci. 64: 177-184. [Several of the species in this Ohio list are said also to be reported (or not reported) from Michigan.]

Moore, R. J., & C. Frankton. 1962. Cytotaxonomic studies in the tribe Cynareae (Compositae). Canad. Jour. Bot. 40: 281-293. [Includes count of 2n = 34 on *Cirsium palustre* from Alger Co.]

Motyka, Józef. 1964. The North American species of Alectoria. Bryologist 67: 1-44. [The lichen *A. nidulifera* is cited from Otsego, Emmet, & Delta counties.]

Mulligan, Gerald A., & Clarence Frankton. 1962. Taxonomy of the genus Cardaria, with particular reference to the species introduced into North America. Canad. Jour. Bot. 40: 1411-1425. [*C. pubescens* cited and mapped from Ypsilanti.]

Norstog, Knut. 1963. Apomixis and polyembryony in Hierochloë odorata. Am. Jour. Bot. 50: 815-821. [Ann Arbor was a chief source of material.]

Payne, Willard W. 1964. The ragweed problem in the eastern and central United States. Ward's Bull. 3(21): 1,6 (May). [Includes pollen observations made at Ann Arbor; we hope that this popular article will aid in reducing the slander heaped upon goldenrod, too often accused of fall hay-fever.]

Piehl, Martin A. 1963. Mode of attachment, haustorium structure, and hosts of Pedicularis canadensis. Am. Jour. Bot. 50: 978-985. [Field studies in Michigan, especially Cheboygan Co.]

Reid, Derek A. 1963. Notes on some fungi of Michigan—I 'Cyphellaceae'. Persoonia 3: 97-154. [Based largely on collections made in the region of the University of Michigan Biological Station.]

Reid, James & R. F. Cain. 1961. The genus Therrya. Canad. Jour. Bot. 39: 1117-1129. [*T. fuckelii* cited from Cross Village.]

Savile, D. B. O. 1961. Some fungal parasites of Liliaceae. Mycologia 53: 31-52. [Includes record of *Uromyces holwayi* from Ann Arbor on "*Lilium superbum*" (presumably *L. michiganense*).]

Schlichting, Harold E., Jr. 1960. The role of waterfowl in the dispersal of algae. Trans. Am. Micr. Soc. 79: 160-166. [Research conducted in Kalamazoo Co.]

Schlichting, Harold E., Jr. 1961. Viable species of algae and protozoa in the atmosphere. Am. Jour. Bot. 48: 543-544. [Abstract. The collections were made at Port Sanilac.]

Schuster, Rudolf M. 1961. Notes on nearctic hepaticae XVIII. Canad. Jour. Bot. 39: 965-992. [*Lophozia groenlandica* cited from Alger Co. and discussed.]

Schuyler, Alfred E. 1964. A biosystematic study of the Scirpus cyperinus complex. Proc. Acad. Nat. Sci. Phila. 115: 283-311. [Maps and selected citations indicate a few Michigan records, and some of the experimental data are from Cheboygan Co.]

Schuyler, Alfred E. 1964. Notes on five species of Scirpus in eastern North America. Bartonia 33: 1-6. [Includes chromosome count on *S. lineatus* from Washtenaw Co.]

Shaffer, Robert L. 1962. Synonyms, new combinations, and new species in Volvariella (Agaricales). Mycologia 54: 563-572. [Type localities of two new species are in Washtenaw Co.]

Smith, Alexander H. 1962. Notes on astrogastraceous fungi. Mycologia 54: 626-639. [Type locality of *Octavianina brunnea* is Wildwood [Cheboygan Co.].]

Soper, James H., W. G. Dore, & G. Boraiah. 1963. Distribution of rue-anemone and its northern limit in Canada. Canad. Field-Nat. 77: 220-225. [Distribution map includes occurrence across southern Lower Peninsula of *Anemonella thalictroides*.]

Sparrow, F. K., Joyce E. Griffin, & R. M. Johns. 1961. Observations on chytridiaceous parasites of phanerogams, XI. A Physoderma on Agropyron repens. Am. Jour. Bot. 48: 850-858. [Description of a parasite found in Michigan.]

Spiegel, Leonard E., Charles E. Huntly, & Gene R. Gerber. 1963. A study of the effects of elk browsing on woody plant succession in northern Michigan. Jack-Pine Warbler 41: 68-72.

Sprague, Roderick. 1960. Some leafspot fungi on western Gramineae—XIV. Mycologia 52: 698-718. [Includes record of *Colletotrichum graminicola* from *Ammophila breviligulata* near Marquette.]

Review

ORCHIDS OF THE WESTERN GREAT LAKES REGION. By Frederick W. Case, Jr. Cranbrook Institute of Science (Bulletin 48), Bloomfield Hills, Mich., 1964. 148 pp. + 9 color plates + 24 halftone plates. $7.00

As is expected of Cranbrook Institute of Science publications, this is a most attractive book. In place of the usual paper dust cover the jacket is clear plastic, which allows a natural-size full-color photograph of the Fairy Slipper, *Calypso bulbosa*, to be readily viewed. Each of the 52 species of native orchids is illustrated by a photograph, including 17 color photos. All photographs were made in the native habitat of the species and in most instances they show the entire plant as one first sees it growing. This is an aid in gaining a first impression, but in several the flowers are too small to show up effectively and unfortunately, as often happens, the color reproductions are not all that could be desired.

The book includes discussions of the orchid family, the origins and distribution patterns of the species in this region, their ecology, and also suggestions for growing native orchids. There is a key to genera, and following each generic description are keys to the species of the region. To supplement the keys, small line drawings accompany them, with arrows used to point out the diagnostic characters mentioned (and some not mentioned). The species descriptions are well written and informative. General observations from the author's personal experience add much to the value of the book. General distribution is indicated in the text, and distribution by counties is shown on maps which include all of Michigan and Wisconsin plus portions of adjacent states and Ontario. A short bibliography of selected titles is included. A glossary and two indices (a combined one would have sufficed) conclude the book.

Such statements as "plants grouping themselves," "the plant shuns," and "it confines itself" seem to imply more self-direction on the part of the plant than most botanists will accept. The author is well known to most Botanical Club members not only for his work with wild orchids but also for his beautiful wild flower garden and his magnificent collection of exotic orchids. Any one interested in the orchids of this area should have a copy of this book.

—Helen V. Smith

PROGRAM NOTES

IMPORTANT MICHIGAN BOTANICAL CLUB DATES:

April 25: Annual Meeting. University of Michigan Botanical Gardens, and Horner's Woods.

May 28-31: Campout. In the Upper Peninsula this year.

Watch our newsletters and announcements for details on these and other forthcoming events.

OTHER DATES:

March 19-20: 69th Annual Meeting of the Michigan Academy of Science, Arts, & Letters, at the University of Michigan, Ann Arbor. Botany section meets Friday in Rackham Amphitheater; Saturday morning, in 2082 Natural Science Building.

April 28-30: Clara B. Ford Garden Forum, at Henry Ford Museum and Greenfield Village, Dearborn, Michigan.

Editorial Notes

The editor is always looking for good black and white photographs suitable for use as cover pictures in THE MICHIGAN BOTANIST.

The January number (Vol. 4, No. 1) was mailed January 8, 1965.

SOME NOTES ON CIRCULATION POLICIES

Prices of back numbers are listed on the inside front cover. These rates apply to members and non-members alike (only one subscription at a reduced rate is included in current membership dues). A discount of 20% is allowed on orders for 20 or more copies (the same or different) sent at one time to the same address. No other discounts are allowed to agents, libraries, etc.

All orders for back numbers and inquiries regarding non-member subscriptions should be sent to the business and circulation manager (not to the editor!). All remittances should be made payable to The Michigan Botanist.

Subscriptions from non-members of the Michigan Botanical Club received prior to the last number of a volume will be understood to begin with the first number of that volume, unless specified to the contrary, and back issues for the year will therefore be sent.

Since the Botanical Club does not maintain a library, THE MICHIGAN BOTANIST is not offered in exchange for other publications. In some instances, however, exchange arrangements can be made through the University of Michigan General Library, which has entered several subscriptions for exchange purposes.

CONTENTS

(On the cover: Longitudinal section of a mushroom spore (Lepiota naucina), *showing the germ pore. Magnification about 15,000 times. Electron micrograph by Robert J. Lowry.)*

Vol. 4, No. 3

THE MICHIGAN BOTANIST

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THE MICHIGAN BOTANIST—Published by the Michigan Botanical Club four times per year: January, March, May, and October. Second-class postage paid at Ann Arbor, Michigan.

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Subscriptions (from those not members of the Michigan Botanical Club) and all orders for back issues should be addressed to the business and circulation manager, who will assume that subscriptions received prior to the last number of a volume are intended to begin with the first number of that volume unless specified to the contrary.

Articles and notes dealing with any phase of botany in the Upper Great Lakes Region may be sent to the editor in chief. The attention of authors preparing manuscripts is called to "Information for Authors" (Vol. 4, p. 38, and also available from the editor).

THE MICHIGAN BOTANICAL CLUB

Membership in the Michigan Botanical Club is open to anyone interested in its aims: conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on the plant life of the State; sponsorship of legislation to promote the preservation of Michigan native flora and to establish suitable sanctuaries and natural areas; and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

Dues are modest, but vary slightly among the chapters. In all cases, they include subscription to THE MICHIGAN BOTANIST.

STUDIES OF ROOT PARASITISM IN *PEDICULARIS LANCEOLATA*

Martin A. Piehl
Department of Botany, The University of Michigan

Pedicularis lanceolata is a widely distributed plant of eastern North America which inhabits lowland areas. It is usually separated ecologically from the familiar *P. canadensis*, a second wide-ranging eastern[1] species of uplands[2] for which some data are available on its parasitic behavior (Piehl, 1963). Because it belongs to a different section of the genus, and since its root environment and general habitat usually contrast markedly with those of *P. canadensis*, the parasitic relationships of *P. lanceolata* seemed particularly worthy of study; furthermore, observations of its parasitism appear not to have been recorded previously.

The "swamp lousewort" or "swamp wood-betony" is a whitish to cream flowered perennial, which in addition to being less showy than *P. canadensis* is also less frequently observed because it flowers in late summer or fall when it is often obscured by the rank growth of associated lowland species. Also, the lower portion of the stem tends to be rather weak and the plant often becomes somewhat decumbent. Its characteristic habitats are fens and wet prairies (Curtis, 1959), marshes, and the margins of lakes and streams. Pennell (1935) reports it particularly from calcareous sites. The observations of parasitism reported herein were made in October, 1960 and 1964, in Washtenaw County, Michigan, primarily along the Huron River near Ann Arbor (sec. 26 and 36, Ann Arbor Twp.). Here this green parasite occurs in open or semi-open sites near or actually on the banks of the river. The soil in which it grows is often wet, mucky, and somewhat clayey, making the observation of parasitic attachments much more difficult than for some comparable parasites like *P. canadensis* which grow in drier, more porous soils.

The generally diffuse root system and the modifications of the roots which invade subterranean tissues of neighboring plants, the haustoria, tend to resemble those of *P. canadensis* (Piehl, 1963). Haustoria usually do not occur on the large roots in the crown region of the mature plant, but, as appears to be characteristic of other parasitic Scrophulariaceae, particularly perennials, are found on the fine, younger roots outward from the center of the plant. There thus tends to be a zone away from the crown and toward the periphery of the root system in which most of the parasitism occurs. This feature,

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[1] *Pedicularis canadensis* also occurs disjunctively in mountainous areas from Colorado to Chihuahua (Pennell, 1935).

[2] Li (1948) unequivocally gives *P. canadensis* (in addition to *P. lanceolata*) as found in lowlands; however, this is not in agreement with my field observations or with statements by other authors (e.g., Gleason and Cronquist, 1963). Like many plants, it on rare occasions is found considerably outside its usual habitats (Deam, 1940).

plus the fact that the small roots are easily broken, often gives the impression that haustoria are lacking or rare when the plant is excavated in the usual fashion. More intensive studies, however, indicate that parasitism is a generally constant feature of this plant's behavior in its natural habitats. Specimens of this species and *P. canadensis* transplanted with or even without some surrounding soil often continue to live, at least for some time, probably because there is sufficient stored food in the rather fleshy roots. New roots subsequently produced may form haustorial attachments to re-establish a partially parasitic nutrition. The usual practices of cultivation, especially removal of the roots of all "weeds," would possibly be disadvantageous. A statement that both species are "regularly" cultivated (Sprague, 1962), should perhaps be open to question.

The haustoria are generally larger than those of *P. canadensis*, averaging 1.5 mm in their longest dimension in surface view. The largest observed was 1.8 × 2.8 mm. The smallest measured 0.5 mm in both dimensions (slightly smaller ones are probable), and although they resembled mere protuberances somewhat suggestive of very young branch roots, they often bore evidence of having been attached to hosts. The smallest haustoria and the small rootlets which bore them were whitish and often nearly hyaline, and their surfaces were sometimes encrusted with rust-colored soil deposits. In longitudinal outline the attached haustoria are nearly hemispherical to somewhat conical, while in surface view they are usually circular to oval. The sides of the haustorium often bear hairs, which in unusual cases are comparatively dense and occur not only in the area of contact with the host, but almost up to the proximal end of the haustorium as well. The hairs appear to be more abundant than in *P. canadensis*. Several haustoria may be produced in rather close succession along a parasite root, and, though sometimes separated by but two or three times the diameter of the haustorium itself, they are not usually formed in essentially continuous succession as they may be in some root and some stem parasites, the latter case abundantly exemplified by the dodders, *Cuscuta*. Some of the haustoria on *Apocynum* were only weakly attached, and there was some suggestion that they do not adhere well to the particularly smooth roots of that host.

The anatomical features of the haustoria approximate, in a general way, those described for similar root parasites. Briefly, the haustoria are differentiated into a loosely organized outer portion and a denser inner part which terminates in a peg-like arm that penetrates the host. The inner portion is traversed by one or a few tracheary elements, connecting the xylem of the parasite with that of the host (Figs. E, F, G)[3].

[3]Tissues used for the anatomical observations were fixed in FFA, prepared for sectioning with the usual TBA-paraffin method, and stained in safranin-fast green.

An appreciably greater proportion of the total evidence for parasitism consisted of dead haustoria and haustorial scars in *P. lanceolata* than in *P. canadensis*, an observation which is probably related to the decay-inducing moist environment in which the roots of the former are found. The haustorial scars left in the hosts represent, of course, areas penetrated by the inner tissue of the haustorium. The maximum penetration observed was to about the middle of the host organ. Like the haustoria themselves, the fissures vary in size, and are characteristically elliptic with their long axes running parallel to those of the host organ (Fig. D). This shape and orientation of the scars appear to be common in many root parasites with generally similar haustoria.

It would seem likely that the majority of scars represent areas of penetration by functional haustoria (thus effecting parasitism), since the differentiation of xylem elements in the distal part of the haustorium appears to occur soon after penetration. In fact, the presence of haustorial scars assures that deep penetration occurred, rather than simply the superficial attachment which characterizes the early development of haustoria.

The whitish roots of some hosts, e.g., *Apocynum*, were often conspicuously darkened in the area of haustorial invasion. Though some darkening was recorded for hosts of *Pedicularis canadensis*, the discoloration appeared to be somewhat more severe in *P. lanceolata*. Occasional haustoria of *P. lanceolata* were attached to partly decayed plant parts. Perhaps it was evidence such as this that prompted Volkart (1899) to record what he considered the killing and comparatively strong saprophytic utilization of hosts by the lowland *P. palustris*.

A rather wide range of taxonomic diversity exists among the hosts observed in this study—horsetails and ferns, as well as angiosperms from 16 families (Table 1). Additional observations would undoubtedly extend the diversity of hosts somewhat. However, the observations at hand indicate that *P. lanceolata* is generally non-specific, and the diversity of its hosts compares favorably with that of *P. canadensis*, for which 80 species from 35 families were recorded in a more extensive study (Piehl, 1963). The observation of fewer hosts for *P. lanceolata* also reflects the increased difficulty of excavation previously mentioned and probably the generally poorer vascular flora in its habitat. Although this parasite invades a variety of hosts, two species, *Aster novae-angliae* and *Eupatorium maculatum*, were frequently parasitized, with the root system of some individuals displaying numerous points of invasion (Fig. B). Conversely, the evidence for parasitism on such associates as *Daucus*, *Peltandra*, and *Typha*, and for intraspecific parasitism, was largely restricted to either dead haustoria and haustorial
Europe, but also known from extreme eastern Canada, Volkart (1899)

scars or both.[4] Haustorial scars were particularly numerous on *Typha*. Any deductions concerning "preferred" hosts need to be made with caution, and it may well be that the most common host species will vary with locality and habitat. However, with non-specific parasites such as these it may be possible to generalize with regard to the type of root system (and thus to a degree the physiognomy of the host) which will be most frequently parasitized, though in most instances more study is needed.

For each host species reported here, haustoria or definite haustorial scars were actually observed on the subterranean parts. What seems to be an obvious point, but one apparently in need of emphasis, is that the observation of non-host-specific root parasites growing in proximity to an associated species is far from proof of parasitism. In fact, in some cases where the subterranean parts of a parasite were nearly or actually touching those of the potential host, no attachments were found. As suggested above, parasitism of a root some distance from the crown of the parasite may be more probable than would be attachments to a root close to the crown. Statements on herbarium specimen labels naming hosts of root parasites have often been found, when a check was made with the collector, to be mere assumptions based on close spatial relations. Even the discussion in a paper dealing specifically with root parasitism appears to confuse *associated* species with *host* species (Sprague, 1962, pp. 193-96). Furthermore, the listing of "probable" and questionable (preceded by "?") hosts, particularly without defining what is meant (Sprague, 1962), likewise adds little to our knowledge of host ranges and parasitic relationships.

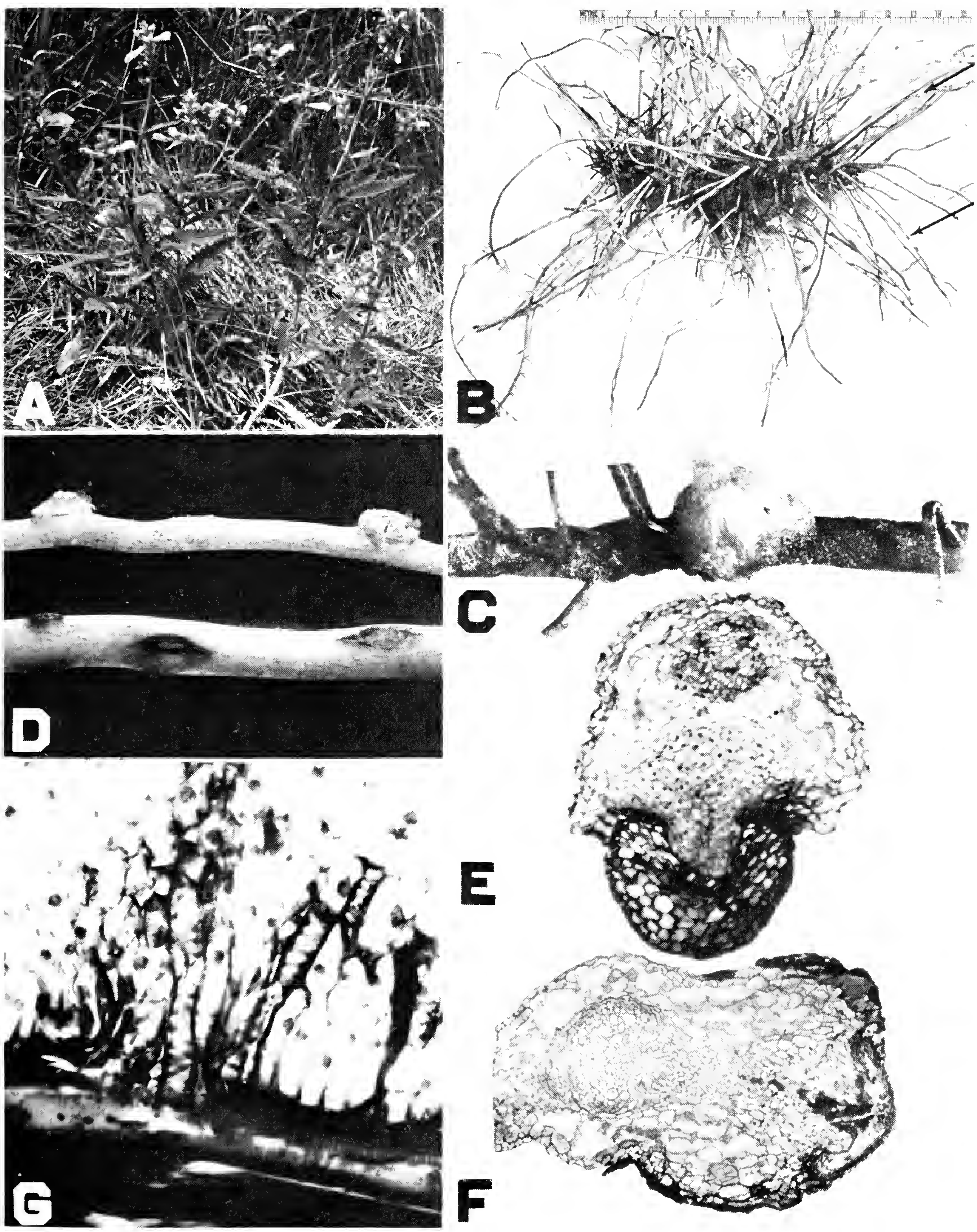
For another lowland species, *Pedicularis palustris* L., studied in

[4]Living haustoria attached to segments of host organs decayed in a mere four days in water at room temperature. This evidence of a fast rate of decay along with observations of an overall high proportion of dead haustoria and scars suggests that the chances are fairly high for finding evidence of former attachments only. However, the proportion may not be the same at other seasons.

Figs. A-G. Habit and haustorial attachments of *Pedicularis lanceolata*. A. Flowering specimen in a dense marsh habitat, Oakland Co., Michigan, $\times \frac{1}{7}$. B. Portion of root system of host *Eupatorium* with particularly numerous haustoria and haustorial scars (e.g., at upper and lower arrows, respectively). C. Single, living haustorium on *Carex* root, × 5.8. D. Characteristic haustorial scars and partly decayed haustoria (above) on *Eupatorium*, × 3.9. E. Longitudinal section of haustorium on *Dryopteris* root (in transection, below), × 43. F. Longitudinal section of unusually elongate haustorium with small decomposing host organ to right. A portion of somewhat curved xylary trace visible at right center (darkened by safranin-staining material apparently involved in breakdown of host tissues), × 35. G. Longitudinal section of haustorium and *Dryopteris* root showing xylem elements of parasite in contact with xylem element of *Dryopteris* (below; horizontally oriented), × 225.

found 11 host species from 5 families, but the predominant hosts were Cyperaceae and Gramineae. The greatest host diversity noted by Volkart, who studied 6 species, was for *P. foliosa* L., and entailed 19 species from 11 families.

In contrast to the broad host ranges reported for *P. lanceolata* and other species of the genus (Volkart, 1899; Piehl, 1963), Sprague (1962) suggests a high degree of host specificity for *P. densiflora*



Benth. ex Hook. and *P. semibarbata* Gray, species often found in the dry Yellow Pine Forest and Chaparral (Munz and Keck, 1959) of the California region.[5] Sprague also reports that *P. densiflora* ssp. *aurantiaca* E. F. Sprague is essentially restricted to ponderosa pine. An alternative explanation for the apparent host specificity in cases such as these should perhaps be mentioned.

If the overall ecological requirements of a generally non-specific parasite and one of its hosts are similar, and particularly if those of the parasite are rather narrow, the likelihood that they will very frequently occur in proximity is high. This is especially true if the host is a dominant member of the community, e.g., the pines in a pine forest, and if the vegetation is comparatively sparse and made up of relatively few species. Furthermore, within the same habitat the subterranean parts of certain potential hosts may be more readily available to the parasite than those of neighboring species (due to root system stratification, etc.; see Piehl, 1963). The result of such ecological factors may be a parasite-host relationship which at first sight suggests host specificity. However, further study may show that this is not a fixed specificity, but a product of interactions between the two plants and their environment. Generally speaking, it seems probable that what are initially casual parasite-host relations may evolve into cases of considerable host specificity due to similarities in the ecological requirements of the parasite and host.

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[5]The hard packed and rocky substrate often make it difficult to obtain a sufficient quantity of data unless observations are made at a sizeable number of sites. In observations made at two sites in the Santa Ynez Mountains near Santa Barbara, California, I found *P. densiflora (Piehl 62425,6304)* attached to an herb, *Hieracium argutum* Nutt., and to a shrub, *Arctostaphylos glandulosa* Eastw. var. *mollis* Adams.

TABLE 1. Some hosts of *Pedicularis lanceolata* near Ann Arbor, Michigan (in general, names are from Fernald's *Gray's Manual of Botany*, 8th ed., 1950).

Equisetaceae
Equisetum arvense L.

Aspidiaceae
Dryopteris thelypteris (L.) Gray var. *pubescens* (Lawson) Nakai
(*Thelypteris palustris* Schott)

Typhaceae
Typha latifolia L.[a]

Cyperaceae
Carex sp.

Araceae
Peltandra virginica (L.) Schott & Endl.[a]

Iridaceae
Iris virginica L. var. *shrevei* (Small) Anders.[a]

Polygonaceae
Polygonum coccineum Willd.

Ranunculaceae
Ranunculus septentrionalis Poir.
Thalictrum dasycarpum Fisch. & Lall.

Balsaminaceae
Impatiens capensis Meerb.

Rhamnaceae
Rhamnus frangula L.

Umbelliferae
Daucus carota L.[a]

Cornaceae
Cornus racemosa Lam.
C. stolonifera Michx.

Primulaceae
Lysimachia quadriflora Sims

Apocynaceae
Apocynum cannabinum L.

Verbenaceae
Verbena hastata L.

Labiatae
Pycnanthemum virginianum (L.) Durand & Jackson

Scrophulariaceae
Pedicularis lanceolata Michx.[a]
Chelone glabra L.[a]

Compositae
Aster novae-angliae L.
A. lateriflorus (L.) Britt.
Eupatorium maculatum L.
Solidago patula Muhl.
S. riddellii Frank

[a]Species for which evidence for parasitism consisted of dead haustoria or definite haustorial scars or both.

Review

TALL TIMBERS AND FAR HORIZONS. Adventures and Discoveries of Early Botanists in America. By Virginia S. Eifert. Dodd, Mead & Co., New York. 1965. 301 pp. $5.00.

A series of biographical sketches, written in a popular and readable style, of early American botanists is a commendable idea, and it is a pity that this particular effort is so careless. Overlooking the logic of including a chapter on Linnaeus in a book on botanists "in America," we read therein, among other errors, that Linnaeus' Lapland trip was in 1730 [it was 1732] and that Dioscorides "produced a magnificent *De Materia Medica*" in 512 A.D. [nearly five centuries after his death!].

Since Thomas Nuttall may well have been the first professional naturalist to collect plants in Michigan, we ought to welcome a popular story of his life. This one, however, is thoroughly inaccurate in details. Nuttall's trip into Michigan was in 1810, as stated in the text, not 1809, as stated in a figure legend. Nuttall did *not* purchase a canoe in Detroit, and he did *not* paddle alone to Mackinac Island. He "hitched" a ride with the surveyor of the Territory of Michigan, Aaron Greeley, who was going to survey the town lots on Mackinac. It was *not* "early June" at all. They left Detroit July 29, 1810. Since he was at the Straits in mid-August, Nuttall could *not* have seen "masses of small, lavender-blue irises," which normally cease blooming in June; although he did (in 1818) describe *Iris lacustris* as new — but from the islands of Lake Huron, *not* Lake Michigan. (Similarly, Michaux could hardly have seen, at Lake Mistassini, Quebec, hosts of *Primula mistassinica* with golden-eyed fragrant blossoms shaking in the wind, since he was there in September of 1792 and the plant blooms in the spring.)

Other important episodes in the botanical history of our region are the Schoolcraft expeditions of 1831 and 1832 to the Mississippi. The 1831 trip rates no word whatsoever, Mrs. Eifert skipping directly from the Cass expedition of 1820 to the 1832 expedition of Schoolcraft, on which (as also in 1831) his company included Douglass [consistently spelled "Douglas"] Houghton — who did not, in the three and a half hours spent at Lake Itasca July 13, 1832, collect the plants listed. Furthermore, he did *not* find there a "new dewberry which later was named for Schoolcraft" [*Rubus schoolcraftianus* was named by Bailey in 1943 from material collected by C. R. Hanes in Kalamazoo Co., southern Michigan]. Torrey and Gray (or Gray) did name a new goldenrod for Houghton, but it was collected by him in 1839 on Lake Michigan and also had nothing whatsoever to do with the 1832 expedition, although the new sedge mentioned in the same sentence did come from Lake Itasca on that historic day in 1832 (see Mich. Bot. 1: 66. 1962).

Having become thus discouraged by the incredibly abundant errors relating to Michigan botanists, I freely admit not bothering to read the rest of the book. Confidence in its reliability is not inspired by seeing George Engelmann consistently referred to as "John" and other names misspelled or worse. A fertile imagination can add life when skillfully and responsibly used to supplement bare facts; when used carelessly and in contradiction to facts, it converts the results, at best, to fiction no more strange or exciting than the truth would have been.

— E. G. V.

DISTRIBUTION OF *PRIMULA MISTASSINICA* IN THE GREAT LAKES REGION

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and Herbarium, The University of Michigan, Ann Arbor

A previous report on distributions of "shoreline plants" around the Great Lakes (Guire & Voss, 1963) included the Bird's-eye Primrose, *Primula mistassinica* Michaux, as a northern species whose distribution southward is largely associated with shorelines. No map was included. The present note will place the local distribution of this attractive and interesting species on record by means of a larger map than the base previously employed, thus calling attention to the northward occurrences, as we have done for another subarctic species, the Black Crowberry, *Empetrum nigrum* L. (cf. Soper & Voss, 1964).

It should be noted that we are not attempting to distinguish *Primula intercedens* Fernald (which was proposed as a new name for *P. farinosa* Nuttall [not Linnaeus] = *P. farinosa* var. *americana* Torrey). Several authors, including Fernald himself in the original description (Rhodora 30: 87-88. 1928), have questioned the distinctness of *P. intercedens*, supposedly an endemic of the northern Great Lakes. (See, for example, C. A. Brown, Ferns & Fl. Pl. Isle Royale, [1937], pp. 77-78; and Butters & Abbe in Rhodora 55: 184-185. 1953.) The detailed investigations of Vogelmann (1960) failed to substantiate any consistent morphological or cytological differences between the two "species." Iltis and Shaughnessy (1960) recognized a single species in Wisconsin, including var. *noveboracensis* Fern. at inland stations.

This is a variable species in leaf shape, amount of "mealiness," flower color, and general robustness, as well as in morphological characteristics of flower and fruit. Although most frequently about 8-12 cm in height, many plants are smaller and some may be as tall as 28 cm. The flowers range from nearly white to lilac or deep magenta (especially when shaded). They are quite fragrant, and attractive to butterflies. Thousands of plants in bloom on moist shores in the region of the Straits of Mackinac or along the west side of the Bruce Peninsula present a handsome sight in mid-May, when they are usually at the peak of blooming.

The map (fig. 1) shows the distribution of *Primula mistassinica* (sens. lat.) in the Great Lakes region and northward through Ontario to Hudson Bay, as well as its few southern stations. No attempt was made to gather and plot records for the Province of Quebec. The single collection shown in Quebec is from Lake Mistassini, the type locality, where the French botanist André Michaux first found it in early September of 1792.

In our region, the species occurs around the shores of Lakes Superior, Michigan, and Huron primarily between 44^{o} and 49^{o} N. lat.;

in the Lake Nipigon region of northern Ontario and along rivers in the James Bay and Hudson Bay drainage areas; in western New York state; and at a few other inland localities, chiefly along rivers (and generally on sandstones or other moist cliff faces). Among the latter are the Iowa River (Iowa Falls, Iowa), St. Croix River (Stillwater,

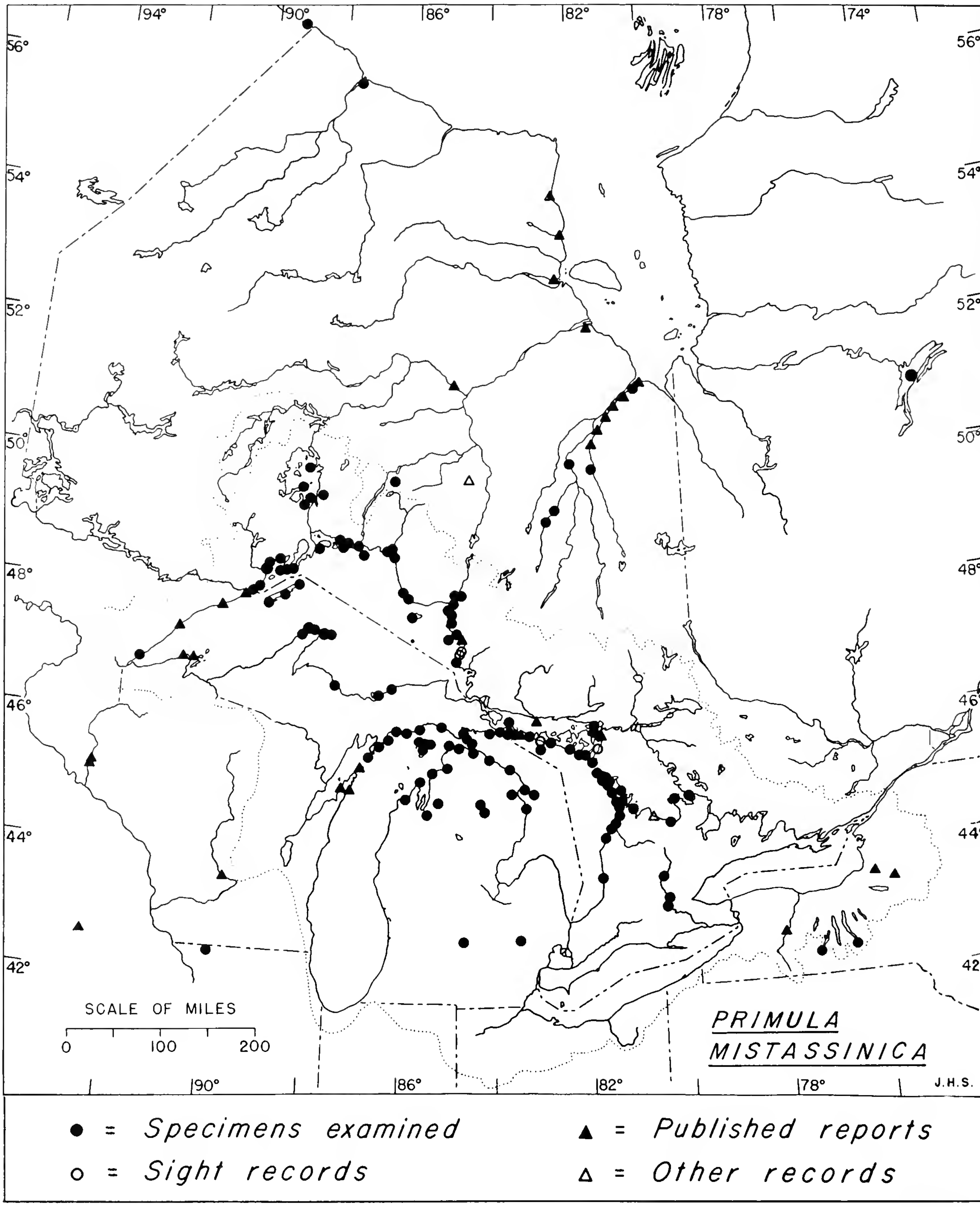

Fig. 1. Distribution records for *Primula mistassinica* in the Great Lakes — Hudson Bay region.

Minnesota, and near Somerset, Wisconsin), Wisconsin River (Wisconsin Dells), Grand River (Grand Ledge, Michigan), and Grand River, Ontario. These southern inland plants of river cliffs (and those of New York) have usually been referred to var. *noveboracensis* Fern. To the inland localities in Michigan cited previously (Brittonia 9: 94. 1957) may be added marly springs near Bridge Lake, Oakland Co. (*F. Case* in 1959). The more northerly inland sites in Michigan are also springy or boggy calcareous or marly places, as indicated, for example, by the presence of *Parnassia glauca* and *Lobelia kalmii.*

Along and near the northern shores of Lakes Michigan and Huron, *Primula* is locally abundant not only on limestone pavements but also in open beach meadows (seldom much shaded) and other moist mossy, sandy, or rocky habitats, rarely if ever far from underlying limestone or dolomite. Around Lake Superior, this species seems almost invariably associated with the Butterwort (*Pinguicula vulgaris*)--as, indeed, it is at some other localities, although the Butterwort is overall more northern in distribution. In eroded pockets and rock crevices, usually near water level, the *Primula* thrives on the sandstones of the Pictured Rocks in Michigan and the igneous rocks of the North Shore.

The distribution patterns typified by such plants as *Empetrum nigrum* and *Primula mistassinica* (especially var. *mistassinica*), and those mapped by Soper and Maycock (1963), are by no means limited to vascular plants. Striking similarities are seen in some of the maps published for liverworts by Schuster (1958a, 1958b), who (1953) referred to a "Tundra Strip" (p. 320) or an "Arctic shoreline strip" (e.g., p. 475) and called attention to the association there of certain hepatics with *Primula, Pinguicula,* and other characteristic plants such as *Scirpus cespitosus, Potentilla fruticosa,* and *Selaginella selaginoides*. He later (1957, p. 261) expanded this idea:

> At the edge of Lake Superior, there is, in addition, a variably wide zone with no arborescent vegetation, because of the cold waters of Lake Superior, ice and wave action, and the inability of a soil-layer to accumulate over the rocks adjacent to the shoreline. This zone may be considered to represent a narrow, edaphically and microclimatically controlled treeless or tundra zone, which in many ways approximates the tundra or treeless regions of the arctic and of alpine summits. . . . This zone along the shoreline and adjacent to the forested region thus supports two distinct communities that recur again far to the north: a hydrarch *Scirpus cespitosus-Primula-Pinguicula* society around sunny rock-pools, and an acid, xerarch *Empetrum-Vaccinium* heath over moist ledges.

Lists (by no means identical) of vascular plants characteristic of the so-called "Tundra Strip" are given by Schuster (1958a, p. 264; 1957, p. 261), besides lists of liverworts and lichens (1958a, p. 264).

Phytogeographers developing any overall interpretation of postglacial vegetational history in the Lake Superior region will do well to take into account the distribution patterns of bryophytes and lichens as well as those of vascular plants.

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KARYOTYPES IN THE ALISMATACEAE OF ITASCA STATE PARK[1]

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The family Alismataceae is represented in the Itasca Park region of Minnesota by *Alisma triviale* Pursh and by four species of *Sagittaria*. A study of the karyotypes of these five species was carried out in 1963 to determine: (1) whether *Sagittaria* has species-specific chromosomal characteristics which could be used as an aid in identification; (2) whether *Alisma triviale* in the Park area is diploid or tetraploid.

Sagittaria is taxonomically difficult because of its great variation in vegetative features. Its karyotype has been studied several times (cf. Brown, 1946; Oleson, 1941; Baldwin and Speese, 1955) and among the later reports there is general agreement that the diploid chromosome number is 22. Oleson (1941) noted the presence of satellites in the meiotic figures of *S. latifolia* Willd. but not in *S. rigida* Pursh. Other workers have stated that there are no species-specific characters in the karyotype of *Sagittaria*.

Alisma is supposedly not taxonomically complex and revisions have been concerned mainly with the rank ascribed to the various taxa. However, a check of the reported chromosome numbers seems to indicate a lack of consistency between specimen identifications and chromosome counts among different workers. Oleson (1941) published a chromosome count of 2n=14 for plants she identified as *A. plantago* L. Brown (1946) also counted 2n=14 for plants he identified as *A. triviale* Pursh. With regard to Oleson's counts Brown stated that "... .Oleson's *A. plantago* is probably *A. triviale*. . ."; while Baldwin and Speese (1955) listed Oleson's counts as being from *A. subcordatum* Raf. Hendricks (1957) reported that *A. plantago-aquatica* L. var. *americanum* J. A. Schultes and Schult. (which includes in part, *A. triviale* Pursh) is basically diploid (2n=14), but that rare tetraploid (2n=28) individuals occur.

Similar discrepancies are found among the reports for *Alisma subcordatum*. As mentioned above, Baldwin and Speese (1955) regarded Oleson's diploid count (2n=14) as being from *A. subcordatum*. Their own counts on this species were also 2n=14. Brown (1946) examined plants from Colorado which were identified as *A. subcordatum* and found them tetraploid. Baldwin and Speese (1955) stated that Brown's plants from Colorado "... may be *A. triviale* rather than *A. subcordatum*. . ." Heiser and Whitaker (1948) also found tetraploid

[1]This investigation was supported by the National Science Foundation Grant No. 16830. The author wishes to thank Dr. G. B. Ownbey, who suggested the study, for his help; also Dr. W. Marshall who provided research space at the Itasca Biological Station.

plants in California and identified them as *A. subcordatum*. No voucher specimen was cited by these authors. Hendricks (1957) however, cited a specimen, *Heiser 1965* (IND), which was collected north of Davis in Yolo County, California, and identified by Heiser as *A. subcordatum*. This specimen was examined by the present author and identified as *A. triviale*.

The most recent work on *Alisma* in North America is that by Pogan (1963). In contrast to the conflicting reports noted above, this worker states that *Alisma triviale* is tetraploid and that *Alisma subcordatum* is diploid.

METHODS

Flower buds were collected from each of the species and fixed and stained according to the schedule proposed by Snow (1963). Two plants of *Alisma triviale*, two of *Sagittaria cristata* Engelm., and at least three plants of each of the other species of *Sagittaria* were analyzed. Mitotic material was obtained root tips of at least three plants of each of the taxa indicated in Table 1. The root tips were prefixed for about 3 hours in monobromonaphthalene to shorten the chromosomes and thereby facilitate photographing them. They were then treated in the same manner as the meiotic material. Photographs (e.g. fig. 2) were taken from each species. The karyotypes (figs. 1 and 3) were constructed by making a print from a negative of the somatic chromosomal complement. The chromosome figures were cut out of the print and arranged into pairs according to size and centromere position. One figure from each pair was then selected and these were arranged in order of descending size with the centromeres along a horizontal line. The resultant figure represents the haploid karyotype.

Herbarium voucher specimens substantiating the identification of the taxa studied will be deposited in the University of Minnesota Herbarium.

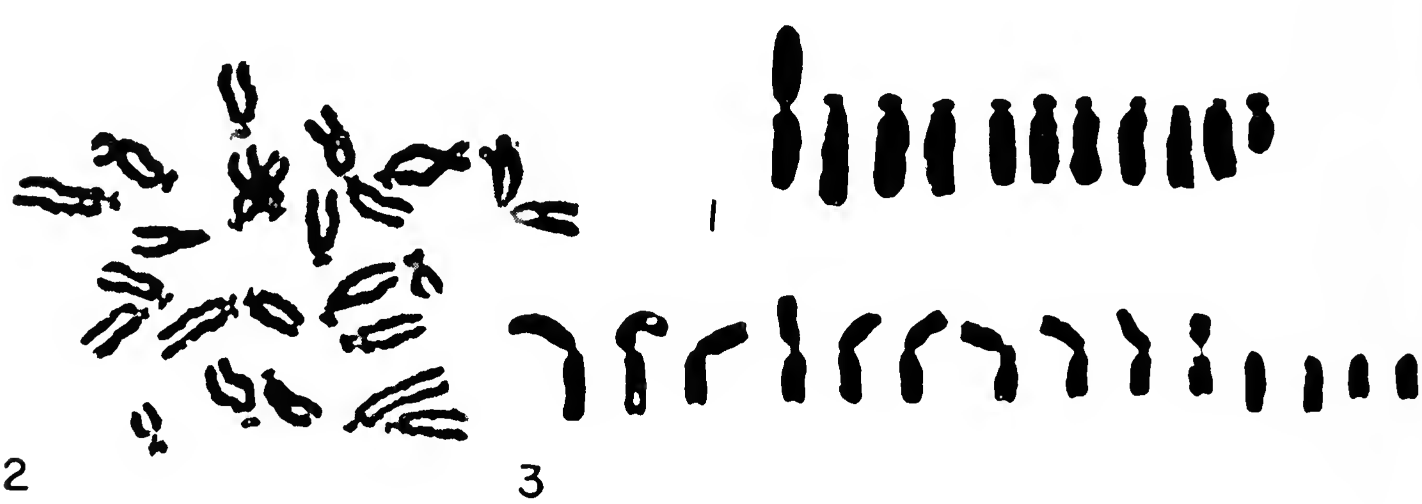

Fig. 1-3. Mitotic chromosomes of Alismataceae, x 1350: 1. Idiogram of *Sagittaria latifolia* Willd. showing prophase chromosomes. 2. Photograph of diploid metaphase of *Sagittaria cristata* Engelm. 3. Idiogram of *Alisma triviale* Pursh showing prophase chromosomes.

OBSERVATIONS

Alisma triviale Pursh was found to have a diploid number of 28. The shortened chromosomes ranged from about 2 to 7.5 microns in length and exhibited a more or less gradual increase in size from smallest to largest. As shown in figure 3 the nine largest somatic chromosomes are metacentric, the four smallest have subterminal centromeres, and the remaining chromosome is intermediate in size and has a submedial centromere. Some difference in chromosome length was noted among the figures examined for each species and this was attributed to variations in the stage of mitosis, in the squashing technique, in the length of time in the prefixative, etc. Therefore, the measurements cited here represent averages rather than absolute dimensions.

The *Sagittaria* species studied possess karyotypes which are indistinguishable from each other. The karyotype of *S. latifolia* in figure 1 is representative. It consists of 11 chromosomes measuring about 3 to 9 microns in length. The smallest chromosome is submetacentric with the longer arm slightly more than twice as long as the smaller arm. The largest chromosome is metacentric and the rest have subterminal centromeres. No evidence was found to support Oleson's report of satellites in *S. latifolia.* (Table 1 provides a list of species and formae studied.) For a listing of previously reported counts see Baldwin and Speese (1955).

DISCUSSION

Pogan's (1963) extensive study of *Alisma* in the United States and Canada indicates that *A. triviale* and *A. subcordatum* must be considered good species entirely distinguishable using flower and fruit characters. This is in contrast to Hendricks' (1957) proposal that these taxa should be rearranged and reduced to three varieties. Pogan further proposed that *A. triviale* is tetraploid and *A. subcordatum* is diploid. This conclusion was reached after cytological studies involving "extensive material" from the United States and Canada. The work of the present author supports the conclusion that *Alisma triviale* is tetraploid. Pogan indicated that more extensive data, such as collection information, was to be published in the future and therefore it is not certain at this time how geographically inclusive her cytological sample was. It is possible that local areas could contain tetraploid populations of an otherwise diploid species (e.g. the population studied by Heiser and Whitaker, 1948). However, Pogan's study of pollen size in the two species supports the conclusion that *A. triviale* is always tetraploid. Numerous herbarium collections were examined and it was found that ". . . the pollen grains of *A. triviale* are 27-36 microns in diameter, whereas those of *A. subcordatum* are 19.5-27 microns. No deviations were met with . . ." Tetraploid species commonly have larger pollen than closely related diploid species.

The karyotypes of over half of the species of *Sagittaria* are known and no consistent deviation from the general type reported here has been found. This led Bogin (1955) to say of *Sagittaria* " . . . polyploidy or aneuploidy do not seem to play any considerable role in speciation."

SUMMARY

The chromosome numbers of *Alisma triviale* Pursh (2n=28) and four species of *Sagittaria* (2n=22), namely, *S. latifolia, S. cuneata, S. rigida,* and *S. cristata,* are reported. Of these five species only *S. cristata* has not been reported previously. A photograph of a diploid metaphase figure of *S. cristata* is presented, as well as idiograms of *Alisma triviale* and *S. latifolia.* The idiogram of *S. latifolia* is representative of all species of *Sagittaria* studied.

TABLE 1. Collections from the Itasca Park Region of Minnesota

Taxon	Collection number	Chromosome count	
Alisma triviale Pursh			
Clearwater Co.: Pond on north side of State Hgwy. 31 about 1 mile S.E. of Lake Itasca Post Office.	Bloom 146	14	28
Hubbard Co.: Pond on south side of U.S. Hgwy. 71 about 3.6 miles east of the town of Lake George	Bloom 157	14	28
Sagittaria cristata Engelm.			
Clearwater Co.: East shore of Wapatus Lake--4.5 miles west, 4 miles south of Zerkel, on Height O' Land Truck Trail.	Bloom 185	11	22
Sagittaria cuneata Sheldon			
Clearwater Co: Pond on north side of State Hgwy. 31 about 1 mile S.E. of Lake Itasca Post Office.	Bloom 130	11	22
Hubbard Co.: Pond on south side of U.S. Hgwy. 71 about 3.6 miles east of the town of Lake George.	Bloom 149	11	22
Sagittaria latifolia Willd.			
Clearwater Co.: Shore of Lake Itasca directly east of Schoolcraft Island.	Bloom 110	11	22
Clearwater Co.: Pond on south side of State Hgwy. 31 about 1 mile S.E. of Lake Itasca Post Office.	Bloom 134	11	22
Sagittaria latifolia Willd. forma *gracilis* (Pursh) Robins.			
Clearwater Co.: East shore of Wapatus Lake--4.5 miles west of Zerkel and 4 miles south on Height O' Land Truck Trail.	Bloom 194	11	22
Sagittaria rigida Pursh			
Clearwater Co.: Pond on north side of State Hgwy. 31 about 1 mile S.E. of the Lake Itasca Post Office.	Bloom 132	11	22
Hubbard Co.: Pond on south side of U.S. Hgwy. 71 about 3.6 miles east of the town of Lake George.	Bloom 150	11	22

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REDISCOVERY OF *CYPRIPEDIUM PASSERINUM* IN THE LAKE SUPERIOR REGION

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In the spring of 1964 my attention was drawn to the fact that Franklin's Lady's-slipper (*Cypripedium passerinum* Richards.) had been reported from the Lake Superior region many years ago by John Macoun (1888). Since my own field work has been extending recently into those areas in Ontario which border the north shore of Lake Superior (Soper, 1963), my interest in the possible occurrence of this northern orchid in the Great Lakes drainage basin was immediately aroused.

The records listed for *Cypripedium passerinum* in Macoun's Catalogue (op. cit., pt.4, pp. 22-23) were as follows: "On wet sand and in swamps; rare. Near Moose Factory, James Bay. (*Cottar* & *Dr. Hayden.*) Charlton Island, James Bay. (*J. M. Macoun.*) On wet sand at the Pic River, Lake Superior; very abundant in a spruce swamp at the Kananaskis station, close to Bow River, Rocky Mountains, and westward to Silver City. (*Macoun.*) Pine woods, from the Saskatchewan to lat. 58°, and in the Rocky Mountains. (*Hooker, Fl.*) Cañon, Yukon River, 1887. (*W. Ogilvie.*)"

In recent years this species has been collected in several additional areas around the shores and islands of James Bay and Hudson Bay. Its occurrence also in Quebec (Anticosti and Mingan Islands), Manitoba, the Rocky Mountains, and other parts of western North America has been well documented by specimens in various herbaria. This species is reported (Case, 1951) to be very common in much of Alaska and the Yukon.

In checking my card-file Catalogue of the Vascular Plants of Ontario, I found that I had seen only one specimen from the Great Lakes region. This was one collected by John Macoun on the northeast shore of Lake Superior on August 1, 1869, and preserved in the Herbarium at McGill University (MTMG). I assumed that this specimen came from the Pic River because that was the only locality cited by Macoun for the Great Lakes region.

In mid-July, 1964, I visited the Pic River with a student assistant and explored the area around the mouth of the river (48^{o} 36' N., 86^{o} 10' W.) and northwestwards along the shore of Lake Superior. I found one small clump and two other plants of *Cypripedium passerinum* within a small area. They were not growing on wet sand as recorded by Macoun for his collection, but on dry sand on the summit and upper slope of a wooded sand dune. Several plants had already been in flower but the flowers had faded and were beginning to wither. Capsules from a previous season still persisted on their brown stems. Two specimens were carefully cut at ground level from the most vigorous clump and pressed for herbarium records. These will substantiate the rediscovery after 95 years of this arctic-cordilleran orchid in the Great Lakes region. The full citation for this collection is as follows: Ontario: Thunder Bay District: growing in sand on north slope of dune under *Picea glauca*, just N. of the mouth of the Pic River, Lake Superior, 16 July 1964, *J. H. Soper & F. A. Fraser 10829* (TRT No. 139227). The duplicate will be deposited in the National Herbarium of Canada (CAN) at Ottawa.

Although there is evidence that Fernald was aware of Macoun's report for *Cypripedium passerinum* in the Lake Superior region, this species was not mentioned in the 8th edition of Gray's Manual (Fernald, 1950). It is doubtful whether Fernald saw Macoun's specimen in the McGill Herbarium. Similarly, Gleason (1952) did not include this species in his revision of Britton and Brown's Illustrated Flora. The report of this rediscovery reached F. W. Case barely in time for the inclusion of a supplementary page (108) in his new book on the orchids of the Great Lakes region (1964).

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A Review on Crataegus

CONTRIBUTIONS TO THE TAXONOMY OF CRATAEGUS. By Emil P. Kruschke. Milwaukee Public Museum (Publications in Botany No. 3), Milwaukee, Wisconsin. 1965. 273 pp. $6.50 (+ $ .15 postage).

The hawthorns (*Crataegus*) have been a challenge to botanists since the beginning of the century. Over 1000 supposedly new species were described from North America between 1900 and 1925, three-fourths of them by C. S. Sargent. The type localities for 52 of these " species" are in Michigan, as a result of collecting by C. K. Dodge of Port Huron and Emma J. Cole of Grand Rapids (and, to a lesser extent, O. A. Farwell of Detroit). These active early botanists in the state sent material to Sargent, and Dodge also sent specimens to W. W. Ashe. Ashe and Sargent visited their Michigan correspondents on more than one occasion and studied some of their plants in the field. Dodge's field notebooks on *Crataegus*, in which he periodically recorded data on approximately 175 numbered plants in St. Clair County and near Sarnia, Ontario, are in the University of Michigan Herbarium, which also includes Dodge's personal herbarium.

More than half of the names so freely published for the thorns have been relegated to synonymy. For many years, the recognized — indeed, the only — authority on the genus was the late Mr. E. J. Palmer, who was once associated with Sargent at the Arnold Arboretum. It takes many years and much field experience to be able to deal constructively with *Crataegus*, and we are fortunate that Mr. Emil P. Kruschke has now reached the point where he can present an outline of his conclusions in regard to taxonomy and synonymy. The present work is not intended for identification, and includes no keys. It is an arrangement (or rearrangement) of the names (including synonyms) for the plants of our region, and thus reveals the author's judgments on taxonomy.

In brief, I will say that I concur with Kruschke's work much more often than I maintain reservations, based on my own experience (which is limited to study of available herbarium material from Michigan). Many of his innovations and alignments are welcome and long overdue; some are presumably debatable. The overall result is a treatment somewhat more conservative than Palmer's, as far as basic species are concerned (a few "lumped"; still fewer "split"), but many of the borderline and questionable species are synonymized as a result of the author's experience in field study of variation within species.

In an earlier publication (1955) Kruschke presented in detail a program of collecting, stressing complete collections with flowers and fruit and extensive notes. The present work is based in large part on his own collections (over 1200) meeting these standards, made in Wisconsin and adjacent areas of Illinois and the Upper Peninsula of Michigan. There has been considerable literature and herbarium work besides, especially in evaluating the types for names.

Parts I and II describe new taxa, including five new subseries and 20 species, varieties, and forms. One wishes that past descriptions in *Crataegus* had been so thoroughly documented in both text and illustrations, the latter consisting of excellent photographs of fertile and vegetative branchlets at times of both flowering and fruiting, as well as of type plants in general aspect. (This is not, however, to defend the basic philosophy of naming something like *C. punctata* var. *punctata* f. *intermedia* because it "has the fruit color intermediate between that of typical *C. punctata* (deep wine-red) and *C. punctata* f. *aurea* (yellow)." The utility of naming such trivial forms is not demonstrated.)

In designating types for his new species and lower taxa the author does not seem to comply with the requirement that one type specimen must be designated for all new specific and infraspecific taxa described since January 1, 1958 (Art. 37, International Code of Botanical Nomenclature). Art. 7, Note 3, of the Code specifically states that when flowering and fruiting specimens have been designated as types, a lectotype must be chosen from among them (this would apply to names published prior to the Jan. 1, 1958, requirements of a single type). Regardless of the biological value of citing what are, in effect, syntypes collected from the same plant, we must either conclude that the practice invalidates the new names or assume from the typography that the intention was only to designate as type the specimen from the date immediately adjacent to the word "TYPE." While the latter interpretation would permit acceptance of Kruschke's new names, it is not supported by the figures, which show flowering and fruiting branchlets from the "type specimen" [meaning, apparently, the plant from which a yet-to-be-selected type specimen was collected]. It would clarify things if the author would promptly publish unquestionably valid type designations for his names — which would then date from the time that all requirements for valid publication have been met (Art. 45). Incidentally, further confusion in regard to types is seen in *C. latisepala* and *C. ater*, for which "lectotypes" are designated, when neotypes are meant. (The only specimens eligible to serve as lectotypes are those before the original describer when he named a taxon; later material, even if by the same collector or from the same plant, can only be neotypes. Of course, a "merotype," from the same plant, would make the most sensible neotype.)

Part III is a re-evaluation of *Crataegus* in northern United States and adjacent Canada, including new combinations and changes in synonymy. After a few explanatory notes on evaluation of certain characters, this is a synonymic list, with only those names numbered for which there are, in Part IV, comments on the reasons for the changes made in Part III. This is a rather awkward separation of data for practical use, made the more so by the lamentable absence of any alphabetical index to the accepted names and synonyms. One of Kruschke's basic premises (repeated over and over again, often in identical words) is that no species can have both 20- (15-20-) and 10- (5-10-) stamened flowers. While some may question his conviction that a species of *Crataegus* can never have a variety with a different stamen number, I think he is right in laying greater stress than has been customary on this feature; furthermore, it helps immensely in preparing keys.

Mr. Kruschke has searched for type specimens and reports many instances in which descriptions of them have been inaccurate. His thorough work and 23 years of field experience make the present treatment of considerable importance. In checking it against the manuscript on *Crataegus* in Michigan which I "finished" seven years ago (after sending copies to both Palmer and Kruschke) and against a few other sources, especially C. K. Dodge's notes, I find the following among points worthy of comment:

It is noted that the type locality for *C. nitidula* (transferred, along with *C. suborbiculata*, *C. celsa*, and others to the Brainerdianae) has sometimes been cited as Port Huron (for some reason also stated by Kruschke) although given as St. Clair in the original description. Dodge's notes definitely give the location of the type tree as "City of St. Clair" in a "thornapple orchard" whence many of his specimens were obtained.

The epithet "*suksdorfii*" is spelled with consistent incorrectness in three places, and there are some other typographical errors — fewer than might be expected, however, in a work with so much detailed matter.

The type locality of *Crataegus dodgei* is evidently in doubt. Kruschke states that, in the absence of Ashe's type, Dodge's "collection from the type tree should be accepted as the type." He does not state the number of the type tree, but cites specimens at New York collected at "Port Huron" May 21 and September 20, 1903, and labeled as "from type tree." Not cited are collections at Michigan State, numbered "6" by Dodge and labeled as from city of St. Clair and "type tree.'' He does cite collections at the Arnold Arboretum made from no. 6 at St. Clair May 21 and ''October 24,'' 1903 [this undoubtedly error for September 24]. According to Dodge's notes, no. 6 was in the thornapple orchard at St. Clair and he collected from it May 21, Sept. 20, and Sept. 24, 1903. He did not collect on all those dates from no. 9, which is also this species and was also in the same orchard. I believe that no. 6 must have been the type tree, and it was not at Port Huron, Ashe's original description and the New York specimens notwithstanding. This is far from the only time that Dodge specimens have been attributed to his home town of Port Huron rather than to their real sources.

There should be no reason to question London, Ontario, as the type locality for *C. flavida*, Sarg., now treated as a synonym of *C. dodgei*. Both St. Clair and London were mentioned in the original description, with priority in listing to the former. However, a year later (''Crataegus in Southern Ontario'') Sargent clearly designated as type a no. 12 collected by himself and J. Dunbar near London (not a Dodge number at all). Palmer in his 1925 list accepted London as the type locality. (Dodge's collections marked as ''type'' we would now call ''paratypes.'')

I fully concur with Kruschke in restoring to *C. dodgei* the var. *lumaria* (Ashe) Sarg., which for a while (though not in his later annotations) was listed by Palmer in the synonymy of *C. chrysocarpa*. On p. 212, Kruschke comments on Bazuin's nos. 7226 and 7397, referring them to *C. dodgei* var. *lumaria* rather than to *C. chrysocarpa* (as one of them had been determined by Palmer). In 1957 I included specimens of both numbers in a loan to Palmer, who confirmed both as *C. dodgei* var. *lumaria*. So there is in fact no disagreement on the disposition of these plants.

In the synonymy of his new combination *C. intricata* var. *neobushii*, based on *C. neobushii* Sarg., Kruschke lists *C. padifolia* var. *incarnata* Sarg. Since the latter epithet was already in varietal rank, the new combination is illegitimate — it should have been based on var. *incarnata*. *C. fulleriana* var. *miranda* is similarly illegitimate — it should have been based on var. *magniflora*, of which *miranda* could then if desired be made a form, but not vice versa. Likewise, instead of making the new combination *C. iracunda* var. *stolonifera*, the listed synonym *C. macrosperma* var. *demissa* should have supplied the basionym; and *C. iracunda* var. *diffusa* would also be illegitimate if *C. silvicola* var. *beckwithae* remains in synonymy. To further complicate matters, *C. populnea* Ashe and *C. brumalis* Ashe (among others) are made varieties of *C. iracunda* Beadle; unfortunately the latter seems to be a *later* name than the other two and therefore one of Ashe's names must be adopted for this species, and *iracunda* (as var. *maineana*) made a variety of it. (Beadle's name is dated April 30, 1902; Ashe's names are dated March, 1902, and I was unable in correspondence in 1958 to learn from librarians or publishers any reason not to accept these title-page dates.)

The original description of *C. incerta* Sarg. gave the type locality as ''on bluffs of Black River ten miles northwest of Port Huron.'' Kruschke merely says ''Port Huron,'' and although he quotes Dodge's notes on the type tree of this species in another context he does not mention the locality, which was on F. A. Beard's farm near Ruby, Clyde Township, St. Clair Co. Although *C. incerta* was made by Palmer a synonym of *C. coleae*, Kruschke keeps it distinct on the basis of stamen number (10, in contrast to 20 in *coleae*).

C. multifida Ashe is listed in the synonymy of *C. roanensis* var. *roanensis*. However, a collection from the type tree (Dodge's no. 43) in the University of Michigan Herbarium was annotated by Kruschke in 1956 as *C. macrosperma* var. *matura* (and is referred to as such in a ''Note'' on p. 233 under *C. streeterae*). This would tend to confirm the belief of Palmer (in which I have concurred) that *macrosperma* and *roanensis* are conspecific.

It might be of interest to note that although Ashe gave the type locality of

C. otiosa and *C. retrusa* (now both in the synonymy of *C. macrosperma*) as "Summerville" [Somersville], this is merely another way, according to Dodge's notes, of locating the same thornapple orchard at St. Clair whence came so many other types of new "species."

C. jesupii Sarg. is (along with others) transferred from the Pruinosae to the Silvicolae, and *C. filipes* Ashe reduced to synonymy under it. The type locality of the latter was said to be Port Huron by Ashe, but Dodge's notes make clear that this was another type from Clyde Township, St. Clair Co.

Several sheets of Dodge's type tree no. 1 of *C. latisepala* Ashe are cited, but not the one in the University of Michigan Herbarium which agrees with Dodge's notes in giving the locality as the city of St. Clair (not Port Huron). The actual type locality for *C. ater* Ashe is also St. Clair.

C. pruinosa var. *virella* is another illegitimate new combination, as an older varietal name (*C. mackenzii* var. *bracteata*) is cited in synonymy. Also in synonymy here is *C. immanis* Ashe, for which, like too many other species, the published type locality of Port Huron is quoted, when the actual locality is Clyde Township. *C. immanis* has long been puzzling, Palmer placing it in the Rotundifoliae. Kruschke's disposition of it, with a long discussion of its variability, is probably the proper course at present; I would only be inclined to add our specimens of *C. compacta* Sarg. to it. (Kruschke transfers *C. compacta* to the Silvicolae as a good species.) In recognizing *C. dissona* Sarg., with 10 stamens, as distinct from *C. pruinosa,* with 20, Kruschke further clarifies the *pruinosa* complex.

In commenting on the usual absence of type specimens for Ashe's *C. glareosa,* Kruschke refers to two collections of Dodge's no. 88 in the University of Michigan Herbarium. Their status is made more clear by the notation (not quoted): "No. 39 type tree has been cut down." Thus, the collections of no. 39, labeled "type tree" and in the Michigan State University Herbarium, although not cited by Kruschke, should be considered important "merotypes." They are presumably from the same plant as the Arnold Arboretum specimens cited by Kruschke without number, also labeled "type plant."

In summary, while I am inclined to go along with Kruschke's taxonomic dispositions (with only a comparatively few exceptions), and applaud a generally successful effort to come closer to a rational order in this chaotic genus, I regreat that equal care has not been given to nomenclatural practices in presenting the results, the new names apparently invalid where syntypes are designated and many of the new combinations illegitimate because not based on the oldest available epithet in the rank adopted. I have gone into some detail in this review not only because Michigan specimens have been especially important in the nomenclatural history of the genus but also because of the opportunity afforded for clarification from Dodge's materials in the University of Michigan Herbarium. Records on over 1200 *Crataegus* collected in Michigan are in my files as a result of preparing a treatment for the state based on the holdings of many herbaria. I can thus appreciate the vast amount of work which Mr. Kruschke has accomplished and express the profound hope that he will soon complete a manual for identification.

— E. G. Voss

Nature education feature--

INTERPRETING NATURE AT A PARK

Jocelyn Moore
Lower Huron Metropolitan Park, Belleville, Michigan

Just 23 miles southwest of Detroit lies a temporary nature center in Lower Huron Metropolitan Park, which is part of the Huron-Clinton Metropolitan Authority. It is ideally close for the city dweller, who has little opportunity to obtain an appreciation of native flora and fauna. The three nature trails are open year round, and the exhibit building is open to the public weekends during spring and fall and daily during the summer. The nature area influences many people who have never thought of visiting such a place and happen to pass by with enough curiosity to see what is inside the dome-shaped building. We also have visitors who know about us and enjoy visiting many times during the year to view the change of seasons. Naturalist service is available to organized groups that wish assistance in nature study. Our groups consist of scouts, day campers, YMCA, school groups, and others.

The Nature Center building houses exhibits of plants and animals which are found in the park area. This helps people who sometimes know more about faraway lands than they do about what is growing right under their feet. There are quiz games which delight both young and old; wood, geology, flower, and nature activities exhibits; and live exhibits of honeybees, turtles, snakes, frogs, and toads.

Being the first woman hired by the Park Authority in this capacity, I received many amusing reactions to my presence. Some of the choice remarks were, "My mother wouldn't pick up a snake," "Hey look, she's a lady!" and "Where is the other *fellow*?" (meaning Mr. Robert Worrall, the naturalist with whom I worked). Whenever adults with an authoritative air asked where the ranger, naturalist, or fellow in charge was, I enjoyed watching eyebrows go up and jaws go down when I explained that I was.

The following are a few of the native plants to be seen in the park.

SPRING HERBACEOUS PLANTS

Aquilegia canadensis	wild columbine
Arisaema atrorubens	Jack-in-the-pulpit
Arisaema dracontium	green dragon
Asarum canadense	wild ginger
Claytonia virginica	spring beauty
Dentaria laciniata	cut-leaved toothwort
Dicentra cucullaria	Dutchman's breeches
Erythronium albidum	white trout lily
Erythronium americanum	yellow trout lily
Hepatica americana	round-lobed hepatica

Polygonatum canaliculatum	large Solomon's seal
Smilacina racemosa	false Solomon's seal
Trillium grandiflorum	large-flowered trillium

SUMMER AND FALL HERBACEOUS PLANTS

Achillea millefolium	yarrow
Adiantum pedatum	maidenhair fern
Agrimonia parviflora	small-flowered agrimony
Amphicarpa bracteata	hog-peanut
Asclepias syriaca	common milkweed
Asclepias tuberosa	butterfly-weed
Aster novae-angliae	New England aster
Convolvulus sepium	wild morning glory
Daucus carota	Queen Anne's lace
Desmodium canadense	trick trefoil
Echinocystis lobata	wild or prickly cucumber
Eupatorium perfoliatum	boneset
Eupatorium rugosum	white snakeroot
Gentiana andrewsii	closed gentian
Habenaria psycodes	purple fringed orchid
Hypericum perforatum	common St. John's-wort
Impatiens capensis	spotted touch-me-not
Liatris cylindracea	blazing star
Lilium michiganense	Michigan lily
Linaria vulgaris	butter-and-eggs
Lobelia cardinalis	cardinal flower
Monarda fistulosa	wild bergamot
Onoclea sensibilis	sensitive fern
Osmorhiza claytoni	sweet cicely
Osmunda cinnamomea	cinnamon fern
Osmunda claytoniana	interrupted fern
Osmunda regalis	royal fern
Polygonum virginianum	Virginia knotweed
Prunella vulgaris	heal-all
Pteridium aquilinum	bracken
Rhus radicans	poison-ivy
Silphium perfoliatum	cup-plant
Vernonia altissima	tall ironweed

SOME UNUSUAL TREES AND SHRUBS

The Pawpaw Trail goes along the Huron River floodplain forest. More than 30 kinds of trees and a dozen different shrubs live here. Some of the trees and shrubs are southern and rarely grow in Michigan. A few of the more interesting ones are these:

Asimina triloba	pawpaw
Celtis occidentalis	hackberry
Cercis canadensis	redbud

Gymnocladus dioica	Kentucky coffeetree
Nyssa sylvatica	black gum (Bob White Trail)
Staphylea trifolia	bladdernut

My work included learning how and what to feed hungry snakes, turtles, toads, and frogs. The only really vicious animal in the Nature Center was the bullfrog. One morning as I put my hand in the aquarium to feed him he attempted (unsuccessfully) to swallow my finger. He just drew a little blood. When I discovered he liked "lady fingers" I tried to keep him well supplied with such tasty items as insects, crayfish, worms, mice, and one day a whole hot dog. He managed to swallow the whole hot dog, but he soon had the shape of what he had swallowed. Then he turned rather pale and regurgitated the whole hot dog--apparently he could not digest the outer skin and did not want to be called a bull dog. He made up for his viciousness by croaking beautifully whenever he heard rain on the roof or certain airplanes overhead.

The climax of my seasonal job was when the Southeastern Chapter of the Michigan Botanical Club descended on the Bob White Trail en masse one Sunday for a field trip. I was the "leader" and merely turned loose a pack of hungry botanical experts. They found the biggest, tallest, fattest, rarest, and prettiest species of everything in the woods. They found species I had never had the time to find. They did not know that the previous week Bill Hopkins (chief naturalist) and Robert Worrall (seasonal naturalist) had personally mowed the trail for them.

There were moments of pleasure, such as watching and photographing a monarch butterfly as he went into the chrysalis and adult stages; getting ready to sneak to the outhouse (about two blocks from the Nature Center) when all was quiet only to see a bus load of galloping boy scouts arriving in the parking lot; being shown a "dangerous water moccasin" and peering in a pail at a baby hognose snake; finding out that it is best not to scare the hognose unless you enjoy the smell of skunk in the building; the expressions of pleasure on people's faces as they recognized Gwen Frostic's unique talent in our Michigan Botanical Club poster; hearing little boys say, "There goes a stolen police car," as I drove the ranger's automobile; and being asked how we trained the bees to come through that tube and into their hive in the building.

I believe some of the purposes of the Nature Center and the Michigan Botanical Club itself are synonymous, namely, "conservation of all native plants; education of the public to appreciate and preserve plant life . . ." We at the Nature Center attempt to conserve native plants by educating the public so that they will appreciate and preserve plant life. By having more centers of this type, particularly close to large metropolitan areas, we can reach and appeal to more people so that they can appreciate the land on which we live and the living things it houses.

MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

The aim of this section is to list all significant literature relating to Michigan botany published since the beginning of 1960, without attempting much coverage of related fields such as agriculture, conservation, and forestry. When the subject matter or relation to Michigan is not clear from the title, annotations are added in brackets.

B. BOOKS, BULLETINS, SPECIAL REPORTS, AND MISCELLANEOUS

Brown, Donald F. M. 1964. A Monographic Study of the Fern Genus Woodsia. Nova Hedwigia Beih. 16. 154 pp. + 40 pl. $15.00. [Includes full citations of specimens examined of species and hybrids from Michigan, and some of the anatomical drawings based on Michigan material; no maps.]

Hauke, Richard. 1963. A Taxonomic Monograph of the Genus Equisetum Subgenus Hippochaete. Nova Hedwigia Beih. 8. 123 pp. + [10] tables + 3 graphs + [20] pl. $10.00. [A few observations are recorded as made in Michigan, and the plates include maps showing general distribution of several taxa to include the state; no specimens cited; with a single exception, the sources of experimental materials are all cited as from Michigan.]

Islam, A. K. M. Nurul. 1963. A Revision of the Genus Stigeoclonium. Nova Hedwigia Beih. 10. 164 pp. + 47 pl. $15.00. [Monograph cites 8 species from Michigan, but data incomplete, e.g. "Round Lake".]

Kruschke, Emil P. 1965. Contributions to the Taxonomy of Crataegus. Milwaukee Public Mus. (Publ. Bot. 3), Milwaukee, Wis. 273 pp. $6.50. [One of the new entities described, *C. chrysocarpa* var. *longiacuminata*, is cited from Marquette Co. In the synonymic listing, and the comments thereon, disposition is made of many species originally described from Michigan and certain later collections, particularly by Bazuin, are cited. See extended review on pp. 93-96 of this issue.]

Thomson, John W. 1963. The Lichen Genus Physcia in North America. Nova Hedwigia Beih. 7. 172 pp. + 1 fig. + [37] maps + 25 pl. $15.00. [Maps show occurrence of 20 species in Michigan; specimens examined are also cited in this monograph.]

C. JOURNAL ARTICLES

Culberson, William Louis. 1963. A summary of the lichen genus Haematomma in North America. Bryologist 66: 224-236. [*H. ochrophaeum* is cited from Houghton Co.]

Hale, Mason E. 1964. The Parmelia conspersa group in North America and Europe. Bryologist 67: 462-473. [Distribution maps show *P. conspersa* and *P. mexicana* in the Keweenaw Peninsula.]

Harrison, K. A. 1964. New or little known North American stipitate Hydnums. Canad. Jour. Bot. 42: 1205-1233. [Several species are noted as occurring in Michigan, including types of three new ones.]

Henssen, Aino. 1963. The North American species of Placynthium. Canad. Jour. Bot. 41: 1687-1724. [The lichen *P. nigrum* var. *nigrum* cited and mapped from Leelanau Co.]

Hollensen, Raymond H. 1964. The morphology of Blepharostoma trichophyllum (L.) Dumort. Jour. Hattori Bot. Lab. 27: 159-177. [Some of the material studied was from Cheboygan Co.]

Lemke, Paul Arenz. 1964. The genus Aleurodiscus (sensu stricto) in North America. Canad. Jour. Bot. 42: 213-285. [3 of the species of this fungus are

cited from Michigan localities.]

Lemke, Paul Arenz. 1964. The genus Aleurodiscus (sensu lato) in North America. Canad. Jour. Bot. 42: 723-768. [3 species of Aleurocorticium are cited from Michigan localities.]

Pobedimova, E. G. 1963. A review of the genus Cakile. Bot. Zhur. 48: 1762-1775. [In Russian, with English summary. Map shows occurrence of *C. lacustris* around Great Lakes.]

Russell, Norman H., & Frank S. Crosswhite. 1963. An analysis of variation in Viola nephrophylla. Madrono 17: 56-65. [Distribution map of the species includes Michigan locations.]

Russell, Norman H. 1965. Violets (Viola) of central and eastern United States: An introductory survey. Sida 2: 1-113. [Consists of keys, comments, good drawings, and distribution maps, the latter including in detail Michigan occurrences. The maps of *V. pubescens* var. *pubescens* and var. *eriocarpa* are reversed.]

Scora, Rainer W., & Warren H. Wagner, Jr. 1964. A preliminary chromatographic study of eastern American Dryopteris. Am. Fern. Jour. 54: 105-113. [The material of *D. goldiana* came from near Ann Arbor; of the other species, from garden plants in Michigan.]

Sierk, Herbert A. 1964. The genus Leptogium in North America north of Mexico. Bryologist 67: 245-317. [8 species of these lichens mapped (and in some cases cited) from Michigan localities:]

St. John, Harold. 1965. Monograph of the genus Elodea: Part 4 and summary. Rhodora 67: 1-35. [*E. nuttallii* cited from Jacobsville and *E. canadensis* from several Michigan localities; distribution maps.]

Stoutamire, Warren P., & William S. Benninghoff. 1964. Biotic assemblage associated with a mastodon skull from Oakland County, Michigan. Pap. Mich. Acad. 49: 47-60.

Walker, S. 1961. Cytogenetic studies in the Dryopteris spinulosa complex. I. Am. Jour. Bot. 48: 607-614. [Some of the material studied was from Michigan.]

Waterman, Ann H. 1960. Pollen grain studies of the Labiatae of Michigan. Webbia 15: 399-415 + pl. 32-43. [Includes a key to 49 species based on pollen grains.]

Wetzel, Robert G. 1960. Marl encrustation on hydrophytes in several Michigan lakes. Oikos 11: 223-236. [A review, plus data from Washtenaw and Livingston counties.]

White, Donald P., & Raymond F. Finn. 1964. Frost damage in a tulip poplar plantation as related to foliar potassium content. Pap. Mich. Acad. 49: 75-80. [Study on plantation at Russ Forest, Cass Co.]

White, Richard A. 1963. Tracheary elements of the ferns. I. Factors which influence tracheid length; correlation of length with evolutionary divergence. Am. Jour. Bot. 50: 447-455. [Includes data on some material from southeastern Michigan.]

Wilson, James S. 1965. Variation of three taxonomic complexes of the genus Cornus in eastern United States. Trans. Kansas Acad. 67: 747-817. [Includes a key to all spp. & subspp. of Cornus in eastern U.S.; special treatment of the *C. foemina*, *C. drummondii*, and *C. amomum* complexes; some Michigan material included in illustrations, distribution maps, and selected citations of specimens.]

Zeller, Sanford M., & Alexander H. Smith. 1964. The genus Calvatia in North America. Lloydia 27: 148-186. [Five species are cited from Michigan, without further locality data. A footnote on the authors' names states that the first-named author died in 1948, yet numerous eager collectors of reprints are addressing post cards to him!]

Zimmerman, James H., & Hugh H. Iltis. 1961. Conservation of rare plants and animals. Wis. Acad. Review, pp. 7-pp. [Map of midwest distribution of pitcher plant includes Michigan counties.]

D. HISTORY, BIOGRAPHY, EXPLORATION

Bean, Ralph C. 1964. Arthur Stanley Pease. Rhodora 66: 3-5 + portr. [Obituary of noted classical scholar and botanist, who collected in the Great Lakes region in 1933 and 1935; see Mich. Bot. 1: 80. 1962.]

Berry, Fern. 1963. Unchanging land: The jack-pine plains of Michigan. Mich. History 47: 15-28. [Popular account of natural history, including some references to plants, berry-picking, etc., in historical perspective. No documentation is given as to source of author's figure of 976,020 acres of jack pine in Michigan, a figure 27,980 acres less than the U.S. Forest Service estimate for the state (1960).]

Bidlack, Russell E. 1962. The Nucleus of a Library. A Study of the Book Collection of The University of Michigan and the Personalities Involved in Its Acquisition 1837-1845. Univ. Mich. Dept. Library Sci. (Stud. No. 6), Ann Arbor. 106 pp. [Includes biographical data, with portraits, of Zina Pitcher, Henry Rowe Schoolcraft, and Asa Gray.]

Eifert, Virginia S. 1965. Tall Timbers and Far Horizons. Adventures and Discoveries of Early Botanists in America. Dodd, Mead & Co., New York. 301 pp. $5.00 [Thomas Nuttall and Douglass Houghton, who botanized in Michigan, are included among the explorers here treated, but with such disregard for facts that the writing can be recommended only for entertainment, not for correspondence to reality. See review on p. 82 of this issue.]

Harding, Walter (ed.). 1962. Thoreau's Minnesota Journey: Two Documents. Thoreau Soc. Bookl. 16. Geneseo, N.Y. 60 pp. [This account which includes Thoreau's botanical notes in Michigan was listed a year ago in section "B" of "New Literature" but propertly belongs here in "D" with history.]

Humphrey, Harry B. 1961. Makers of North American Botany. Ronald Press, New York. 265 pp. $6.00 [A series of 122 (not 121 as implied in the Foreword) brief, obituary-style biographical sketches of deceased botanists, edited by the late author's son. A review by Ewan (Rhodora 64: 186-190. 1962) has commented well on conspicuous omissions and questions of interpretation as well as a higher incidence of errors than desirable in a work intended for reliable reference. Among the included botanists whose careers were significant in Michigan are Liberty Hyde Bailey, W. J. Beal, C. H. Kauffman, F. C. Newcombe, and Volney M. Spalding. It is also interesting to note that some famous botanists not otherwise associated with Michigan were born in the state, among them D. C. Eaton, A. S. Hitchcock, and Conway MacMillan. It is not quite correct to say that Asa Gray "never entered upon the duties" of his University of Michigan appointment, for his duties at first were not to teach but to obtain books for the library, a task attended to with conspicuous success. It is misleading to read (under Newcombe) that the University of Michigan Botanical Gardens are "now known as the Nichols Arboretum" (the old garden site was absorbed by the Arboretum, but administratively the one never became the other; they simply became separate entities half a century ago after a period of joint administration). Wiegand's thesis certainly never "won for him his election to Sigma Chi" (Sigma Xi is more likely). References to published biographical sketches, although incomplete, increase considerably the value of this work.]

Welch, Winona H. 1964. Truman George Yuncker. Bull. Torrey Bot. Club 91: 406-412. [Obituary, with bibliography. Dr. Yuncker was a native of Michigan, received his B.S. in horticulture from Michigan State in 1914; his postgraduate training and entire professional life were out of the state.]

PROGRAM NOTES

"BACKYARD BOTANY" course: Dr. C. Marvin Rogers of Wayne State University will teach this course beginning July 1; field trips will be arranged. Emphasis will be on common plants found in yards, vacant lots, lawns, and such places. Sponsored by Southeastern Chapter of Michigan Botanical Club; registration fee for members, $2.00, for non-members, $13.50. Further information available from Tom Varley, program chairman, 14110 Sorrento, Detroit 48227 (phone WE 4-9885).

"WILDERNESS CANOE TRIPS, Inc." may be of interest to MBC members. Trips to the Algoma District wilderness of Ontario leave the Detroit area each Saturday June 19 - August 29. Only 5 persons in each group; 7 days canoeing and tenting beyond the Ranger Lake region; program tailored to photographic, nature study, or other interests of group. For information write George Merring, 4351 Bluebird, Rt. 1, Union Lake, Michigan (phone 363-0472). (Mr. Merring, president of Wilderness Canoe Trips, Inc., wrote his master's thesis on the ethnobotany of the Chippewa Indians of Walpole Island.)

HORNER WOODS DEDICATION

An important milestone in Botanical Club history occurred Sunday afternoon April 25, with the formal dedication of Horner Woods (see Mich. Bot. 4: 9. 1965). Following the Annual Meeting of the Michigan Botanical Club at The University of Michigan Botanical Gardens, the ceremonies were opened with introductory remarks by A. H. Smith, director of the University Herbarium. H. Lewis Batts, Jr., representing the Nature Conservancy, spoke briefly. Clarence Messner, a past chairman of the Michigan Conservation Commission (and of the Michigan Botanical Club), then spoke on "The Significance of a Nature Preserve," commenting on the importance of such areas for a variety of uses. Charles Barclay, president of the Botanical Club, reviewed the history of the Club and its activities, including now the establishment of a plant sanctuary. He called on Genevieve Gillette to introduce Mrs. Horner, whose cooperation had made possible the purchase of her property. He then presented the deed for the property to Stephen H. Spurr, Dean of the Horace H. Rackham School of Graduate Studies of The University of Michigan. Dean Spurr responded with the thanks of the University and pledged adherence to the terms of the deed, that the tract be "forever held as a nature preserve."

Despite the abnormally late spring and rainy weather, the large crowd of Club members and friends departed in two busloads and several cars to the woods. At the entrance is a plaque presented by the Southeastern Chapter and reading: "Horner Woods. Dedicated a perpetual plant sanctuary. Presented to The University of Michigan by the Michigan Botanical Club April 25, 1965." Catkins of hazelnut waved in the breeze; little else was in flower, but buds of spring beauty, trout lily, rue anemone, pink spring cress, and twinleaf were ready to open with only a day or two of warm sunshine.

Editorial Notes

In this issue, we launch a new feature which we hope will appear from time to time: a "Nature Education Feature." Under this general heading we expect to include appropriate, informative, brief articles on such topics as nature interpretation, teaching techniques, conservation education, nature photography, and related matters. Short, carefully prepared manuscripts are solicited for this section as well as for regular articles.

The March number (Vol. 4, No. 2) was mailed March 3, 1965.

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(*On the cover: Bird's-eye Primrose,* Primula mistassinica, *from Miner's Falls, Alger Co., Michigan (white-flowered plants). Photo by H. W. Vogelmann.* *See p. 83.*)

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THE MICHIGAN BOTANIST

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Subscriptions (from those not members of the Michigan Botanical Club) and all orders for back issues should be addressed to the business and circulation manager, who will assume that subscriptions received prior to the last number of a volume are intended to begin with the first number of that volume unless specified to the contrary.

Articles and notes dealing with any phase of botany in the Upper Great Lakes Region may be sent to the editor in chief. The attention of authors preparing manuscripts is called to "Information for Authors" (Vol. 4, p. 38, and also available from the editor).

THE MICHIGAN BOTANICAL CLUB

Membership in the Michigan Botanical Club is open to anyone interested in its aims: conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on the plant life of the State; sponsorship of legislation to promote the preservation of Michigan native flora and to establish suitable sanctuaries and natural areas; and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

Dues are modest, but vary slightly among the chapters. In all cases, they include subscription to THE MICHIGAN BOTANIST.

PLANT ASSOCIATES OF *SARRACENIA PURPUREA* (PITCHER PLANT) IN ACID AND ALKALINE HABITATS[1]

Adrienne J. Mandossian
Cass Technical High School, Detroit

INTRODUCTION

The floristic structure of a bog is characteristically different from that found elsewhere, as a result of two factors. One is the physical condition of the habitat that plays a selective role on the flora. The second factor is the reaction of the bog flora to the habitat and their interaction with each other. This second factor will be studied here, particularly in relation to *Sarracenia purpurea* (pitcher plant). An attempt will be made to answer the question: "Does *Sarracenia purpurea* form a definite association with another plant or group of plants?"

The five *Sarracenia* habitats selected for this study are located within twenty-five miles of the Kellogg Gull Lake Biological Station of Michigan State University. The first one, at Purdy Lake, and the second one, at Otis Lake, are *Sphagnum* bogs. The third one, at McKay Lake, and the fourth one, on the northeastern shore of Deep Lake, are alkaline bogs. The fifth bog, on the southeastern shore of Deep Lake, has both acid and alkaline zones within a few feet of each other. Map coordinates and descriptions of these *Sarracenia* habitats will be given below.

MATERIALS AND METHODS

The method used for this study was an examination of the reproductive vigor of *Sarracenia purpurea* in several different types of bog and a study of the species composition in sites supporting this plant. No attempt was made to make a statistical study of the floristic structure of each bog. Instead, an alphabetical list was made of all the species of plants present in each bog in order to sort out any plants that were found in all five bogs along with *Sarracenia purpurea*. Size and number of pitchers of *Sarracenia*, and lack or relative abundance of seedlings, were noted as an indication of how well this plant was established in a particular bog. Nomenclature for species follows Gleason (1952). The Bryophytes were identified by Dr. Howard Crum of the University of Michigan.

The field work was done during the month of August, 1960. Determinations of pH in four of the five habitats were made on August

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[1] From a thesis submitted to the Department of Botany and Plant Pathology, Michigan State University, in partial fulfillment of the requirements for the Doctor of Philosophy.

26 and 27, 1961, by inserting the electrodes of a portable Beckman pH meter into the substrate, and the average of five readings was recorded. The fifth bog, located at the northeast shore of Deep Lake, was not discovered until the following year and pH determinations were made by the Soil Testing Laboratory of Michigan State University from oven-dried soil samples removed during the first and second weeks of August, 1962.

DESCRIPTIONS OF THE BOGS

1. Purdy Lake Bog. Purdy Lake (Barry Co., Michigan, T1N, R9W, Sect. 36) is located about five miles east of the Kellogg Gull Lake Biological Station of Michigan State University. It is a typical acid bog lake (pH of surface water, 6.5 in August, 1961), which is becoming gradually shallower. Long-time residents of the area as well as Dr. W. E. Wade, who teaches the course on aquatic plants at the Biological Station, attest to this fact. The surrounding organic soil was characterized as Greenwood Peat in the Soil Survey of Barry Co. (Deeter & Trull, 1928).

One well established colony of *Sarracenia purpurea* was found over a partially grounded *Sphagnum* mat within a few meters of the lake. The entire circumference was not examined, and the statements apply to an area of about 50 × 150 meters on the southern shore of the lake.

The large leaves of the pitcher plants were partially buried in a more or less continuous cover of *Sphagnum*, and the primary associated plant species at this point, listed in approximate order of cover were *Sphagnum capillaceum* var. *tenellum*, *Drosera rotundifolia*, *Vaccinium macrocarpon*, *Andromeda glaucophylla*, *Rhynchospora alba*, and *Utricularia cornuta*. A thorough search of this area revealed only about a dozen *Sarracenia* seedlings. *Sarracenia* was not found on the older and outer parts of the bog mat where *Chamaedaphne calyculata* is the dominant species. The pH readings taken in August, 1961, are listed in Table I, all showing varying degrees of acidity.

2. Otis Lake Bog. Otis Lake (Barry Co., Michigan, T3N, R9W, Sect. 30 and 31) is located approximately twenty miles northeast of the Biological Station. Surface lake water is quite alkaline (pH of 7.9 in August, 1961). The tamaracks on the surrounding peat are young and during the six years that the bog has been under observation by the writer, conspicuous development of the floating mat into the open water has taken place. Blueberry pickers questioned at the scene have substantiated this observation. The surrounding organic soil was classified as Rifle Peat in the Soil Survey of Barry Co. (Deeter & Trull, 1928).

About one-half of the circumference of the lake was examined but no *Sarracenia* colonies were found except on the south shore of the lake in a narrow band of about 10 × 200 meters. They were young, vigorous plants, with large red leaves, growing in the open, close to the water's edge with *Sphagnum recurvum* and *Decodon verticillatus*.

There were many seedlings in various stages of development. Farther away from the water's edge, *Chamaedaphne calyculata* was the dominant plant species instead of *Decodon* and pitcher plants did not occur here.

The pH readings of this bog, made on August 27, 1961, are listed in Table I. As has already been noted above, the lake water was distinctly alkaline (pH 7.9). The surface *Sphagnum* was distinctly acid (pH 6.0 and 6.6), while about 10 cm below, where the roots of *Sarracenia* penetrate, the substratum had a pH of 7.0 and 7.1.

3. McKay Lake Bog. McKay Lake (Kalamazoo Co., Michigan, T1S R9W, Sect. 24) is located about eight miles southeast of the Biological Station. It is a small alkaline lake (pH of 9.1 in August, 1961) east of Stony Lake, adjacent to property belonging to Mr. H. H. McKay. I have named it "McKay Lake" for this study. Fifteen small pitcher plants were found here on the north shore of the lake, on marly substrate in a clearing of about 20 square meters bounded on three sides by tamarack. The *Sarracenia* was concentrated in a rectangular area of about 5 x 10 meters in the center of this clearing, about 20 meters from the water's edge. The entire circumference was not examined as it was privately owned and the owners could not be located.

The pitcher plants appeared healthy, with a large number of small leaves, ranging from 1 cm up to 12 cm in length. No *Sphagnum* was found here. There were no *Sarracenia* seedlings and the pitcher plants were associated with the moss *Thuidium delicatulum*. Besides this moss, the dominant plant species associated with *Sarracenia* were *Potentilla fruticosa, Scirpus acutus,* and *Solidago spathulata*. Other common species nearby were *Cornus amomum, Aster junciformis, Thelypteris palustris, Eupatorium maculatum, E. perfoliatum, Triadenum fraseri, Lobelia kalmii, Parnassia glauca,* and *Pycnanthemum virginianum*.

The pH readings taken on August 26, 1961, are listed in Table I. It will be noted that not only the lake water but also the marly material in which the small *Sarracenia* plants were growing was decidedly alkaline, with a pH of 9.1 and 8.9, respectively.

4. Deep Lake (Northeast Bog). Deep Lake (Barry Co., Michigan, T3N, R10W, Sect. 26) is located in the Yankee Springs Recreation Area, about twenty miles northeast of the Biological Station. No pitcher plants were found on its northeastern shore until the summer of 1962, even though a thorough search had been made the previous summer of the entire shoreline of the lake from a boat. The bog is completely hidden from the lake side behind *Cornus stolonifera* shrubs. The substrate in the study site is a marly material of about 25 square meters, with a large colony of small-pitchered *Sarracenia*. The soil type is classified as Rifle Peat in the Soil Survey of Barry Co. (Deeter & Trull, 1928).

There was no *Sphagnum* or any other moss associated with the pitcher plants over this white marly substratum. Instead, *Rhyncho-*

spora capillacea, Scleria verticillata, Parnassia glauca, and *Tofieldia glutinosa* grew at the base of *Sarracenia* and all over the bog. There were many seedlings and young plants of *Sarracenia* interspersed with the older plants.

Surface lake water was alkaline (pH of 8.9 in August, 1961), with clear water and a large amount of marl-encrusted *Chara* on the bottom. A pH value of 7.8 at both surface and root-level of *Sarracenia purpurea* was reported by the Soil Testing Laboratory of Michigan State University from oven-dried soil samples taken in August, 1962 (Table I).

5. Deep Lake (Southeast Bog). The southeastern bog of Deep Lake is an extremely interesting one as it includes both acid and alkaline situations in an area of about 200 square meters.

On the east, about 50 meters from the water's edge is the tamarack zone with *Sphagnum* and several species of ferns. Here *Sarracenia* grew in the shade and protection of tamaracks, partially embedded in *Sphagnum*. pH readings on August 27, 1961, were 6.5 and 7.5 at the surface and depth of 10 cm, respectively. (See Table I). The plants had large, green pitcher leaves but no fruits were seen during the summers of any year from 1960 to 1964, inclusive. No seedlings of pitcher plants were discovered here.

Associated plants in the tamarack zone were *Sphagnum magellanicum, Osmunda regalis, Rhus vernix, Andropogon scoparius, Cirsium* sp., *Amelanchier* spp., *Thelypteris palustris, Epilobium coloratum, Equisetum pratense, Steironema quadriflorum, Eupatorium maculatum,* and *E. perfoliatum.*

In the center of the bog, about halfway between the lake and the tamarack zone, some pitcher plants grew on small hummocks not necessarily associated with *Sphagnum* but with other mosses such as *Thuidium delicatulum* or *Campylium stellatum.* All looked rather small in size, with many leaves, and all were fruiting in August, 1960. No seedlings or young plants were found here. The pH readings on August 27, 1961, are given in Table I, and show these sites to be more alkaline than the former (8.4 at base of *Sarracenia* and 8.0 at depth of 10 cm).

The associated species growing on the hummocks with *Sarracenia* were *Cladium mariscoides, Eleocharis robbinsii, Gerardia purpurea, Lobelia kalmii, Campanula aparinoides, Potentilla fruticosa, Scleria verticillata,* and *Solidago* spp.

South of this area is a slough formed from bubbling springs. The pH of the spring water on August 27, 1961, was 8.1 and that of the slough, 8.8. *Sarracenia* with fruits grew around the slough associated with *Nymphaea odorata, Nuphar advena, Triadenum fraseri, Scirpus acutus, Eleocharis rostellata,* and *Utricularia cornuta.* Of 45 plants counted in this area, all but seven had capsules in August, 1960. However, no seedlings or young plants were discovered in the entire bog.

TABLE I. pH readings of 5 *Sarracenia* bogs and of surface water of 4 lakes.[1]

	PURDY	OTIS	McKAY	DEEP N. E.	DEEP S.E.
Lake water	6.5	7.9	9.1	8.9	8.9
Open water: Surface moss at base of *Sarracenia*	5.2 (*Sphagnum*)	6.0 (*Sphagnum*)	8.9 (*Thuidium*)	7.8* (no moss)	8.4 (*Thuidium*)
Depth of 10 cm. at root-level of *Sarracenia*	6.1	7.1	8.5	7.8*	8.0
Under tamaracks: Surface moss at base of *Sarracenia*		6.6			6.5
Depth of 10 cm. at root-level of *Sarracenia*		7.0			7.5

[1]Taken by inserting the electrode of a portable Beckman meter directly into the substrate, on August 26 and 27, 1961. Measurements with asterisks were made by the Soil Testing Laboratory of Michigan State Unversity from oven-dried soil samples taken in August, 1962.

DISCUSSION

Among the five bog lakes studied, *Sarracenia purpurea* seems to form no consistent close association with any other plant species. Along a slough or spring, it grows alongside such aquatic plants as *Nymphaea odorata* and *Nuphar advena*. In marly substrate, it thrives in the company of such basicolous plants as *Scleria verticillata* and *Eleocharis rostellata*. In the shade of tamaracks, it associates with ferns such as *Woodwardia virginica* and *Osmunda regalis*. However, in most situations, there seems to be some species of moss with which it is closely associated. If the moss is *Sphagnum*, as in Purdy Lake, Otis Lake, and under the tamaracks of Deep Lake, the substrate is acid, and the pitchers of *Sarracenia* are large in size but few in number. In alkaline areas, as in McKay Lake, and the marly zone of the southeastern bog of Deep Lake, although *Sphagnum* is present, *Sarracenia* does not necessarily grow in close association with it. Some other moss, such as *Campylium* or *Thuidium*, is more often found at the base of *Sarracenia* than is *Sphagnum*. In the small alkaline bog at the northeastern shore of Deep Lake, neither *Sphagnum* nor any other species of moss is found growing with *Sarracenia purpurea*. The pitcher leaves in the alkaline areas are smaller in size but greater in number.

In " The Bogs of Northern Lower Michigan," Gates (1942) regards *Sarracenia purpurea* as one of the most striking plants of the *Chamaedaphne* association. Other characteristic or striking plants listed by Gates for this association are *Drosera rotundifolia*, *D. intermedia*, a few species of orchids, *Scheuchzeria palustris*, several species of *Carex*, *Andromeda glaucophylla*, *Kalmia polifolia*, *Ledum groenlandicum*, and *Vaccinium oxycoccos*.

A comparison of the plant species of the five bogs of this study with those in the *Chamaedaphne* association of northern Lower Michigan (Gates, 1942) and the open bogs of Wisconsin (Curtis, 1959) shows that *Cladium mariscoides* and *Thelypteris palustris* are the only plants common to all areas supporting *Sarracenia*. However, as noted in the descriptions of the bogs, above, these plants are not always found in close association with *Sarracenia* in the present study sites. Curtis (1959) considers only one of them, *Cladium*, as modal for an open bog. *Thelypteris* is merely rated as prevalent. Gates (1942) does not consider either one of these species of plants as characteristic to a *Chamaedaphne* association, but only relics of a former association. Waterman (1926), too, does not include them among his typical bog species.

Four of the five bogs of this study (all except the very small alkaline area on the northeastern shore of Deep Lake) and the bogs studied by Gates, have *Larix laricina* in common. The one exception, however, would seem to eliminate this species from the role of indicator plant for *Sarracenia purpurea*.

Again, the above-mentioned four bogs and the bogs of Wisconsin (Curtis, 1959) have *Rhus vernix* in common which Gates does not list because this plant does not grow that far north. This species cannot be considered as an indicator plant because it, too, is missing from the very small alkaline bog located on the northeastern shore of Deep Lake.

The two acid bogs of this study, the *Chamaedaphne* association of the bogs of northern Lower Michigan (Gates, 1942), and the open bogs of Wisconsin (Curtis, 1959) have, in addition, the following plants in common: *Andromeda glaucophylla*, *Chamaedaphne calyculata*, *Potentilla palustris*, and *Vaccinium macrocarpon*. These species are missing from the alkaline areas of this study. Therefore, they cannot be considered as essential for the presence of *Sarracenia purpurea*.

Bird (1923) reports that in an artificially constructed bog he was able to grow a number of bog plants from widely separated localities, which do not usually occur together in nature. In the experiment cited he had brought together a group of mature plants. Whether or not seeds of these plants would germinate in this artificial environment was not investigated. As is well known, a bog has a plant population quite distinct from the surrounding area. Therefore, significant invasion of species adapted to non-bog conditions is quite unlikely. Germination obviously must occur before any plant species may become established in a bog. Then, the species must be adapted to an environment characterized by low levels of dissolved nutrients, periodic flooding, lack of aeration in the substrate, etc., perhaps generally unfavorable to most species, but favorable to others. I have found that *Sarracenia purpurea* seeds will germinate under conditions normally prevailing in a bog. Once past the hurdle of germination, this species, like other bog species, has many adaptations for life in a bog. Like many of them, it can reproduce vegetatively and can hold its own against the competition of other species for space and nutrients. In addition, it has evolved the insectivorous habit by means of which it is generally assumed that it has become partially independent of the substrate for minerals and can supply itself with nutrients throughout the growing season.

It would appear, therefore, that the presence of *Sarracenia purpurea* in an area is not dependent on the presence of any other particular species of plant. Rather, it is due to the special adaptations that this species has evolved for competing successfully with other species growing in a bog.

SUMMARY AND CONCLUSIONS

1. In the two acid bogs of this study (Purdy L. and Otis L.), *Sarracenia purpurea* was found associated with *Larix laricina*., *Cladium mariscoides*, *Rhus vernix*, *Andromeda glaucophylla*, *Chamaedaphne calyculata*, *Eriophorum virginicum*, *Vaccinium macrocarpon* and *Sphagnum* spp.

2. These plant species were included in the list by Gates for the *Chamaedaphne* association for northern Lower Michigan bogs, with the exception of *Rhus vernix*, which does not grow in the north.

3. The plant species given in No. 1 above were also included in the list compiled by Curtis of prevalent and modal species of the open bogs of Wisconsin with only two exceptions. *Larix laricina* is not listed among the *Sarracenia* associates even though it is treated as a bog tree, and *Eriophorum virginicum* is not listed at all.

4. In the two acid bogs (Purdy L. and Otis L.), in one alkaline bog (McKay L.), and in both the acid and alkaline zones of the southeastern bog of Deep Lake, *Sarracenia purpurea* was found growing with *Larix laricina* and *Rhus vernix*. In the very small alkaline bog (northeastern bog of Deep Lake), neither of these species was present.

5. *Sarracenia purpurea* was usually closely associated with a moss. If the substrate was acid, the moss was *Sphagnum*, and the pitchers were large in size but few in number, as in Purdy Lake, Otis Lake and the southeastern bog of Deep Lake (under the tamaracks).

6. If substrates were alkaline, as in McKay Lake and the marly zone of the southeastern side of Deep Lake, the moss with which *Sarracenia* was associated was not necessarily *Sphagnum*, even though some *Sphagnum* was present. Rather, the moss was *Thuidium* or *Campylium*. Here the pitchers were small in size but great in number.

7. In the northeast bog of Deep Lake, again an alkaline bog, *Sarracenia* was not found associated with any moss at all. Rather, it grew in close association with basicolous plants such as *Scleria verticillata*, *Rhynchospora capillacea*, *Parnassia glauca*, and *Tofieldia glutinosa*. The pitcher leaves were small in size but great in number as in the two alkaline bogs mentioned in No. 6 above.

8. Of the two acid bogs, Purdy Lake contained about a dozen seedlings; Otis Lake bog, a large number of seedlings. The acid zone under the tamaracks of Deep Lake had no seedlings. Of the three alkaline bogs, only the northeastern bog of Deep Lake had *Sarracenia* seedlings.

9. It would appear from the study of these five bogs of central Lower Michigan that *Sarracenia purpurea* grows over a variety of substrates (semi-aquatic, soft organic soil, and hard marl), over a pH range of 5.2 to 8.9, that it forms no consistent association with any single plant species, and that within the range examined its reproductive vigor is not determined by the reaction of the substrate.

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NOTES ON THE DISTRIBUTION OF *CAREX* IN MICHIGAN

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Hermann in 1941 published the only treatment of *Carex* in Michigan, supplementing it in 1951. He reviewed key herbaria basing the distribution maps of species upon personally inspected specimens. The present report is concerned with range extensions of Michigan Carices found by the author from 1954 to 1965. The same or other findings may well have been made by others collecting in the years since 1951. Such collections, if deposited in various herbaria, but not reported, would not be known to the writer who has made no attempt to search herbaria. Some recently published records (e.g., Hebert, 1956; Voss, 1957) and unreported data have been made available to me through the assistance of Dr. Edward Voss.

The notes presented here are limited to new county stations for species of *Carex* for which previous Michigan reports were from fewer than ten counties or from stations two hundred or more miles distant.

Voucher specimens upon which this report is based are deposited in the herbaria of Cranbrook Institute of Science and the University of Michigan. The nomenclature of *Carex* used here is consistent with that used by Hermann.

1. *Carex gynocrates:* Charlevoix Co., Evangeline Twp., Section 21, T33N, R6W, bog, Young State Park. 29 May 1965.

2. *Carex laevivaginata:* Calhoun Co., Tekonsha Twp., Nottawassepee Lake, low elm woods, south shore, Section 3, T4S, R6W. June 1964. Also, St. Clair Co., Clyde Twp., Section 17, T7N, R16E, rich springy wooded slope of Black River. May 1964. This sedge so simulates the abundant *C. stipata* that it is probably overlooked. Nine county stations have been reported previously.

3. *Carex crus-corvi:* Macomb Co., Warren Twp., Section 35, T1N, R12E, in a mud wallow at the edge of Plum Brook Golf Course. 18 June 1956. This is the most easterly of four localities in the state.

4. *Carex tenuiflora:* Mackinac Co., St. Ignace Twp., Section 3 near M-134, T42N, R3W, in Thuja-sphagnum swamp. 5 July 1964. Probably much commoner than the eight previous county locations would suggest.

5. *Carex exilis:* Chippewa Co., Whitefish Twp., 2 miles south of Shelldrake, Section 10, T49N, R6W, sphagnum bog. 3 July 1964.

6. *Carex suberecta:* Lenawee Co., Cambridge Twp., Allens Lake, Section 10, T5S, R2E. July 1955. Reported from nine other counties.

7. *Carex backii:* Antrim Co., Custer Twp., Section 9, T29N, R7W, M-88, Saloon Creek, sandy edge of woodland. 28 May 1965. The sixth county reported.

8. *Carex umbellata:* Chippewa Co., Detour Twp., 3 miles northwest of DeTour, Sweets Point, Section 21, T42N, R4E, gravelly ground, 29 May 1957. Previously reported from four other counties. *Carex concinna* also found at this locality.

9. *Carex hirtifolia:* Mackinac County, St. Ignace Twp., M-123, Section 11, T41N, R3W, rich hardwood forest. Other stations are 200 miles to the south or west. 3 July 1964.

10. *Carex livida:* Charlevoix Co., Evangeline Twp., Section 21, T33N, R6W, Young State Park. 29 May 1965. Mackinac Co., Clark Twp., 1 mile north of Cedarville, M-129, Section 19, T42N, R1E, in sphagnum bogs. 5 July 1964. Marquette Co., Powell Twp., Section 18, T51N, R27W. 16 August 1965. Collected 50 years ago on Bois Blanc Island and also reported from four other counties. Known from Beaver Is. (Voss).

11. *Carex saltuensis:* Mackinac Co., St. Ignace Twp., M-134, Section 3, T42N, R3W, in Thuja-sphagnum swamp. 5 July 1964. Reported from only three other counties.

12. *Carex oligocarpa:* Calhoun Co., Tekonsha Twp., Section 9, T4S, R6W. 26 June 1964. Reported only from adjacent Kalamazoo and Berrien counties and also Wayne Co.

13. *Carex hitchcockiana:* Mackinac Co., St. Ignace Twp., M-123, Section 11, T41N, R3W, rich hardwood forest. 2 July 1964. This station is the first for the Upper Peninsula.

14. *Carex capillaris:* Mackinac Co., St. Ignace Twp., M-134, Section 3, T42N, R3W, in Thuja-sphagnum swamp. 5 July 1964. Abundant in Mackinac Co., though previously reported from only six other counties.

15. *Carex lenticularis:* Chippewa Co., Whitefish Twp., 2 miles south of Shelldrake, Section 10, T49N, R6W, sphagnum bog. 3 July 1964. Otherwise known in northern Michigan from four counties to the west.

16. *Carex michauxiana:* Alger Co., Au Train Twp., M-28, Section 28, T47N, R19W, boggy sandy soil. 15 August 1965. Reported from four other counties.

17. *Carex atherodes:* Alger Co., Burt Twp., swampy north shore of Long Lake, Co. Rd. 637, Section 33, T48N, R16W. 7 July 1964. This station is located over 200 miles north of the six other reported stations; known but unreported from Otsego and Presque Isle counties.

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Voss, Edward G. 1957. Observations on the Michigan flora—VI. Distribution records of some Angiosperms new, rare, or misinterpreted in the state. Brittonia 9: 83-101.

News of Botanists

Three good friends of the Michigan Botanical Club were among those honored at the 28th Annual Convention of the Michigan United Conservation Clubs in Cadillac last June. The Governor's Award for the outstanding conservationist of the year went to Stanley A. Cain, on leave as Professor of Conservation and of Botany at the University of Michigan. Dr. Cain, a former chairman of the U. of M. Conservation Department and of the Michigan Conservation Commission, was appointed last February by President Johnson as Assistant Secretary of the Interior for Fish and Wildlife. The forest and park conservationist of the year was Miss E. Genevieve Gillette, president of the Michigan Parks Association and a professional landscape architect. Clarence Messner, another former chairman of the Michigan Conservation Commission, was named conservation educator of the year. The awards were part of a new nationwide program sponsored jointly by the National Wildlife Federation and the Sears Roebuck Foundation. The Michigan winners will be eligible for consideration for national awards in the respective categories.

Gwen Frostic, honorary member of MBC and designer of our current wildflower protection poster (see Mich. Bot. 4: 9-10, Jan. 1965) was awarded an honorary Doctor of Laws degree at Eastern Michigan University's 112th Commencement last June.

While Dr. John H. Beaman, curator of the Beal-Darlington Herbarium, is on leave from the Department of Botany and Plant Pathology at Michigan State University, to study at the Smithsonian Institution this year, his place at MSU is being taken by Dr. Warren P. Stoutamire, botanist of the Cranbrook Institute of Science.

Dr. Howard Crum, formerly of the National Museum of Canada, is now Curator of Bryophytes and Lichens in the University Herbarium and Associate Professor of Botany at the University of Michigan. (Dr. Crum's annotated list of the mosses of the Douglas Lake region appeared in Vol. 3 of THE MICHIGAN BOTANIST.)

DISCOVERY OF THE NORTHERN TWAYBLADE (*LISTERA BOREALIS*) IN THE LAKE SUPERIOR REGION OF ONTARIO

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On June 30, 1965, while vacationing on the north shore of Lake Superior, I visited the region of Dr. James Soper's notable rediscovery of *Cypripedium passerinum* (Soper, 1965). I hoped to see this arctic orchid in the Great Lakes Region. Northwest from the Pic River mouth lies a series of rolling, partially wooded sand dunes. On and behind these dunes lies an open forest of White Spruce (*Picea glauca*) and Balsam Fir (*Abies balsamea*). This forest similar to the habitat of Franklin's Lady's-slipper in the arctic, seemed the ideal place to search. Much time spent working this cover yielded an abundance of *Calypso bulbosa,* still in bloom, and large colonies of *Goodyera repens* var. *ophioides*.

Finally, in a difficult-to-penetrate thicket of brush and tangled windfalls of spruce and fir, we succeeded in locating *C. passerinum.* As we examined one of the colonies of this fascinating lady's-slipper, my wife discovered twayblades growing among them. The plants appeared to be typical *Listera borealis* Morong, the Northern Twayblade.

I had long felt that *L. borealis* should occur in this district; in fact, I have even suggested that possibility (Case, 1964, p. 67). The twayblade grew, here, in a rather different situation than that to which I was accustomed for it in Yukon, British Columbia, and Alaska. Since Correll (1950, p. 119) considers the Auricled Twayblade (*L. auriculata* Wieg.) extremely close to *L. borealis* and since *L. auriculata* is frequent on the North Shore, I wished to compare living material of the two twayblades to be absolutely sure that I had not mistaken aberrant Auricled Twayblades for the Northern. The next day, therefore, I visited a prolific station for *L. auriculata* at Coldwater Bay. The plants differed greatly in details of structure in spite of their superficial similarity. In *L. auriculata* the rounded-cleft tip of the lip bears scarcely diverging lobes. Little or no sign of a tooth appears in the sinus between the tip-lobes. The most distinctive features of the lip, the basal auricles, are rounded and slightly in-curved, almost clasping the column. Along its median portion, the lip bears a slightly raised and thickened dark greenish area. In *L. borealis,* the tip of the lip appears slightly more divergent, owing more to the fact that the lip is slightly constricted at its middle than to actual divergence. The sinus between apical lip lobes is wider in *L. borealis,* and usually bears a small but distinct tooth. The basal auricles differ greatly from those of *L. auriculata* in diverging from the column rather than in clasping it, and in being oblong-cuneate rather than rounded. The median portion of the lip in *L. borealis* bears two parallel ridges of heavily thickened dark green tissues with a whitish line between. These features show fairly well on the enlarged flowers in Fig. 1.

Listera borealis differs from *L. auriculata* in other features as well. Its raceme is more elongate, the fewer flowers are wider-spaced, the individual florets larger. *L. borealis* has narrower, oblong-elliptic acuminate leaves which in early stages of flowering appear ascending, somewhat thickened, and with the major veins prominent. In *L. auriculata* the rather uniformly broad, ovate-elliptic to suborbicular leaves have only the midrib prominent. The differences in aspect of fresh material of both these similar species can be seen in the photographic comparison, Fig. 2, and the habit photograph of the Northern Twayblade, Fig. 3. Comparison left no doubt that our plant *was* the Northern Twayblade, *L. borealis*.

Fig. 1. Flowers (about 2-1/4 times natural size) of *Listera borealis* from Lake Superior station, showing the prominent dark green ridges of tissue and the divergent basal auricles of the lip.

To the best of my knowledge, this is the first report of this very distinctly arctic-cordilleran orchid in the Great Lakes region. Correll (1950) gives its geographical distribution as Hudson Bay, Mackenzie, Alberta, British Columbia, the Yukon, Alaska, Colorado, Montana, Wyoming, Idaho, Utah, and Mingan Islands. Fernald (1950) states "local, nw. Nfld.; Mingan Ids. and Anticosti, Que.; Hudson Bay reg., Mackenz. to Alaska, s. to mts. of Colo., Ida., and s. B.C." Gleason (1952) does not include the species.

At this Lake Superior Station, the Northern Twayblade grew in a wooded trough between dunes. Tree cover consisted of *Picea glauca* and *Abies balsamea*. Shrub cover consisted of Red Osier Dogwood, *Cornus stolonifera*, and Canada Buffalo-berry, *Shepherdia canadensis*. On the ground grew a sparse moss cover with an overlay of rawish, wind-blown sand mixed with humus. We did not see the plant elsewhere in the area, but the plant is inconspicuous and may be more abundant than we realized.

Six specimens were taken to substantiate this find; these will be distributed to the following herbaria: University of Michigan, United States National Herbarium, Canadian National Herbarium, and the University of Toronto. The full citation for this collection is: Ontario,

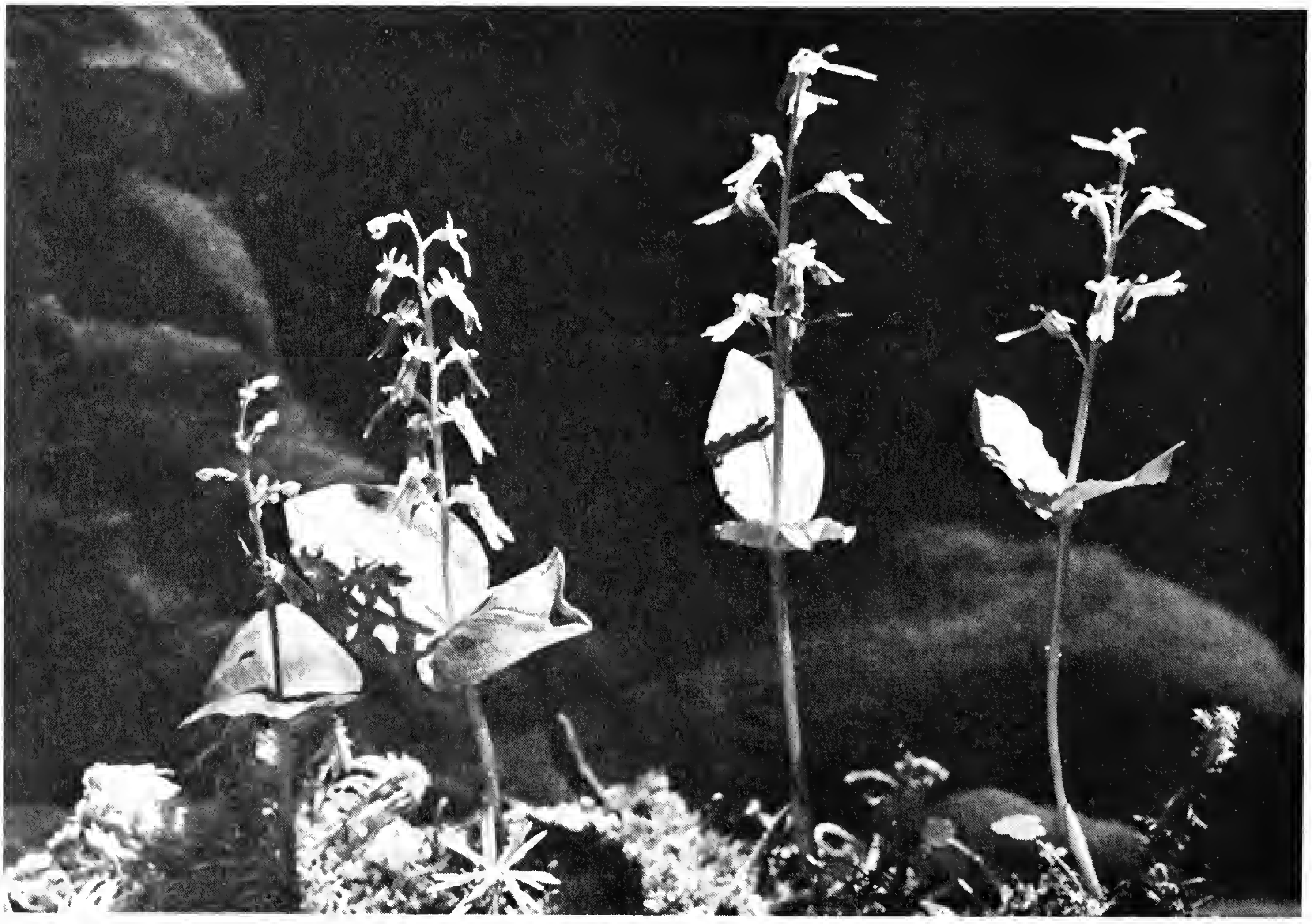

Fig. 2. Comparison of growth habit of *Listera borealis*, right, with *L. auriculata*, left, from Lake Superior stations. Note particularly the differences in leaf shape and in flower carriage and placement. (About 3/8 natural size.)

Thunder Bay District: Wooded, north-facing trough among sand dunes, northwest from the mouth of the Big Pic River, Lake Superior shore, June 30, 1965, F. W. Case, Jr., Roberta and David Case. About 40 flowering plants and numerous seedlings growing in moss and sand under *Picea glauca*, *Abies balsamea*, and *Cornus stolonifera*, with *Cypripedium passerinum* and *Goodyera repens* var. *ophioides*.

Fig. 3. *Listera borealis*, 2/3 natural size, at Banff, Alberta.

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Fernald, M. L. 1950. Gray's Manual of Botany. Ed. 8. Am. Book Co., New York. lxiv + 1632 pp.

Gleason, H. A. 1952. The New Britton and Brown Illustrated Flora of the Northeastern United States and Adjacent Canada. N. Y. Bot. Gard. 3 vol.

Soper, James H. 1965. Rediscovery of Cypripedium passerinum in the Lake Superior region. Mich. Bot. 4: 91-92.

Nature education feature --

NATURE IS FOR CHILDREN[1]

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Nature is for children. It is for adults too, but not in the same sense, for somewhere along the way we have lost a portion of the wonder and imagination and faith which is the essence of childhood. It is these qualities, when coupled with a still uncluttered and unbiased mind, which makes a child so receptive to each new experience.

So many parents say, "I would like to have my children know and understand the joys of the out-of-doors but how and where do I begin?" Unfortunately there is no single answer to this question. The laws of learning are many and varied and much of the way is still uncharted. However, we do know that learning is connecting a response with a stimulus. If the stimulus is provided under pleasurable conditions, learning is simpler and more lasting. Here every situation is as unique as the child himself and method must be timed and tuned to each urgency. This is where the resourceful teacher and parent enter.

There is a first requisite for a child's natural and full acceptance of the world which is his home; this is that he be allowed to experience it firsthand and without undue pressures. It is one of the greatest privileges of my life that for many years I was a happy participant in a camp situation in Michigan where this happened every day all summer long.

But it can happen anywhere. It happens at school, at home, in a museum, on quiet and unscheduled roamings, on vacation trips, at scout meetings, at camps. It happens alone or in groups. It happens at any place and in any season.

Books are indispensable aids and checks but for children they should accent something which has already taken place. Nothing can substitute for a firsthand experience in the out-of-doors. For nothing in nature can be viewed singly. Everything is a part of the whole and to be fully appreciated and understood it must be experienced in its natural setting.

A whip-poor-will's song can be heard on a record. But it is something else to hear it as part and parcel of darkness and longing,

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[1]Reprinted by permission from CANADIAN AUDUBON (May-June 1959), published by the Canadian Audubon Society, Toronto. We hope in future issues to include some specific illustrations of the principles here expounded, whether by the author or other of our members.—Ed.

of seclusion and deep woods. An orchid can be purchased in a florist's shop. But it is quite another experience to be kneeling in a bog to watch a bee find its way out of a delicately veined pouch on a morning when the world is alive with all the sights and sounds of early summer.

It is good to read about animals and plants and to see their pictures on page and screen. But this is a second-hand experience with a go-between writer's or artist's point-of-view prefacing and preparing it for us. To meet a butterfly or a beetle, a snake or a skunk; to know intimately any of the wild creatures of earth in a firsthand experience is to grow in comradeship and understanding with life itself.

As an adult, you can alert a child to his surroundings and follow up his nature experiences with appropriate guidance. One valid approach can come through your wise planning for his vacation days. For him these represent a quality of leisure and a favorable tone of acceptance which are often denied him during the school year. Over and over again I have been amazed at a child's response to a nature-alerted situation where with proper guidance he arrives at "understanding" rather than at learning disconnected facts and names. Using this approach I have seen my own three children and scores of others develop a growing interest in nature which they are now sharing with their families and their communities.

A child is eager and alive. He is potentially interested in everything. For him each day is filled with new wonder and experience. He loves to discover; he is thrilled by exploration. He possesses a quality of aliveness and curiosity which you and I as adults have long since left behind but which is the key to his future. His kind of delight in water, earth, and sky is something we have forgotten. The odor of meadows and fields, the feel of wind and water on face and hands and feet, the mysterious sounds of night and morning; these, though often inarticulate, are elemental in his world.

Too often children are offered inferior opportunity because they are children. Or we try to offer something simple where all is profound. It has been my experience that children are equal to the truth even if it implies mental and emotional maturity far beyond our poor estimate of their powers.

If you have interested a child in the out-of-doors you have given him a beautiful and lasting gift. If you have helped him to become aware of his place in life's on-going continuity, you have given him a sense of lasting security which will fortify him for all the years ahead.

MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

This section lists new literature relating to Michigan Botany under four categories: A. Maps, Soils, Geography, Geology (new maps and selected bulletins or articles on soils and geology as these may be of use to field naturalists and students of plant distribution); B. Books, Bulletins, etc., and C. Journal Articles (listing, respectively, all separate publications and articles in other periodicals which cite Michigan specimens or include research based on plants of wild origin in Michigan; —not generally including work on cultivated plants nor strictly economic aspects of forestry, conservation, or agriculture); D. History, Biography, Exploration (travels and lives of persons with Michigan botanical connections). When the subject matter or relation to Michigan is not clear from the title, annotations are added in brackets. Readers are urged to call to the editor's attention any titles (1960 or later) which appear to have been overlooked—especially in less well known sources.

B. BOOKS, BULLETINS, SPECIAL REPORTS, AND MISCELLANEOUS

Brewer, Richard. 1965. Vegetational Features of a Wet Prairie in Southwestern Michigan. Occas. Papers Adams Ctr. Ecol. Stud. 13. 16 pp. [The area studied (recently destroyed) was in Kalamazoo Co.]

Hooper, Frank F., et al. 1964. Aquatic Weeds and their Control in Michigan. Mich. Dept. Conservation. 31 pp. [More important for chemical and legal aspects of control than for identification.]

Rudolf, Paul O., & John W. Andresen. 1965. Botanical and Commercial Range of Red Pine in the Lake States. Lake States Forest Exp. Sta., U.S. Forest Serv. Res. Note LS-62. 4 pp. [Includes detailed distribution map.]

Rudolf, Paul O., & John W. Andresen. 1965. Botanical and Commercial Range of Eastern White Pine in the Lake States. Lake States Forest Exp. Sta., U. S. Forest Serv. Res. Note LS-63. 4 pp. [Includes detailed map.]

Van Arsdel, E. P. 1965. Relationships between Night Breezes and Blister Rust Spread on Lake States White Pines. Lake States Forest Exp. Sta., U. S. Forest Serv. Res. Note LS-60. 4 pp. [Includes map and diagram of rust distribution and breeze patterns in eastern Upper Peninsula.]

C. JOURNAL ARTICLES

Anon. 1965. Aeroallergens. An interdisciplinary study. Research News, Office of Research Admin., Univ. Mich. 15(6-7): 1-16. [General discussion of botanical, meteorological, and other research on ragweeds in Michigan at the University of Michigan.]

Ashby, William Clark. 1961. Responses of American basswood seedlings to several light intensities. Forest Sci. 7: 273-281. [One source of the experimental material was southwestern Michigan.]

Barghoorn, Elso S., Warren G. Meinschein, & J. William Schopf. 1965. Paleobiology of a Precambrian shale. Science 148: 461-472. [Paleobiochemical studies on samples from the Nonesuch Formation (at White Pine, Ontonagon Co.) strongly indicate that these sediments (approx. 1 billion years old) contain products of primary photosynthetic activity.]

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STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION
(Act of October 23, 1962: Section 4369, Title 39, United States Code)

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INDEX

NOTICE TO LIBRARIANS, SUBSCRIBERS, & BINDERS

An annual index is not compiled for THE MICHIGAN BOTANIST. At the conclusion of Vol. 3, a cumulative index to volumes 1-3 was printed. It is planned to continue issuing an index for each three volumes, in the expectation that these will make a more convenient unit for binding and for consultation. All subscribers may rest assured that they will receive any index published, as it will be included in a regular issue.

Editorial Notes

Rather than delay the mailing of this number, it has been issued with somewhat fewer pages than usual. However, a number of manuscripts are in process and should swell the January and March numbers to greater than customary size.

Most of our readers are probably interested chiefly in modern plants, but one of the most exciting recent discoveries in the state has been evidence of plant life as long ago as one billion years. See the titles listed under Barghoorn, Eglinton, and Meinschein, in section C of the "New Literature" in this number.

The May number (Vol. 4, No. 3) was mailed May 26, 1965.

Errata

In addition to a few obvious typographical errors, the following more serious ones have been noted in previous numbers of Vol. 4:

January, p. 36, line 11 up, for "week" read "weed"

March, p. 63, line 1, for "spp" read "ssp."

line 4, for "timentosa" read "tomentosa"

May, p. 77, bottom line should be bottom line (above footnote) on p. 78

p. 102, line 2, for "7-pp." read "7-11"

PROGRAM NOTES

IMPORTANT DATES:

Oct. 24: Kalamazoo Nature Center, first anniversary open house.

Dec. 5: Michigan Botanical Club, Board Meeting.

Jan. 16: 1966: MBC general meeting. Genevieve Gillette will report on President Johnson's natural beauty conference. Watch for further details.

Julia Hunter has been named Historian for the Michigan Botanical Club.

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(On the cover: "Bryophyte Collecting Paradise," photo by Carl B. Obrecht in March, 1949, southwest of Watersmeet, Gogebic Co., Michigan.)

Vol. 5, No. 1

THE MICHIGAN BOTANIST

January, 1966

THE MICHIGAN BOTANIST—Published by the Michigan Botanical Club four times per year: January, March, May, and October. Second-class postage paid at Ann Arbor, Michigan.

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Subscriptions (from those not members of the Michigan Botanical Club) and all orders for back issues should be addressed to the business and circulation manager, who will assume that subscriptions received prior to the last number of a volume are intended to begin with the first number of that volume unless specified to the contrary.

Articles and notes dealing with any phase of botany in the Upper Great Lakes Region may be sent to the editor in chief. The attention of authors preparing manuscripts is called to "Information for Authors" (Vol. 4, p. 38, and also available from the editor).

THE MICHIGAN BOTANICAL CLUB

Membership in the Michigan Botanical Club is open to anyone interested in its aims: conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on the plant life of the State; sponsorship of legislation to promote the preservation of Michigan native flora and to establish suitable sanctuaries and natural areas; and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

Dues are modest, but vary slightly among the chapters. In all cases, they include subscription to THE MICHIGAN BOTANIST.

FOSSIL PLANTS IN MICHIGAN

Chester A. Arnold
Department of Botany & Museum of Paleontology,
The University of Michigan, Ann Arbor

Directly beneath the glacial drift in the central part of the Lower Peninsula of Michigan lies a series of rocks with a thickness of about 900 feet. These rocks consist of two parts, the lower one being the Saginaw Formation and the upper the Grand River Group. The Saginaw Formation contains coal, which sets it apart from the Grand River Group which consists mainly of sandstone without appreciable amounts of coal. These rocks fill a broad shallow depression in the underlying Mississippian age rocks. This rock-filled depression is known in Michigan geology as the Coal Basin.

The Michigan Coal Basin has an area of about 11,500 square miles. Its north-south axis extends from Higgins Lake to Jackson. Its eastern bulge cuts off the southern end of Saginaw Bay, and its western limit lies a few miles west of Big Rapids.

The Saginaw Formation consists largely of sandstone and shale with some coal and limestone. Most of the coal layers are thin and of relatively small lateral extent, and only a few are thick enough to be profitably mined. However, during the past Michigan did have a small but thriving coal industry, and in 1907, the banner year, 2 million tons were sold. There is no commercial coal mining in the state at present, the last mine having closed down in 1952.

The Saginaw Formation belongs to the sequence of rocks formed during the Pennsylvanian period. Consequently it dates back some 250 million years. This period represents the great Coal Age, that interval in geologic history when large swamps choked with luxuriant vegetation existed over large areas of eastern North America, western Europe, and other parts of the earth. The sediments that ultimately filled these swamps entombed countless numbers of plant fossils, which when unearthed today give us brief but vivid glimpses of the strange vegetation that grew during the far-distant past. Presumably the fossils represent for the most part the vegetation that inhabited the swamps, though it is likely that a few plants from the neighboring hills also found their way in. Some of the rocks of the Saginaw Formation contain fossil marine organisms, which show that at intervals the floor of the basin lay sufficiently low to permit sea water to flow in. When the land surface was lifted the salt water flowed out, and the swamps became refilled with fresh water.

The fossil plants in the Saginaw Formation occur in those sandstones and shales that were formed in fresh water. Although coal itself consists of a mass of compacted and physically and chemically altered plant residue, no plant fossils other than microscopic spores, fragments of cutinized leaf epidermis, or bits of carbonized woody tissues can ordinarily be recognized in it. The other fossils, which we may designate macrofossils to distinguish them from the microfossils, consist mostly of broken parts of fronds, pieces of stems, leaves, cones of various kinds, and seeds. These all became compressed between heavy sand and mud layers that entombed them before hardening into stone.

As compared with the less disturbed conditions that prevailed in larger coal swamps in some of the other parts of eastern North America, the rocks of the Michigan basin show evidence of considerable turbulence at the time the sediments were deposited and the plants fossilized. This was detrimental to good preservation, with the result that the fossil plants in Michigan are highly fragmented. Most of them seem to represent vegetable material that had floated for considerable distances before it sank into the protective depths of deep quiet water. Those large and beautiful fernlike fronds from coal mines in West Virginia, Pennsylvania, and elsewhere, and often on display in museums, are extremely rare or virtually non-existent in Michigan.

Since most of southern Michigan is covered by a thick layer of glacial drift, places where the rocks of the Coal Basin can be seen at the surface are very few. For that reason the number of localities where plant fossils can be collected is rather severely limited. During coal mining days small but well preserved plant fragments could be found, often in large numbers, on the mine dumps in the Saginaw Valley and near Bay City and Jackson. In the collections of the Museum of Paleontology of the University of Michigan there are specimens from the mines at these and other places in the state. Fairly good specimens can sometimes still be found on some of the old dumps. One that continues to yield modest amounts of material is located a few hundred yards south of the expressway (US-10) about

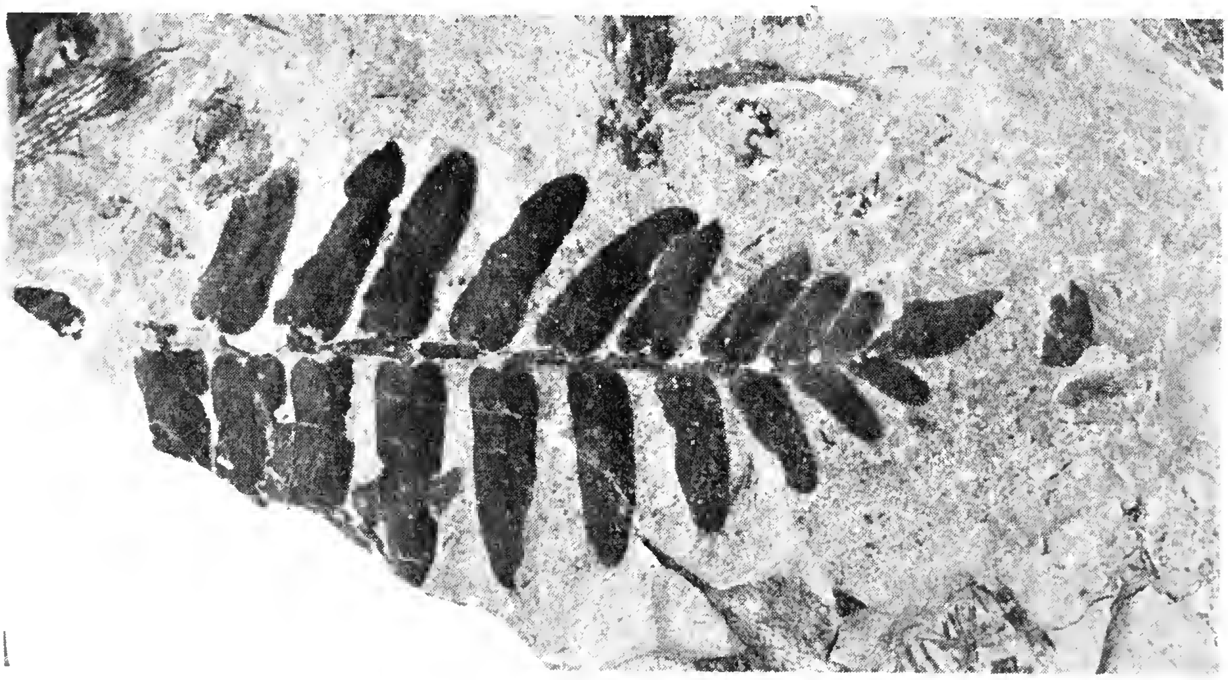

Fig. 1. *Neuropteris tenuifolia*, natural size. (All photographs of fossils illustrate specimens from Grand Ledge.)

Fig. 2. *Lepidodendron lanceolatum*, natural size.

halfway between Bay City and Midland. There are other old dumps in Bay and Saginaw counties that might be investigated with profit. On these old dumps fragments of almost any kind of Pennsylvanian age plant may be found. Most abundant is the fernlike foliage of the seed-ferns *Neuropteris* (Fig. 1) and *Alethopteris*. Persistent searching is almost certain to reveal shale slabs bearing the bark imprints of *Lepidodendron* (Fig. 2), one of the extinct treelike lycopods. The coal miners often mistook these imprints for fish or snake skins, or even tire marks.

For several years, especially since suspension of coal mining in the state, the best places to look for plant fossils have been in the

Fig. 3. *Cordaites* leaves, about one-half natural size.

shale quarries near Grand Ledge. Here the Grand River cuts through the drift into the underlying rock, and along the river northwest of the town are the most extensive exposures of Pennsylvanian age rocks that can be seen anywhere in the state. These natural outcrops have been greatly enlarged by quarrying. The main product of the quarries is clay used in the manufacture of brick and tile. During quarrying operations coal seams are frequently uncovered, and when there is enough of it the coal is taken out as a byproduct. The plants are to be looked for in the shale.

The one quarry that has yielded the most plant fossils over a thirty-year period is operated by the Grand Ledge Clay Products

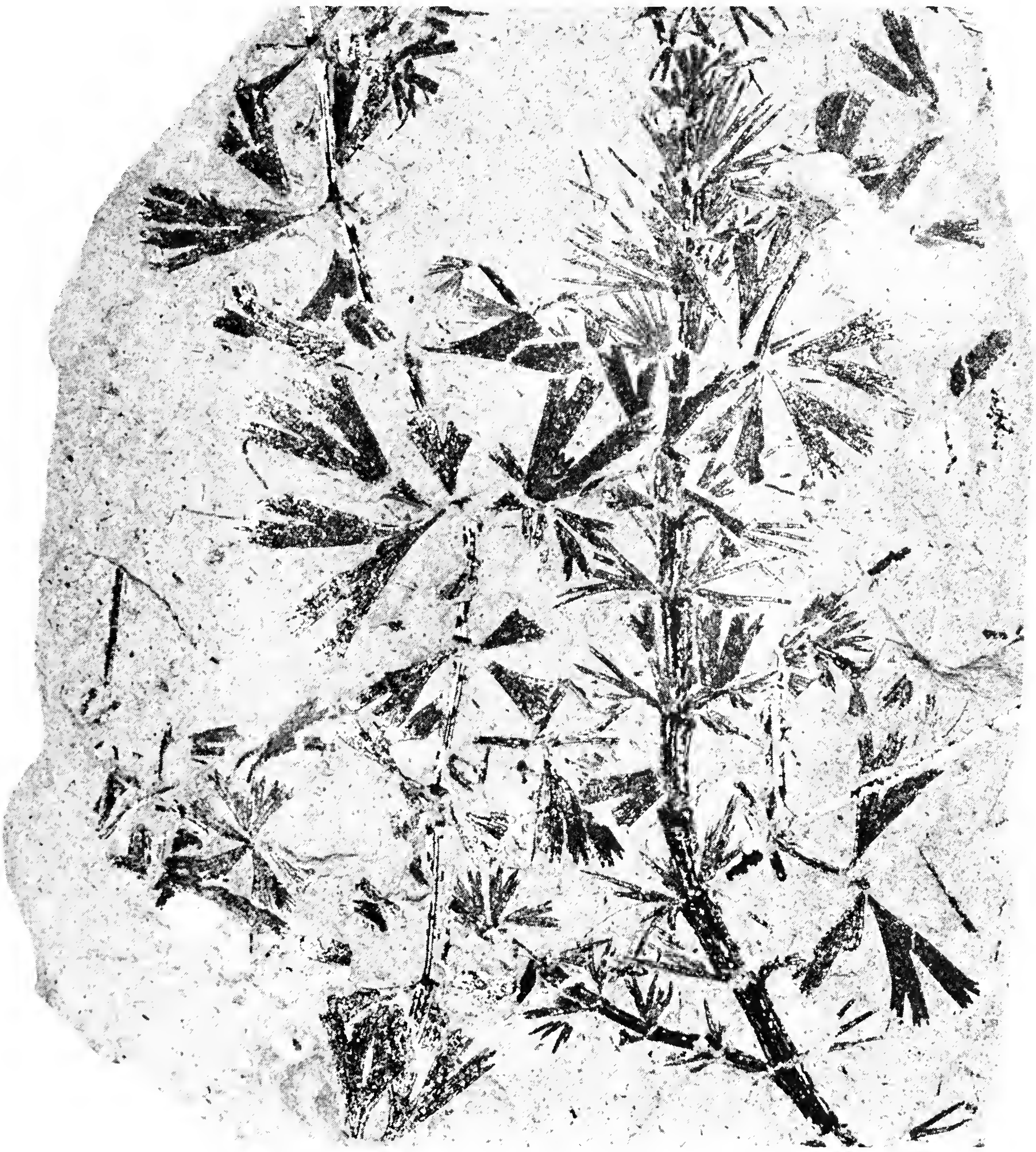

Fig. 4. *Sphenophyllum cuneifolium*, natural size.

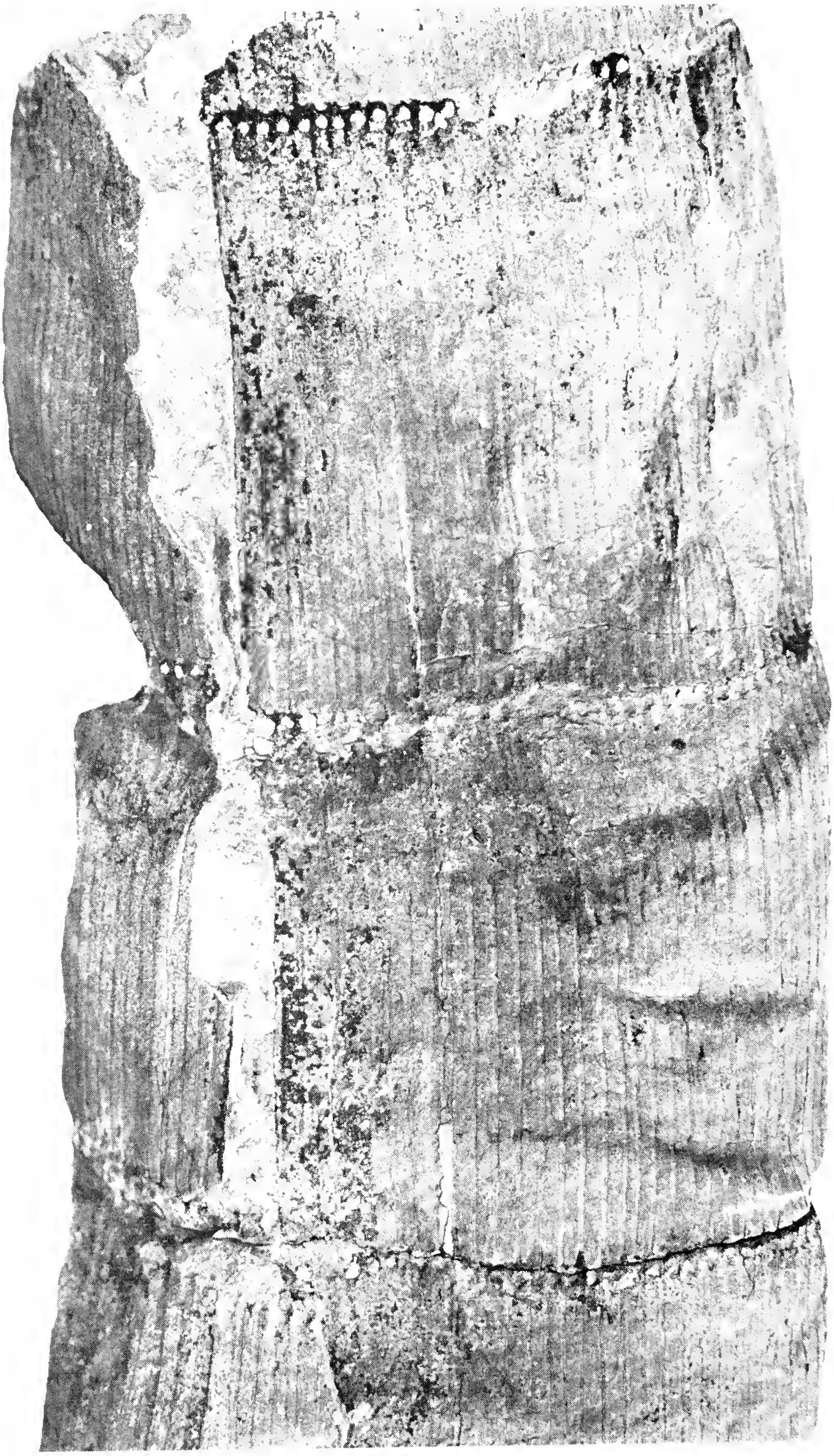

Fig. 5. *Calamites cistii*, natural size.

Company. It lies approximately a mile northwest of the center of Grand Ledge, and is reached by turning off Business M-43 onto Lawson Road west of the town. On Lawson Road one first crosses a railroad track, then a bridge over a small creek, and a little farther on one sees the roadway to the right that leads into the quarry. A heavy wire cable usually barricades the entrance.

What one finds during a visit to this quarry is likely to depend on two things—in which part the power shovel has recently been working, and one's willingness to do some digging. For digging, a cool day with low humidity is recommended. In the west wall of the quarry, which rises to the left as one enters the main excavation from the road, there seems to be an inexhaustible supply of well preserved fragments, but they have to be dug out. This side of the quarry has not been worked for several years and the soft shale disintegrates when it becomes wet. Most of the surface rock is extremely fragile, and to find good specimens it is necessary to dig back into the less weathered shale. This is not easy because the slope is rather steep. If nothing turns up after digging a small hole, it may pay to sample a fresh spot. The plants occur in thin zones an inch or two thick, and one may dig energetically just above or below a fossiliferous layer, finding nothing. As a rule, however, one seldom labors very long before the pinnules of *Neuropteris* turn up on freshly broken surfaces. One is certain to find *Cordaites* (Fig. 3) leaves, but as these originally had the size and shape of cat-tail leaves, even to similar parallel surface striations, nothing but fragments will be found. *Sphenophyllum* (Fig. 4), an extinct member of the scouring-rush class, is rather common at this site. This plant had small stems with clearly marked nodes and internodes about a centimeter long, and at the nodes were whorls of 6-9 wedge-shaped leaves with notches at the tips. Larger jointed axes with longitudinal ribs extending between transverse nodal lines are the casts of *Calamites* (Figs. 5 & 6), also an extinct sphenopsid

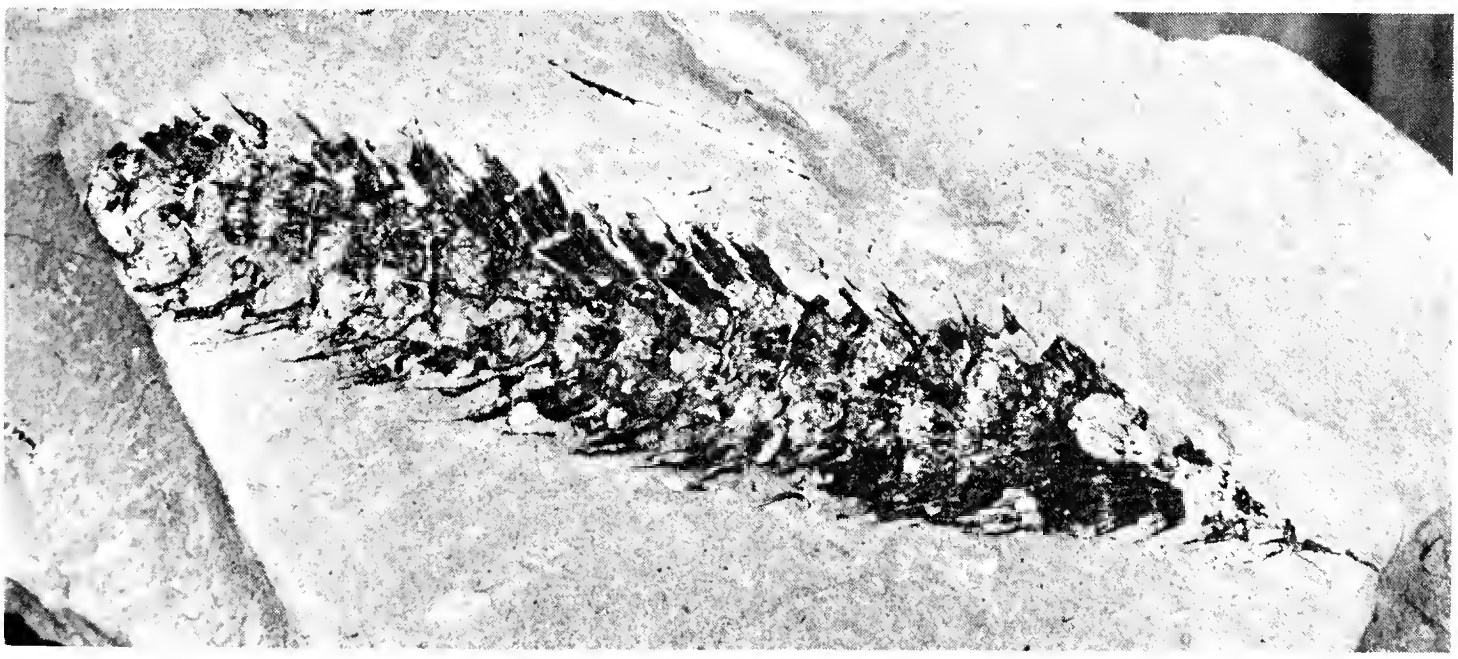

Fig. 6. *Macrostachya* sp., the inflorescence of *Calamites*, slightly reduced.

and a relative of *Equisetum*. This quarry has yielded some very fine *Calamites* casts. Several years ago specimens 6 inches in diameter and a yard long were dug out of the west wall. However, no large ones have been seen there for a long time. Those you will find will probably range from one inch to two inches wide. With good luck you may extract fragments of the trunk surfaces of *Sigillaria* (Fig. 7), a relative of *Lepidodendron* and one of the largest trees that grew in the coal swamps. These plants were distant relatives of the living selaginellas. Other plants may turn up, but those mentioned are the ones most likely to be found during a few hours of work.

At places near the top of the excavation, and just below the surface soil, one may see old mine props left in tunnels dug many years ago to remove coal from a 3-foot seam that lay at the top of the Saginaw Formation below the glacial drift. The westward expansion of the quarry removed most of the coal from this place, though some remains farther back underground.

Over in the eastern part of the quarry and near the bottom of the pit the oldest rocks visible anywhere in the coal basin are exposed.

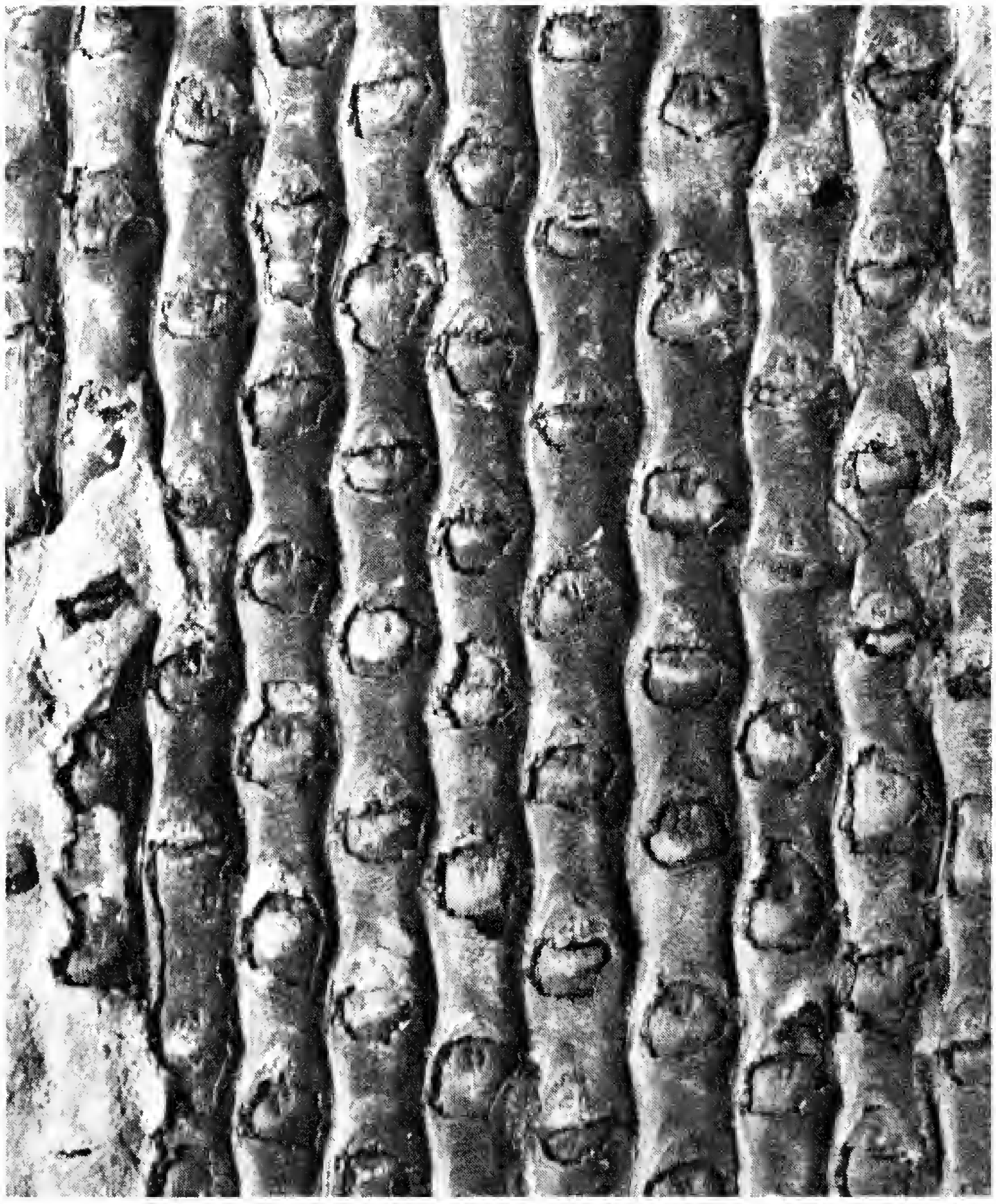

Fig. 7. *Sigillaria scutellata,* natural size.

Some of the rocks here are highly fossiliferous, and excellent specimens have been collected, but unless work has recently been going on here, little is to be found. One may, however, find fragments of the ever-present *Cordaites* leaves and, with good luck, pieces of the inflorescences and detached seeds. The inflorescences are lax conelike organs that cannot be well described in a few words, and it is best to consult illustrations in textbooks or Plate XXXIII in my "Fossil Flora of the Michigan Coal Basin," where examples are shown. The seeds are easier to recognize and, if luck is good, hundreds of them may be seen. They are flattened, sharply outlined carbonaceous bodies less than an inch long with a thick central part surrounded by a distinct border. Actually there are three different kinds of these seeds, but usually only one turns up at any particular spot. The largest (and incidentally the rarest) is circular in outline and about the size of a 25-cent coin. The others are smaller and triangular or heart-shaped. One of them has a conspicuously drawn out apex that resembles the neck of a wine flask.

Asterophyllites (cover photo), the name given the detached leafy twigs of the *Calamites* plant, is common here, though not often well preserved. These twigs somewhat resemble the leaf-bearing stems of *Sphenophyllum*, but the whorled leaves are pointed, not wedge-shaped. Sometimes cones are found attached to the leafy shoots (Fig. 6).

If collecting in the deep part of the quarry happens to be especially good, you may find fragments of deeply incised fronds that remind one of carrot tops more than anything else. Of course these are not

Fig. 8. ***Rhacopteris michiganensis***, natural size.

carrots, but the foliage of an extinct plant that we would like to know more about. This plant is believed to have borne spores like the ferns. It is called *Rhacopteris* (Fig. 8), though when my "Coal Basin Flora" was written, it was misidentified as *Eremopteris*, which it does somewhat resemble.

There are plant-bearing rocks in other quarries in the vicinity, but collecting in these may not be especially rewarding. One quarry which is being actively worked, and which sometimes yields large numbers of *Cordaites* leaves, can be reached by continuing north on Lawson Road to its end at the county line (see accompanying map, Fig. 9). Here it makes a right-angle turn to the left (west). A few yards west of the turn there is a road to the right (north), which is also barricaded, that leads into the quarry of the American Vitrified Tile Company, the factory of which is passed on the left (south) as one comes from town. Recently some fossil lungfish burrows were found in the easternmost excavation but they are now under water and cannot be seen.

One of the older quarries that yielded considerable plant material when it was in operation is the quarry of the Grand Ledge Face Brick Company, which lies just across the Grand River (nearly due north) of the first quarry described. To reach it, one must go back to town and cross the river.

Still another quarry, that was abandoned about 1932, belongs to the American Vitrified Tile Company. Little is to be seen there now except a dense growth of poplars which seem to thrive in the moist quarry bottom. It was from the stratigraphic sequence exposed in this quarry that Professor W. A. Kelly determined the sedimentary cycles in the Pennsylvanian age rocks in the Grand Ledge area, which he described in some detail in 1936. This quarry can be reached from the picnic park, the entrance of which is passed between town and Lawson Road.

The small creek that flows into the Grand River east of the park cuts a small gorge in the cross-bedded standstone that constitutes the topmost of the sedimentary cycles of the sequence in the Grand Ledge area. A walk along the well-maintained path that leads from the mouth of the creek along the south bank of the river toward town brings one close to what is probably the best natural rock outcrop in southern Michigan. This path is a favorite haunt of the bryologists, because at places the moist northerly exposed sandstone is covered with dense growths of thallose liverworts. Farther back, up the creek, are some shallow caverns formed by overhang of the sandstone, and in some of these one can see irregular seams of coal only a few inches thick. These thin coal seams contain numerous interesting large spores that were shed from the *Lepidodendron* and *Sigillaria* trees that grew in the ancient swamps. These coal layers were probably formed from floating peat masses.

The largest collection of fossil plants from the Michigan Coal

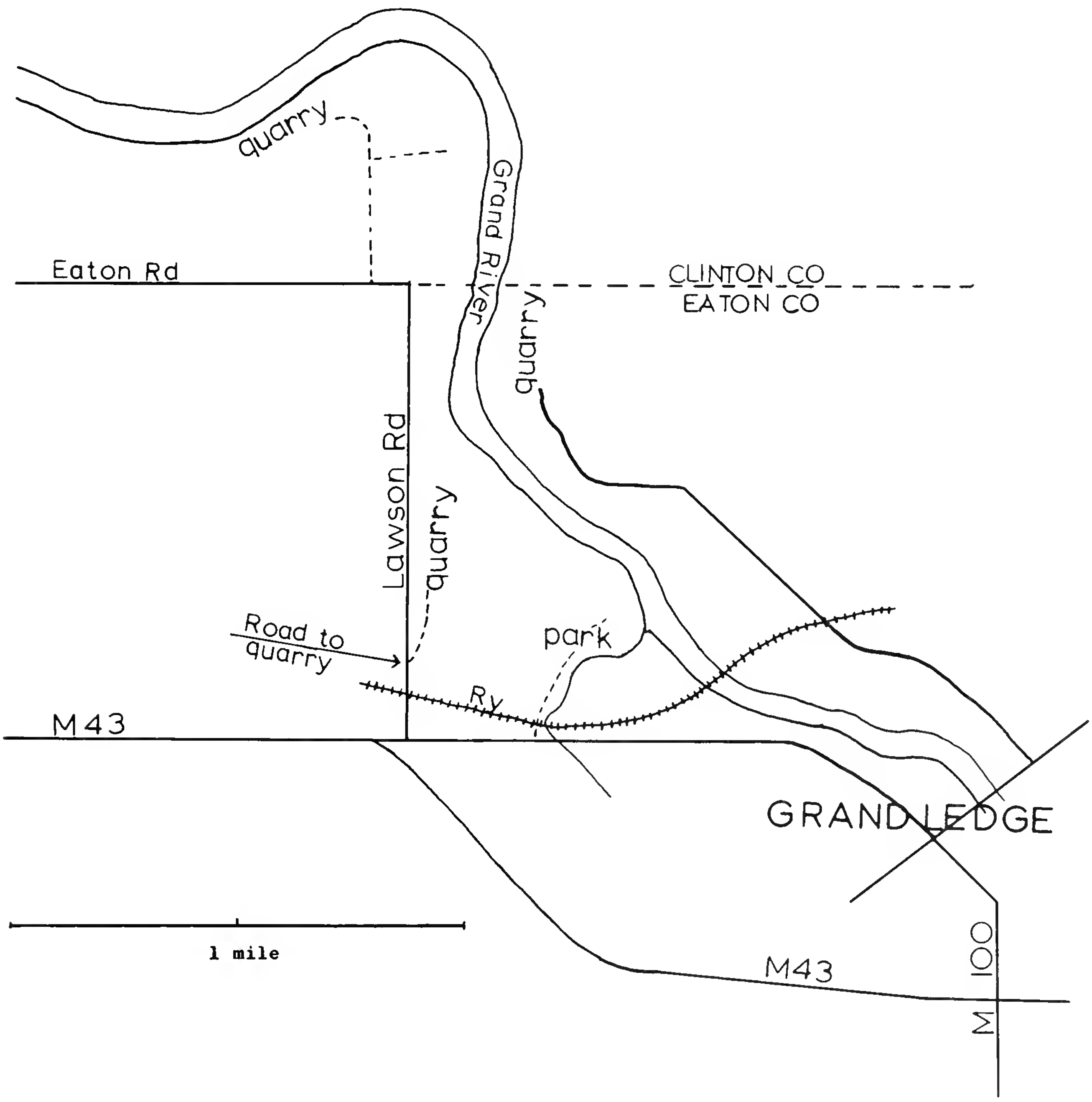

Fig. 9. Map of the Grand Ledge area (northwest of bridge on highway M-100 over the Grand River).

Basin, and which contains more than 100 species, is housed in the Museum of Paleontology of the University of Michigan at Ann Arbor. Most of these have been described and figured in the "Fossil Flora of the Michigan Coal Basin." The collection, however, is continually being enlarged because more material continues to turn up; and more will continue to become available as long as quarrying or coal mining is carried on in the Coal Basin.

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UTILIZATION OF ANIMAL PROTEIN BY THE PITCHER PLANT, *SARRACENIA PURPUREA*

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The College of Wooster, Wooster, Ohio

Today it is generally accepted that insects are trapped in the hollow trumpet-shaped leaf of the pitcher plant (*Sarracenia purpurea*), drowned in the rain water which collects in the trumpet, and then digested by plant enzymes. Although many theories have been formulated in the past (see Lloyd, 1942, pp. 32-35), there is still no conclusive evidence to substantiate what is generally accepted.

Due to this lack of evidence, I have performed a series of experiments using $carbon^{14}$ isotope as a tracer.

METHODS

Plants of *Sarracenia purpurea* (obtained commercially) were kept in covered glass containers filled partially with a mixture of sphagnum moss and humus. The acidity of the environment was maintained by adding a few drops of hydrochloric acid to the soil when necessary.

The source of animal protein for the testing of the pitcher plants was fruit flies (*Drosophila melanogaster*). At first flies were fed C^{14}-labelled glucose (six micro-curies/gram) with a wheat germ—glucose medium. The ratio of glucose to wheat germ was approximately 1 to 2; however, a wide ratio range was found to be satisfactory. Each culture bottle contained 1.2 or 4.5 micro-curies of C^{14}. Later radioactive glucose in solution was substituted for the granular sugar. In addition, an agar-base medium replaced the wheat germ—glucose medium. This medium consisted of 1700 ml. distilled water, 20 g. agar, 100 g. glucose, 50 g. sucrose, 100 g. cornmeal, and 30 g. yeast, with 0.5 g. of a mold inhibitor ("Moldex") per 100 g. of medium. After placing the media in culture bottles, 10 micro-curies of C^{14}-labelled glucose solution were placed on top of the medium in each bottle. The culture bottles were then placed in an incubator to allow the glucose solvent to evaporate.

Flies were found to be most easily transferred from culture to culture after having first spent 15 minutes in a refrigerator at 1^{o} C. The fruit flies were allowed to starve to death in empty bottles after feeding on radioactive media for 8 to 15 days. This was done to insure that the glucose in their bodies had been assimilated. The dead flies were then tested for radioactivity with a thin-walled Geiger-Mueller counter. Ten-minute background counts were run in a counting chamber after which dehydrated flies were introduced and counted for ten- and twenty-minute periods. Later, X-ray plates were substituted for the counting equipment. Fly samples were sealed in cellophane and then attached to the inside of X-ray plate holders and the X-ray plates were exposed in this manner for a period of three weeks. Development of the plates showed that the flies had assimilated the C^{14} into their tissues.

Radioactive flies were transferred to pitcher plants via a clean, creased piece of waxed paper. The paper was carefully lowered into the trumpet of a pitcher plant and the flies removed by gently tapping the paper. Small body fragments which had stuck to the paper were placed into the trumpet by use of forceps. Distilled water was added until the trumpet was approximately half full. The water level was marked with a special ink. Adult and juvenile leaves were fed the radioactive flies. Since actual rates of absorption and metabolism by this species were unknown, two months were allowed to elapse between the time the flies were fed to the plants and the time the plants were cut for analysis. After this period any fruit fly remnants as well as all water were removed from the leaf, which was then thoroughly cleaned with distilled water.

Analysis of the plant tissue for radioactive materials was carried out in several different ways. Geiger-Mueller readings were taken of dehydrated plant tissue at, above, and below the marked water level of the trumpet. Some plants were placed in X-ray plate holders and the plates exposed for three-week periods. Further analysis of plant tissue was carried out by refluxing leaf specimens and conducting chromatographic analysis of the refluxed material. A refluxing solution of 1N sulfuric acid was used at a temperature of $100^{\circ}C$. The samples were refluxed from 24 to 30 hours.

After refluxing, descending chromatographic analysis employing a ninhydrin solution for developing purposes was used to separate and identify the amino acids in the plant tissue. Fruit fly samples were also treated in the above manner. It was hoped that a comparison could then be made between the fly and plant material to give further conclusive proof that plant proteins had become radioactive from utilization of the animal proteins. Prior to this, chromatographic analysis of 22 known amino acids revealed their migration rate values (R_f's). The R_f value was determined for each amino acid using N-butanol, acetic acid, and distilled water in the ratio of 8:1:8 as a solvent system. At least six chromatograms were run on each amino acid.

RESULTS

Geiger-Mueller analysis showed an average radiation level per fruit fly culture of 113 counts/minute above background. Fly cultures tested by use of X-ray plates also proved to be radioactive. After allowing two months for digestion of the fruit flies, 0.2 g. samples of dehydrated plant tissue were checked with a thin-walled Geiger-Mueller tube and found to be radioactive. (Table I) The degree of radioactivity increased from the tops of the trumpets to their bases, and was not limited to just a small area for any section of the plant. Juvenile leaves assimilated the tracer at a faster rate than the mature adult leaves. This would be expected if the plants were using the animal materials to construct their own protoplasmic tissue. These data were confirmed by X-ray plate exposures. This rate of uptake was nearly twice as great in the juvenile leaves as in the mature ones.

Chromatograms of the refluxed plant tissue were placed next to X-ray film for a period of three weeks, as were the fruit fly chromatograms. Neither showed signs of being radioactive. This was not unexpected since the level of radioactivity before refluxing was small. Moreover, the level of detection was also reduced since only a very minute portion of the sample could be placed on one chromatogram.

TABLE I. Radioactivity in (1) mature pitcher plant leaf "fed" for 58 days with fruit flies whose relative radioactivity was 348 counts per minute above background and (2) juvenile (newly opened) leaf "fed" for 47 days with fruit flies whose relative radioactivity was 406 counts per minute above background.*

1. Mature Leaf

	Duration of count (minutes)	Counts per minute
background activity	35	6.3
lower part of leaf	35	9.4
upper lip of leaf	35	7.6
background	25	6.6
upper lip	15	7.5
background	20	6.2
lower part	10	9.5
upper lip	10	8.1
background	10	6.4
upper lip (smaller piece)	10	7.3
background	30	6.3
middle part of leaf	20	8.4

2. Juvenile Leaf

	Duration of count (minutes)	Counts per minute
background	10	6.3
lower part	10	12.1
upper lip (small piece)	10	10.1
background	10	6.4
lower part	22	12.0
upper lip	15	10.2

*Actual plant radiation can be calculated by use of the formula: plant counts/minute minus background counts/minute equals actual plant counts/minute.

DISCUSSION

The trumpets fed the radioactive fruit flies were examined for radioactivity by Geiger-Mueller and X-ray techniques and proved to be radioactive, thus showing that the animal amino acids were inside the plant tissue. The radiation was found to be coming from all parts of the trumpets and decreased as the distance above the waterline increased. It is felt that decreased radioactivity above the waterline indicates active transport of the animal proteins to a site where their utilization by the plant occurs. Since juvenile leaves took up the animal protein at a faster rate than the adult plants, strong indication is given that the animal protein is definitely used in metabolism.

It is unfortunate that the chromatograms did not prove to be radioactive. However, since neither fly nor plant chromatograms were positive this additional evidence, supporting as it would have been, does not detract from the total results. The flies themselves, when placed on X-ray film or checked with the Geiger-Mueller tube, proved to be radioactive. Plant tissue samples also proved to be radioactive as determined by either of these techniques.

SUMMARY

From the study of *Sarracenia purpurea*, the well known insectivorous pitcher plant, conclusive evidence using tracer techniques shows that the plant does absorb C^{14}-labelled animal proteins and in all probability uses them in metabolism and growth. The younger juvenile tissues incorporate the digested fly materials at a greater rate than the older, more mature plant tissues. Future analysis using chromatographic, electrophoretic, and microradioautographic techniques should substantiate and expand these findings.

ACKNOWLEDGMENTS

I thank Paul R. Zurakowski, presently of the Lawrence Radiation Laboratory, and Robert H. Winkler, of Mount Clemens (Michigan) High School for their guidance throughout this study.

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NEW AND NOTEWORTHY HIGHER FUNGI FROM MICHIGAN

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Herbarium, The University of Michigan, Ann Arbor

The season of 1965 was a peculiar one as to the pattern of rainfall throughout the state and the generally low temperature. The result was that in certain areas a relatively large number of unusual fungi were found fruiting, and an equal number of so-called common species did not appear or were found very sparingly. One of the areas which was particularly fruitful was Sugar Island in the St. Mary's River, east of Sault Ste. Marie, and from there westward along the Lake Superior shore to Grand Marais. Heavy rains in July and August kept the pine barrens well soaked, and it was this type of habitat—open pine forests with large patches of *Cladonia* in open spaces—that produced some of the most unusual fungi. This was especially true of areas ordinarily so hot and dry during midsummer that one would never think of looking for fleshy fungi in them. The largest single group of species in this category belongs to the genus *Rhizopogon*. Three previously undescribed species and one new record for the state were found in this habitat. Ordinarily, species of *Rhizopogon* are considered hypogeous, but in the Culhane Lake area, for the most part, they simply occurred on the duff under the dense cover of lichens (mostly species of *Cladonia*).

The specimens cited are deposited in the Herbarium of the University of Michigan, and the color names within quotation marks are taken from Ridgway, Color Standards and Color Nomenclature, 1912.

I wish to acknowledge assistance from the National Science Foundation, Grant G-23139, which made my work on *Rhizopogon* possible.

BASIDIOMYCETES

RHIZOPOGON GELATINOSUS sp. nov.

Fructificationes 6-12 mm latae, globosae vel subglobosae, fibrillosae, albidae tactu vinaceae vel aurantio-cinnamomeae, tarde avellaneae, cum KOH rufae vel rufobrunneae, cum $FeSO_4$ olivaceae vel atro-olivaceae. Gleba gelatinosa, alba demum olivacea, tarde sordide luteobrunnea. Sporae 7-8.5 x 3-4.5 μ, truncato-cupulatae. Typus: Smith 72002 (MICH).

Basidiocarps 6-12 mm diam., globose to nearly globose, surface white when young but epicutis soon flushed vinaceous-tan to pale orange-cinnamon, becoming dingy vinaceous to avellaneous over a wheft of surface fibrils, with a thin network of fine appressed rhizomorphs, drying pale reddish brown, with KOH reddish to rusty brown, with $FeSO_4$ olive becoming blackish. Gleba white becoming olivaceous and in oldest one dark yellow-brown (but merely dull brown as dried), chambers small and labyrinthiform. Columella absent.

Spores 7-8.5 x 3-4.5 μ, in optical section shaped like a *Bidens* fruit (often as broad at base as in midportion and with two prominent "basal" teeth), in other words truncate-cupulate, yellow-brown in KOH in groups but yellowish singly, in Melzer's solution pale tawny, smooth, a small percentage obscurely angular but basic shape more or less ovate to elliptic.

Basidia soon gelatinizing, those seen 4- or 6-spored, about 5-7 μ broad when sporulating. Hyphae of tramal plates gelatinous and interwoven. Peridium of interwoven hyphae 3-6 μ diam., no vesiculose or inflated cells found, hyaline in H_2O, reddish to rusty brown in KOH, pale yellowish orange in Melzer's solution with some pigment balls formed, revived in KOH with some or most of the layer remarkably clean. Clamp connections none.

Solitary under duff, Little Lake, Luce County, Mich., Aug. 6, 1965 (Smith 72002).

The species, though rare during the 1965 season, is very distinct. First, the peridium is relatively clean in KOH as revived. Usually basidiocarps drying reddish brown show much inter-hyphal debris when revived. Secondly, the hymenium and tramal plates gelatinize very early. Specimens dried in silica gel (without heat) showed practically no hyphal structure in the gleba even on specimens so young that few spores were present. The appearance of fresh specimens is deceiving in that as the outer wheft of hyphae ages and becomes avellaneous one is reminded of species of section *Villosuli*; but the resemblance ends there, as there is no appreciable differentiation of an epicutis. It differs from *R. pinicola* in the soft gleba when fresh as contrasted to a rather dry gleba for *R. pinicola*. The latter gave no reaction with $FeSO_4$.

RHIZOPOGON PINICOLA sp. nov.

Fructificationes 8-27 mm latae, globosae vel subglobosae, siccae, sericeae, candidae demum obscure argillaceae, tarde obscure luteobrunneae, cum KOH tarde lilaceae, cum $FeSO_4$ immutabilis. Gleba alba dein subolivacea, tarde obscure olivaceobrunnea. Sporae 6-7 × 3-3.5 μ, leves, truncato-cupulatae. Typus: Smith 71997 (MICH).

Basidiocarps 8-27 mm broad, globose to subglobose or ellipsoid, surface dry, dull and unpolished to silky, snow-white young, slowly dingy and the few appressed rhizomorphs yellowish to tan, becoming dingy cinnamon-buff to finally near snuff-brown in old age, no color change showing when handled or cut, KOH on peridium no reaction when young specimens are tested but lilac on older ones, $FeSO_4$ no reaction, ethanol no reaction. Gleba white when young, becoming olive-buff and finally dark olive to olive-brown and retaining an olive tone on drying, consistency rather dry and not at all cartilaginous, chambers minute and labyrinthiform, empty. Columella none.

Spores 6-7 × 3-3.5 μ, smooth, elliptic-truncate in optical section, with a "cup" at truncate end, yellow-brown in KOH, paler in Melzer's solution, false septum often present, walls thickened (about 0.3 μ).

Basidia 6- to 8-spored, 6-9 μ diam. Brachybasidioles[1] clavate to subglobose, hyaline, wall becoming refractive and decidedly thickened, 10-13 μ diam. (hymenium appearing gelatinous when fresh and mounted in KOH). Subhymenium and tramal plate hyphae indistinct at maturity because of gelatinization. Peridium of narrow interwoven hyaline hyphae 3-5 μ diam., clean as mounted in KOH until late maturity when yellow-brown pigment deposits are observed, in Melzer's solution large globules present but hyaline to merely yellowish. Some amyloid granules present in the mount but their presence hardly distinctive. Clamp connections absent.

In open places covered by *Cladonia* and other lichens in a *Pinus resinosa* stand, Culhane Lake, Luce County, Mich., August 6, 1965 (Smith 71997).

This was the common species in the area occurring on and in the duff under the lichens. Most of the basidiocarps collected were white. *R. pinicola* does not appear to be closely related to others in section *Fulviglebae*. Its outstanding features are the spores which remind one of a fruit of *Bidens* (as seen in optical section), the persistently olive to olive-brown gleba, the lilac KOH reaction of old specimens, and the white to dingy yellow-brown color pattern with no change to red either when injured or in drying.

RHIZOPOGON SUPERIORENSIS sp. nov.

Fructificationes 10-15 cm latae, subglobosae, pallide aurantiae, in siccatis obscure rufis, fibrillosae. Gleba olivacea. Sporae 8-12 × 3-4.5 μ, cupulato-truncatae. Typus: Smith 71953 (MICH).

Basidiocarps 10-15 mm diam., globose to ellipsoid, surface dry and with inconspicuous appressed somewhat rusty orange rhizomorphs, under a hand lens seen to be netted from rhizomorphs incorporated in the peridium, colors pale to bright orange-yellow ("light orange-yellow" to "Capucine-yellow"), KOH on the fresh peridium vinaceous-red progressing to rusty brown, $FeSO_4$ olivaceous to olive-black, ethanol giving an olivaceous tone (from dissolving the yellow pigment thus allowing the gleba color to show through). Gleba pallid becoming olivaceous and finally olive-brown, showing dingy yellow streaks reminding one of subgenus *Rhizopogonella*, texture moist and cartilaginous, chambers minute, sinuous near peridium. Columella none.

Spores 8-10.5(12) × 3-4.5 μ, smooth, basically narrowly ellipsoid but varying to angular-elongate or narrowly ovate, base usually truncate-cupshaped, wall only slightly thickened, yellowish hyaline in KOH, ochraceous in Melzer's solution. Basidia 1-8 spored, 6-8 μ broad, varying to filamentous in age (conidiophores?). Subhymenium of narrow (3-5 μ) interwoven hyphae. Brachybasidioles thin-walled. Tramal hyphae interwoven, hyaline, becoming somewhat gelatinous. Peridium

[1] This term is proposed in place of brachycystidia and/or paraphyses for sterile supporting structures in the hymenium.

of interwoven hyphae 4-8 μ diam., many rhizomorphs imbedded in matrix of peridium, with KOH much rusty reddish debris between hyphae, hyphal walls somewhat gelatinous, in Melzer's solution giant orange-brown pigment balls or globules and versiform bodies forming, no amyloid granules seen; clamp connections none. Vesiculose cells none.

Solitary under *Pinus resinosa*, Culhane Lake, Luce County, Mich., Aug. 2, 1965 (Smith 71953).

This species differs from *R. truncatus* in narrower hymenial elements, the peridium being red in KOH not sulphur yellow, and in KOH the hyphal walls are somewhat thickened and distinctly refractive. Also in *R. truncatus* properly dried basidiocarps are yellow, not bay-red. *R. atlanticus* Coker & Dodge has a clean peridium, smaller and more highly colored spores, and rhizomorphs were not incorporated into the peridium to any degree. In this last respect as well as in the color when fresh *R. superiorensis* is close to *R. ochraceo-rubens* Smith, but the latter has strikingly different spores.

Rhizopogon couchii Smith

Basidiocarps up to 3.8 cm broad, subglobose, surface evenly fibrillose and unpolished, lacking rhizomorphs, pallid when young, becoming dingy cinnamon-buff and finally bister where exposed (dark sordid yellowish brown), when injured staining vinaceous; with KOH dull red, with $FeSO_4$ no reaction whatever, peridium separable in flakes. When dried dingy olive-brown. Gleba pallid becoming olivaceous, stained pale pinkish where cut, texture dry and cartilaginous but sectioning readily dried. Columella lacking.

Spores 6-7 × 2.5 μ (more or less), oblong, hyaline in KOH singly, yellowish in Melzer's solution, thin-walled. Basidia 8-spored, 8-12 μ diam., ovate to elongate, thin-walled. Brachybasidioles ovate to ellipsoid, 8-12 μ diam., thin-walled. Subhymenium cellular, cells 6-10(14) μ diam. In KOH the hymenium and subhymenium soon gelatinous but not so in Melzer's solution. Hyphae of tramal plates gelatinous, hyaline, 3-9 μ diam., branched-interwoven. Peridium of interwoven hyphae with red walls in KOH and red intercellular debris (fresh material), in Melzer's solution soon showing large orange-red pigment balls, some amyloid debris seen. Clamp connections none.

Along a sandy road, under mixed jack and red pines, Culhane Lake, Luce County, Mich., Aug. 7, 1965, Nancy Jane Smith collector (Smith 72020).

This collection extends the range of the species north to the Lake Superior shore, but in much the same habitat as it occurs in our southeastern states. The gleba staining pink, the narrow oblong spores, lack of a distinctive $FeSO_4$ reaction, and white to dull yellow to yellow-brown color pattern are distinctive. *R. vulgaris* has more rhizomorphs—is rooted by them at times—and gives a strong positive $FeSO_4$ reaction.

Rhizopogon subaustralis Smith

Basidiocarps 1-4 cm diam., globose to variously lobed or irregular, surface dry and cottonly fibrillose, with scattered appressed rhizomorphs, becoming dingy olive yellowish finally becoming dark yellow-brown (bister) or nearly cinnamon brown, white when young, slowly staining reddish on handling, with ethanol pinkish, with KOH dull lilaceous. Gleba white to cinnamon buff drying olivaceous to dull tan and then firm but sectioning easily.

Spores 8-9.5 × 3-3.3 μ, suboblong to subfusoid, yellow-brown in KOH in groups, pale yellow in Melzer's solution, smooth, usually with a false septum. Brachybasidioles nearly all thick-walled in age, central body very small and in old material distinctly yellowish in Melzer's solution. Peridium a thick layer of interwoven hyphae 3-12 μ diam., in KOH with dark reddish brown pigment patches on or between hyphae, in Melzer's solution with numerous pigment balls orange-brown in color, no pockets of inflated cells seen (cross sections of wide hyphae may appear as inflated cells). Clamp connections none.

Gregarious in grass near a road cut, *Pinus resinosa* nearby, Oct. 22, 1965, Stinchfield Forest, Dexter, Michigan (Smith 72863).

The basidiocarps show a strong tendency to become blackish in some areas as dried. In some the peridium was areolate as though from the breaking up of an outer layer. The gleba becomes tan to rusty brown late in the life of the basidiocarp. The very striking $FeSO_4$ reaction distinguishes it at once from *R. rubescens*.

Pisolithus tinctorius (Pers.) Coker & Couch

This species was found by Dr. Roy Watling in the Pinckney Recreation Area, Washtenaw County, Michigan, Sept. 3, 1965. The specimen is a small one, but unmistakable in its features. This is the first record of its occurrence in Michigan which has come to my

Fig. 1. *Gautieria morchelliformis* Vitt. × 0.7 (Smith 72874)

attention. It remains a puzzle to me why we do not find this fungus more frequently.

Gautieria morchelliformis Vitt. Fig. 1.

Although this species is not as rare as at first though here in Michigan, the collection photographed is worth placing on record. One feature of the species is that during wet seasons when there are heavy rains late in August and September, it fruits in clusters to the extent that we have collected as much as half a peck in one pile in a small depression, as though some rodent had stored them there. It is a Basidiomycete in the "false truffle" group (Hymenogastrales), and, as seen in the photo (Fig. 1), there is no outer wall or peridium. All you see is the chambered spore-bearing "interior" which in this case is very persistent. The specimens illustrated were collected at Haven Hill, Highland Recreation Area, Oakland County (Smith 72874, September, 1965).

ASCOMYCETES

Elaphomyces uliginosus Hesse

Ascocarps 1-2.5 cm broad, globose to irregular in outline, black and appearing smooth when wet, blackish brown and minutely verrucose when faded, more or less covered with an olive-ochraceous mycelium. Outer layer of peridium about 0.5 mm thick, when fresh and forming a distinct blackish line, composed of tightly interwoven blackish-brown-walled hyphae 3-7 μ diam. and with walls about 1 μ thick, smooth or incrusted and not gelatinous. Inner layer 1-2 mm thick, of tightly interwoven mostly hyaline to grayish refractive (somewhat gelatinous) hyphae 3-8 μ diam. and with walls about 2 μ thick. Gleba grayish pallid young, slowly blackening, cottony in texture at first and powdery in age. Asci subglobose, 40-65 μ wide, 8-spored. Spores globose, 20-27 μ in diam. hyaline at first, becoming dark olive-brown, surface subreticulate from openings of canals penetrating and outer somewhat transparent layer, the inner wall thick and dark colored. Glebal hyphae 2-4 μ in diam., non-gelatinous, often incrusted, in KOH becoming olive.

Under *Pinus resinosa*, Vermilion, Chippewa Co., Mich., July 29, 1965 (Smith 71897).

We have no previous collections of this species or of *E. anthracinus* from Michigan in the University Herbarium. To say the least, it is to be regarded as extremely rare. We have used Hesse's name because the spores of our collection average around 22 μ diam., which is the size reported by Dodge for collections he studied from Germany, but is not the size originally given by Hesse. The olive-ochraceous mycelium, black carbonaceous ascocarps and large spores in 8-spored asci are a very distinctive combination of features.

Myriosclerotinia caricis-ampullaceae (Nyberg) Buchw.

This is a typically arctic-alpine cup-fungus parasitic on *Carex* species. My only previous collection (Smith 28984) was made near

Fig. 2. *Myriosclerotinia caricis-ampullaceae* (Nyberg) Buchw. ×1 (Smith 28984)

Snow Lake in Mt. Rainier National Park, Washington. This year, on June 1, while on a trip to Vermilion, Chippewa County, Michigan, we stopped in a bog about a quarter of a mile from the Lake Superior shore. Here, in the course of searching for species of *Galerina*, my wife (Helen V. Smith) asked me if I wanted the discomycete that was "growing all over the place". It was the above species.

The fungus infects the *Carex* plant in the blossom stage and the mycelium gradually spreads through the heart of the plant making a blackened mummy out of it as is shown in Fig. 2. In the spring, when the temperature of the bog water is only slightly above freezing, the black mummies (called sclerotia) "germinate" producing clusters of long-stemmed cups as shown. It would be interesting for residents in the Upper Peninsula to start looking for this fungus early in the spring to see how widespread it is in the area.

I am indebted to Professor Richard Korf of Cornell University, the American specialist on Discomycetes, for verifying the identification. The collection (Smith 71512) is deposited in part in the University of Michigan Herbarium and part in the Cornell Herbarium (Department of Plant Pathology).

Tuber californicum Harkness

Ascocarps 0.5-3.5 cm in diam., globose to irregularly bulgy and creased, surface dry, white and unpolished, slowly changing to dingy grayish and finally in age pale purplish drab, more or less glabrous in age, long remaining white in the creases; no openings to exterior and no basal attachment obvious. Interior watery-pallid with meandering white veins through it, solid, veins opaque, the remainder translucent, slowly becoming violaceous brown as spores mature (pale "benzo brown") with the white veins then more conspicuous, rarely some of the interior canals empty. Odor faintly fragrant, taste not distinctive. Spores brown in KOH, in Melzer's solution orange-brown to yellowish, 40-50 μ, globose to broadly ellipsoid, reticulate, 1-2 in an ascus and asci dispersed in the translucent material, ascus content orange-red in Melzer's solution when spores are immature. Peridium of an inner layer of pseudoparenchyma hyaline in KOH and yellowish in Melzer's solution; the cells up to 30 μ diam. thin-walled and not gelatinous; exterior to this a wheft of projecting short hyphae 3-5 μ diam., tubular, thin-walled and with no distinctive apical differentiation. KOH, $FeSO_4$, and Melzer's solution all negative on fresh peridium.

In the duff under *Pinus strobus*, Stinchfield Forest, Dexter, Michigan, Oct. 21, 1962 (Smith 66468 and 66475; again in 1965 by Richard Homola).

This is apparently a late-fruiting species which so far has been found only in the one locality in the state, each time after heavy frosts. I am indebted to Dr. Lilian E. Hawker of Bristol, England, for the identification. The genus *Tuber* comprises the true truffles.

VARIATIONS IN THE LEAF OF *SARRACENIA PURPUREA* (PITCHER PLANT)[1]

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The present study was undertaken to determine whether or not some of the variations in leaf form within *Sarracenia purpurea* were due to genetic differences or to environmental influences. Two acid bogs (Purdy Lake and Otis Lake) and two alkaline bogs (McKay Lake and the alkaline area of the southeastern bog of Deep Lake) were selected for this study. Descriptions of these bogs, in Barry and Kalamazoo counties, Michigan, have been given in a previous paper (Mandossian, 1965).

The problem was attacked from three angles: (1) A study of size of pitcher leaves was made in the field. (2) Reciprocal transplants were made from the two acid bogs to the two alkaline bogs, and vice versa. (3) Variation in leaf shape was induced in the laboratory.

A. STUDY OF SIZE OF PITCHER LEAVES

A preliminary examination of the pitcher plants in the four bogs under study showed that the plants in the acid bogs had rather large but fewer leaves, while those in the marly or alkaline bogs had small but numerous leaves; some of the plants had a single flower while others had two or more flowers. No sooner was an examination of these variations undertaken, however, than it became clear that the plants with numerous leaves and more than one flower were not single plants but several plants formed by vegetative reproduction of the rhizome. Each had its own growing point, with its own rosette of pitcher-leaves and in no instance was there more than a single flower on a single plant, despite Hooker's (1874) assertion that "they send up at the end of the flowering season one or more slender stems bearing each a solitary flower."

With this information in mind the quantitative study of the variations was continued as originally planned because the variations still existed—some of the "plants" or colonies did have larger but fewer leaves, while others had a large number of smaller leaves. No attempt was made to select plants of the same age for this study because there seems to be no way of determining the age of pitcher plants. They are perennials but form no annual rings which might serve as an indication of their age. The number of leaf bases on the rhizome was also of no value because it was known from studies of

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[1]From a thesis submitted to the Department of Botany and Plant Pathology, Michigan State University, in partial fulfillment of the requirements for the Doctor of Philosophy.

seedlings by the author that the number of leaves produced each year is highly variable.

METHODS

Selecting a method for comparing the pitcher leaves of *Sarracenia* presented a unique problem. It was difficult to decide whether to use their absorptive or their photosynthetic capacity for this comparison, or to use both. If we were to compare the absorptive surfaces, then only the inner surface area of the leaf cone would have to be measured. Those of the hood and wing would have to be excluded. However, the pitchers are not always full to capacity with fluid and insect material, so their volume may not form a sound basis for comparison. Also, not the entire inner surface of a pitcher is actively engaged in absorption (Hooker 1874, Russell 1919, Lloyd 1942). Whether this absorptive area varies in proportion to the size of the leaves is not known. It is reasonable to assume that a large leaf would have a large absorptive surface. However, it is also possible that a younger leaf might have a larger absorptive surface in comparison to its size than a larger, more mature leaf. For these reasons, it was decided to eliminate the absorptive surface of the cones from consideration and to measure only the photosynthetic capacity of the leaves by the following methods.

Ten mature "plants" (colonies) were selected that were typical for each of the four bogs under study, and the length and width of the leaves were measured with a flexible plastic ruler the end of which was placed against the point of insertion of the leaf into the rhizome. In situations where *Sphagnum* was deep and the pitcher-leaves were almost completely submerged in it, the solid petiole at the base of the pitcher was rather long and it was not possible to determine where it ended and where the hollow part began. For this reason the length of the entire leaf was measured from its point of insertion to its tip and no attempt was made to distinguish between the solid petiole and the hollow pitcher. The width was measured across the widest part of the leaf, including the wing. A leaf area index was used based on the formula two-thirds length × width used by Cain et al. (1956) for tropical rain forest species and adopted by Cooper (1960) for all species of temperate vegetation. In the present study the area index was selected as a simple procedure for comparing relative leaf areas and not for the purpose of placing the leaves in definite Raunkiaer leaf-size classes as in the two cited studies. The results are summarized in Table I.

RESULTS AND DISCUSSION

A study of the figures in Table I will show that *Sarracenia purpurea* plants growing at Purdy Lake, which is a well established *Sphagnum* bog (pH of 5.2-5.4 at the surface and 5.9-6.4 at the root-level of *Sarracenia*), have an average of 17 leaves per plant, but the pitchers are unusually large, having an average LW value of 65.

Likewise, Otis Lake, another *Sphagnum* bog (pH of 5.9-6.0 at the surface and 7.0-7.2 at the roots of *Sarracenia*), had fewer (12) but larger pitchers per "plant" (LW value of 51).

McKay Lake, an alkaline bog (pH of 8.3-9.1 at the surface and 8.3-8.6 at the roots of *Sarracenia*), had a greater number (3) but smaller pitchers per plant (LW value of 15).

Deep Lake (the alkaline area of the southeastern bog, with a pH of 8.3-8.4 at the surface and 8.0 at the roots of *Sarracenia*), supported plants that had a greater number (27) but smaller pitchers per colony (LW value of 21).

TABLE I. Number and average 2/3 LW values of pitcher leaves for 10 plants in 4 bogs, recorded in August, 1961.

	PURDY L. (acid)		OTIS L. (acid)		McKAY L. (alk.)		DEEP L. (alk.)	
	(a)*	(b)	(a)	(b)	(a)	(b)	(a)	(b)
	13	43.1	24	35.7	24	8.0	72	20.0
	16	78.9	6	45.2	44	22.0	25	17.2
	24	39.0	15	37.5	46	17.6	20	22.2
	33	54.9	17	47.7	46	20.8	62	20.3
	9	99.0	7	68.0	25	23.5	9	22.8
	13	52.0	9	47.9	17	19.4	8	27.7
	5	78.0	16	43.3	25	8.4	20	16.2
	11	91.5	6	62.5	25	9.0	10	18.4
	6	44.5	9	59.5	22	9.8	25	15.9
	39	65.3	12	62.6	26	14.8	15	23.7
$\bar{x}$ =	16.9	64.6	12.1	51.0	30.0	15.3	26.6	20.5
$s_{\bar{x}}$ =	±3.64	±6.71	±1.87	±3.57	±3.45	±1.93	±7.06	±6.52

*(a) shows number of pitcher leaves per plant
(b) shows average 2/3 LW value of pitchers per plant

CONCLUSION

Sarracenia purpurea in the two acid bogs (Purdy Lake and Otis Lake), produce fewer but larger pitchers per "plant" or colony than those growing in the two alkaline bogs (McKay Lake and the marly zone of southeastern Deep Lake bog).

B. RECIPROCAL TRANSPLANT EXPERIMENTS

The existence of significant differences in leaf size and number could be due to the plants' being from genetically different stock or it could represent an environmental response of the same basic genetic stock. Reciprocal transplants have long been used in helping to discriminate between these two alternatives (Bonnier 1920, Clements 1929, Turesson 1922, Clausen et al. 1940, McMillan 1959, and Mooney et al. 1964). If plants from acid bogs transplanted into alkaline bogs continued thereafter to produce long pitchers, it would be reasonable to assume that the variation was genetic in nature and not induced by environmental factors. The same conclusion would be drawn if plants from the alkaline areas continued to produce smaller pitchers when transplanted into acid bogs.

METHODS

During the week of August 10, 1961, three mature plants of about the same size were selected in Otis Lake bog and transplanted into the marly zone of Deep Lake bog into the holes left by the removal of similarly selected three plants which were in turn transplanted into holes left in Otis Lake bog. Mutual transplants of three plants each were also made in the same manner between McKay bog and Purdy bog.

RESULTS AND DISCUSSION

A year later, these 12 plants were examined for any change in general appearance, particularly in the size of new leaves produced. Eleven of the 12 transplanted plants had survived. The plants transferred from the alkaline bogs (McKay and Deep Lake) into the acid bogs (Otis Lake and Purdy Lake) had produced some longer leaves, close to the size of the neighboring plants. However, their flower stalks and size of flower and capsule remained small, like those of their former habitat.

Similarly, the plants that had been brought from the two acid bogs had produced somewhat smaller leaves than the older ones. Their flower stalks were quite long and the floral parts and capsules were much larger than those of the surrounding plants. Thus, in both instances, the flowers had remained true to the old form, at least during the first season, but the leaves had begun to be affected by their new environmental conditions.

Incidentally, the transplants in Deep Lake had accidentally brought with them several cranberry plants (*Vaccinium macrocarpon*) and a single orchid (*Pogonia ophioglossoides*), all of which bloomed and formed fruit.

In the second spring following transplanting, a sudden drop of temperature on May 21, 1963, to 27^{o}F. resulted in extensive frost damage to pitcher plants. Many leaves, both young and old, had their hood and the upper part of the pitcher frozen and these parts became necrotic. The transplants suffered more damage by this freeze than the other plants. All three transplants at McKay Lake and one each at Deep Lake and Purdy Lake began to die soon after this date. The surviving individuals were examined again on August 30, 1963, at which time the leaves were counted and measured. The results are summarized in Table II.

None of the plants in these bogs, either in the natural populations or among the transplants, bloomed in 1963. It is assumed that the flower buds which had already been formed on May 21st were killed by the freeze.

The orchid and cranberry transplants at Deep Lake bloomed and formed fruit for the second year.

A comparison of the figures in Table II with those in Table I brings out the fact that the transplants show significant departures in leaf size and leaf number from those of plants of their former habitat. The most spectacular change occurred in the transplants to the marly zone of Deep Lake of plants from the acid bog at Otis Lake, where the number of new leaves of the transplants (26) is more than twice the average number of leaves on plants growing in Otis Lake. This increase in leaf number brings the count about identical to the number of leaves (26.6) on plants normally growing in Deep Lake. Similarly, the LW value of the transplants (27.5) has been reduced considerably from the average figure (51.0) for the plants in Otis Lake, and is close to the LW value (20.5) of the plants of Deep Lake.

The least modification in number of leaves of all transplants was obtained in the reciprocal of the above transplanting, i.e., from Deep Lake to Otis Lake. However, even here, a definite trend toward a smaller number of leaves (from 26.6 to 23) and greater LW value (from 20.5 to 29.7) is to be noted.

The second set of transplants from an alkaline bog (McKay) to an acid bog (Purdy) shows this trend to a greater extent. Leaf number has been reduced from 30 to 15.5 and LW value increased from 15.3 to 36.2.

The gradual manner in which these transplants became morphologically adjusted to their new habitat is reminiscent of a phenomenon that has attracted considerable attention (Clements 1929, Went 1959, Mooney et al. 1964, Rowe 1964). The fact that it took two full growing seasons to make the adjustment has two possible interpretations.

TABLE II. Number and average 2/3 LW values of pitcher leaves of transplants from acid to alkaline bogs and vice versa, recorded in August, 1963, two years after the transplants were made.

	OTIS L. (acid) to DEEP L. (alk.)		DEEP L. (alk.) to OTIS L. (acid)		McKAY L. (alk.) to PURDY L. (acid)	
	(a)*	(b)	(a)	(b)	(a)	(b)
	26	32.1	23	24.9	18	37.6
	26	22.9	35	27.5	13	34.7
			9	36.7		
$\bar{x}$ =	26	27.5	23	29.7	15.5	36.2
$s_{\bar{x}}$ =	±0	±4.58	±7.47	±3.56	±4.29	±1.44

*(a) shows number of pitcher leaves per plant
(b) shows average 2/3 LW value of pitchers per plant

First, the root systems were not thoroughly washed free of soil and the lag may simply reflect the attenuation of the small mass of original substrate. Secondly, the metabolic pools within the plants take time to attenuate as Went (1959) has shown for potatoes, and Highkin (1958, 1961) for peas, and as Rowe discusses generally. The earlier habitat appears to leave a gradually attenuating impression. It would be useful to learn whether both or only one of these mechanisms was involved. The fact that death and freeze damage of the transplants exceeded that of the indigenous population suggests that metabolic pools were out of balance.

CONCLUSION

It may be concluded from these transplant experiments that leaf size and number are highly variable in *Sarracenia purpurea* and that these variations are determined by ecological factors. This is not to imply, however, that the capacity to make a response of leaf size to substrate chemistry might not itself be the product of adaptation. It is possible that many small leaf cones would result in a high internal surface area to leaf mass ratio and partly accommodate for a reduction in availability of some nutrient such as iron in the marly bog.

C. INDUCED VARIATIONS IN LEAF SHAPE

While taking measurements of pitcher-leaves for the preceding experiments, it was noted that some of the leaves were flat, having a very narrow pitcher and a very wide wing (Fig. 1). Robinson (1908) reported that plants of *Sarracenia purpurea* kept under glass for a year at the New York Botanical Garden showed a marked tendency to form blade-like structures instead of pitcher-shaped leaves. Shufeldt (1918) made the observation that the leaves of pitcher plants changed very materially in several respects when the plants were kept in the house and did not receive much light, and that "the most curious and interesting thing was to see the hollow pitcher-part gradually becoming absorbed, almost disappearing in some specimens." The idea seemed fantastic, especially as several plants kept in my Detroit classroom during the school year had produced normal leaves.

About the first of July, 1962, while the problem was being considered, three plants brought into a Detroit classroom in April and transferred to the Kellogg Biological Station in June, suddenly sprouted flattened leaves. Obviously, there was some factor in the new location that hindered the normal development of pitcher leaves. Since the plants in question had been kept indoors in two different locations and it was already known that the Detroit site had not induced the formation of flat leaves in these and several other plants, it was obvious that the variation was due to conditions in the second location. In Detroit, the plants had been kept in front of a window facing west, with strong fluorescent lighting during the day. At the Station, they were placed on an open window sill of a study room facing south, with practically no artificial lighting.

The environmental conditions in the Detroit classroom, subject to severe temperature changes during week-ends, were thought to be too complex for use in this study. On the other hand, Purdy Lake bog and the Biological Station, which are located only about five miles apart, presented relatively simpler conditions for comparison. The study room was practically never used, so any effect that fluorescent lighting might have on the morphology of leaves could safely be eliminated from consideration. Furthermore, the window was open for long periods during this study and thus deficiency of ultraviolet light could probably be eliminated from any consideration. Temperature and relative humidity at both locations were considered essentially similar, leaving total amount of incident light as the most likely variable that might effect a change in leaf form. Three plants were freshly dug out of Purdy Lake, placed on the study window sill, and light intensity measured both in the bog and in the window location.

METHODS

Light readings were made in foot candles with a Weston Illumination Meter, Model 756, between 12 noon and 12:15 p.m., from June 28 to July 28, 1963. Altogether 22 readings were taken. For the study room the light meter was held parallel to the wing of a particular pitcher-leaf, facing south, measuring light falling directly on the leaf.

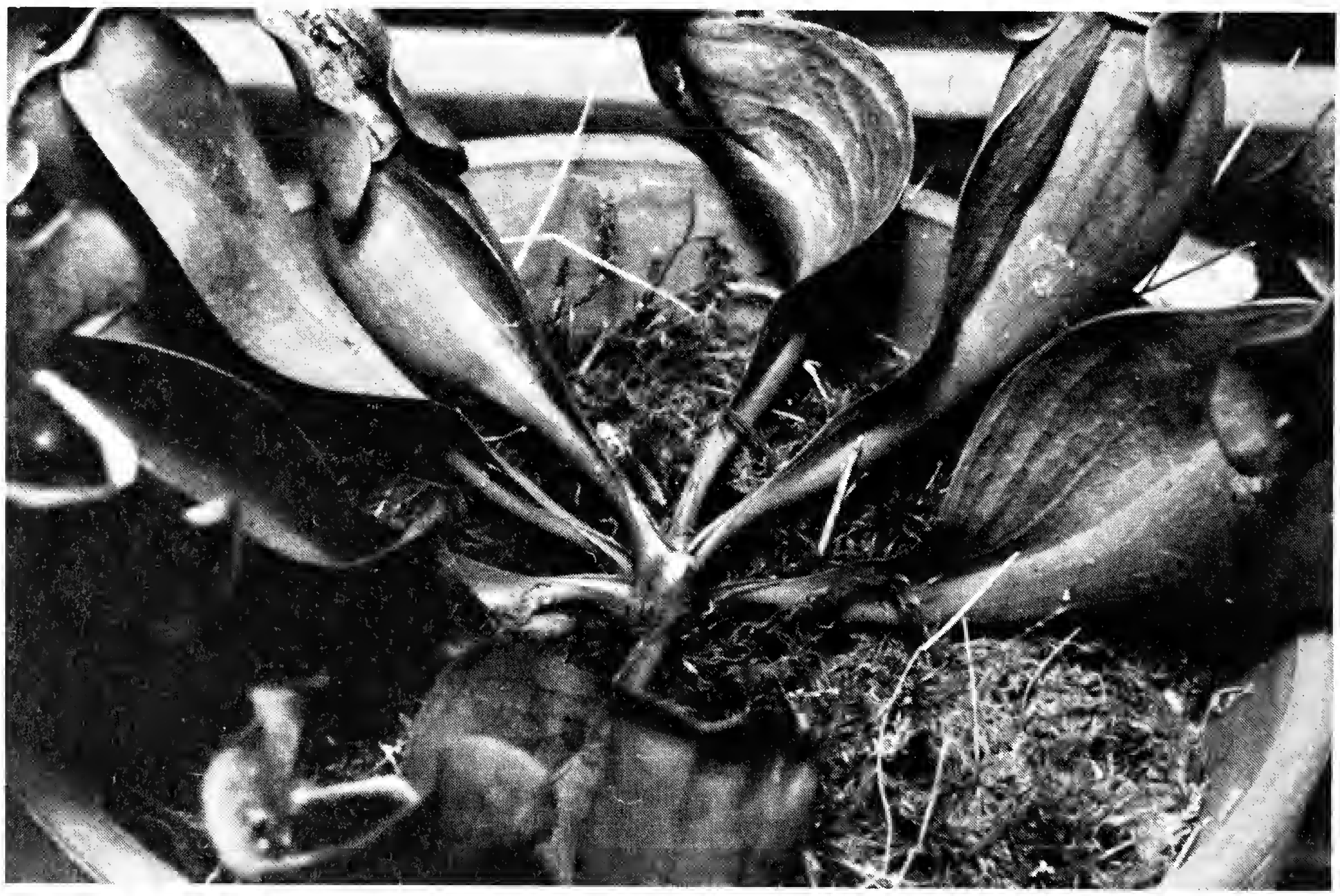

Fig. 1. Plant removed from Purdy Lake bog to photograph the flattened leaf.

Fig. 2. Experimental plants showing blade-like leaves produced under low intensity of illumination.

At the bog, the meter was similarly held facing south, parallel to the wing of the same pitcher-leaf each day. The r esults are summarized in Table III.

TABLE III. Light intensity in foot candles, based on 22 readings around noon time, June 28 - July 28, 1963.

Study window sill	Average:	755 ft-c (100-1400 ft-c)
Purdy Lake bog	Average:	1356 ft-c 400-2600 ft-c

RESULTS AND DISCUSSION

In a study of light three values are of paramount importance: quality or wavelength of the light, duration or time of illumination, and intensity of illumination. In this study quality and duration of light were considered constant in the two areas under comparison. Only intensity remained as a variable to be compared. It was found that light intensity values for the study were considerably lower than those for the bog (Table III). All new leaves of the three experimental plants in the study were flat in shape (Fig. 2). The older leaves remained normal and their pitchers were not "absorbed" during the experimental period.

CONCLUSION

In view of the above observations it seems reasonable to conclude that for *Sarracenia purpurea*, which lives mainly in open sunny places, light intensity is an important factor in the normal development of its leaf form, and that low intensity of illumination is a major cause for the production of flattened leaves.

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Publications of Interest

We here call attention to several recent publications which may be of interest to our readers although they do not happen to qualify for the regular listings of new literature relating directly to Michigan botany.

FLORA OF WEST VIRGINIA. By P. D. Strausbaugh & Earl L. Core. West Virginia University, Morgantown, 1952-1964. xxxi + 1075 pp. $10.00 (in 5 paper-bound parts) or $15.00 (hard cover). This thoroughly illustrated work is now complete, with the appearance late in 1964 of the introductory section (general features of the vegetation and a key to families) and Part IV (Rubiaceae-Compositae, additions and corrections to previous parts, and complete index). The introductory section ($ .50) and each of the four main parts ($2.50 ea.) is available separately.

THE MORTON ARBORETUM QUARTERLY. Vol. 1, No. 1 of this new periodical (which replaces the Bulletin of Popular Information) is dated Spring, 1965. Handsomely printed and illustrated, the Quarterly will include horticultural essays as well as reports of the Arboretum's scientific research and educational activities. Subscriptions are $2.00 per year, from The Morton Arboretum, Lisle, Illinois 60532.

PRAIRIE PLANTS OF THE CHICAGO REGION. By Robert F. Betz. Morton Arboretum Booklet 3. 1965. 14 pp. $ .50. Consists of brief general remarks and a checklist which should prove useful in southwestern Michigan as well.

(Continued on page 47)

VEGETATION OF TWO BOGS IN SOUTHWESTERN MICHIGAN

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Although Michigan has long been a site of bog study (e.g., Transeau, 1903; Gates, 1942), virtually no work has been done in the southwestern part of the State. The information presented here on vegetational characteristics of two bogs in Kalamazoo County was gathered as a background for faunal studies. From the phytosociological standpoint the data have certain defects, but in view of the scarcity of such observations for southwestern Michigan they may, nevertheless, be of interest.

I am indebted to Jack W. Kammeraad, Arlo Raim, and Willard Holley, who assisted in sampling and mapping; to Richard W. Pippen for a critical reading of the manuscript; and especially to J. R. and B. Morren and C. S. Warren for access to the study areas. Names of vascular plants follow Gleason and Cronquist (1963).

SAMPLING

The first area (Portage Bog) consisted of a 16.5-acre tract of sphagnum-leatherleaf-tamarack bog located south of Portage (NE 1/4, Sec. 28, R 11 W, T 3 S). It is part of a much larger area of similar peatland about one-quarter mile wide and one and one-half miles long. The study area was situated wholly on deep peat (about 17 feet). No open water exists on the tract, although a small pond with its southwest shore near the northeast boundary of the tract is indicated on the USGS quadrangle map based on surveying done in 1920. Since that time a drainage channel running from Sugarloaf Lake to West Lake has been dug; the channel lies near the edge of the peatland and about 150 feet from the southeast edge of the study tract. No part of the tract has been burned since observations began in 1961. There is, however, evidence of earlier fires, especially on the western portion, and in the spring of 1964 areas were burned between the drainage ditch and the study tract (as well as areas across the ditch).

The vegetation was studied in 1963 and 1964 by a series of samples taken at 56 points located systematically at 100 × 200 foot intervals. At each point, the following data were recorded:

(a) the species, diameter at breast height (dbh), and distance of the closest individual tree of at least 3 inches dbh (for a discussion of the closest individual method see Cottam and Curtis, 1956);

(b) all species (other than trees of 3 inches or more dbh) occurring in a square meter quadrat;

(c) subjective estimates of the denseness of the vegetation at various heights;

(d) subjective estimates of the relative wetness of the substrate.

These data were analyzed and a classification devised for the vegetation based on physiognomy and species composition. Six vegetation types were recognized: open wet areas, open dry areas, parkland, low thicket, high thicket, and tamarack forest. These vegetation types were mapped in 1964-65 using a Brunton pocket transit and steel tape. Additional points were sampled in 1965, randomly located in those vegetation types for which fewer than 10 samples had been obtained in the original survey. In all, 75 points were sampled.

The second area (Sugarloaf Bog) was a bog forest lying north of Sugarloaf Lake (Sec. 32, R 11 W, T 3 S). It occupied a strip about 500 feet wide between a bog mat about 65 feet wide adjacent to the lake and an upland area (two to three meters higher than the bog forest) supporting an oak-pine forest. The area of bog forest studied was on compact peat about 6 feet deep; this depth decreased toward the upland and increased to more than 10 feet near the bog mat. The hummocky surface was wet underfoot early in spring, but was thoroughly dry by late June.

This area was sampled in August and September, 1965, along a line 1000 feet long through the center of the bog forest and roughly parallel to the lake shore. At 11 points 100 feet apart, trees of 3 or more inches dbh were sampled by the point-centered quarter method (Cottam and Curtis, 1956). For all other plants, a series of 42 systematically arranged square meter quadrats 5-25 feet on each side of the line of sample was used.

Portage Bog seems fairly representative of many peatland areas in southwestern Michigan, although it is much more extensive than most. Sugarloaf Bog is less typical in that few similar forests, except near Lake Michigan, have white pine so well represented.

VEGETATION OF PORTAGE BOG

The study area was a mosaic of the six vegetation types. The mosaic possessed a noticeable pattern, one basic feature of which was the preponderance of open bog in the eastern part separated by a band of forest or parkland from thicket in the western part (see the vegetation map, Fig. 1). (It should be emphasized that this map, like any vegetation map, is a simplification of the intergradations and patchiness of the vegetation it attempts to represent.) Acreages as mapped and calculated with a planimeter were as follows: open dry bog, 8.7 (53%); high thicket, 4.7 (29%); forest, 0.9 (6%); low thicket, 0.9 (6%); parkland, 0.8 (5%); and open wet bog, 0.3 (2%).

Open wet and dry bog. Open areas which have a wet surface through or nearly through the summer tended to occur as patches in open dry areas. The patches of open wet bog as indicated on the map represent general location and size, but were not precisely surveyed. The two communities are similar in having leatherleaf, *Chamaedaphne calyculata*, at nearly 100 per cent frequency (Table 2),

Fig. 1. Vegetation map of Portage Bog.

but the leatherleaf is lower and sparser in open wet areas. In open dry areas, the leatherleaf is frequently dense and high enough (often knee-high) to make travel difficult. Continuous sphagnum, *Sphagnum* spp., usually forms the surface of open wet areas (Table 3); but in dry areas, other mosses, especially haircap, *Polytrichum juniperinum*, occur with the sphagnum. Lichens of the genus *Cladonia* are also frequent. Both communities have spotted through them occasional clumps of blueberry, *Vaccinium corymbosum*, and less commonly swamp birch, *Betula pumila*. Scattered small tamaracks are present; large tamaracks are present but at very low density (Table 1). (Closest individual tree samples were usually not taken at points where the nearest tree was more than 30 feet away; occasionally the distance to such trees was estimated. In such cases, density was calculated using measured distances, estimated distances, and a figure of 30 feet where neither of the foregoing was available. For this reason, densities calculated for open bog and thickets are all somewhat higher than the true values; accordingly, they are indicated in Table 1 as "less than" the calculated density.)

Cranberries, *Vaccinium oxycoccus* and *V. macrocarpon*, and white beak-rush, *Rhynchospora alba*, reach their greatest abundance in open

TABLE 1. Characteristics of the tree stratum in two bogs.

Character	Portage Bog					Sugarloaf Bog
	Wet & Dry Open	Park-land	Low Thicket	High Thicket	Tamarack Forest	Mixed Forest
Density (trees/acre)	Less than 4	47.7	Less than 9	Less than 21	418.8	347.4
Mean diameter (inches) of trees at least 3 inches dbh	4.0	4.4	5.5	4.4	4.7	8.0
Basal area (square feet) per acre	Less than 0.5	4.9	Less than 1.5	Less than 2.2	51.2	121.8
Species composition (relative abundance)						
Larix laricina	100%	100%	50%	50%	100%	----
Quercus palustris	---	---	33	25	---	----
Acer rubrum	---	---	17	--	---	29.5%
Pinus strobus	---	---	--	25	---	25.0
Betula lutea	---	---	--	--	---	36.4
Fraxinus nigra	---	---	--	--	---	4.5
Amelanchier canadensis	---	---	--	--	---	4.5

wet areas. The same is true of sundew, *Drosera rotundifolia.* In other vegetation types on the tract, this plant is almost wholly restricted to mammal trails, which could perhaps be regarded as narrow extensions of open wet bog into other communities. *Drosera intermedia* occurred in some open wet areas between the edge of the study tract and the drainage ditch, but was most common along the ditch where it carpeted large areas of bare peat.

Parkland. Parkland is similar to open bog except that larger tamarack trees, 20-40 feet tall and 3-8 inches dbh, are numerous enough to give the community an orchard-like appearance (Table 1).

TABLE 2. Percentage frequency of shrubs, vines, and trees less than 3 inches dbh. (Only species of at least 20 per cent frequency listed for Sugarloaf Bog)

Species	Portage Bog						Sugarloaf Bog
	Open Wet	Open Dry	Parkland	Low Thicket	High Thicket	Tamarack Forest	Mixed Forest
Chamaedaphne calyculata	100	95	80	20	20	40	--
Vaccinium oxycoccos and macrocarpon	93	20	80	10	10	20	--
Populus tremuloides	27	5	--	--	--	--	--
Larix laricina	20*	20*	40*	30*	60*	60*	--
Vaccinium corymbosum	--	--	20*	70*	90*	90*	--
Quercus palustris	--	5	--	--	10*	20*	--
Aronia prunifolia	--	--	--	60*	30*	--	--
Rubus hispidus	--	--	--	90	80	--	--
Rubus sp.	--	--	--	10	20	--	--
Gaultheria procumbens	--	--	--	10	10	10	33
Acer rubrum	--	--	--	10	30*	20*	83
Cornus alternifolia	--	--	--	--	--	10*	--
Rhus radicans	--	--	--	--	--	10	36
Ilex verticillata	--	--	--	--	--	10	35*[a]
Lindera benzoin	--	--	--	--	--	--	85
Parthenocissus quinquefolia	--	--	--	--	--	--	45
Gaylussacia baccata	--	--	--	--	--	--	38*
Ulmus spp.	--	--	--	--	--	--	38*
Quercus spp.	--	--	--	--	--	--	21

*Indicates species was present as high shrub, 3 feet or more tall.
[a]Based on 20 quadrats.

The community intergrades on the one hand with open bog and on the other with forest. As a consequence, density is variable, but was 25-100 trees per acre for the areas designated parkland here. Some differentiation of wet and dry areas could be seen, but the difference was slight compared with open bog. In general, the lower strata, even in relatively dry sites, resembled open wet bog. Leatherleaf occurred in most quadrats but was short and sparse (Table 2). *Sarracenia purpurea*, and yellow-fringed orchid, *Habenaria ciliaris*, reached their greatest densities in parkland and open wet bog (Table 3). Scattered large blueberry clumps were frequent.

Low and high thickets. Low thickets were areas where the vegetation grew so thickly that an observer was in contact with it on nearly every side at knee and waist level but not at eye level. The taller shrubs and trees composing the thicket were chokeberry, *Aronia prunifolia*, in pure stands; tamarack in nearly pure stands; or mixtures of species including chokeberry; tamarack; mountain-holly, *Nemopanthus mucronatus*; red maple, *Acer rubrum*; trembling aspen, *Populus tremuloides*; and pin oak, *Quercus palustris* (Table 2). Cinnamon fern, *Osmunda cinnamomea*; sphagnum; haircap moss; and dewberry, *Rubus hispidus*, were among the more frequent ground and field layer species (Tables 2 and 3).

In high thickets, the observer was in contact with the vegetation

TABLE 3. Percentage frequency of herbs in six vegetation types at Portage Bog.

Species	Open Wet	Open Dry	Parkland	Low Thicket	High Thicket	Tamarack Forest
Number of samples	15	20	10	10	10	10
Sphagnum spp.	80	70	100	80	80	90
Rhynchospora alba	60	20	50	--	--	--
Polytrichum juniperinum	40	95	40	50	40	80
Unidentified Cyperaceae and Juncaceae	20[a]	--	30[a]	20	30	20
Cladonia floerkeana and others	7	75	10	20	--	--
Osmunda cinnamomea	7	20	20	80	100	100
Eriophorum virginicum	7	5	--	--	--	--
Sarracenia purpurea	7	--	30	--	--	--
Cypripedium acaule	--	10	50	--	--	70
Habenaria ciliaris	--	--	10	--	--	--
Drosera rotundifolia	--	--	10	--	--	--
Monotropa uniflora	--	--	--	--	--	10

[a]Probably mainly Eriophorum virginicum.

on nearly all sides at knee, waist, and eye levels (and usually also at hand level with the arms upraised). The vegetation was often nearly impenetrable and vision was restricted to only a few feet. The plants composing these thickets were usually tamaracks with some chokeberry and mountain-holly present. Blueberry bushes were numerous. Cinnamon fern and dewberry were abundant.

In both high and low thicket, scattered larger trees (i.e., 3 or more inches dbh) were present at a density well below that of parkland (Table 1). These were mainly tamarack, but red maple and pin oak were well represented, and a very few white pines, *Pinus strobus*, were present. In addition to these living trees, scattered large dead tamaracks killed by fire were present.

Tamarack forest. Here large tamaracks 20-40 feet tall and 3-8 inches dbh formed a closed or nearly closed canopy (Table 1). Forest occurred only as narrow bands and patches surrounded by other communities. Sphagnum, haircap moss, cinnamon fern and moccasin-flower, *Cypripedium acaule*, were important ground and field layer plants (Table 3). There were scattered areas of dense shrubs, especially blueberry and mountain-holly (Table 2).

SEASONAL CHANGE IN PORTAGE BOG

A deep snow cover is present most winters. By late April, tamarack has begun to leaf out with small leaves that grow in size through the early part of May. Leatherleaf blooms early and by the beginning of May is past its peak. Blueberry begins to bloom near the middle of May and by early June has green developing fruits. The flowering period of moccasin-flower extends from middle May to middle June. Pitcher-plant may begin flowering as early as late May and continue through July or even through August. Time of flowering and vigor seem highly variable in this species.

In early June new cones of tamarack are seen and cranberry has begun to flower. Late in June, the pure stands of *Aronia* are white with flowers around which swarm immense numbers of minute flies, apparently gall midges (Cecidomyidae). By the first of July, new growth of tamaracks is noticeable, and in the ground stratum, wintergreen, *Gaultheria procumbens*, has also made new growth. Grass-pink, *Calopogon pulchellus*; Indian pipe, *Monotropa uniflora*; *Drosera rotundifolia*; white beak-rush; and dewberry all begin flowering around the beginning of July. The first blueberries ripen in July, but a few are still green to the end of the month. By this time, however, most of the ripe berries have been eaten by birds or have fallen off. Scattered cranberry blossoms and many yellow cranberries are present through July. Flowering begins at the bottom of the tall spike of the yellow-fringed orchid somewhat past the middle of the month and proceeds upward through July and early August. Cottongrass, *Eriophorum virginicum*, and wintergreen bloom late in July and are the latest species of any importance to flower.

By middle August, cottongrass is in fruit. New growth of leatherleaf is noticeable, and the flower buds that will open the following spring are present. Cinnamon fern has begun to die, although in the mixed forest at Sugarloaf Bog, the fronds remain green well into September. Ten to fourteen inches of new growth may be seen on the branches of small tamaracks, giving them a frosty-green appearance in contrast to the larger tamarack which usually show less new growth and appear darker. By the end of the month, blueberries are almost completely gone, but dewberries are ripening, and cranberries are beginning to redden.

Tamarack retains its needles far into the autumn. As late as mid-November, there may still have been little leaf fall, although the color has turned a golden yellow. Shortly, however, the needles begin to drop and by December only small trees still have a few pale yellow needles at the tips of their branches.

VEGETATION OF SUGARLOAF BOG

This forest was heavily dominated by yellow birch, *Betula lutea*; red maple, *Acer rubrum*; and white pine (Tables 1 and 4). Only two additional species, shadbush, *Amelanchier canadensis*, and black ash, *Fraxinus nigra*, were encountered in the 44 trees included in the sampling. Several other species of very low density were present; these included pepperidge, *Nyssa sylvatica*; tulip tree, *Liriodendron tulipifera*; tamarack; and elm, *Ulmus* spp. Spice-bush, *Lindera benzoin*, and huckleberry, *Gaylussacia baccata*, predominated in the high shrub layer (Table 2). Black ash from high shrub size to about 4 inches dbh was fairly common although not well represented in the quadrat samples; smaller sizes were scarce. Of potential canopy species, the most frequent in the quadrat samples (less than 3 inches dbh) were red maple, which occurred mainly as small seedlings, elms, oaks, and birch. Small white pines were uncommon, occurring in only two quadrats.

As is often the case with wetland forests, lianas (in this case, poison-ivy, *Rhus radicans*, and Virginia creeper, *Parthenocissus*

TABLE 4. Number of trees by species in four diameter classes at Sugarloaf Bog.

Species	Diameter class (inches)			
	3.0-6.9	7.0-10.9	11.0-14.9	15.0-18.9
Betula lutea	8	5	3	-
Acer rubrum	6	3	3	1
Pinus strobus	4	4	3	-
Fraxinus nigra	2	-	-	-
Amelanchier canadensis	1	1	-	-

quinquefolia) were prominent both in the field stratum and as climbers. The herbaceous cover was luxuriant. Cinnamon fern and skunk-cabbage, *Symplocarpus foetidus*, along with the slightly less common royal fern, *Osmunda regalis*, and jack-in-the-pulpit, *Arisaema triphyllum*, formed a high herbaceous layer (Table 5). A lower stratum consisted of wild lily-of-the-valley, *Maianthemum canadense*; partridge-berry, *Mitchella repens*; gold-thread *Coptis trifolia*; and starflower, *Trientalis borealis*. This dense herbaceous cover remaining through the summer is markedly different from the bare floors of more mesic forests.

DISCUSSION

The number of species occurring in the various vegetation types of Portage Bog is low in comparison to most communities of southwestern Michigan, even when allowance is made for the presence of some unidentified species. There is a slight trend toward increasing species diversity from open bog to tamarack forest. If we take as an index to diversity the total number of species found in the first ten samples (quadrat + closest individual tree) of each vegetation type, the values are open wet bog, 10; open dry bog, 10; parkland, 15; low thicket, 17; high thicket, 17; and tamarack forest, 19. The increase in the thicket and forest areas is largely the product of more woody species, especially shrubs. The ground and field layers, relatively depauperate through the whole series, are poorest in the thickets.

TABLE 5. Percentage frequency of herbs occurring in at least eight of forty-two quadrats at Sugarloaf Bog.

Species	Per cent frequency
Maianthemum canadense	100
Mitchella repens	98
Coptis trifolia	83
Trientalis borealis	80[a]
Osmunda cinnamomea	79
Arisaema triphyllum	62
Symplocarpus foetidus	48
Viola spp.	45
Osmunda regalis	40
Medeola virginiana	35[a]
Galium triflorum	33
Aralia nudicaulis	29
Rubus pubescens	21

[a]Based on 20 quadrats.

These layers are most diverse in the parkland which shares species of open bog and tamarack forest as well as having some characteristic species of its own.

The mixed bog forest, Sugarloaf Bog, is a much more diverse community. The index value for it, calculated as above, was 41.

Certain successional relationships among the various communities seemed fairly clear. Invasion of open bog by small tamaracks, giving rise to low thicket, occurred during the five years of observation. This was particularly noticeable along the edges of tamarack forest; elsewhere young tamaracks tended to remain scattered. Growth of scattered tamaracks in open bog tended to give rise to parkland. Growth of small tamaracks (and to a lesser degree, chokeberries) in areas of low thicket produced high thicket. This trend was perhaps the one most prominent change in the vegetation during the time of observation; considerable portions of the high thicket areas of 1965 were low thicket in 1961. It is likely that continued growth and natural thinning of high thickets will produce tamarack forest. In more northerly areas, tamarack forest is often replaced by black spruce, *Picea mariana*, which may in turn be replaced by white cedar, *Thuja occidentalis*; spruce may also invade bogs without an intervening tamarack stage. Both spruce and cedar are, however, almost entirely absent in bog succession in southwestern Michigan. According to Livingston (1902), an extensive black spruce swamp was once present about five miles east of Grand Rapids, Kent County, and I am aware of one cedar bog near Fennville, Allegan County (white cedar is, of course, relatively common on sand dune areas along Lake Michigan).

If undisturbed, tamarack forests (and possibly also mixed high thickets) in southwestern Michigan might give rise to mixed forests like Sugarloaf Bog; however disturbance by such agents as changing water levels, fires, and insect damage appears to be the rule rather than the exception in all stages of bog succession (Pennington, 1906; Gates, 1942, p. 241; Aldrich, 1943; Martin, 1959; Curtis, 1959, pp. 286 & 383). The paths of succession following such disturbance seem fairly complex. For fire, succession has been observed to differ according to severity of the burn, frequency of fires, the kind of vegetation burnt, season (Gates, 1942, p. 244), and the location in the bog, marginal or central (Pennington, 1906, p. 56). The charred bases of large dead tamaracks in the western part of Portage Bog suggest that fire has had a role in the development of the thickets there.

SUMMARY

Two bogs in Kalamazoo County, Michigan, were investigated between 1961 and 1965. One area consisted of a mosaic of six vegetation types, including open bog, thickets, parkland, and tamarack forest. The other area was a bog forest dominated by yellow birch, red maple, and white pine. The vegetation of these areas is described quantitatively and seasonal change is described for the first area. This area, a sphagnum-leatherleaf-tamarack bog was poor in

species relative to the second area and to most southwestern Michigan vegetation types. Some successional trends are pointed out, and the importance of disturbance in vegetation change in bogs is emphasized.

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MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

C. JOURNAL ARTICLES

Edelstein, Tikvah, & G. W. Prescott. 1964. Rayssiella, a new genus of oocystaceae (Chlorophyta) from Spring Lake, Michigan. Phycologia 4: 121-125. [Based on a new species from "Spring Lake . . . near Lake Michigan in Kent County"; neither of the two Spring Lakes in Kent Co. is really "near" Lake Michigan.]

Gilbertson, Robert L. 1965. Some species of Vararia from temperate North America. Pap. Mich. Acad. 50: 161-184. [*V. granulosa*, cited from East Tawas.]

Hilliard, Douglas K. 1964. Epipyxis michiganensis, a new Chrysophyte from Michigan. Phycologia 4: 117-120. [From "Paulding Pond, Michigan"—presumably in Ontonagon Co.]

Sparrow, F. K., R. A. Paterson, & R. M. Johns. 1965. Additions to the Phycomycete flora of the Douglas Lake region. V. New or interesting fungi. Pap. Mich. Acad. 50: 115-123.

Voss, Edward G. 1965. Comparative revegetation of denuded areas in northern Michigan. Pap. Mich. Acad. 50: 139-160. [10-year study in different habitats trenched for laying of oil pipeline.]

PROGRAM NOTES

Jan. 23: Michigan Botanical Club, general meeting. 2:00 p.m., Kresge Science Lecture Room, Wayne State University, Detroit. Main speaker: Genevieve Gillette, on the White House Beautification Conference.

Jan. 29: Southeastern Chapter winter outing and potluck.

Jan. 30: Michigan Natural Areas Council. 2:30 p.m., University of Michigan Herbarium.

March 26 - April 3: Flower and Garden Show, Michigan State Fairgrounds, Detroit.

May 27-30: Michigan Botanical Club, Spring Campout. Bruce Peninsula, Ontario. Save these dates; details later!

The October number (Vol. 4, No. 4) was mailed October 20, 1965.

Publications of Interest

(Continued from page 35.)

STRUTENES. CELANDINE (Chelidonium majus L.). By R. O. Jakobsons. 1963. 55 pp. A description of celandine, its cultivation, methods of preparation and use in Latvian folk medicine, and chemical constituents. Essentially bilingual (Latvian version followed by English translation). The author, who is now a chemist with the Michigan Health Department, began this work when he was manager of the Wholesale House of Latvian Medicinal Plants in Riga. Copies are available from R. Kruklitis, 511 Charles St., East Lansing, Michigan 48823, at $1.00 each.

INSECTIVOROUS PLANTS. By Stanwyn G. Shetler & Florence Montgomery. Smithsonian Institution, Museum of Natural History, Information Leaflet No. 447. 1965. 23 pp. A non-technical and well illustrated general discussion of insectivorous plants of North America.

CONSUMERS ALL. The Yearbook of Agriculture 1965. 496 pp. This year's volume in a familiar series includes a section of 15 short articles on plants (lawns, diseases and pests, trees, weeds, house plants, etc.) as well as several articles on outdoor activities. The volume sells for $2.75 from the Superintendent of Documents, Washington 20402, and is also available without charge from one's Congressmen.

QUEST FOR QUALITY. U. S. Department of the Interior Conservation Yearbook. 1965. 96 pp. $1.00 (Superintendent of Documents). A copiously and colorfully illustrated survey of programs related to conservation, under the Department of the Interior.

CONTENTS

(On the cover: Asterophyllites equisetiformis, *a plant fossil from Grand Ledge, Michigan, shown natural size. See p. 3.)*

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THE MICHIGAN BOTANIST

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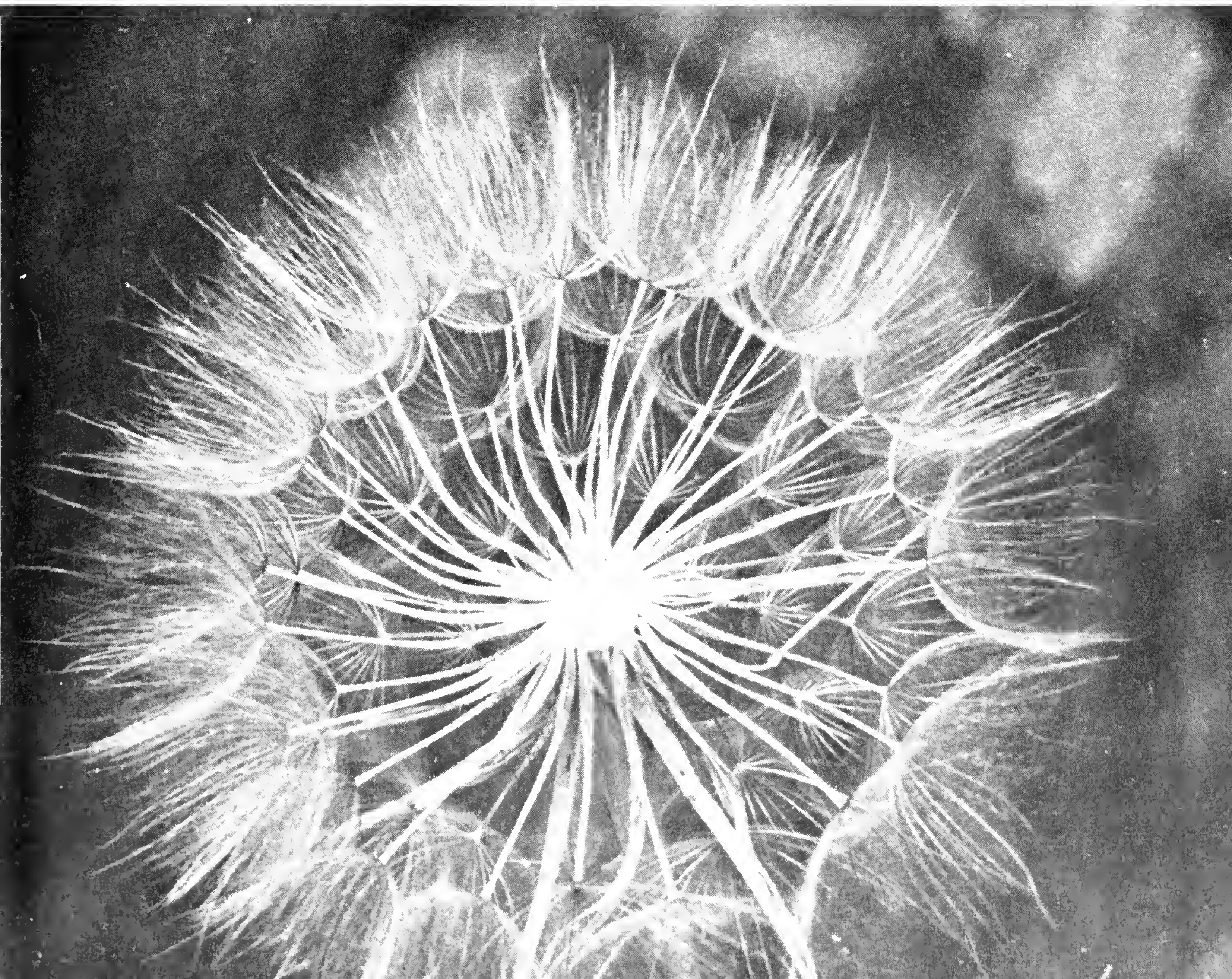

THE MICHIGAN BOTANIST—Published by the Michigan Botanical Club four times per year: January, March, May, and October. Second-class postage paid at Ann Arbor, Michigan.

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Articles and notes dealing with any phase of botany in the Upper Great Lakes Region may be sent to the editor in chief. The attention of authors preparing manuscripts is called to "Information for Authors" (Vol. 4, p. 38, and also available from the editor).

THE MICHIGAN BOTANICAL CLUB

Membership in the Michigan Botanical Club is open to anyone interested in its aims: conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on the plant life of the State; sponsorship of legislation to promote the preservation of Michigan native flora and to establish suitable sanctuaries and natural areas; and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

Dues are modest, but vary slightly among the chapters. In all cases, they include subscription to THE MICHIGAN BOTANIST.

STUDIES OF THE BYRON BOG IN SOUTHWESTERN ONTARIO. XXVI. DISTRIBUTION OF SHRUBS AND VINES

William W. Judd
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University of Western Ontario, London, Ontario

The Byron Bog has been described by Judd (1957). It lies in a hollow at the southwest corner of Oxford Street and Hyde Park Road in London, Ontario. There are three vegetation zones, A, B, and C, in the bog. The central part is a mat of floating *Sphagnum* moss (Zone A), the outer limit of which is shown as a - a on the map (Fig. 1). Surrounding this is an expanse of low woods, permanently damp or flooded (Zone B), the outer limit of which is shown as b - b. The outer rim of the bog consists of dry, wooded slopes (Zone C), the outer limit of which is shown as c - c. In the floating bog is Redmond's Pond (D). An account of some of the plants characteristic of the three zones is given by Judd (1957) and an account of the succession and duration of blooming of some plants is given by Judd (1958).

The first collection of plants was made by the writer in 1956 and other specimens have been accumulated since then. Among those collected are specimens from various shrubs and vines. The present account draws attention to these with a consideration of their distribution in the bog. Identifications were made by using keys and descriptions in Fernald (1950) and Soper and Heimberger (1961).

DISTRIBUTION OF SPECIES

The following list shows the three zones of the bog and the species which are completely or mainly concentrated in them.

Zone A

Kalmia polifolia
Andromeda glaucophylla
Chamaedaphne calyculata
Gaylussacia baccata
Vaccinium atrococcum

Zone B

Ribes americanum
Spiraea latifolia
Pyrus floribunda
Rubus odoratus
Rosa palustris
Ilex verticillata
Nemopanthus mucronata
Rhamnus frangula
Cornus stolonifera
Cornus obliqua
Cephalanthus occidentalis
Sambucus pubens

Zone C

Smilax herbacea
Smilax hispida
Salix interior
Corylus americana
Clematis virginiana
Berberis vulgaris
Berberis thunbergii
Ribes cynosbati
Hamamelis virginiana
Physocarpus opulifolius
Crataegus spp.
Rubus spp.
Prunus americana
Prunus virginiana
Rhus typhina
Rhus radicans var. *rydbergii*
Euonymus obovatus
Staphylea trifolia
Rhamnus cathartica

Zone C (cont'd)

Parthenocissus inserta
Vitis riparia
Cornus racemosa
Cornus alternifolia
Solanum dulcamara
Lonicera tatarica
Lonicera dioica
Viburnum rafinesquianum
Viburnum trilobum
Viburnum lentago
Sambucus canadensis

ACCOUNT OF SPECIES

The following account lists the species in the same sequence as in Fernald (1950). For those species which were found at only one or a few places in the bog. the numbers from the list below are shown on the map (Fig. 1). The accession numbers of specimens in the writer's herbarium are noted, ranging from 557 to 691.

Liliaceae

1. *Smilax herbacea* L., Carrion-flower (665) - commonly found twining over shrubs on the upper slopes of Zone C.
2. *Smilax hispida* (Muhl.) Fern., Bristly Greenbrier (689) - one plant twining over a stump and through the branches of a tree in the southwest part of Zone C.

Salicaceae

3. *Salix interior* Rowlee, Sandbar-willow (668) - several shrubs concentrated in a clump along the eastern border of Zone C.

Corylaceae

4. *Corylus americana* Walt., American Hazel (671) - along sunny slopes of Zone C.

Ranunculaceae

5. *Clematis virginiana* L., Virgin's Bower (691) - one group of vines sprawling over shrubs on the southeast slope of Zone C.

Berberidaceae

6. *Berberis vulgaris* L., Common Barberry (674) - on sunny upper slopes in southwest part of Zone C.
7. *Berberis thunbergii* DC., Japanese Barberry (683) - on upper slopes of Zone C.

Saxifragaceae

8. *Ribes cynosbati* L., Prickly Gooseberry (681) - in shade of trees in Zone C.
9. *Ribes americanum* Mill., Wild Black Currant (680) - scattered plants in Zone B.

Hamamelidaceae

10. *Hamamelis virginiana* L., Witch-hazel (648) - in shade of trees throughout Zone C.

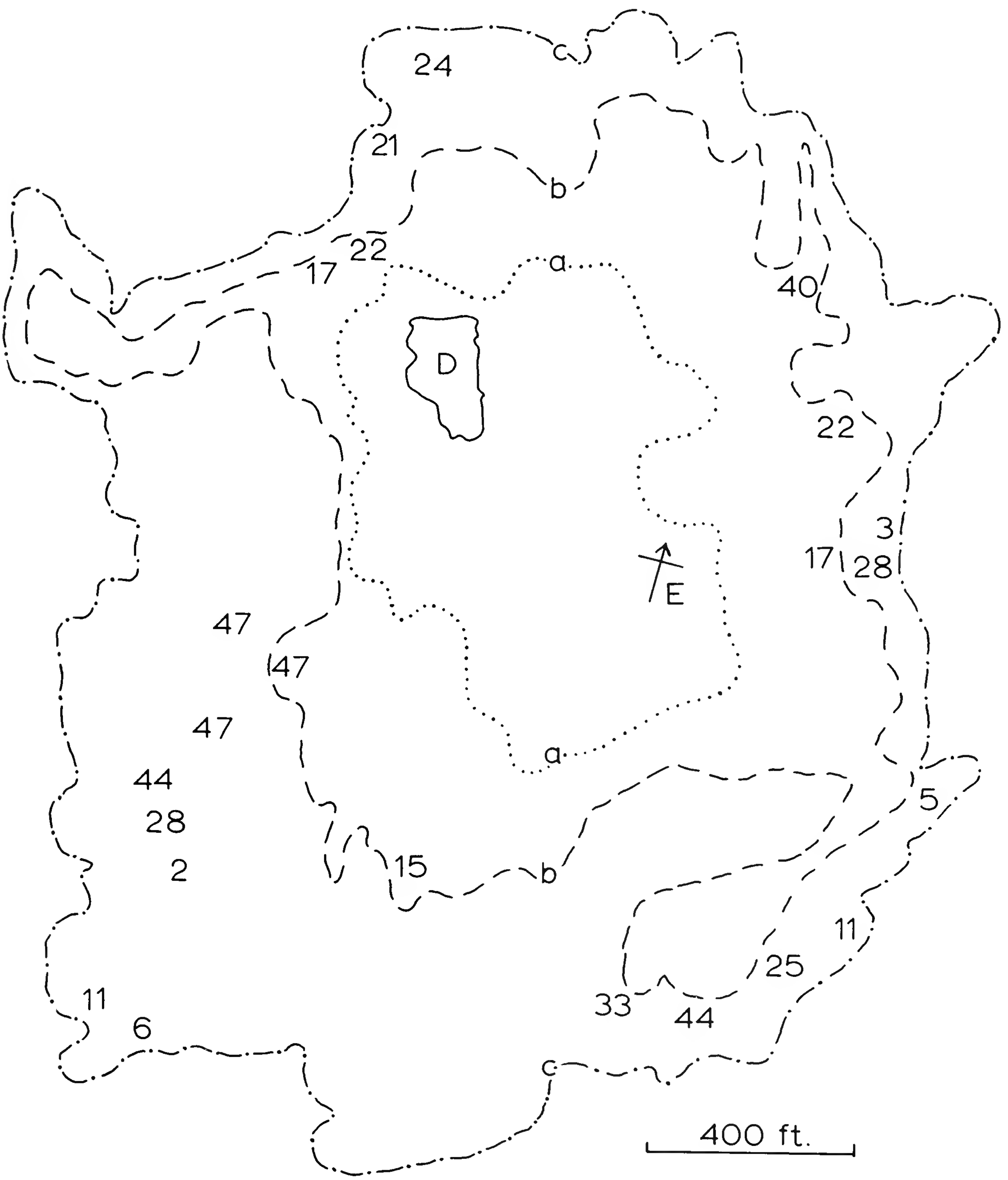

Fig. 1. Byron Bog:
a - a : outer border of open floating bog
b - b : outer border of lower, damp woods
c - c : outer border of wooded slopes
D : Redmond's Pond
E : location of co-ordinate point 42° 58' 15"N 81° 19' 15"W

Rosaceae

11. *Physocarpus opulifolius* (L.) Maxim., Ninebark (682) - a few shrubs on the sunny outer slopes in southwest and southeast parts of Zone C.
12. *Spiraea latifolia* (Ait.) Borkh., Meadow-sweet (687) - in several places in damp soil, open to the sun, in Zone B.
13. *Pyrus floribunda* Lindl., Purple Chokeberry (562, 563, 564) - along the border between Zone A and Zone B where the shrubs are exposed to the sun.
14. *Crataegus* spp., Hawthorn (none collected) - along the outer, sunny slopes of Zone C. The growth of trees around the slopes of the bog has been uninterrupted by cutting or other disturbance, so most of the hawthorns have achieved the stature of trees, and only a few remain as shrubs.
15. *Rubus odoratus* L., Purple-flowering Raspberry (688) - one patch of shrubs in shade of trees in the southwest part of Zone B.
16. *Rubus* spp., Raspberry (not collected) - occasional clumps of white-flowered raspberries occur along the upper slopes of Zone C, particularly north and south of the bog. These areas have long been parts of farms and these plants may well be remnants of once-cultivated raspberry patches.
17. *Rosa palustris* Marsh., Swamp Rose (686) - in patches of damp ground in northwest and eastern parts of Zone B.
18. *Prunus americana* Marsh., Wild Plum (658) - on outer slopes of Zone C where exposed to the sun.
19. *Prunus virginiana* L., Choke Cherry (659) - abundant throughout Zone C, particularly on the upper slopes.

Anacardiaceae

20. *Rhus typhina* L., Staghorn-sumac (667) - along upper slopes of Zone C where exposed to the sun.
21. *Rhus radicans* var. *rydbergii* (Small) Rehd., Poison Ivy (675) - a cluster of plants on the northwest slopes of Zone C.

Aquifoliaceae

22. *Ilex verticillata* (L.) Gray, Winterberry (649, 684) - under shade of trees in northwest and northeast parts of Zone B.
23. *Nemopanthus mucronata* (L.) Trel., Mountain-holly (646) - scattered shrubs in deep shade in Zone B.

Celastraceae

24. *Euonymus obovatus* Nutt., Running Strawberry-bush (657) - in shade of trees and shrubs on upper slopes of northwest part of Zone C.

Staphyleaceae

25. *Staphylea trifolia* L., Bladdernut (650, 661) - a cluster of about twelve shrubs in shade of trees on lower slopes in southeast part of Zone C.

Rhamnaceae

26. *Rhamnus cathartica* L., Common Buckthorn (663) - along upper slopes of Zone C where exposed to the sun.
27. *Rhamnus frangula* L., Alder-buckthorn (567) - abundant throughout Zone B. This is the most abundant shrub in this zone, forming dense thickets and producing many seedlings beneath the shrubs. During the war of 1939-1945 many of the shrubs were removed by the Department of National Defence, for the wood is an excellent source of a component of fuse powder. In spite of this extensive removal of shrubs, the growth has returned to its former abundance. Occasional shrubs are found on the slopes of Zone C.

Vitaceae

28. *Parthenocissus inserta* (Kerner) K. Fritsch, Virginia Creeper (672) - twining up trees at one location in southwestern Zone C and over shrubs and trees along part of eastern Zone C.
29. *Vitis riparia* Michx., Riverbank Grape (670) - twining over shrubs throughout Zone C.

Cornaceae

30. *Cornus stolonifera* Michx., Red Osier (680) - in damp ground at outer borders of Zone B.
31. *Cornus obliqua* Raf., Silky Dogwood (685) - scattered shrubs throughout Zone B.
32. *Cornus racemosa* Lam., Gray Dogwood (676) - abundant along the upper slopes of Zone C.
33. *Cornus alternifolia* L. f., Alternate-leaved Dogwood (690) - one shrub about eight feet tall on lower slopes in southern part of Zone C.

Ericaceae

34. *Kalmia polifolia* Wang., Bog-laurel (561) - scattered shrubs in Zone A.
35. *Andromeda glaucophylla* Link., Bog-rosemary (560) - scattered shrubs in Zone A.
36. *Chamaedaphne calyculata* (L.) Moench, Leather-leaf (557) - abundant over Zone A. This shrub forms a compact growth over the *Sphagnum* moss throughout Zone A, with the branches of the shrubs extending over the border of Redmond's Pond. Occasional clumps are found in Zone B where openings among the trees admit full sunlight.
37. *Gaylussacia baccata* (Wang.) K. Koch, Black Huckleberry (565) - scattered clumps of shrubs on hummocks of *Sphagnum* and among leather-leaf bushes in Zone A.
38. *Vaccinium atrococcum* (Gray) Heller, Black Highbush-blueberry (558, 559) - scattered clumps of shrubs on hummocks of *Sphagnum* and among leather-leaf bushes in Zone A; occasional shrubs in Zone B.

Solanaceae

39. *Solanum dulcamara* L., Nightshade (662) - climbing over logs, stumps and shrubs in Zone C.

Rubiaceae

40. *Cephalanthus occidentalis* L., Buttonbush (677) - a few shrubs growing among other species of shrubs in northeast part of Zone B.

Caprifoliaceae

41. *Lonicera tatarica* L., Tartarian Honeysuckle (660) - on drier parts of upper slopes of Zone C.
42. *Lonicera dioica* L., Glaucous Honeysuckle (673) - twining over shrubs and through lower branches of trees on upper slopes of Zone C.
43. *Viburnum rafinesquianum* Schultes, Downy Arrow-wood (664) - mainly on upper slopes, occasionally on shaded lower slopes, of Zone C.
44. *Viburnum trilobum* Marsh., Highbush-cranberry (669) - a few shrubs on southeastern and southwestern slopes of Zone C.
45. *Viburnum lentago* L., Nannyberry (666) - abundant on upper slopes and less so on lower slopes of Zone C.
46. *Sambucus canadensis* L., Common Elder (678) - on lower slopes of Zone C bordering on Zone B, where the ground is damp and the shrubs are open to the sun.
47. *Sambucus pubens* Michx., Red-berried Elder (656) - in Zone B, forming a particularly dense growth in shade beneath trees in the western part of this zone, and in nearby parts of Zone C.

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Soper, J. H., & M. L. Heimberger. 1961. 100 Shrubs of Ontario. Ontario Department of Commerce and Development, Toronto. 100 pp. + 100 pl.

BRYOPHYTES NEW TO THE DOUGLAS LAKE AREA[1]

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The bryophytes of the Douglas Lake area of northern Michigan (including Cheboygan, Emmet, Mackinac, and Presque Isle counties) have recently been dealt with in detail by Arzeni (1950) and Crum (1964, 1965); but, particularly as a result of field work during the summer of 1965, several bryophytes can be added to the flora. These and other unreported species noted incidental to herbarium studies at the University of Michigan Biological Station (UMBS) and at the University of Michigan (MICH) are presented here, together with previously published records of a number of liverworts which Arzeni apparently overlooked. In the following list, species preceded by an asterisk (*) are new to the flora.

HEPATICAE

Calypogeiaceae

**Calypogeia meylanii* Buch. Cheboygan Co.: On humus mounds in woods, Reeses Bog, Margaret Fulford, July 3, 1951 (UMBS, as *C. neesiana*); on humus bank at base of stump, Reeses Bog, Margaret Fulford, July 3, 1951 (UMBS, as *C. neesiana*); *Thuja* bog, Reeses Bog, R. E. Hatcher, August 7, 1952 (UMBS, as *C. neesiana*); on ground, Reeses Bog, C. M. Roberts, July 14, 1924 (UMBS, as *C. neesiana*); on rotten log, Reeses Bog, Frances E. Wynne 2459, June 27, 1942 (UMBS, as *C. neesiana*); on moist, decorticated log, Iron Bridge area of Carp Creek, N. G. Miller 2482, July 17, 1965 (UMBS). Emmet Co.: On moist organic soil at edge of beach pool, Cecil Bay, N. G. Miller 2593, July 31, 1965 (UMBS); over rotting *Sphagnum* and organic debris with *Cephalozia pleniceps*, bog forest S. of Wycamp Lake, N. G. Miller 2673, August 14, 1965 (UMBS). Mackinac Co.: Mackinac Island, G. E. Nichols, August 16-18, 1921 (MICH). No previous report of this species from the state is known.

**Calypogeia muelleriana* (Schiffn.) K. Müll. While several local collections seem best referred here, they approach *C. fissa* (L.) Raddi in having the lateral leaves slightly longer than broad. Cheboygan Co.: On moist humified soil, bog forest, Mud Lake, Inverness Township, N. G. Miller 2383, July 8, 1965 (UMBS); on moist humus, Iron Bridge area of Carp Creek, N. G. Miller 2406, July 10, 1965 (UMBS). Emmet Co.: On humus, steep bank of creek, Cross Village, H. Crum, July 22, 1965 (UMBS).

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[1]Contribution from the Biological Station of The University of Michigan.

Cephaloziaceae

Cephalozia compacta Warnst. Cheboygan Co.: Along side of trail in open *Sphagnum* bog bordering Little Lake Sixteen, G. E. Nichols, det. A. W. Evans. Reported from the area by Steere (1942) but not included in Arzeni's treatment of the Hepaticae.

Cephaloziellaceae

**Cephaloziella byssacea* (Roth) Warnst. Cheboygan Co.: On banks of ditches leading to Burt Lake, Colonial Point, C. B. Arzeni, August 12, 1950 (UMBS); roadside, Sec. 17, Inverness Township, R. E. Hatcher, July 10, 1952 (UMBS, as *Isopaches bicrenatus*).

Cephaloziella spinigera (Lindb.) Schust. [*C. striatula* (C. Jens.) Douin; *C. subdentata* Warnst.] Cheboygan Co.: In bog near Burt Lake, with *Microlepidozia setacea*, P. M. Patterson (Schuster, 1958, p. 220).

**Cephaloziella rubella* (Nees) Douin var. *sullivantii* (Aust.) K. Müll. Mackinac Co.: On wet log, south shore of Bois Blanc Island, A. J. Sharp MH561, July 29, 1956, det. R. M. Schuster (UMBS, MICH).

Harpanthaceae

Harpanthus drummondii (Tayl.) Grolle. Cheboygan Co.: Vicinity of Burt and Douglas Lakes, G. E. Nichols 225 and 510, 1920 (NY, as *H. scutatus*). These two collections among others from Ontario, Connecticut, New York, North Carolina, Vermont, and Wisconsin were cited by Grolle (1965) in his recent paper dealing with the genus *Harpanthus* and the separation and distribution of its constituent species.

Jungermanniaceae

Lophozia capitata (Hook.) K. Müll. [*L. mildeana* (Gottsche) Schiffn.] Cheboygan Co.: Mixed with other liverworts (*Calypogeia sphagnicola* and *Microlepidozia setacea*) in open *Sphagnum* bordering Little Lake Sixteen, G. E. Nichols, August 1936, det. A. W. Evans (MICH); on moist peaty soil in animal run beneath *Chamaedaphne*, low shrub zone about Little Lake Sixteen, ca. 8 mi. SE of Cheboygan, N. G. Miller & H. Crum M2642, August 5, 1965 (UMBS). Not included in Arzeni (1950), although previously reported from the area by Steere (1942). Schuster (1953, pp.346 - 347) reported this species to be "particularly common in relatively dry Chamaedaphne heaths, over sand, in Jack Pine barrens" in Michigan.

**Solenostoma pumilum* (With.) Steph. Mackinac Co.: On moist humus over rocks, north side of Mackinac Island, C. B. Arzeni, July 10, 1950 (UMBS).

Metzgeriaceae

**Metzgeria furcata* (L.) Dum. Emmet Co.: On rock in beech-maple woods, Pellston Hills, 3.2 mi. W. of Pellston on Robinson Road, H. Crum, July 14, 1965 (UMBS).

Porellaceae

**Porella pinnata* L. Cheboygan Co.: Attached to root and submerged, Mud Creek, at Black Lake, John Russell, August 11, 1965 (UMBS); on submerged trunks, roots, and stumps, mouth of Mud Creek (at Black Lake), H. Crum & N. G. Miller, August 13, 1965 (UMBS). Widely distributed in North America though rarely collected in Michigan, this species has been recorded from Lapeer, Marquette, and Iosco Counties (Gilbert, 1958). We have included a reference to this interesting addition to the flora through the courtesy of Mr. Russell, who plans to publish on his discovery in greater detail.

Radulaceae

**Radula obconica* Sull. Cheboygan Co.: On *Peltigera aphthosa* at base of tree, Hermits Bog, near Burt Lake, A. J. Sharp H561, August 6, 1956 (UMBS).

Frullaniaceae

**Frullania oakesiana* Aust. Cheboygan Co.: On tree in woods, Wolffs Bog, Margaret Fulford, July 10, 1951 (UMBS).

Several other collections made during the summer are noteworthy. A form of *Frullania eboracensis* Gottsche with caducous leaves and frequently bearing numerous propagula along lateral leaf margins was encountered several times. Although adequate reference to the reproductive function of these structures has already been made in the literature (Fulford, 1956; Lorenz, 1912), the keys most frequently used to identify local Hepaticae include no mention of them. They are noted here primarily as an aid to the students of the local bryophyte flora. Cheboygan Co.: On ash, 2.7 mi. N. of Cheboygan on Hwy. 23, H. Crum, July 1965 (UMBS); on elm, along small creek, swamp 2.7 mi. N. of Cheboygan on Hwy. 23, H. Crum, July 22, 1965 (UMBS); on arbor vitae in woods, Reeses Bog, Margaret Fulford, July 3, 1951 (UMBS). Emmet Co.: On *Thuja*, Big Stone Creek, Lake Michigan shore, H. Crum, July 15, 1965 (UMBS).

A single collection of gemmiparous *Nowellia curvifolia* (Dicks.) Mitt. was made. Mackinac Co.: On moist, decorticated log, woods along Leslie Avenue, Mackinac Island, N. G. Miller & H. Crum M2631, August 4, 1965 (UMBS). The oval, one-celled gemmae reported to occur at stem apices (Frye & Clark, 1945, p. 506; Macvicar, 1926, p. 279) were found in the present collection in light-green clusters at the tips of the bilobed leaves. When the clusters were detached, two or three gemmae frequently remained attached to each other in short chain-like groups.

MUSCI

Pottiaceae

**Desmatodon obtusifolius* (Schwaegr.) Jur. Mackinac Co.: On limestone boulder, Lime Kiln Trail, Mackinac Island, H. Crum & N. G. Miller M2624, August 4, 1965 (UMBS). This species, new to the flora of the state, is infrequently collected but widely distributed in eastern North America from Ontario and Quebec to the Gulf of Mexico and also, in the West, from Alaska to Colorado and California.

Grimmiaceae

**Grimmia apocarpa* Hedw. Cheboygan Co.: On concrete abutment of railroad bridge and on calcareous boulders, Mill Creek, 3 mi. S. of Mackinaw City on Highway 23, H. Crum, July 31, 1965 (UMBS). A very common, widely distributed calciphile, in Michigan and elsewhere, but not previously recorded locally. The very similar *G. alpicola* Hedw. is common in the Douglas Lake area.

Splachnaceae

**Splachnum ampullaceum* Hedw. Emmet Co.: On old cow dung in open bog forest 1/2 mi. SE of Stutsmanville, H. Crum & N. G. Miller, July 29, 1965 (UMBS). A rare species growing on old dung of herbivores, especially of cows, this species has been collected elsewhere in Michigan only on Isle Royale, where its occurrence is presumably linked to the moose population. The species has also been found in British Columbia and Alberta, and in the East it ranges from Newfoundland and Nova Scotia to Ontario and southward to Michigan, New York, and Massachusetts.

Amblystegiaceae

**Hygroamblystegium noterophilum* (Sull.) Warnst. Cheboygan Co.: Attached in flowing water, Nigger Creek, Barbara Morrison, July 6, 1959 [UMBS, erroneously reported as *H. tenax* var. *spinifolium* (Schimp.) Jenn. by Crum (1964)]; submerged, attached to rocks near culvert, Nigger Creek at South Extension Road, N. G. Miller 2561, July 30, 1965 (UMBS). Emmet Co.: Submerged in swift brook from artesian well, on concrete, Ramona Beach, E. of Harbor Springs, H. Crum & N. G. Miller, July 29, 1965 (UMBS). Previously recorded from Alger and Charlevoix Counties, this moss is widely distributed in Ontario and the northern United States east of the Rockies.

Brachytheciaceae

**Eurhynchium hians* (Hedw.) Sande-Lac. Cheboygan Co.: On wet humified soil along creek, Gorge of Carp Creek, ca. 5.5 mi. E. of

Pellston on Riggsville Road, H. Crum & N. G. Miller M2377, July 5, 1965 (UMBS). A species of wide distribution in eastern North America, from Ontario and Quebec to Florida, Texas, and northeastern Mexico.

Hypnaceae

**Platydictya confervoides* (Brid.) Crum. Cheboygan Co.: On limestone cliff and rocks, Mill Creek, H. Crum, July 18, 1965 (UMBS). Mackinac Co.: On dry limestone rocks, Mackinac Island, H. Crum & N. G. Miller, August 4, 1965 (UMBS). Apparently widespread in calcareous habitats, particularly in stream valleys, in southeastern Canada and northeastern United States but probably often overlooked because of its small size, modest appearance, and unstable and usually uninteresting habitat.

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MOSS FROM THE BOTTOM OF THE GREAT LAKES

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Aquatic mosses are not uncommon, but records of deepwater species are few, and none may exist for the Great Lakes. Therefore, a new record of a benthic moss from the Great Lakes is particularly noteworthy.

In September, 1962, I was engaged in limnological sampling on Lake Michigan, approximately one mile offshore in Whitefish Bay, about 7 miles north of Milwaukee harbor. At this location, a routine attempt was made to secure a sample of the lake bottom from a depth of 34 feet. However, the bottom was hard and the sampling device (Petersen dredge) would only bring up a few chips of clay. The sample was rejected as useless for quantitative evaluation of the fauna, but, as I was about to discard the lumps of clay, I noticed a turf of tiny "rooted" plants (ca. 3 mm tall) on the mud-free surface. Upon examining them more closely in the laboratory, I concluded that the plants belonged to the moss genus *Fissidens* and, perhaps, the species *F. minutulus*. I sent a few specimens to Prof. Lewis Anderson for verification. He agreed that it was *Fissidens* but the material was inadequate for species determination.

In September, 1963, while engaged in sampling the bottom of Lake Erie at a station about one-half mile south of Port Dover, Ontario, I found another colony of submerged moss. At this station (depth: 18 feet) I encountered a hard bottom--gravel atop clay. Although the sample was unacceptable for zoological purposes, I found a small patch of moss attached to the clay surface. It was again a species of *Fissidens*. Prof. Anderson determined it to be *F. debilis* Schwaegr., which characteristically grows attached to sticks, logs, or the bases of trees in lowland swamps subject to periodic inundation. According to Dr. Anderson, it also grows at the margins of lakes and even in the brackish water of estuaries. The species is not common in the Great Lakes area, however, and it has apparently not been noted locally in deepwater environments.

Recently I have seen detached specimens of *Fissidens* from bottom samples from Lakes Superior and Ontario. Apparently this genus is widely distributed in the Great Lakes, especially in places where there is a hard clay substrate.

F. debilis (as *F. julianus*) has long been known from northern Europe, but was considered rare until Lohammar (1954) listed many records, mostly from Sweden. He reports that it has been found to grow on loose mud, on hard bottom, on other aquatic mosses, and even on mollusk shells, but never in depths greater than 4 meters (ca. 13 feet). Lohammar considers the species to prefer eutrophic waters but to be intolerant of severe pollution. The site for *F. debilis* in Lake Erie may be somewhat eutrophic but the habitat in Lake Michigan is at most mesotrophic.

I wish to sincerely thank Prof. Anderson for his examination and determination of the species.

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A NEW VARIANT OF *ERYTHRONIUM AMERICANUM* (YELLOW FAWN LILY)

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In May, 1964, and again in 1965, during a study of variation in *Erythromium americanum* in Wisconsin, a new variant in anther color was collected in Manitowoc County by Professor Alvin L. Throne of the University of Wisconsin, Milwaukee. It was widely distributed in a large (ca. 80 acres) typical beech-maple climax woods. Thirty specimens were collected and at least as many more were observed but not disturbed.

This variant has orchid colored anthers which are very narrow and completely sterile. They are borne on extremely thin, flexible filaments which cause the anthers to hang down rather than to stand up rigidly as in the other two variants. The tepals are strongly recurved, with few magenta flecks. The petals have smaller auricles and there is greater stigma divergence than in the other two variants.

To our knowledge, specimens with orchid colored stamens have never been reported for *E. americanum*. We would appreciate any information concerning the collection or observation of *E. americanum* flowers similar in any respect to the above description.

LYGODIUM PALMATUM, THE CLIMBING FERN, IN SOUTHWESTERN MICHIGAN

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The American climbing fern, or Hartford fern, *Lygodium palmatum* (Bernh.) Sw. (Schizaeaceae) is the only species of this tropical genus that grows in the United States. The plant is remarkable because of its vine-like nature, the leaves twisting around the stems of other plants. Because of its unusual nature and paucity of occurrence it was protected from careless uprooting by Connecticut law in 1869 (Wherry, 1961), thus being the first fern to be so distinguished. *Lygodium palmatum* is usually considered rare and local over most of its range and has never been reported from the state of Michigan.

One may, therefore, imagine the surprise of my students and me when we found a stand of *Lygodium palmatum* while on a systematic botany class trip in May, 1965, through the Gourdneck State Game Area on the western edge of the city of Portage, Kalamazoo County.

The plants formed an entangled mass approximately six feet by six feet, twining with each other and with any other plants within reach. The clone was growing in sandy soil along a path about twenty feet from the edge of a marsh.

Some of the more prominent plants growing in the immediate vicinity of the *Lygodium* were *Osmunda cinnamomea* and *O. regalis*, *Lycopodium flabelliforme*, *Rhus vernix*, *Populus tremuloides*, *Spiraea tomentosa*, *Pinus sylvestris*, and *P. banksiana* (the latter two were planted).

The general locality in which the *Lygodium* is growing consists of a high sandy field in which pines, mostly *Pinus resinosa*, have been planted. Dewberry, *Rubus hispidus*, is the dominant ground cover and there are scattered stands of *Sassafras albidum*, *Rhus typhina*, and *Quercus* sp. This area slopes at the north end to a low marsh through which a small stream meanders and finally becomes lost in a grass-sphagnum marsh. Some important members of this marsh community are *Potentilla fruticosa*, *Betula pumila*, *Cornus racemosa*, and *Larix laricina* (the latter around the margin).

This is the northernmost record of *Lygodium palmatum* west of the Appalachian Mountains to my knowledge, and extends the range of climbing fern approximately 250 miles from its previously known occurrences (as given in Vannorsdall, 1956, p. 212). As hitherto described, the range of this fern extends from New England southwest to southern Ohio and Kentucky, south through the mountains and coastal plain to Florida (Fernald, 1950; Gleason, 1952).

The area in which the climbing fern was found in Michigan was thoroughly studied by Mr. and Mrs. Hanes in preparation of their Kalamazoo County flora but they did not report finding it (Hanes, 1947).

Possibly it was introduced after they did their collecting, or more likely it was overlooked.

It is interesting to note that range disjunctions in North American ferns are not unusual. Examples of these are discussed by Wagner (1965) in connection with a recent discovery of a fern in North Carolina that extended its range more than 1000 miles.

Woodwardia areolata (L.) Moore, the net-veined chain fern, in Michigan has a distribution similar to that of the climbing fern. L. H. Bailey collected this fern at South Haven, Van Buren County, hundreds of miles north of its other known inland stations (Billington, 1952). Like the climbing fern, this chain fern must be very rare and local, for it has not been rediscovered since 1880.

Specimens of *Lygodium palmatum* from the new station in Michigan are on file in the Hanes Herbarium at Western Michigan University and in The University of Michigan Herbarium (Kalamazoo County, Portage Township, T3S, R11W, northwest quarter of section 19, Gourdneck State Game Area. One-fourth mile south of the intersection of Centre Street and U. S. 131. Richard W. Pippen 159, 17 September 1965).

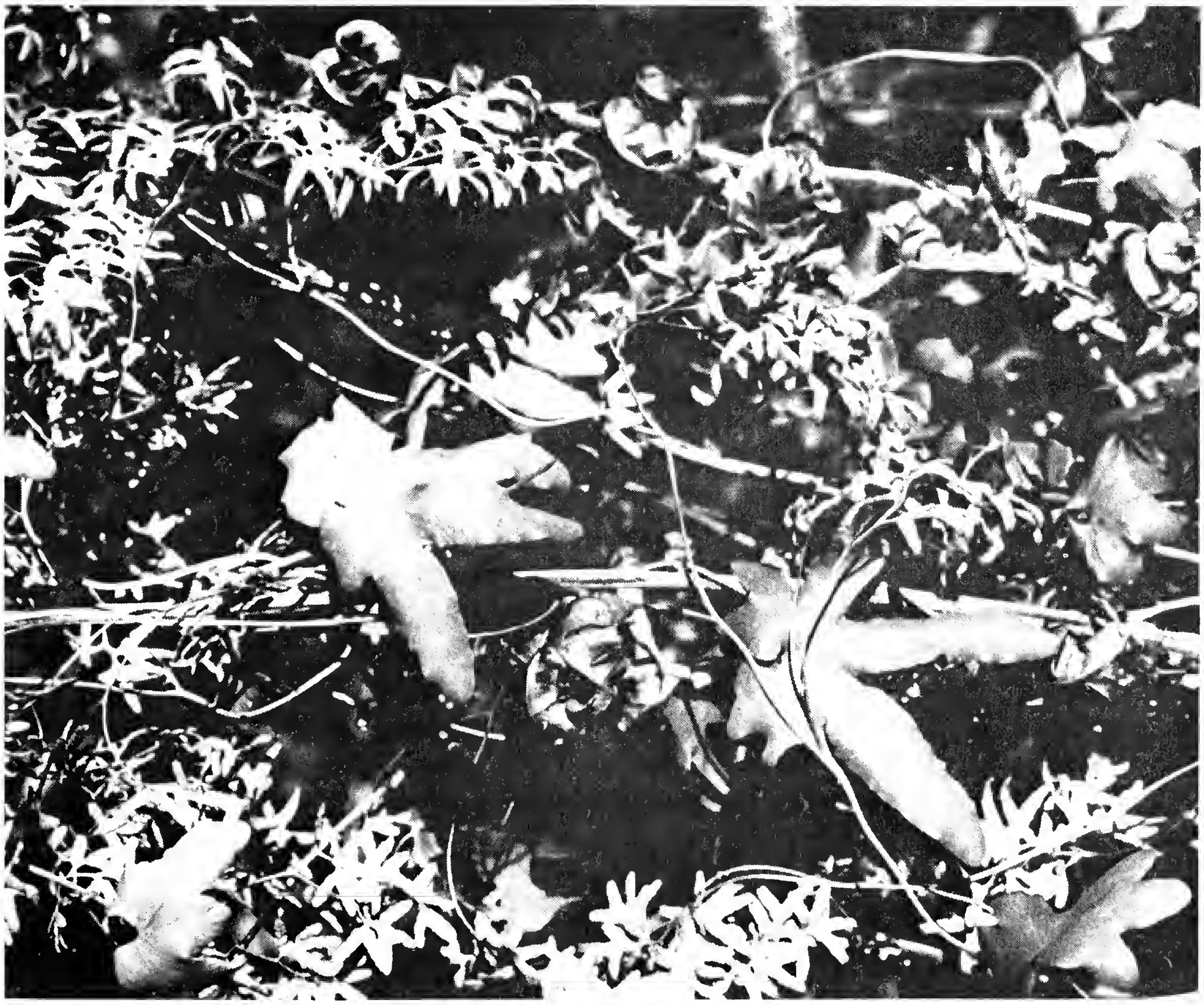

Fig. 1. *Lygodium palmatum* at Portage, Michigan.

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GERMINATION OF SEEDS IN *SARRACENIA PURPUREA* (PITCHER PLANT)[1]

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During the last century *Sarracenia purpurea* and its hybrid forms were popular horticultural plants in Europe, and although many were raised from seeds, there are no detailed accounts of methods used. In *Gardeners' Chronicle* of 1874, David Moore, speaking of pitcher plants in general and a *Sarracenia* hybrid in particular, states that the seed was ripened in 1868. In the following spring the seeds were sown and the pot was placed in a moderately warm house when the seeds began to germinate about a month after they were sown. It is not stated here under what conditions the seeds were kept over the winter months prior to being placed in the pots in the spring.

There are only two other references of more recent date about germination of *Sarracenia purpurea* seeds. Shreve (1906) reports that "seeds of the crop of 1901, which in October of that year were placed in *Sphagnum* in a loosely covered glass vessel, germinated in July 1902." Macfarlane (1908) in his monograph on the Sarraceniaceae, states: "The ripe capsules of *Sarracenia* shed their seeds from July to September in their native haunts. Germination takes place in from three to five weeks, and a small seedling may be formed before Winter in the warmer Southern States, or germination may be delayed until the succeeding Spring in colder States."

According to Baldwin (1942), "knowledge of the proper pretreatment to induce prompt and complete germination can best be gained by a study of the ecological factors affecting the seed in its natural habitat between the time of maturity and germination." Consequently, this series of experiments was carried out in an effort to establish the ecological factors controlling seed germination in nature.

During studies on the ecological life history of pitcher plant, I noted a puzzling lack or scarcity of seedlings in some of the Michigan bogs investigated (see Mandossian, 1965, 1966). In Purdy Lake bog, which is a *Sphagnum* bog containing a large, well-established *Sarracenia purpurea* population, only about a dozen seedlings and young plants were found after a thorough search during the summer months of 1960 to 1963. On the other hand, Otis Lake bog, also a *Sphagnum* bog, contained a large number of seedlings. The seedlings

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[1]From a thesis submitted to the Department of Botany and Plant Pathology, Michigan State University, in partial fulfillment of the requirements for the Doctor of Philosophy. Contribution Number 129 from the W. K. Kellogg Biological Station, Michigan State University. The two previous articles in this series (October, 1965, and January, 1966) should have Contribution Numbers 127 and 128 respectively.

were so crowded that it was not immediately possible to determine which pitcher-leaf belonged to which plant without untangling them from one another. It looked as if a number of seeds had fallen in a certain spot and had all germinated at once. At Rose Lake, another *Sphagnum* bog, there were hundreds of seedlings. McKay Lake bog, an alkaline bog, had no seedlings at all. Deep Lake had no seedlings in its southeast bog (both acid and alkaline areas), but in its northeast bog, which is alkaline in reaction, there were almost as many seedlings and young plants as mature ones.

As a result of these observations it would appear that the degree of acidity or alkalinity was not the determining factor controlling germination. It was also apparent that lack or scarcity of seedlings was not necessarily caused by lack of seeds because in Purdy Lake bog 95 "plants" out of 140 had one to four fruits per "plant" in the fall of 1960, and yet, only about a dozen seedlings could be found. Furthermore, the plants were known to have flowered at least in the preceding three years.

At Proud Lake bog (Oakland Co., Michigan, T2N, R8E, Sec. 21), about 12 miles southwest of Pontiac, no seedlings were found in October of 1960 even though at least 300 plants had capsules full of seeds and were mature enough to have flowered in previous years. All the seeds used for the germination experiments in this study were collected at the Proud Lake bog in 1960.

These observations suggest that germination of seeds may be a critical aspect in the ecology of this plant. At the same time, reports of delayed germination given by Moore (1874), Shreve (1906), and Macfarlane (1908), point to the possibility that dormancy is involved in the problem. This part of the study was therefore undertaken to identify factors inducing germination under controlled conditions and to correlate these results with those operative in nature.

LITERATURE SURVEY

It is known that many seeds of wild plants, apparently mature, fail to germinate even when all their specific environmental requirements are met. This failure of seeds to sprout because of internal causes is called dormancy (Meyer & Anderson, 1952). This condition is considered to be of survival value to the species through unfavorable seasons. Crocker and Barton (1953) state that dormancy is typically a selective adaptation of plants in temperate regions which prevents seeds from germinating in the fall of the year when the seedlings would be quite vulnerable to severe weather conditions.

Dormancy may be due to many factors. A very important factor may be the impermeability of the seed coat to water. This condition prevents imbibition which is the mechanism that triggers all activity connected with germination. With absorption of water the seed coat becomes more permeable to gases, allowing oxygen to enter and carbon dioxide to leave the seed. The water activates enzymes within the seed, causing digestion of stored foods and their translocation to growing parts. As the embryo grows, the seed coat is ruptured permitting the emergence of the radicle. Without imbibition of water, none of these activities would take place.

A second common cause of dormancy may be the mechanical strength of the coat, which may prevent the expansion of the embryo (Amen, 1963). Still another cause of dormancy connected with the seed coat may be the impermeability of this structure to the diffusion of gases, particularly oxygen and carbon dioxide (Thornton, 1945). Some of the methods which have been used to break dormancy caused by the seed coat are scratching or cracking of the coat by mechanical means (Crocker and Barton, 1953) or by removing some of the external tissues with strong acids (Steinbauer & Frank, 1954, and Burns, 1959).

It is also known that minimal, optimal, and maximal temperatures exist for the germination of seeds. In many plants germination occurs only within a very narrow range of temperature (Whitney, 1942). Also, it is known that seeds of plants of the temperate regions require a long period of low temperature under moist conditions before germination may take place (Toole et al., 1956). Stratification in moist peat at $5^{o}C.$ to $10^{o}C.$ for two or three months was found effective in breaking the dormancy of certain seeds (Barton, 1930). Likewise, Cross (1931) and Steinbauer & Frank (1954) found alternating temperatures effective in inducing germination.

Light and darkness, alone or in combination with temperature, are other important factors to be considered in the germination of seeds. Evenari (1956) gives numerous examples of both inhibition and enhancement of germination by light. Certain seeds are known to germinate poorly when held continually in either light or dark, while other seeds respond most favorably to continuous irradiation (Toole et al., 1956) or continuous dark (Meyer & Anderson, 1952). Likewise, Toole et al. (1962) found that continuous or repeated exposures of pine seeds to light shortened the period of stratification necessary for complete germination. Photoperiodism was considered by Koller et al. (1962) to be another factor influencing germination of seeds. They noted that some seeds may be "long day" and others "short-day" seeds and that this requirement may be correlated with temperature changes.

Another widespread mechanism of dormancy may be the occurrence in the seed of chemical inhibitors (Randolph et al., 1943, and Went, 1957). Evenari (1949) listed many species of plants from the seeds of which germination inhibitors have been isolated. On the other hand, certain other chemicals, such as nitrates and nitrites, are known to be effective promotors of germination in certain seeds (Heit, 1948).

MATERIALS AND METHODS

Seeds were collected during the first week of October, 1960, from Proud Lake bog. Maturity of the seeds was determined by observing that many of the capsules had dehisced and lost some of their seeds. As flowering of a pitcher plant population in a given bog is almost simultaneous, the seeds would probably never be more than a few days apart in maturity. The capsules were broken off the scapes and the seeds extracted by hand. Almost all of the capsules were heavily infested with the lepidopteran larvae of *Endothenia habesana* Wlk. and many of the seeds were partially eaten or the seed coat punctured. The seeds were sorted out under a dissecting microscope and only those that showed no injury were retained. The seeds were then stored in a refrigerator at 5°C. in a tightly stoppered glass jar, and removed as needed for the various experiments.

The seeds were shaken in Arasan in order to prevent the growth of fungi. Then they were placed in one of the following light and temperature conditions and moistened with distilled water, bog water, or 0.2% potassium nitrate.

1. At 22°C., in constant light
2. At 22°C., in constant darkness
3. At 22°C., in alternate light (8 hrs.) and darkness (16 hrs.)
4. At 33°C., in constant light
5. At 33°C., in constant darkness
6. At 33°C., in alternate light (8 hrs.) and darkness (16 hrs.)
7. In alternating light (at 22°C., 8 hrs.) and darkness (at 5°C., 16 hrs.)
8. In alternating light (at 33°C., 8 hrs.) and darkness (at 5°C., 16 hrs.)
9. At 28°C., in constant light
10. At 28°C., in constant darkness

A preliminary test indicated that germination took at least nine days. Therefore, counts of germinated seeds were started on the ninth day and were continued every other day throughout the test period. The seedlings were removed when fully germinated. As defined by Baldwin (1942), germination was considered to be "the development of the plantlet from the seed."

EXPERIMENT A — *To determine the effect of moistening agents on germination of seeds under different light and temperature conditions and different pre-chilling periods.*

The Arasan-coated seeds were spread on blotters in 30 Petri dishes in lots of 100 seeds each. Ten of these were moistened with distilled water, 10 with bog water, and 10 with 0.2% potassium nitrate. All dishes were then kept in the refrigerator at 5°C. for two weeks.

Three other sets of seeds were similarly started. These were pre-chilled for one month, two months, and three months, respectively. Again, 10 dishes of each were moistened with distilled water, 10 with bog water, and 10 with 0.2% potassium nitrate.

Whenever necessary, during the pre-chilling as well as the germination period of this and the other series of experiments, bog water was added to the dishes initially moistened with bog water. Distilled water was added to seeds initially moistened with distilled water and also to those moistened with potassium nitrate. Both bog water and distilled water were brought to the same temperature as the dishes, when used.

The bog water used in these and the following experiments was obtained in all cases as follows: a centrally located spot containing typical bog flora was selected in Proud Lake bog. A little pressure on this spot formed a cavity which soon filled with water. The water was dipped in wide-mouth glass jars, filtered, and stored in the refrigerator.

EXPERIMENT B — *To determine the effect of sulphuric acid on germination of seeds under different light and temperature conditions, without pre-chilling.*

Seeds were treated with concentrated sulphuric acid for one minute and spread in 30 Petri dishes over blotters. Ten of the dishes were moistened with distilled water, 10 with bog water and 10 with 0.2% potassium nitrate solution. Each dish was then placed in one of the 10 experimental environmental conditions.

Another lot of seeds was treated with concentrated sulphuric acid for five minutes and similarly placed in the ten environmental conditions.

EXPERIMENT C — *To determine the effect of the substrate on germination of seeds under different light and temperature conditions, with and without pre-chilling.*

Arasan-coated seeds were spread over minced *Sphagnum* and moistened with bog water in 20 Petri dishes, each containing 100 seeds. Ten of these were pre-chilled for two weeks and ten were not. One of each series was then placed in each of the 10 environmental conditions.

In a similar manner, seeds were spread over marl, moistened with distilled water, in 20 Petri dishes. Ten of these were pre-chilled and 10 were not. They were then placed in the 10 environmental conditions as above.

At the same time, seeds were spread in 10 Petri dishes over blotters moistened with distilled water. These were not pre-chilled.

All dishes were kept moist throughout the course of the experiment with their respective moistening agents.

EXPERIMENT D — *To observe germination of seeds under natural light and temperature conditions in a bog.*

Proud Lake bog was chosen for this experiment because of its relative proximity to Detroit and also because all seeds used for the present series of germination experiments were obtained at this bog.

In November of 1960, 800 seeds, untreated in any way, were spread in the bog between two quarter-inch layers of glass wool and covered with about half an inch of *Sphagnum*. The spot was staked and left undisturbed until the following spring.

RESULTS AND DISCUSSION

EXPERIMENT A — The results of these experiments are summarized in Tables I to VI. In the first column are given the moistening agents. In the second through the fifth columns, the percentage of germination is given first; then come, in order, the number of days required for initial germination to take place, the number of days required for germination to reach its peak (this number is underlined), and finally, the last day at which germination took place.

1. At 22°C. in constant light

The results summarized in Table I indicate that at 22°C., in constant light, the moistening agent made no difference in the percentage or time of germination.

Three months of pre-chilling produced the highest percent germination and the 2-week pre-chilling the lowest percent germination.

TABLE I. Germination (percent, and number of days to first, peak, and last) of pre-chilled, moistened seeds kept at 22°C. in constant light. 100 seeds used per dish.

Moistening agent	2-wk. prechills		1-mo. prechills		2-mo. prechills		3-mo. prechills	
Dist. water	22%	9-12-24	50%	9-12-27	50%	9-12-18	62%	9-12-24
Bog water	19	9-12-18	43	9-12-24	44	9-12-21	58	9-12-18
KNO_3 (0.2%)	21	9-12-24	50	9-12-21	50	6- 9-21	59	9-12-24
Average	21%		48%		58%		60%	

2. At 22°C. in constant darkness

The results summarized in Table II show that at 22°C. in continuous darkness, the moistening agent potassium nitrate increased the percentage of germination in all except the 2-week pre-chills. The 3-month pre-chilled seeds gave the best germination results and the 2-month pre-chills the next best. The 1-month pre-chilling resulted in considerably less germination while the 2-week pre-chills gave the poorest results.

TABLE II. Germination of pre-chilled, moistened seeds kept at 22°C. in constant darkness. 100 seeds used per dish.

Moistening agent	2-wk. prechills		1-mo. prechills		2-mo. prechills		3-mo. prechills	
Dist. water	1%	18	6%	12-15-21	22%	12-12-24	15%	9-12-15
Bog water	6	21	8	12-15-18	23	12-12-21	39	9-12-24
KNO_3 (0.2%)	2	15-21	19	12-12-24	50	12-12-24	47	12-12-24
Average	3%		11%		32%		44%	

3. At 22°C. in alternate light (8 hrs.) and darkness (16 hrs.)

The results summarized in Table III show that at 22°C., in alternate light (8 hrs.) and darkness (16 hrs.), the moistening agent, potassium nitrate, gave the best germination in all cases. Two-month and 3-month pre-chilling gave equally good germination, and 2-week pre-chilling gave the poorest results.

TABLE III. Germination of pre-chilled, moistened seeds kept at 22°C. in alternate light (8 hrs.) and darkness (16 hrs.). 100 seeds used per dish.

Moistening agent	2-wk. prechills		1-mo. prechills		2-mo. prechills		3-mo. prechills	
Dist. water	1%	21	5%	12-12-18	39%	9-12-18	30%	9-12-24
Bog water	2	15-18	10	12-12-18	44	9-12-21	47	9-12-21
KNO_3 (0.2%)	5	12-18	18	12-12-21	56	9-12-21	55	9-12-24
Average	3%		11%		46%		44%	

4. At 33°C., in constant light

5. At 33°C., in constant darkness

6. At 33°C., in alternate light (8 hrs.) and darkness (16 hrs.)

In the environmental conditions No. 4, 5 and 6, listed above, in all pre-chilling series, the primary root broke through the coat in many seeds, but soon turned reddish and shriveled up. In certain other seeds germination progressed up to the partial emergence of the cotyledons, but the entire plantlet was soft and limp, remained flat on the blotter, and disintegrated before completion of the germination process. It was therefore concluded that a temperature of 33°C., whether in constant light, in constant darkness, or in alternate light and darkness, was too high to permit germination of *Sarracenia purpurea* seeds. This phase of the experiments in this as well as in the following series was therefore abandoned.

7. In alternating light (at 22°C., 8 hrs.) and darkness (at 5°C., 16 hrs.)

Results shown in Table IV below indicate that in alternate light and darkness with alternating temperatures of 22°C. and 5°C., all pre-chilled seeds in all moistening agents gave consistently good results. This is very interesting when one considers the fact that in nature these are probably the conditions most closely occurring for germination of seeds of this plant.

TABLE IV. Germination of pre-chilled, moistened seeds kept in alternating light (at 22°C., 8 hrs.) and darkness (at 5°C., 16 hrs.). 100 seeds used per dish.

Moistening agent	2-wk. prechills		1-mo. prechills		2-mo. prechills		3-mo. prechills	
Dist. water	55%	24-33-48	56%	24-36-48	59%	18-24-39	57%	21-27-39
Bog water	54	24-39-51	64	24-30-54	48	21-36-42	60	18-24-39
KNO_3 (0.2%)	58	24-36-48	56	24-30-48	54	18-21-42	66	15-24-39
Average	56%		59%		54%		61%	

8. In alternating light (at 33°C., 8 hrs.) and darkness (at 5°C., 16 hrs.)

As stated in Experiments 4, 5 and 6, above, 33°C. was found to be too high to permit germination of *Sarracenia purpurea* seeds.

9. At 28°C., in constant light

At 28°C., in constant light, all pre-chilled seeds gave excellent results in a shorter germination period than in Experiment No. 7. The 1-month, 2-month, and 3-month pre-chilled seeds gave almost equally good germination percentages; the 2-week pre-chills gave the smallest number.

All moistening agents gave about the same results (Table V).

A comparison of the figures in Tables I and V indicates that in constant light seeds germinate equally well at 22°C. and 28°C. in all

TABLE V. Germination of pre-chilled, moistened seeds kept at 28°C. in constant light. 100 seeds used per dish.

Moistening agent	2-wk. prechills		1-mo. prechills		2-mo. prechills		3-mo. prechills	
Dist. water	42%	12-12-24	56%	9-15-24	60%	9-15-24	72%	9-15-18
Bog water	42	12-12-27	71	9-15-21	46	9-12-24	45	9- 9-18
KNO_3 (0.2%)	46	12-12-24	55	9-12-18	68	6- 9-24	60	9- 9-18
Average	43%		61%		58%		59%	

except the 2-week pre-chills. The 2-week pre-chills had much less germination at 22°C. (21%) than at 28°C. (43%). Type of moistening agent made no appreciable difference in the germination results at these two temperatures under constant light.

10. At 28°C., in constant darkness

As shown in Table VI, at 28°C., in continuous darkness, germination percentages were considerably lower than in constant light (Table V). Apparently light has a stimulating effect on the dormant seeds of *Sarracenia purpurea.*

The 3-month pre-chilled seeds gave the best and the 2-week pre-chills the poorest results. The moistening agent, potassium nitrate, gave the best results in practically all cases.

A comparison of the results shown in Table II with those in Table VI will indicate that in constant darkness, the 2-month and 3-month pre-chilled seeds gave about the same results at both 22°C. and 28°C. The 2-week and 1-month pre-chills gave definitely better results at the higher temperature. Potassium nitrate increased the percentage of germination in most cases, indicating that in the absence of light this chemical may have a stimulating effect on seeds.

TABLE VI. Germination of pre-chilled, moistened seeds kept at 28°C. in constant darkness. 100 seeds used per dish.

Moistening agent	2-wk. prechills		1-mo. prechills		2-mo. prechills		3-mo. prechills	
Dist. water	15%	12-12-24	25%	12-15-30	28%	12-15-15	65%	12-15-18
Bog water	10	12-12-21	31	12-15-30	23%	12-15-21	27	12-15-18
KNO_3 (0.2%)	20	12-12-21	41	12-15-30	48	12-15-24	41	12-15-18
Average	15%		32%		33%		44%	

EXPERIMENT B — Seeds treated with concentrated sulphuric acid for one minute or five minutes, moistened by all three moistening agents and placed in all experimental environmental conditions, failed to germinate. It was concluded that the embryo had been injured by the acid.

EXPERIMENT C — The results of the various experiments in this series are summarized in Table VII. It will be seen that the 2-week pre-chills in *Sphagnum* and marl (3rd and 5th columns) gave about the same results as the 2-week pre-chills over blotters obtained in Experiment A (Tables I-VI). This indicates that the substrate made no appreciable difference in the rate or speed of germination.

In the absence of pre-chilling, there was no germination except in alternate light and darkness at 22°C. (8 hrs.) and 5°C. (16 hrs.), respectively. However, germination was considerably delayed under these conditions, requiring at least 39 days as against 24 days (Table IV) or 18-27 days (Table VII) for 2-week pre-chills. The percentage of germination, too, was much lower, being less than one-half of the comparable figures (column 2, Table IV; columns 3 and 5, Table VII).

TABLE VII. Germination of seeds over Sphagnum, marl, and blotter, moisened with distilled water, and placed in all environmental conditions. 100 seeds used per dish.

	Sphagnum		Sphagnum Prechilled 2-wk.		Marl		Marl Prechilled 2-wk.		Blotter	
1. 22°C. const. light	0		24%	9-21	0		15%	9-27	0	
2. 22°C. const. dark	0		1		0		2	15	0	
3. 22°C. alt. lt/dk	0		3		0		2	12-18	0	
7. alt. lt/dk 22°C/5°C	20%	39-69	50%	27-33-48	29%	39-45-66	61%	18-30-57	7%	45-72
9. 28°C const. light	1%	24	47	12-12-21	1	36	57	12-12-36	0	
10. 28°C. const. dark.	0		18	12-21	0		13	12-21	0	

EXPERIMENT D — In May of 1961, an examination of the area at Proud Lake where 800 seeds had been placed the previous November disclosed only one seedling pushing up through the glass wool. There was no trace left of the remaining seeds. The seedling survived the summer months producing several intensely red-colored small leaves and appeared to be well established. Then, in the fall, it could no longer be found. It is assumed that it was pulled up by someone, as it was not in a location where anyone could have stepped on it.

Germination of one seed out of 800 indicates a very high mortality rate. This fact, coupled with the following observations made in this study, may at least partially answer the question as to why certain bogs contain seedlings and others do not.

The first and most obvious reason for lack of seedlings is, of course, the lack of seeds. In all the bogs, except Rose Lake, the seeds were almost completely destroyed by the phytophagous larva of *Endothenia habesana* Wlk. during the two years that these bogs were under observation. It is not inconceivable to assumed that most of the seeds in some bogs may be destroyed in this way. Also, it was observed that presence of mature plants does not necessarily insure seed production. In early May of 1963 a number of flower buds had been staked out for pollination experiments at Rose Lake and Bridge Lake. A sudden drop of temperature to 27°F. on May 21 completely wiped out the Rose Lake crop of buds and about 95% of those at Bridge Lake. This may explain why many observers in the past have recorded that *Sarracenia purpurea* does not flower every year.

It was also observed that seeds, whether pre-chilled or not, remained afloat in distilled or bog water. Those that were not pre-chilled did not germinate and soon became moldy. Those that were pre-chilled germinated while remaining afloat. Since many bogs are subject to periodic flooding, this characteristic of seeds and seedlings to remain afloat may of course be of tremendous advantage to the plant. Seed and seedling may be carried away by the water and may thus find favorable locations for establishment. Or, on the other hand, they may be taken out into open water with no chance of ever reaching a suitable substrate for ecesis. Also, floating seeds, whether in bog or open water, would be exposed to the elements. It will be recalled that 33°C. was not found to be conducive to germination of these seeds. If the seeds remained exposed during the fall and winter months, they would of course be subject to freezing, which too might prevent germination. Of one hundred seeds, placed in the usual manner over moistened paper in a Petri dish, none survived the -5°C. temperature of the freezer compartment of a refrigerator.

SUMMARY AND CONCLUSIONS

1. The dormancy of a majority of seeds of *Sarracenia purpurea* was broken by pre-chilling to 5°C. In most cases the 2-week pre-chilling produced the poorest germination results, the 1-month somewhat higher results, and the 2-month and 3-month pre-chilling the best germination results.
2. Treatment by sulphuric acid to break the dormancy of the seeds resulted in injury to the embryo. Consequently, there was no germination in such seeds.
3. The substrate, whether *Sphagnum*, marl, or blotter, had no appreciable effect on the germination of seeds.
4. Peak germination in the shortest possible time (9-15 days) was achieved in constant light at 28°C., with either 1-month, 2-month, or 3-month pre-chilled seeds, in any moistening agent.
5. At 22°C., 2-month and 3-month pre-chilled seeds germinated equally well in total darkness and alternate light and darkness. At 28°C., there was somewhat higher germination in constant light than in constant darkness.
6. In the absence of pre-chilling, there was practically no germination over any substrate, with any moistening agent, except in alternate light and darkness in alternating temperatures (light at 22°C., 8 hrs. and darkness at 5°C., 16 hrs.), in which case germination required at least 39 days. These results substantiate Macfarlane's report that in the south *Sarracenia purpurea* seeds germinate in three to five weeks after ripening, at least to the extent that pre-chilling is not necessarily a prerequisite for germination of these seeds.

7. With as little as a 2-week pre-chilling period, under the same temperature and light conditions as in No. 6 above, germination time was reduced to 24 days, and germination rate more than doubled.

8. Under the same temperature and light conditions as in No. 6 above, namely light at 22°C., 8 hrs. and darkness at 5°C., 16 hrs., all pre-chills gave consistently good results in all moistening agents. These experimental conditions roughly approximate natural conditions in a northern bog in the spring and support Macfarlane's and Shreve's findings that in the north *Sarracenia purpurea* seeds germinate in the spring.

9. Lack or scarcity of seedlings in a bog may be due to any number of factors such as frost damage to flower buds in early spring, unavailability of pollinating insects during the very short flowering period of this plant, damage to ripening seeds by the larva of *Endothenia habesana*, the floatability of seeds which may carry them into open water or which may subject them to extreme temperatures, and unavailability of sites suitable for germination and ecesis.

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VARIABILITY IN WILD POPULATIONS IN THE GENUS *TRAGOPOGON* IN MICHIGAN AND INDIANA

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INTRODUCTION

In the United States, the three species of the genus *Tragopogon* L. ("goat's-beard," in the family Compositae), *T. pratensis* L., *T. porrifolius* L. ("salsify" or "oyster-plant"), and *T. dubius* Scop. (*T. major* Jacq.) are widely distributed weeds which grow in well disturbed sites along roadsides, railroads, and unkept lots and fields.

These stout biennial herbs have large terminal, solitary heads of yellow or purple flowers which are surrounded by a single row of involucral bracts. The flowering heads open in the morning hours and close completely by noon, a diurnal response which controls the schedule for field studies. The alternate, grass-like leaves of these herbs clasp a terete stem; both stem and leaves contain a bitter milky latex. Each species is highly intra-fertile since in pure stands not more than two or three percent of the flowers fail to produce viable achenes. Cross- and self-pollination are both common. Since the three species have similar flowering cycles, interspecific hybridization is common, but these hybrids are highly sterile. The common field pattern is a few F_I's where ample populations of the species occur together. Occasionally, hybrids develop to equal the species in numbers. The biennial habit, similar ecology, sympatric distributions of populations, ability to form hybrids in any direction, distinct if subtle differences in morphology, seemed of sufficient interest to

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require a thorough field study of these populations in the Midwest. The study resulted in data on comparative morphology of the species, variability among hybrid colonies, and ecology of the species with particular reference to the persistence of hybrids.

Tragopogon originated in the Old World but has become world-wide in distribution because of man's activities. There are fewer than fifty species, including the three weedy species of this investigation. *Tragopogon pratensis*, *T. porrifolius*, and *T. dubius* have spread fan-wise from the Mediterranean Sea area north into England, Sweden, Norway, Finland, and Russia and later were introduced into Australia, North America, and South America. Clapham, Tutin, and Warburg (1962) report *T. pratensis* as native throughout the British Isles and *T. porrifolius* as introduced, "occasionally escaping" from cultivation.

All three species are widely distributed in the United States and have been subjects of careful cytogenetic studies by Marion Ownbey and his students (1950, 1952, 1953, 1954). In fact, most of the work on the species in the United States has been done by Ownbey. His investigations of wild populations of *Tragopogon* in Washington and Idaho clearly define the variations that exist in the morphology and genetics of the three species, the hybrids, and certain amphiploid populations. He easily distinguished the hybrids by their recombinations of dominant traits of the parental species involved and their high sterility. His analysis of meiosis in pollen mother cells is of particular importance for an explanation of the low fertility observed in F_1 hybrids. In all three species Ownbey showed that meiosis was regular with six bivalents at Metaphase I, but irregular in the F_1 hybrids of all three species combinations. Ownbey (1950, 1952) also discovered and investigated four small amphiploid populations. The two amphidiploids which Ownbey named *T. miscellus* (*T. dubius* × *pratensis*) and *T. mirus* (*T. dubius* × *porrifolius*) are established as true breeding entities and morphologically correspond to the diploid F_1 plants except for conspicuous "gigas" features and their fertility, which he found to be 52-66 percent. Pollen mother cells were fairly regular meiotically, usually forming twelve bivalents at Metaphase I.

The present study was to demonstrate variability in wild populations of these three *Tragopogon* species from widely spaced localities in the midwestern United States. Variability in gross morphology, chromosome morphology, and in habitat, and in particular the relative persistence in time of these populations of species and hybrids were characterized.

MATERIALS AND METHODS

The Populations. Populations of these *Tragopogon* species and hybrids were studied and sampled throughout Michigan and Indiana. Seed samples were grown to maturity at the University of Michigan Botanical Gardens for eight successive seasons to supply materials for the study of variations. All data presented here are from local field measurements of fresh material. Oakland County population samples were grown in the Botanical Gardens' plots at Ann Arbor for comparison with variations in the natural stands.

The three populations presented here by locality represent the basic picture regarding variation in *Tragopogon* species in Michigan and Indiana. *Tragopogon dubius* has the greatest ecological amplitude, occurring most widely in disturbed soils of old fields, to dry hillsides, to moist roadside ditches and swales. Local distribution shows that *T. dubius* prefers sandy well-drained soils where competition is limited by disturbance, but this species has wide enough requirements to grow in habitats also typical for the other two species. At the other extreme is *T. pratensis*, which prefers moist clay soils of roadside ditches and swales. *T. porrifolius* requires good moisture relations but excellent drainage and little competition. In the glacial soils of Michigan and Indiana complex mixtures of sands and clays produce numerous habitats where the three species occur together forming hybrids: F_1's three ways and F_2's. While these *Tragopogon* species are biennials, the stands of species and hybrids regenerate and persist under conditions of mild and infrequent disturbance. They disappear as a result of frequent mowing, heavy grazing, frequent fire, or increasing cover and competition in the field or roadside. As long as these plants are allowed to mature seed in a fairly open habitat, they persist. One stand in Oakland County, Michigan, has remained stable through twelve years of observation.

The Midland County, Michigan, stand which we measured contained the three species and hybrids. It occurred for several miles along U. S. Highway 10 near Midland and occupied sandy-clayey roadside ditches and embankments. Table 1 presents data for eight characters based on a sample size of 50 plants for each species. *Tragopogon dubius* occurred throughout the stand but with greater density on the embankment slopes and summits. *T. pratensis* and *T. porrifolius* occurred with nearly equal frequency, *pratensis* on the heavier moist soil and *porrifolius* in the sandy slightly acid soils at the bases of the embankments. Hybrids were numerous throughout the stand.

The Oakland County, Michigan, stand contained roughly equal numbers of the three species of *Tragopogon* and a variety of hybrids. This stand was located in fields along 14 Mile Road just east of Southfield Road in Southfield Township. These stands were observed for twelve years during which time the expansion of Birmingham encroached upon them. These areas were mowed in late June and again in early September. This did not interfere with the development or dispersal of *Tragopogon*. The soil was a neutral, clay-loam member of the Detroit Interlobate Moraine drained by the Rouge River.

The Marion County, Indiana, stand was located along the east side of Indiana State Road 431 and occupied principally an abandoned interurban track. The three species were present with occasional hybrids. The soil was a neutral, sandy glacial till, well compacted by the former interurban activity. *T. pratensis* was more abundant than the other two species. The weedy flora, consisting of four-o'clocks, bindweed, black medic, peppermint, yarrow, milkweed, dogbane, oxalis, mullein, clover, alfalfa, brome grass, orchard grass, timothy, and Kentucky bluegrass, was more dense with better soil moisture conditions than in the Michigan stands. These three habitats were very similar except for the mean and extreme annual temperatures.

Comparative morphology. Tables 2 and 3 summarize the major characteristics of these three species of *Tragopogon* and their hybrids from the area included in the study. The statistical data pertain only to the populations reported here. For these three populations, measurements were made on 50 individuals for five quantitative and three qualitative characters. Means and ranges are given in Table 1. Graphs showing means, ranges, and 95% confidence limits (the rectangle about the mean) are presented in Figure 1. Ideographs were prepared showing inter-relations of three other characters: petal (ligule) limb and phyllary length to width (Figure 2), leaf length to width combined with leaf base length to leaf base angle (Figure 3). A total of eleven characters for these populations were studied and related.

The quantitative characters measured (Table 1 and Figure 1) were (1) leaf base length, (2) peduncle width at maximum flare, (3) phyllary length, (4) petal limb length, (5) petal limb width. The qualitative characters were (6) petal limb-tip shape, (7) leaf margin, crimped or smooth, (8) plant floccose and gray green, green, or glaucous.

Chromosome idiograms. Even though measurements were made from 100 slides for each idiogram, *Tragopogon* chromosomes are so small that the length-width values are not reliable. The overall shapes and relative positions of constrictions are reliable and the idiograms give an accurate means of comparing the chromosome sets between species. *T. dubius* presents the greatest variation in chromosome morphology but also resembles *T. porrifolius* more closely as it does in many other characters. *T. pratensis* has picked up an extra satellite on its long chromosome, presenting unusual tandem satellites, at least in its midwestern range. Figure 4 compares and contrasts the chromosomes of these three *Tragopogon* species in Michigan and Indiana.

Distribution of species and hybrids. Figure 5 shows the distribution (in Michigan and Indiana) of the three species and localities where hybrids occur between all three as determined by comparing with known hybrids from the breeding plot. *T. dubius* shows the widest ecological tolerances; *T. pratensis* demonstrates intermediate tolerances; *T. porrifolius* grows best on the better soils of relatively older glacial materials— the Tazewell tills of the Wisconsin glaciation and the Illinoian drift.

TABLE I. Variability in the genus *Tragopogon* in Michigan and Indiana. Data are for each of three species from three stands (Midland Co., Mich.; Oakland Co., Mich.; and Marion Co., Indiana). Number in each sample = 50.

	Leaf base, length mm.	Peduncle width, maximum flare mm.	Phyllary length mm	Petal limb, length mm.	Petal limb, width mm	Petal limb-tip shape	Leaf margin crimped or smooth	Plant floccose and gray-green; green, or glaucous
Tragopogon pratensis L., Midland County, Michigan.								
Mean:	11.0	5.6	21.5	15.8	3.80	Truncate	Crimped	Light
Range:	7.2-17.0	4.7-6.8	19.0-26.5	12.5-18.0	3.35-4.30		& curled	green
T. pratensis L., Oakland County, Michigan.								
Mean:	11.4	3.80	22.50	16.0	4.0	Truncate	Crimped	Light
Range:	7.5-17.5	3.0-5.0	20.0-28.0	12.0-19.0	3.40-4.30		& curled	green
T. pratensis L., Marion County, Indiana.								
Mean:	12.2	5.8	24.7	16.4	4.20	Truncate	Crimped	Light
Range:	8.0-18.0	5.0-7.0	22.0-27.2	14.0-18.0	3.50-4.50		& curled	green
T. porrifolius L., Midland County, Michigan.								
Mean:	15.5	10.0	32.0	19.0	2.75	Elongate	Smooth	Blue-
Range:	9.0-20.0	8.0-12.0	28.0-38.0	16.9-22.0	2.40-3.40	rounded	& strict	green
T. porrifolius L., Oakland County, Michigan.								
Mean:	16.0	9.7	33.0	20.0	2.80	Elongate	Smooth	Blue-
Range:	9.0-21.0	8.0-12.0	28.0-39.0	18.0-23.0	2.45-3.50	rounded	& strict	green
T. porrifolius L., Marion County, Indiana.								
Mean:	17.2	13.7	39.0	19.4	2.90	Elongate	Smooth	Blue-
Range:	10.0-24.0	11.0-18.0	34.4-44.0	17.0-24.0	2.50-3.50	rounded	& strict	green
T. dubius Scop., Midland County, Michigan.								
Mean:	11.5	7.8	33.5	19.0	3.60	Rounded	Smooth,	Gray-
Range:	8.0-18.0	5.0-10.5	27.0-38.0	15.0-23.0	2.50-3.80		lax & thin	green
T. dubius Scop., Oakland County, Michigan.								
Mean:	12.0	8.0	34.0	21.0	3.60	Rounded	Smooth,	Gray-
Range:	8.5-19.0	5.0-11.0	26.0-39.0	13.0-25.0	2.50-3.90		lax & thin	green
T. dubius Scop., Marion County, Indiana.								
Mean:	12.8	9.5	39.8	19.0	3 70	Rounded	Smooth,	Gray-
Range:	9.0-20.0	8.0-11.0	34.4-41.6	17.0-22.0	2.50-4.00		lax & thin	green

TABLE 2. Comparative morphology of the three species of *Tragopogon*.

	T. pratensis	T. porrifolius	T. dubius
ROOTS:	dark brown	brown	brown
LEAVES:	leaf long, base broad, narrowed abruptly into a linear-lanceolate blade, tips recurved, margins concave, crisped, keeled; base 12-22 mm broad at widest point; margined with red or purple; both surfaces glabrate.	leaf long, base broad, narrowed somewhat abruptly or gradually tapering into a lanceolate blade, tips not recurved, margins not concave nor crisped, slightly keeled; base 12-20 mm broad at widest point; not margined with red or purple; both surfaces glabrate.	leaf long, base less broad, narrowed gradually into a linear-lanceolate blade, tips not recurved, margins not concave nor crisped, slightly keeled; base 10-17 mm broad at widest point; not margined with red or purple; white woolly on dorsal surface, woolly to glabrate and glaucous on lower surface.
STEM:	1-3 ft tall; light-green; slender, strict, not branching; streaked with red or purple; internodes long, plants not leafy in aspect.	2-4 ft tall; blue-green; stout, strict, slightly branching; not streaked with red or purple; internodes intermediate between the other two species, leaves acute-clasping & straight, well spaced, giving a rigid leafy aspect.	1-3 ft tall; gray-green; slender, slightly divergent, much branching to bushy, not streaked with red or purple; internodes short, leaves closely spaced, somewhat divergent giving a relaxed, closely spaced, very leafy aspect.
PEDUNCLE:	not inflated; length to first node 6.0-17.3 cm	inflated gradually; length to first node 6.5-21 cm	abruptly inflated; length to first node 4.8-18 cm
HEADS:	3.0-4.0 cm broad.	5.0-6.0 cm broad; later flowering but overlapping the other two species in time.	4.0-7.0 cm broad.
PETAL LIMB:	chrome-yellow; rectangular; truncate and five-toothed; 12-19 mm in length; 3.3-4.5 mm in width.	purple; elliptic; tip slightly concave and five-toothed; 16-24 mm in length; 2.4-3.5 mm in width.	pale, lemon-yellow; obovate; tip strongly concave and five-toothed; 13-25 mm in length; 2.5-4.0 mm in width.
BRACTS:	as long as or shorter than outer ligules; margins crisped and purple; woolly; keeled; 19-28 mm in length; 5.0-6.0 mm in width.	longer than to nearly equal to the outer ligules; margins entire and green; glabrate; vaguely keeled; 28-44 mm in length; 4.5-6.0 mm in width.	longer than outer ligules; margins entire and blue-green; densely woolly dorsally; keeled; 26-42 mm in length; 4.0-7.0 mm in width.
ACHENES:	body of achene moderately ribbed; ribs bearing retrorsely spined tubercles of intermediate length; the wire-like beak as long as or longer than body of the achene; pappus a funnel-formed parachute of tawny to whitish plumose bristles with downy interlacing branches, longer than beak and body.	body of achene shallow ribbed; ribs bearing very short retrorsely spined tubercles; slender beak longer than body of achene; pappus a funnel-formed parachute of tawny to whitish plumose bristles with downy interlacing branches, longer than beak and body.	body of achene deeply ribbed; ribs bearing longer, broader, retrorsely spined tubercles; beak coarse and tapering from the body of the achene; pappus a funnel-formed parachute of tawny to whitish plumose bristles with downy interlacing branches, as long or longer than beak and body.

TABLE 3. Comparative morphology of the three F_1 hybrids.

	T. dubius × porrifolius	T. porrifolius × pratensis	T. dubius × pratensis
LEAVES:	leaf rather short, intermediate in width, uniformly tapering; tips not recurved; margins not crisped or concave; base 8-16 mm in width; leafy plants erect, not branched to slightly branched to bushy.	leaf intermediate in length, abruptly tapering; margins crisped; tips recurved; slightly keeled; base 14-20 mm broad at widest point; margined with purple; glabrate; pale glaucous; plants not leafy but well-branched.	leaf long, gradually to abruptly tapering to a thin grass-like blade; tips recurved; margins crisped; keeled; base 10-20 mm broad at widest point; leafy plants, slightly branched, with lax thin leaves.
PETAL LIMB: (ligule)	bicolored, pale purple to pale purple-maroon distally and yellow at base; narrow-elliptic; tip slightly concave.	bicolored, red-maroon, maroon, and yellow-maroon distally and yellow at base; rectangular; subtruncate and five-toothed.	light yellow; narrow rectangular to slightly obovate; tip subtruncate to truncate and five-toothed.
BRACTS:	longer than to nearly equal to the outer ligules; margins entire and green, woolly dorsally; vaguely keeled; 24-40 mm in length; 3.5-6.0 mm in width; tapering gradually and uniformly as in T. porrifolius.	as long as or shorter than outer ligules; margins crisped and purple; woolly dorsally; keeled; 20-43 mm in length; 3-8 mm in width; tapering gradually or somewhat abruptly.	longer than the outer ligules; margins entire and purple; lightly woolly dorsally; keeled; 26-32 mm in length; 4-6 mm in width; tapering somewhat abruptly.
PEDUNCLE:	gradually inflated.	gradually inflated but narrow.	gradually inflated but narrow.

RESULTS

In the field the distinctiveness of each of the three species is quite obvious. The particular species characters, when integrated, are well defined even though there are considerable variations in both vegetative and floral characters in each of the three.

The major useful single field character is flower color, which is always reliable. Examination of Table 1 and Figure 1 shows that the species have a repeated ranking with respect to one another when compared, character by character. *Tragopogon pratensis* varies least and is the most different of the three. *T. dubius* varies most. In all characters *T. dubius* is close to *T. porrifolius* while mostly varying in the direction of *T. pratensis*. The data tempt one to speculate on the origin of *T. dubius*. In most qualitative as well as quantitative characters *T. dubius* is intermediate and more variable relative to the other two species. It may well be the result of selection of recombinant genes from ancient old-world hybrid swarms.

It is also clear that, aside from flower color, no single measurement serves as a criterion for separating the three species which are yet quite distinct in overall aspects. By combining sets of measurements into scatter diagrams (not shown in this paper), quantitative and proportional differences emerge. The species characters

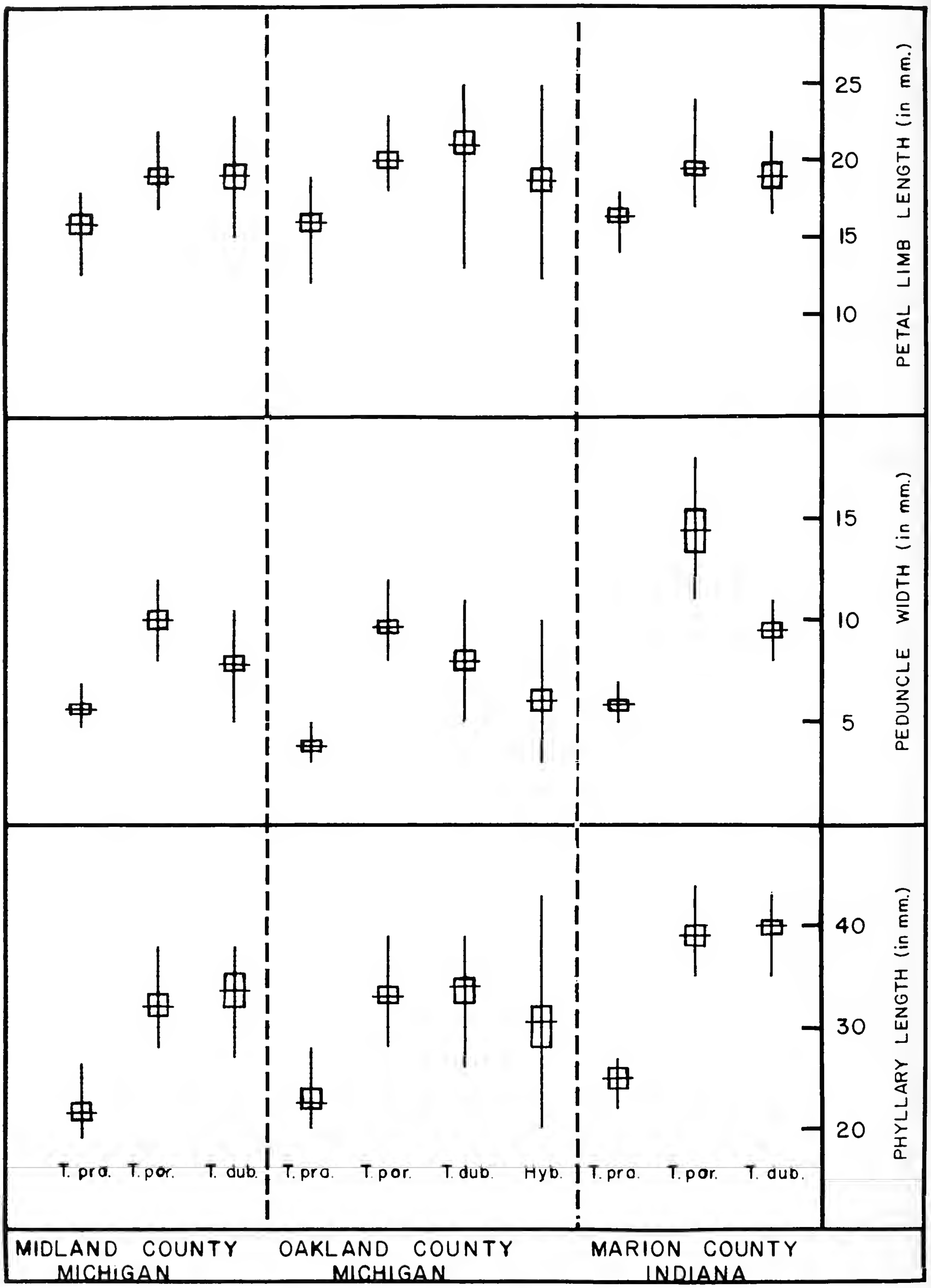


Fig. 1. Parameters of three characters for three populations of *Tragopogon* species in Michigan and Indiana. The Oakland County, Michigan, hybrid sample represents three-way hybrids. Vertical line, range; horizontal bar, mean; rectangle, 95% confidence limits.

merge into one another without masking the basic character trends or tendencies. As far as phyllary length and peduncle width are concerned, *T. pratensis*, with the shorter phyllaries and narrower peduncles, is quite different from *T. dubius*, with longer phyllaries and wider peduncles. On the other hand, if *T. dubius* and *T. porrifolius* are compared, the former on the average has longer phyllaries and wider peduncles.

When these measurements are combined with ligule color and shape, each species, *T. pratensis* with chrome-yellow, truncate ligules, *T. porrifolius* with purple, lanceolate ligules, *T. dubius* with lemon-yellow, obovate ligules, may be readily distinguished.

Natural hybridization occurs among all three species. The hybrids were not found except in patches where both parents were present. All three possible hybrids were found and in some stands formed a large percentage of the individuals. The hybrids display recombinations of characters from their parents and show the expected recombination spindle for loosely linked characters. Hybrids which are most like either parent in any one character tend to resemble that parent in other characters. Hybrids between *T. porrifolius* and the two yellow species are easily identified with respect to ligule color. The appearance of bicolored ligules in the hybrids is a distinct new feature. Ownbey (1950) accounts for bicolored ligules as resulting from the interaction of genes for anthocyanin coloration derived from *T. porrifolius* and for yellow plastids from the yellow-flowered parents. He suggests there is also a gene involved which restricts the anthocyanin to the distal portion of the ligule. This variation may be

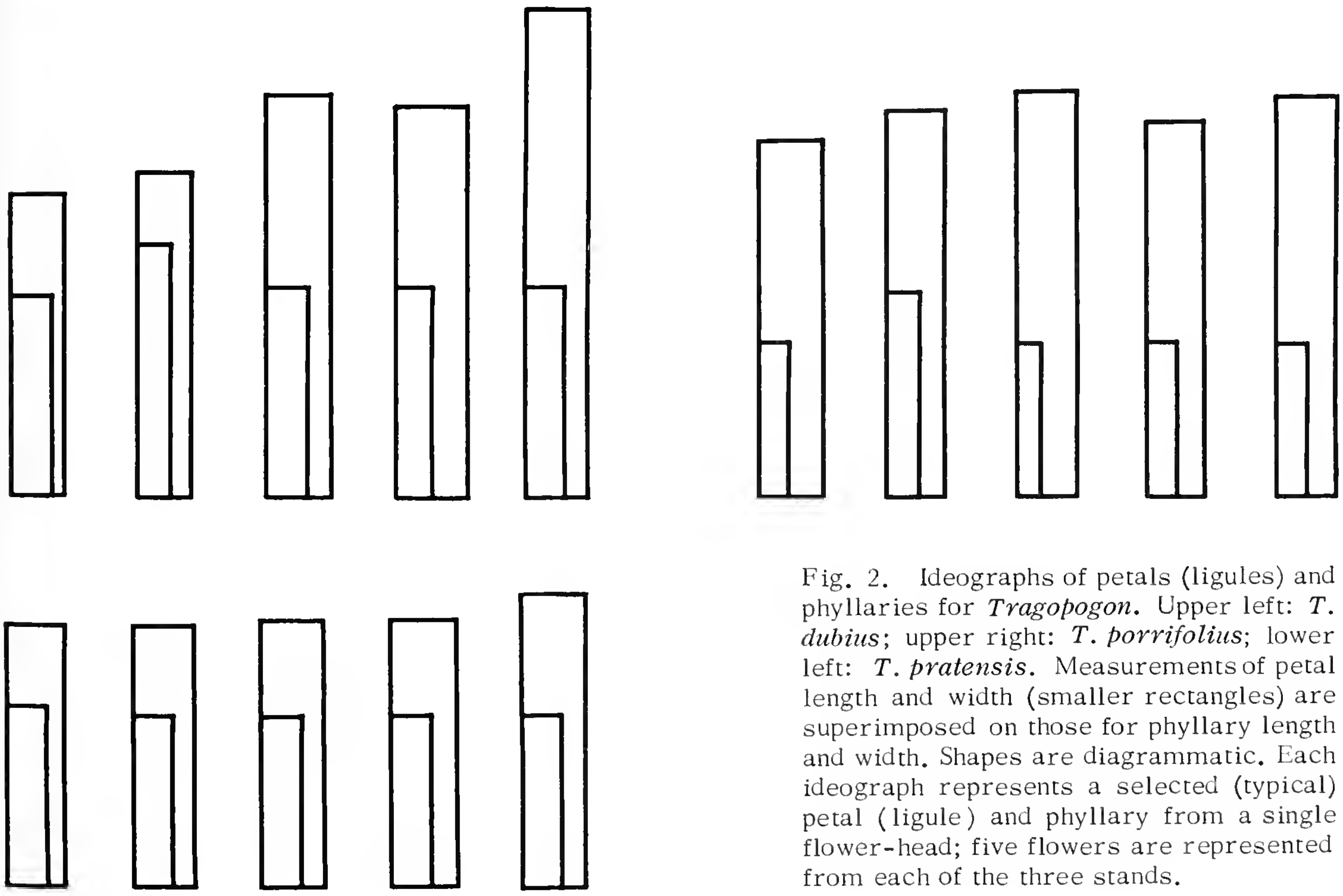
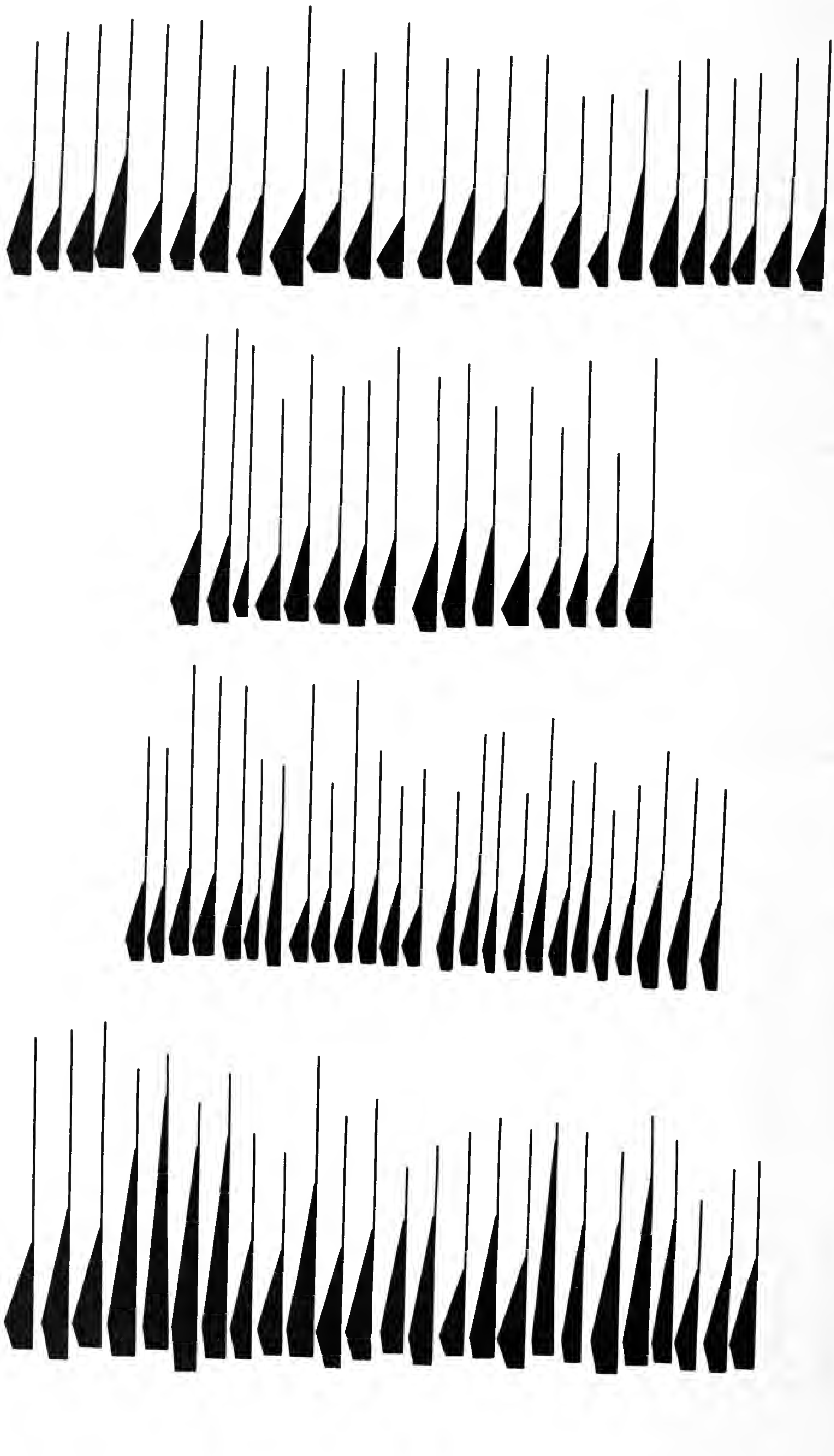


Fig. 2. Ideographs of petals (ligules) and phyllaries for *Tragopogon*. Upper left: *T. dubius*; upper right: *T. porrifolius*; lower left: *T. pratensis*. Measurements of petal length and width (smaller rectangles) are superimposed on those for phyllary length and width. Shapes are diagrammatic. Each ideograph represents a selected (typical) petal (ligule) and phyllary from a single flower-head; five flowers are represented from each of the three stands.



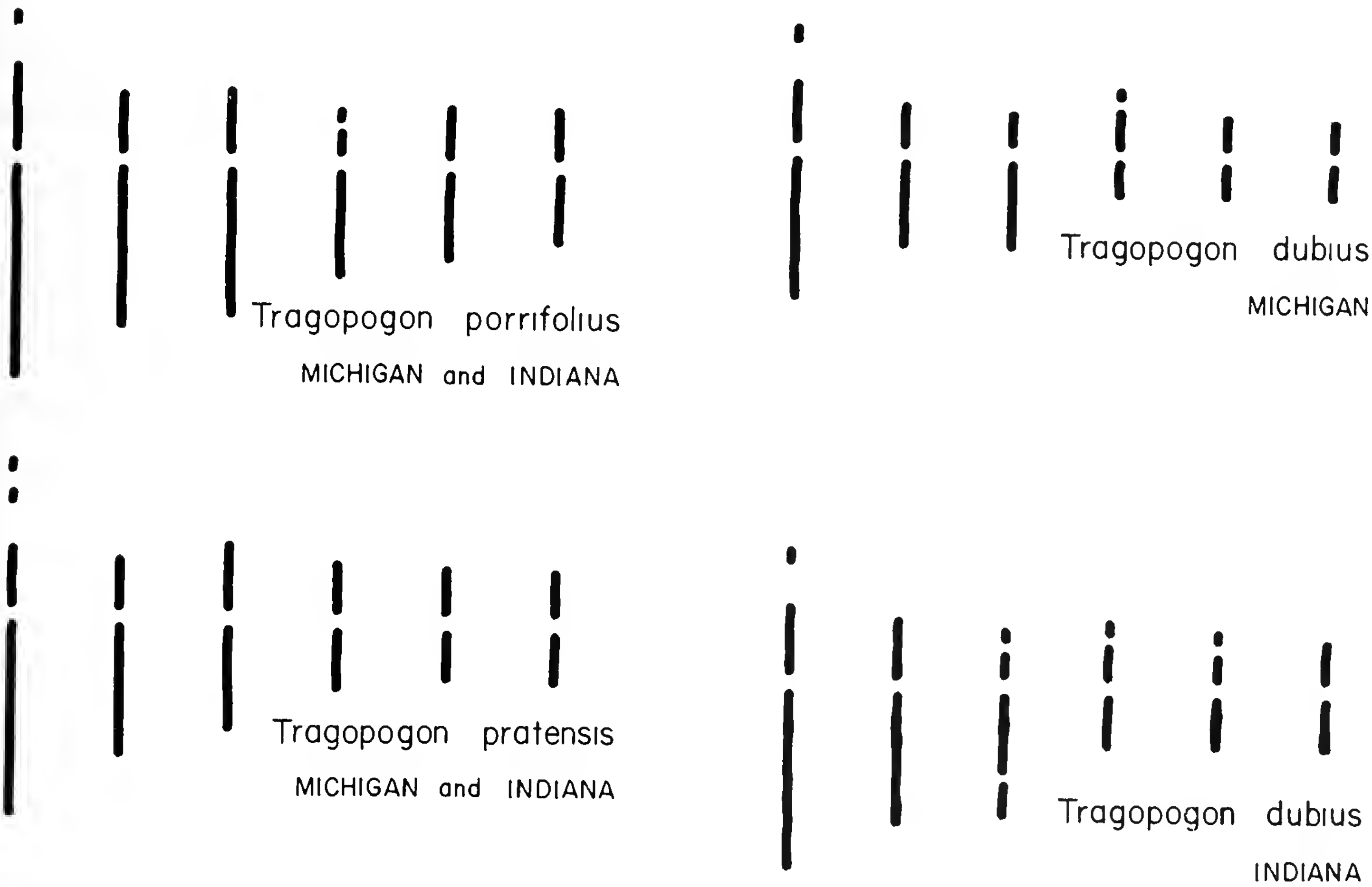


Fig. 4. Idiograms showing chromsome morphology for three species of *Tragopogon* from Michigan and Indiana. Measured and drawn by micro-projection.

tagged as an intermediate character and serves as a marker for the hybrids. Ligules of hybrids between the two yellow-flowered species are also of an intermediate color.

There is no evidence from either field studies or breeding plot studies that F_2's are anything but rare. Sterility of the hybrids is great enough to inhibit backcrossing and selfing of the F_1 even though hybrids may persist in about equal numbers with the species for many years as shown by the Oakland County, Michigan, stand. Populations of species and hybrids elaborate and persist in areas where the habitats are varied and present conditions not only characteristic for the species but mixtures as well, again as shown by the Oakland County, Michigan, stand. In the Indiana stand studied, the habitat was less varied and the populations displayed fewer hybrids which did not

←

Fig. 3 (facing page). Leaf ideographs for three species and a hybrid sample in *Tragopogon*. Top row, *T. pratensis*; second row, hybrids between *pratensis* and *dubius*; third row, *T. dubius*; bottom row, *T. porrifolius*. Vertical line, leaf length; widest point, 1/2 leaf base width; solid portion showing leaf base length and average angles for left side of leaf, adaxial view. (About 1/6 natural size). Median leaf from twenty-five plants of each of the three stands and sixteen plants from the hybrid colony.

persist but fluctuated from time to time from a seemingly pure species stand to one showing as high as 20 percent hybrids each way. No evidence of introgression is demonstrated so that the midwestern pattern of behavior follows that for the Pacific Northwest as described by Ownbey.

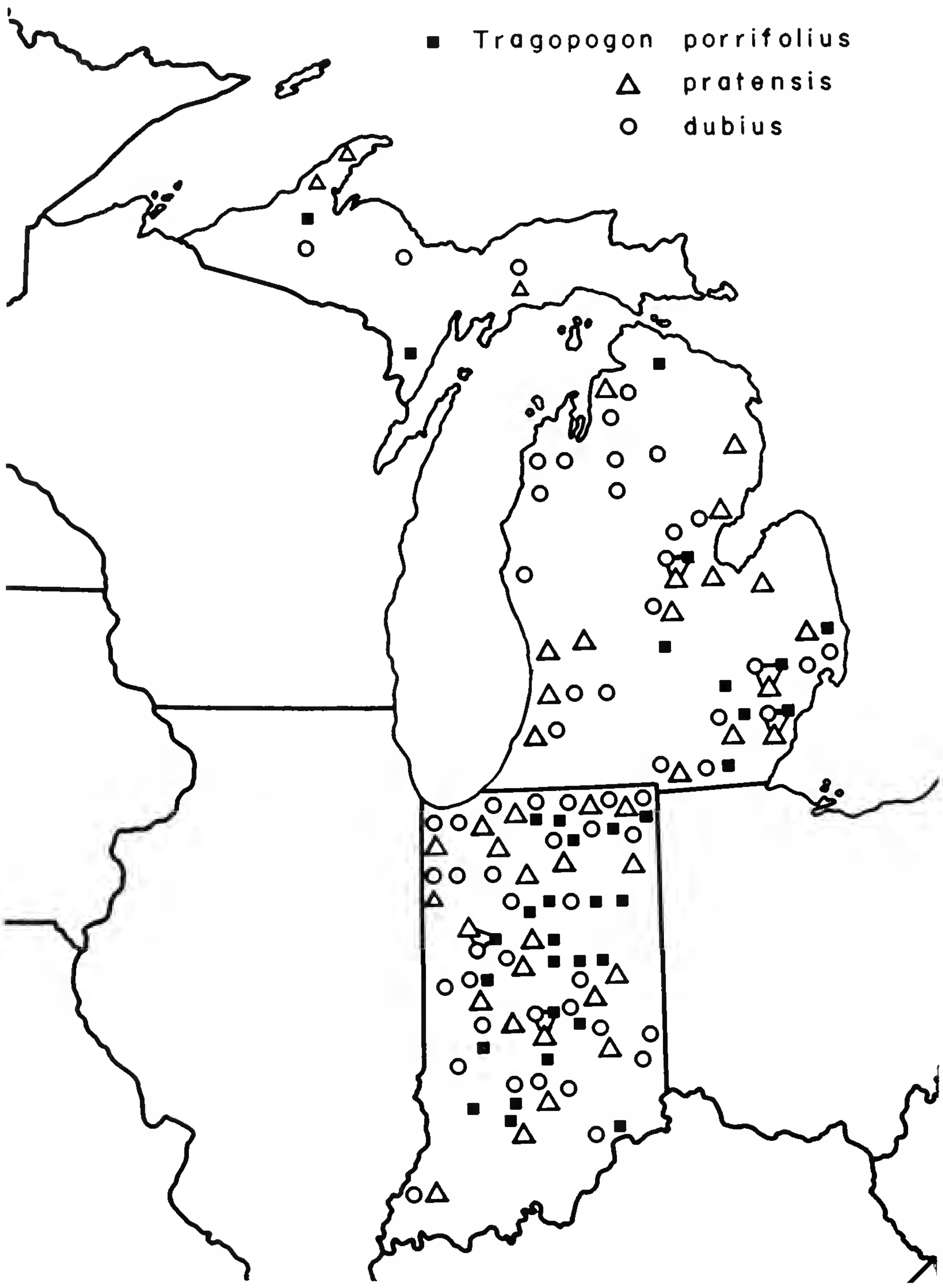


Fig. 5. Distributions for the three species of *Tragopogon* for Michigan and Indiana only. Lines connecting symbols indicate areas where hybrids between all three species were abundant. Data from collections of Hall, Persell, and Thompson.

ACKNOWLEDGMENTS

We are indebted to Marion Ownby for his comments and criticisms, the Cranbrook Institute of Science for facilities, and to the University of Michigan Botanical Gardens for space and cultivation of species and hybrids.

REFERENCES CITED

Clapham, A. R., T. G. Tutin, & E. F. Warburg. 1962. Flora of the British Isles. ed. 2. Univ. Press, Cambridge. 1269 pp.
Ownbey, Marion. 1950. Natural hybridization and amphiploidy in the genus Tragopogon. Am. Jour. Bot. 37: 487-499.
Ownbey, Marion. 1952. Cytoplasmic inheritance and reciprocal amphiploidy in Tragopogon [abstract]. Genetics 37: 611-612.
Ownbey, Marion, & Gilbert D. McCollum. 1953. Cytoplasmic inheritance and reciprocal amphiploidy in Tragopogon. Am. Jour. Bot. 40: 788-796.
Ownbey, Marion, & Gilbert D. McCollum. 1954. The chromosomes of Tragopogon. Rhodora 56: 7-21.

MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

This section lists new literature relating to Michigan Botany under four categories: A. Maps, Soils, Geography, Geology (new maps and selected bulletins or articles on soils and geology as these may be of use to field naturalists and students of plant distribution); B. Books, Bulletins, etc., and C. Journal Articles (listing, respectively, all separate publications and articles in other periodicals which cite Michigan specimens or include research based on plants of wild origin in Michigan; —not generally including work on cultivated plants nor strictly economic aspects of forestry, conservation, or agriculture); D. History, Biography, Exploration (travels and lives of persons with Michigan botanical connections). When the subject matter or relation to Michigan is not clear from the title, annotations are added in brackets. Readers are urged to call to the editor's attention any titles (1960 or later) which appear to have been overlooked—especially in less well known sources.

A. MAPS, SOILS, GEOGRAPHY, GEOLOGY

The following topographic maps for Michigan have been published by the U. S. Geological Survey, Washington, D. C. 20242, since the previous listing in the January, 1965, issue. Those marked with an asterisk are 7-1/2-minute quadrangles (scale of 1:24,000 or about 2-1/2 inches to a mile); the other are 15-minute quadrangles (scale of 1:62,500 or about 1 inch to a mile). Maps are supplied with green overprint showing woodland areas unless request is made to the contrary. Maps may be ordered from the survey at $.30 each (20% discount on orders for $10.00 or more). Following the name of the quadrangle, the county or counties in which it primarily lies are added in brackets in the list below:

Backus Lake* [Roscommon]
Bark River [Menominee, Delta]
Barnes Lake* [Lapeer]
Blanchard* [Isabella, Mecosta]
Burnside* [Lapeer]
Caro* [Tuscola]
Colling* [Tuscola]
Columbiaville* [Lapeer]
Deckerville* [Sanilac]
East Dayton* [Tuscola]
Edmore* [Montcalm]
Elba* [Lapeer, Genesee]
Juhl* [Sanilac]
Juniata* [Tuscola]
Langston* [Montcalm]
Lyon Manor* [Roscommon]
Marinette [Menominee, + Wisconsin]
Mayville* [Tuscola, Lapeer]
Mecosta* [Mecosta]
North Branch* [Lapeer]
Ozark SE* [Mackinac]
Pembine [Menominee, + Wisconsin]
Powers [Menominee]
Prudenville* [Roscommon]
Roscommon South* [Roscommon]
Schaffer [Menominee, Delta]
Sebawaing* [Huron, Tuscola]
Six Lakes* [Montcalm, Mecosta]
Snover* [Sanilac]
Stephenson [Menominee, + Wisconsin]
Watson [Marquette]

The United States Series of topographic maps, at a scale of 1:250,000, was described in Vol. 2, pp. 59-60 (March, 1963), where those covering portions of Michigan were listed; revisions were reported in Vol. 4, p. 34 (Jan., 1965). "Limited revisions" of the following sheets have recently been published, including portions of Michigan: Chicago (NK 16-8), Detroit (NK 17-4. "second ed."), Iron Mountain (NL 16-7), Traverse City (NL 16-12). [$.50 each]

A new index map to topographic mapping in Michigan was announced last August (free).

Humphrys, C. R., et al. 1965. Michigan Lakes and Ponds. Mich. Agric. Exp. Sta., Dept. of Resource Development. 2 + 6 + 15 + [215] + 33 + 14 pp. [Readers who want to know anything about Michigan lakes should be aware that a limited edition of 100 copies of this monumental compilation has been distributed to research workers dealing with water problems and to libraries, where it may be consulted for reference. It consists of six sections: (I) Water Bull. No. 15 (Summary of Acreage Analysis Charts from Lake Inventory Bulletins 1 to 83) gives for each county in the state the number of lakes and ponds and their total acreage, plus a breakdown by 25 types of lakes and ponds. (It is not clear how these are defined: why, for example, only Chippewa and Grand Traverse counties are credited with any "bog" lakes.) Summary columns rank the counties by number and acreage of lakes. The "total number of water bodies in Michigan" tabulated is 35,068.—(II) Water Bull. No. 16 (Selected Data from Lake Inventory Bulletins 1 to 83) gives such information as number of lakes and ponds by size classes in each county, with figures on land and water area of each county, given by acreages and percentages. The total number of natural lakes and ponds tabulated in this section is 30,574 entirely within the state, plus 38 "interstate lakes."—(III) Water Bull. No. 17 (Alphabetical Index of Michigan Lake and Pond Names from Lake Inventory Bulletins 1 to 83), after a page detailing the procedure for naming (or changing the name of) a lake, provides an index to 8,632 named lakes and ponds for which data are given in the next section. Here we can learn such depressing facts as that there are 276 Mud Lakes in Michigan, and only 70 Round Lakes. Such figures should stress to every botanist the necessity of completely citing the location of any collection; there may even be several lakes of the same name in one county, and to say merely "Round Lake, Michigan" is absurdly imprecise and frustrating to other workers.—(IV) Michigan Lake Inventory Bulletins 1 to 83 provide an alphabetical index to the named lakes of each county, followed by a listing of each lake (including many designated "No name" and hence not indexed) in a geographic sequence (township, sections), with data not only on acreage but also, when available, on maximum depth, presence of inlet and outlet, percentages of organic and mineral shoreline, and presence of panfish, pike, or trout. The list for Iron Co. is the longest, with 2,149 lakes.—(V) Water Bull. No. 12 (Preliminary Inventory of Michigan's Artificial Surface Water) presents data on artificial lakes and ponds.—(VI) Water Bull. No. 13 (Michigan Inland Lake Reference List) is a bibliography of published and unpublished books, articles, theses, reports, maps, etc. (914 entries).

This large (11-1/2 x 17-1/2 inch, 9-1/2 pound) volume must be seen and used to be appreciated. It will be an invaluable reference to botanists who desire data on our lakes—and who will be in a position, too, to respond to the invitation to submit corrections.]

Veatch, J. O., & C. R. Humphrys. 1964. Lake Terminology. Mich. Agric. Exp. Sta., Dept. of Resource Development, Water Bull. No. 14. 271 p. [Another useful reference volume, giving definitions and brief discussions of many terms related to lakes, whether legal, ecological, recreational, or limnological. Sometimes it labors the obvious, as when defining a "goose pool" as "an artificial pool that is stocked with captive wild geese for public observation"; sometimes it displays an unexpected point of view, as after defining "pond scum," the statement: "Unsightly and obnoxious to humans but not so regarded by frogs." There are some newly proposed words and phrases, of which two examples will suffice: "Purgatorial reliction": "...lake bed that has been recently exposed by recession of a shoreline and whose natural fate is uncertain..."; "lake smirchment": "...an inclusive term for modification, including additions of extraneous matter to water, bottoms, and shorelines, which affect adversely, in a demonstratable way, economic and aesthetic values."]

Hunt, George S. 1965. The direct effects on some plants and animals of pollution in the Great Lakes. BioScience 15: 181-186. [Almost all direct references are to animals, but *Vallisneria* in the Detroit River is mentioned and there is a useful bibliography on pollution.]

Kelley, Robert W. n. d. Guide to Michigan Fossils. Department of Conservation. 16 pp. [Brief general discussion and 9 pages of illustrations with legends, of which one page is fossil plants.]

Kirkby, Edward A. 1961. Bibliography of Michigan Geology 1956-60. Department of Conservation, Geological Survey. 66 pp. (processed). [A useful supplement to Publ. 50, which is an index to literature on Michigan geology 1823-1955. The original bibliography (461 pp.) and supplement are available together for $1.00 (plus tax) from Publications Room, Department of Conservation, Stevens T. Mason Bldg., Lansing, Michigan 48926.]

(Michigan Geological Survey). 1964. Our Rock Riches. Mich. Geol. Surv. Bull. 1. 109 pp. $ .50. [A collection of 22 selected articles, said to be reprinted although original source is not always given, pertaining to Michigan geological resources, from salt and gravel to coal, copper, and gold.]

Poindexter, O. F., H. M. Martin, & S. G. Bergquist. 1965. Rocks and Minerals of Michigan. 5th ed., revised. Mich. Geol. Surv. Bull. 2. 103 pp. $ .50. [Slight revision of this standard general work, previously designated as Publ. 42.]

C. JOURNAL ARTICLES

Brewer, Richard. 1963. Composition and production of a remnant prairie in southwestern Michigan. [Abstract] Bull. Ecol. Soc. Am. 44: 121.

Brooks, Travis E., & Donald T. Kowalski. 1965. New reports of Myxomycetes from Michigan. Pap. Mich. Acad. 50: 135-138. [Data on 23 species previously unreported from Michigan.]

Brown, Robert T. 1962. Germination influencing substances in living and dried plants. [Abstract] Bull. Ecol. Soc. Am. 43: 117-118. [Effects on germination of jack pine in northern Michigan.]

Brown, Robert T., & Joseph Roti Roti. 1963. The 'Solidago factor' in jack pine seed germination. [Abstract] Bull. Ecol. Soc. Am. 44: 113. [Study in inhibiting effect in northern Michigan.]

Cantlon, J. E., & E. J. C. Curtis. 1963. Population studies of the parasite, Melampyrum lineare. [Abstract] Bull. Ecol. Soc. Am. 44: 73. [Study in "Michigan's jack pine region."]

Ching, Te May, & Leo W. Mericle. 1960. Some evidences of premature stoppage of sugar maple sap production. Forest Sci. 6: 270-275. [Histological and physiological study on trees in Michigan State University woodlot.]

Cooke, Wm. Bridge, & Josiah L. Lowe. 1964. The 1955 Michigan foray. Mycologia 56: 602-607. [List of over 200 species of fungi collected in southwestern Michigan on Mycological Society of America foray.]

Culberson, William Louis. 1965. Cetraria chicitae, a new and widely distributed lichen species. Bryologist 68: 95-99. [Cited from Isle Royale and Gogebic Co.]

Ebinger, John E. 1964. Taxonomy of the subgenus Pterodes, genus Luzula. Mem. N. Y. Bot. Gard. 10: 279-304. [*L. acuminata* var. *acuminata* is cited from "Michigan" and mapped in the state.]

Farmer, Robert E., Jr. 1963. Vegetative propagation of aspen by greenwood cuttings. Jour. Forestry 61: 385-386. [Clones of 2 species from near Pellston provided material.]

Garrett, Peter W., & Robert Zahner. 1964. Clonal variation in suckering of aspen obscures effect of various clearcutting treatments. Jour. Forestry 62: 749-751. [Studies of regeneration in "northern Lower Michigan."]

Hauke, Richard L. 1965. An analysis of a variable population of Equisetum arvense and E. × litorale. Am. Fern. Jour. 55: 123-135. [A Monroe Co. population.]

Johns, Robert M. 1964. A new Polyphagus in algal culture. Mycologia 56: 441-451. [An addendum mentions *P. laevis* from Emmet Co.]

Miller, Orson K., Jr. 1964. Monograph of Chroogomphus (Gomphidiaceae). Mycologia 56: 526-549. [Four species are cited from "Michigan," *C. rutilus* also specifically from Pellston.]

Shaffer, Robert L., & Margaret G. Weaver. 1965. A new species of Crinipellis. Mycologia 57: 472-475. [Type locality is southwest of Cross Village, Emmet Co.]

Spurr, Stephen H. 1965. Michigan's forests over ten thousand years. Cranbrook Inst. Sci. News Letter 35: 52-54.

Van Asdall, Willard, & Charles E. Olmsted. 1963. Corispermum hyssopifolium on the Lake Michigan dunes its community and physiological ecology. Bot. Gaz. 124: 155-172. [Work done in Indiana dunes but with reference to occurrence of the species north to Sleeping Bear.]

Wagner, W. H., Jr., & Katherine Lim Chem. 1965. Abortion of spores and sporangia as a tool in the detection of Dryopteris hybrids. Am. Fern Jour. 55: 9-29. [Based mostly on Michigan observations, including many spore outlines drawn from local material.]

Whitehead, Donald R. 1964. Fossil pine pollen and full-glacial vegetation in southeastern North Carolina. Ecology 45: 767-777. [Includes data on pine pollen sizes from Michigan specimens of all 3 native species.]

Whitmire, Robert S. 1965. Ecological observations on Splachnum ampullaceum. Bryologist 68: 342-343. [Material from moose dung on Isle Royale.]

Wilbur, Robert L. 1964. A revision of the dwarf species of Amorpha (Leguminosae). Jour. Elisha Mitchell Sci. Soc. 80: 51-65. [Map shows *A. canescens* in Michigan.]

PROGRAM NOTES

March 26 - April 3: Flower and Garden Show, Michigan State Fairgrounds, Detroit.

April 1-2: Michigan Academy of Science, Arts, and Letters, 70th Annual Meeting, Wayne State University, Detroit.

April 18: Huron Valley Chapter, Michigan Botanical Club. George Thomson will give an illustrated presentation on the Bruce Peninsula of Ontario.

May 1: Tours of Horner Woods, our plant sanctuary, starting at 2:00.

May 19-21: Clara B. Ford Garden Forum, Henry Ford Museum and Greenfield Village, Dearborn.

May 27-30: Michigan Botanical Club, Spring Campout, Bruce Peninsula, Ontario.

At the general meeting in Detroit, January 23, the Michigan Botanical Club was pleased to present an honorary membership to Miss E. Genevieve Gillette, whose boundless devotion and service to conservation in Michigan has long been an example to us all.

EDITORIAL NOTES

We continue to be grateful to those authors and institutions whose subsidy of page costs in THE MICHIGAN BOTANIST enables us to produce larger issues than subscription income alone would allow and to avoid postponing or fragmenting longer articles.

IMPORTANT NOTICE TO ALL PAST AUTHORS: Authors of articles which have appeared in past issues of THE MICHIGAN BOTANIST should advise the editor if they wish to have their original manuscripts and/or art work returned. All manuscripts, photos, etc., not already returned to authors are still on file, but some must be discarded soon to conserve space.

The January number (Vol. 5, No. 1) was mailed January 4, 1966.

ERRATA

Among the more serious errata in recent issues are these:

Vol. 4, p. 30 (Jan. 1965), line 16, for "stripes" read "stipes"
Vol. 4, p. 65 (March 1965), line 2 of figure legends, for "ssp. *glabra*" read "ssp. *linifolia*"
Vol. 4, p. 82 (May 1965), line 1, for "TIMBERS" read "TREES" (the same correction p. 102, line 19, & p. 104, line 3)
Vol. 4, p. 128 (Oct. 1965), line 2 from bottom, for "March" read "Summer"
Vol. 5, p. 23 (Jan. 1966), line 4, for "though" read "thought"

CONTENTS

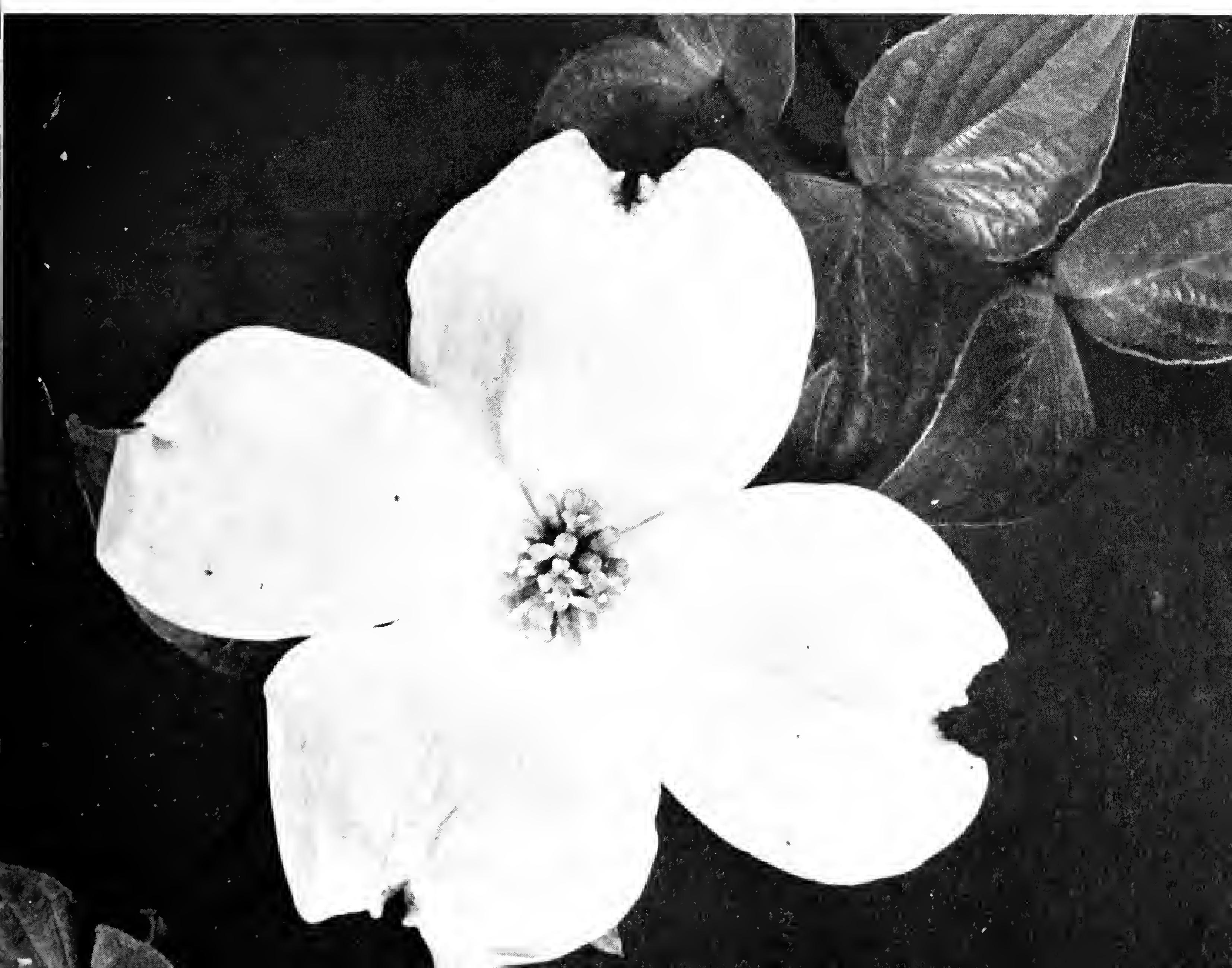
(On the cover: A fruiting head of Goat's-beard, Tragopogon; *photo taken by Doug Fulton near Ann Arbor, 1962.)*

Vol. 5, No. 3

THE

MICHIGAN BOTANIST

May, 1966



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DIFFERENCES IN HABITATS AND ASSOCIATES OF THE VARIETIES OF *RORIPPA ISLANDICA* IN THE DOUGLAS LAKE REGION OF MICHIGAN[1]

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During the summer of 1962, as a preparatory investigation toward a taxonomic monograph of the genus *Rorippa* (Cruciferae) for North America (Stuckey, 1965), I studied one of the extremely variable species, *R. islandica* (Oeder ex Murray) Borbás, marsh yellow cress, in the Douglas Lake region of northern Michigan. *R. islandica* is a summer, fall, or winter annual with simple or much branched stems, 0.1-1.4 m. high. The leaves are oblong to oblanceolate in outline with irregularly serrate, incised, or deeply cleft margins. The small obovate yellow petals (0.8-2.0 mm.) are shorter than the ovate to oblong green sepals (1.2-2.5 mm.).

In our region two varieties are recognized, var. *fernaldiana* Butters et Abbe and var. *hispida* (Desvaux) Butters et Abbe. They are morphologically separable on fruit shape and distribution of pubescence on the plants. The var. *fernaldiana* is distinct with its short-cylindrical to ellipsoid siliques constricted at the center. The replum in outline is elongate-oblong usually with a concave margin and when dry often becomes twisted. The basal and cauline leaves are glabrous on the lower surface, and the stems are glabrous throughout or sparingly hirsute below. In var. *hispida* the siliques are globose to subglobose and not constricted at the center. The replum is circular to elliptic in outline with a convex margin and when dry does not become twisted. The basal and cauline leaves are hirsute on the lower surface, and the stems are hirsute usually up to the terminal raceme.

This study was conducted to reveal the kinds of habitats in which these two varieties of *R. islandica* grow and to determine with which plant species they most often associate. Although the greatest morphological diversity within the genus and the largest number of species in North America is in the Rocky Mountains of western United States, the species are not prominent and conspicuous

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[2]This study was begun while I was a graduate teaching assistant in the aquatic flowering plants course at the University of Michigan Biological Station in the summer of 1962, and was continued in 1964 as part of my research supported by a National Science Foundation Summer Fellowship for Graduate Teaching Assistants.

members of any part of the North American flora. Large populations of plants are seldom found; rather, only a few plants live together. Sometimes only one plant is present in a given locality. This behavior is in sharp contrast to many other species of Cruciferous genera, such as *Brassica*, *Barbarea*, or *Sisymbrium*, in which one may find large numbers of plants in a wide diversity of habitats in eastern North America. The habitat of *R. islandica* in our region is relatively limited, and as a corollary the species most commonly associated with it are also relatively limited. These habitats are moist or wet open roadside and drainage ditches, alluvial banks of creeks and streams, and exposed sandy shores of lakes.

METHOD OF STUDY

During the summer of 1962, plants of both varieties were somewhat difficult to find. Localities where plants of var. *hispida* had been collected in previous years, as indicated by specimens in the University of Michigan Biological Station Herbarium, such as at North Fishtail Bay, Pine Point, and Grapevine Point on Douglas Lake, and at Smith's Bog, yielded no plants. Other localities, for example at Bessey Creek and near Carp Lake, where specimens had been obtained previously, yielded only a few plants in these places. At a total of 21 localities, however, plants of either variety were found. The appendix identifies the localities where *R. islandica* was growing, gives the approximate number of plants and their assigned collection number, and notes the kind of disturbance the site had undergone. A map (Fig. 1) shows the distribution of both varieties in the Douglas Lake region based on plants secured in this study or by previous workers. Voucher specimens are at MICH, MSC, OS, or UMBS.

At each study locality all of the species of plants that were growing within about a meter radius of *R. islandica* were noted. The scale of abundance used is that of Braun-Blanquet (1932) which it was possible to define more strictly, as indicated below Table 1.

According to Curtis (1959) disturbance of the habitat can be of two types: Natural disturbance as induced by fire, wind, wave action, or flooding; and artificial disturbance as induced by man's actions upon the soil in the form of road building and farming, for example. In Table 1, the localities are arranged horizontally from left to right in the following manner: Those that were believed to be the most artificially disturbed are at the left, proceeding to the more stable sites listed near the middle of the table. The latter localities include those numbered 9 through 15, especially numbers 11-14. Localities at the right of the page are naturally disturbed sites along lake shores, primarily on beach sand. Localities 1-12 contain var. *fernaldiana* and sites 13-21 contain var. *hispida*.

Vertically arranged is a list of the species growing with *R. islandica*. For each of the 21 localities the abundance of each species is indicated. The plants of each species are also classified as annual, biennial, or perennial according to McDonald (1937). If she does not list the species, Fernald (1950) and/or Gleason (1952) was consulted for this information, as well as for status (native or introduced).

Small plants of woody species, such as *Acer rubrum*, *Ulmus* sp., *Cornus* sp., and *Salix* sp. were sometimes growing nearby, but have not been included in Table 1. A few unidentified grasses are also not listed. Plants of genera such as *Aster*, *Cirsium*, *Galium*, *Equisetum*, *Eleocharis*, and *Rubus*, although included, are not identified to species, since in many instances they were insufficient for accurate determination.

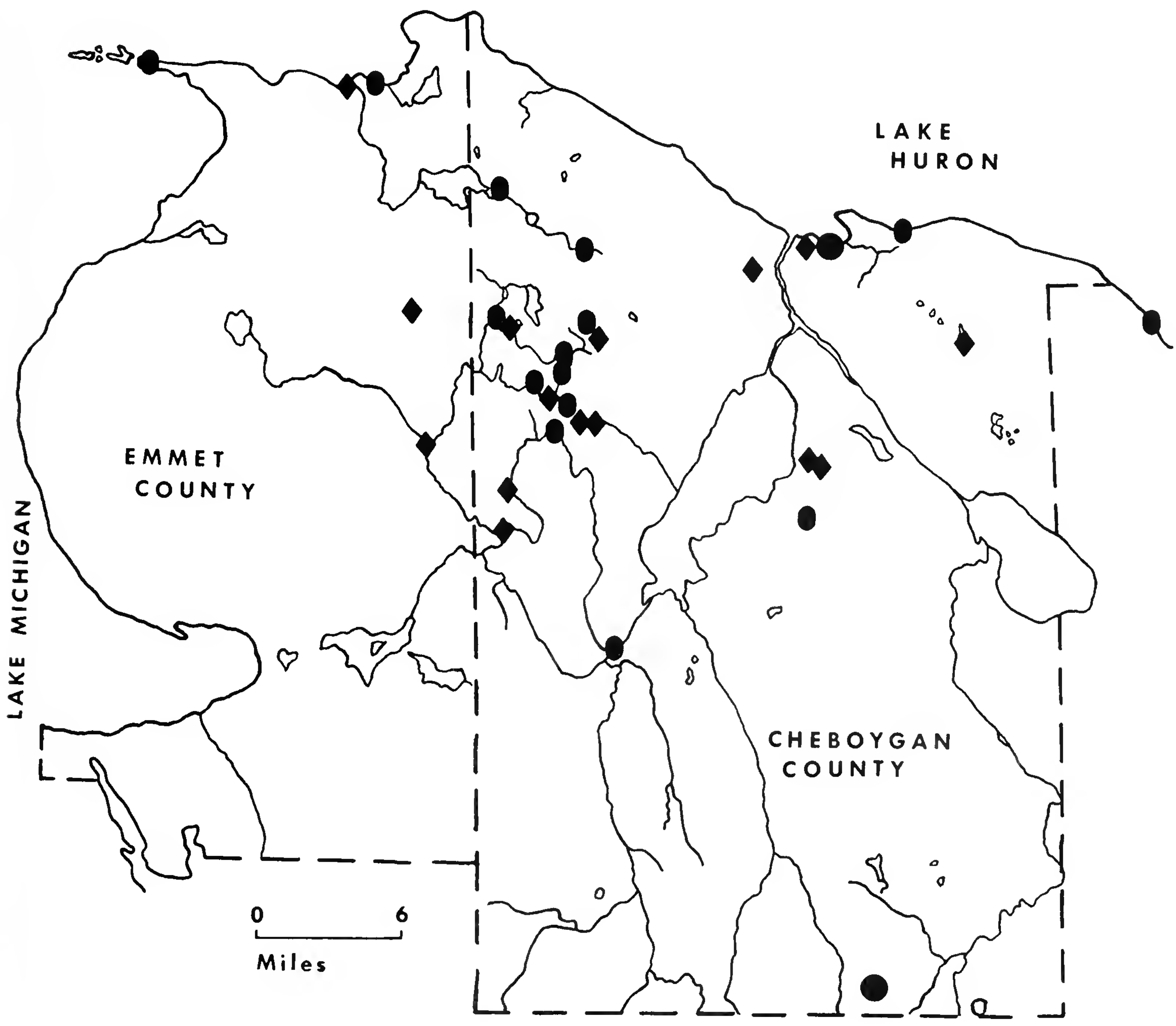

Fig. 1. Distribution of *Rorippa islandica* in the Douglas Lake Region of northern Michigan, based on preserved specimens. Diamonds represent localities for var. *fernaldiana*; flattened ovals represent localities for var. *hispida*; the two round dots represent the localities where both varieties and their hybrid have been found.

RESULTS

Species occurring frequently with both varieties are *Lycopus americanus*, *Agropyron repens*, *Agrostis alba*, *Rumex crispus*, and *Equisetum* sp. These and a few other less common species are listed in the center of Table 1. More noticeable, however, is a group of species which grow with each variety. The annual species are nearly always associated with var. *fernaldiana*. Common species in this group are *Ambrosia artemisiifolia*, *Chenopodium album*, *Medicago lupulina*, *Polygonum persicaria*, *P. convolvulus*, and *Amaranthus graecizans*. Common biennials or perennials are *Trifolium hybridum*, *Daucus carota*, *Melilotus alba*, *Verbascum thapsus*, and *Plantago major*.

In the more stable habitats representing site numbers 9-15, a group of native perennial species consisting of *Eupatorium perfoliatum*, *Mentha arvensis*, *Typha latifolia*, *Cardamine pensylvanica*, *Carex bebbii*, *C. stipata*, and *Onoclea sensibilis* is associated. The most stabilized habitats, site numbers 12-14, support a characteristic flora of *Calamagrostis canadensis*, *Ludwigia palustris*, *Cicuta bulbifera*, *Asclepias incarnata*, *Mimulus ringens*, *Veronica salina*, and *Sagittaria latifolia*. In these relatively stable sites both varieties of *R. islandica* were found.

Several species distinctive to sandy beaches were found only with var. *hispida*. Prominent among these are *Potentilla anserina*, *Solidago graminifolia*, *Scirpus americanus*, *Elymus canadensis*, and *Gerardia paupercula*.

Species blocked off in groups indicate some correlation with the kind and degree of disturbance. Most of the annuals and introduced perennials grow in the artificially disturbed sites and are recorded at the left in Table 1. Most of the native perennial species belong either to the relatively stable habitats and are placed in the lower center of the table, or they are characteristic of sandy beaches and are listed at the bottom right in the table.

OBSERVATIONS IN 1964

Two years later, on a return visit to eleven of these localities, I did not find any plants of var. *fernaldiana* at the artificially disturbed sites (1, 2, 3, 4, 5, and 12). These habitats now supported a flora of mostly perennial species in a less disturbed situation than two years previous. At five of the naturally disturbed sites (13, 14, 17, 19, and 21), var. *hispida* was represented with several plants at each place. Fewer plants of var. *hispida* were noticed on the north shore of Burt Lake (17) and at the locality near Cecil Bay (13), but the plants were more numerous on the shore of Devereaux Lake (19) and at Duncan Bay (21).

During that season, both varieties were found at Cornwall Lake, about 10.2 miles southwest of the town of Tower in southern Cheboygan

County and at Duncan Bay at the eastern limits of the city of Cheboygan. At these localities were found a few plants with the silique shape of var. *fernaldiana* and the pubescence distribution of var. *hispida*. These plants that combine the distinctive characteristics of each variety are of hybrid origin. The evidence supporting hybridization is discussed in Stuckey (1965, pp. 373-379).

CONCLUSIONS

These data show that each variety of *R. islandica* associates with a different group of species in essentially two different kinds of habitats in the Douglas Lake region of northern Michigan. The var. *fernaldiana* primarily grows with annual and introduced perennial species in artificially disturbed habitats; var. *hispida* associates almost entirely with native perennial species in naturally disturbed habitats. Evidence obtained from over half of the sites two years later further suggests that the artificially disturbed habitats are temporary and when additional perennial species invade and the site becomes more stable, var. *fernaldiana* dies out; the naturally disturbed habitats continue to exist since they are constantly being disturbed, providing a place for var. *hispida* to grow at the same site year after year. Even the naturally disturbed sites may change to an extent that var. *hispida* may also disappear. Some evidence for this is gathered when one notes that no plants of var. *hispida* were found at the locations on Douglas Lake and at Smith's Bog where once they were known to have grown.

This study also suggests that var. *fernaldiana,* although native to North America, may possibly be introduced into the Douglas Lake region, since it usually grows in the artificially disturbed habitats; var. *hispida,* on the other hand, is doubtless native, since it forms a part of the characteristic sandy shore flora of the Great Lakes and other inland lakes on territory that was once covered by Wisconsin glaciation in eastern North America. Owing to a habitat distinction between the two varieties, they are separated ecologically, and therefore they have in the past maintained their morphological distinctions. When var. *fernaldiana,* evidently the more "aggressive" member, reaches the sandy lake shore where var. *hispida* usually grows, the two may hybridize, producing plants with the distinctive characters of each variety combined in the offspring. If var. *fernaldiana* continues to spread, and hybridization and back crossing with var. *hispida* continues, we may expect the morphological characters separating the two varieties to become less distinct.

ACKNOWLEDGMENTS

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TABLE 1. Species Associated with *R. islandica* in 21 Localities in the Douglas Lake Region, Michigan, Summer 1962.

List of Species	*	**	Localities																				
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
R. islandica var. fernaldiana	N	A	1	+	3	3	2	+	r	+	+	r	+	3	.	.	.	.	.	.	.	.	.
Ambrosia artemisiifolia	N	A	r	.	+	+	.	.	r	.	+	+	.	.	.	.	.	.	.	.	.	.	.
Ranunculus sceleratus	N	A	.	.	+	+	.	+	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.
Juncus bufonius	N	A	.	+	3	.	1	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Anthemis cotula	I	A	.	.	r	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Chenopodium capitatum	N	A	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Chenopodium album	I	A	1	1	2	1	+	+	+	.	.	+	.	.	+	.	.	.	.	.	.	.	.
Medicago lupulina	I	A	+	+	+	.	.	.	1	+	3	.	.	.	.	.	.	.	.	.	.	.	.
Polygonum persicaria	I	A	.	+	+	.	+	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Amaranthus graecizans	I	A	2	+	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Polygonum convolvulus	I	A	+	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Erigeron philadelphicus	N	P	.	.	.	r	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.
Oxalis stricta	N	P	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Plantago rugelii	N	P	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Plantago major	I	P	+	+	.	+	+	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.
Artemisia biennis	NI	AB	.	+	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Arctium minus	I	B	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Chrysanthemum leucanthemum	I	P	.	.	.	.	.	.	.	+	.	r	.	.	.	.	.	.	.	.	.	.	.
Phleum pratense	I	P	.	.	+	+	.	.	.	1	+	+	.	.	.	.	.	.	.	.	.	.	.
Dactylis glomerata	I	P	.	.	2	+	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Trifolium hybridum	I	P	+	+	.	+	+	.	.	1	.	+	1	.	.	.	.	.	.	.	.	.	.
Daucus carota	I	P	.	.	.	+	.	.	+	.	+	r	.	.	.	.	.	.	.	.	.	.	.
Melilotus alba	I	B	+	+	.	1	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Trifolium pratense	I	P	.	.	.	+	r	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Taraxacum officinale	I	P	r	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Rumex acetosella	I	P	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Barbarea vulgaris	I	P	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Mentha piperita	I	P	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Verbascum thapsus	I	B	.	+	.	1	.	+	r	.	.	.	.	.	1	.	.	.	.	.	.	.	.
Asclepias syriaca	N	P	+	+	.	1	.	.	.	.	.	.	.	+	.	.	.	.	1	.	.	.	.
Pastinaca sativa	I	B	.	r	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
Agropyron repens	I	P	.	+	.	+	+	+	+	+	+	+	.	.	.	.	1	.	2	.	.	.	.
Agrostis alba	I	P	.	.	1	1	1	.	.	1	1	+	+	+	1	.	1	.	2	.	.	.	.
Rumex crispus	I	P	.	.	+	+	.	.	.	+	.	r	r	+	.	.	+	.	+	.	.	.	.
Potentilla norvegica	I	AB	.	+	.	+	.	+	.	.	.	.	.	+	.	.	.	.	.	.	+	.	+
Capsella bursa-pastoris	I	A	.	+	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Impatiens capensis	N	A	.	+	.	.	.	.	.	.	+	1	+	.	.	.	+	.	.	.	.	.	+
Ranunculus pensylvanicus	N	A	.	.	r	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Bidens frondosa	N	A	.	.	.	+	.	+	.	.	.	+	.	.	.	.	.	.	.	.	r	1	+
Bidens cernua	N	A	.	.	.	.	.	.	3	.	+	.	.	.	.	.	.	.	.	.	.	.	+
Equisetum sp.	N	P	.	+	1	.	.	.	+	1	+	+	+	1	+	+	.	1	2	.	.	.	1
Lycopus americanus	N	P	.	+	.	+	.	.	.	.	.	+	+	+	+	.	+	+	1	+	1	1	+
Oenothera biennis	N	B	.	+	.	+	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	r
Juncus dudleyi	N	P	.	.	.	.	r	.	+	.	+	.	+	.	.	.	.	.	.	.	.	.	.
Carex vulpinoidea	N	P	.	.	.	+	r	.	.	.	+	+	+	.	.	.	r	.	.	.	.	.	.
Carex retrorsa	N	P	.	.	.	1	.	.	.	.	.	+	1	1	.	.	.	.	.	.	.	.	.
Eupatorium maculatum	N	P	.	.	.	+	.	.	.	.	.	r	+	+	1	.	.	.	.	.	.	.	.
Cirsium sp.	N	P	.	.	.	+	.	.	.	.	2	+	.	.	1	.	.	.	r	.	.	+	+
Rubus sp.	N	P	.	.	.	.	.	2	.	2	.	.	.	.	+	.	.	.	.	r	.	.	.
Eleocharis sp.	N	P	.	.	.	.	.	4	.	.	+	.	.	.	.	+	.	.	.	.	+	2	.
Lycopus uniflorus	N	P	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Achillea millefolium	NI	P	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	r	.
Galium sp.	N	P	.	.	.	.	.	+	.	.	.	.	.	2	.	r	+	.	.	.	.	.	+
Scirpus atrovirens	N	P	.	.	.	.	.	.	r	.	1	+	2	+	.	.	.	+	.	.	.	.	.
Aster sp.	N	P	.	.	.	.	.	.	.	.	2	.	.	.	1	.	.	.	.	.	.	+	+
Panicum implicatum	N	P	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.
Solidago canadensis	N	P	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	+	.	r	.	.
Localities			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Carex hystricina	N	P	.	.	.	.	.	.	.	.	1	.	+	.	.	.	.	.	1	.	.	.	.
Eupatorium perfoliatum	N	P	.	.	.	.	.	.	.	.	.	+	+	+	1	r	.	+	+	.	1	r	+
Mentha arvensis	N	P	.	.	.	.	.	.	.	.	.	1	+	+	1	.	+	.	2	.	.	.	+
Typha latifolia	N	P	.	.	.	.	.	.	.	.	1	+	2	1	r	.	.	.	.	.	.	.	.
Cardamine pensylvanica	N	P	.	.	.	.	.	.	.	.	+	.	+	.	.	+	.	.	.	.	.	.	.
Carex bebbii	N	P	.	.	.	.	.	.	.	.	r	.	+	+	.	.	+	.	.	.	.	.	.
Carex stipata	N	P	.	.	.	.	.	.	.	.	+	.	.	+	.	+	+	.	.	.	.	.	.
Onoclea sensibilis	N	P	.	.	.	.	.	.	.	.	.	+	.	+	+	1	1	.	.	.	.	.	.
Calamagrostis canadensis	N	P	.	.	.	.	.	.	.	.	.	.	.	2	3	4	.	.	.	.	.	.	+
Ludwigia palustris	N	P	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	+
Cicuta bulbifera	N	P	.	.	.	.	.	.	.	.	.	.	.	+	.	r	.	.	.	.	.	.	+
Asclepias incarnata	N	P	.	.	.	.	.	.	.	.	.	.	.	1	+	+	.	.	.	.	.	.	.
Mimulus ringens	N	P	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.
Veronica salina	N	P	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.
Sagittaria latifolia	N	P	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	+	.
Lysimachia thyrsiflora	N	P	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.
Carex stricta	N	P	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.
Campanula uliginosa	N	P	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	+	.	.	.	.	.
Lysimachia terrestris	N	P	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.
R. islandica var. hispida	N	AB	.	.	.	.	.	.	.	.	.	.	.	.	1	+	r	r	2	r	+	+	+
Juncus nodosus	N	P	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	3	.
Potentilla anserina	N	P	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	3	+	.	1	+
Solidago graminifolia	N	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	+	.	1	+
Scirpus americanus	N	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	1	+
Elymus canadensis	N	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	r	+
Carex viridula	N	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+
Juncus alpinus	N	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	+
Juncus balticus	N	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.
Gerardia paupercula	N	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	r	.
Localities			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

KEY

Nomenclature follows Fernald (1950).
*Status: N = Native
I = Introduced
**Longevity: A = Annual
B = Biennial
P = Perennial

Abundance of plants at each locality:
r = rare, one plant
+ = occasional, a few plants, up to about 5
1 = common, about 5-10 plants
2 & 3 = abundant, usually more than 10 plants and covering a large portion of the site, usually extending beyond the meter limits

SPECIES FOUND AT ONLY ONE LOCALITY (indicated in parenthesis before the abundance symbol):

Erigeron annuus (1) +
Portulaca oleracea (1) r
Rumex obtusifolius (1) +
Lepidium virginicum (2) r
Lychnis alba (2) r
Rumex mexicanus (2) r
Sisymbrium altissimum (2) r
Amaranthus retroflexus (3) +
Matricaria matricarioides (3) r
Polygonum aviculare (3) 1
Thlaspi arvense (3) 1
Cichorium intybus (4) +
Cirsium vulgare (4) +
Polygonum coccineum (4) r
Hypericum boreale (6) +
Malva neglecta (6) +
Nepeta cataria (6) +
Glechoma hederacea (7) +
Cerastium vulgatum (8) +
Juncus tenuis (8) r
Medicago sativa (8) 1
Plantago lanceolata (8) +
Veronica peregrina (8) r
Ranunculus acris (9) 1
Lobelia cardinalis (10) 1
Sium suave (10) 2
Carex pseudo-cyperus (11) 2
Juncus effusus (11) +
Scirpus atrocinctus (11) 2
Alisma plantago-aquatica (12) +
Convolvulus sepium (13) +
Juncus nodosus (13) 1
Scirpus validus (13) 1
Thalictrum dasycarpum (13) 1
Carex rostrata (14) 1
Nuphar variegatum (14) 1
Rumex orbiculatus (14) r
Satureja vulgaris (14) +
Lysimachia ciliata (16) +
Hieracium florentinum (17) r
Scutellaria epilobiifolia (17) r
Satureja arkansana (18) +
Carex lasiocarpa (19) +
Cladium mariscoides (19) 2
Eriocaulon septangulare (19) +
Hypericum majus (19) +
Juncus pelocarpus (19) +
Lobelia kalmii (20) +
Polygonum pensylvanicum (20) +
Triglochin palustre (20) +
Scirpus acutus (21) +

Gardens, Hamilton, Ontario, Canada), Mrs. Rebecca Nunan (Atlanta, Georgia), and the curators of the herbaria whose specimens were studied.

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APPENDIX

Descriptions of the localities were *R. islandica* was found in the Douglas Lake Region, Michigan, Summer 1962.

LOCALITY 1 (var. *fernaldiana*)

CHEBOYGAN CO.: Several plants in flower bed outside of the University of Michigan Biological Station dining hall, NE$\frac{1}{4}$ Sec. 33, Munro Twp., 3 Aug, *Stuckey 1322* (OS).

Disturbance: Soil worked by man in the spring provided exposed places where *R. islandica* grew.

LOCALITY 2 (var. *fernaldiana*)

EMMET CO.: Four plants in newly constructed drying roadside ditch, NE$\frac{1}{4}$ of SW$\frac{1}{4}$ Sec. 29, Wawatam Twp., ca. 4.5 mi n w of Carp Lake, 28 Jul, *Stuckey 1266* (OS).

Disturbance: Road was widened and ditch was dug either the previous fall or the present spring.

LOCALITY 3 (var. *fernaldiana*)

CHEBOYGAN CO.: Numerous plants in bottom of drying roadside ditch, w edge of SW$\frac{1}{4}$ Sec. 9, Aloha Twp., ca. 9 mi s of Cheboygan, 26 Jul, *Stuckey 1251* (MICH, OS).

Disturbance: Ditch appeared to have been cleaned about two years ago. Plenty of exposed soil in bottom of the ditch.

LOCALITY 4 (var. *fernaldiana*)

CHEBOYGAN CO.: Numerous plants on freshly exposed soil on bank of drainage ditch, SE$\frac{1}{4}$ Sec. 29, Benton Twp., corner of Duncan and Eastern Ave. in the city of Cheboygan, 21 Jul, *Stuckey 1174* (OS).

Disturbance: Plants were growing on soil which was taken out of the ditch and placed on the bank. This soil was subsequently driven over by vehicles.

LOCALITY 5 (var. *fernaldiana*)

EMMET CO.: Numerous plants, but very localized in an area of approximately four square meters in dried depression of driveway which extends from Cecil Bay Rd. to Cecil Bay Beach, SW$\frac{1}{4}$ of NW$\frac{1}{4}$ Sec. 29, Wawatam Twp., ca. 4.5 m n w of the town of Carp Lake, 1 Jul, *Stuckey 1001* (OS).

Disturbance: Soil driven over by vehicles.

LOCALITY 6 (var. *fernaldiana*)

CHEBOYGAN CO.: Several plants on e bank of Nichols Bog, C Sec. 2, Burt Twp., ca. 7 mi e of Pellston, 26 Jun, *Stuckey 966,* 10 Jul, *Stuckey 1064* (both OS).

Disturbance: On the dry bank the soil was exposed owing to fires and dumping of rubbish; in the low wet area next to the open water of the bog, *R. islandica* grew among a dense stand of *Eleocharis smallii* trodden by cows.

LOCALITY 7 (var. *fernaldiana*)

CHEBOYGAN CO.: One plant in bottom of drainage ditch along w edge of NW$\frac{1}{4}$ Sec. 1, Inverness Twp., ca. 1 mi w of Cheboygan on Riggsville Rd., 3 Jul, *Stuckey 1016* (OS).

Disturbance: Exposed soil from water erosion.

LOCALITY 8 (var. *fernaldiana*)

CHEBOYGAN CO.: Five plants in the bottom of an open drying roadside ditch, ca. 1.7 mi n of Riggsville Rd. on Weadock Rd. (the latter is a service road which parallels the w side of Interstate Highway No. 75), 2 Jul, *Stuckey 1004* (OS).

Disturbance: Ditch dug about four or five years previous. Water erosion created some exposed soil.

LOCALITY 9 (var. *fernaldiana*)

CHEBOYGAN CO.: Five plants in bottom of drying roadside ditch, C Sec. 1, Burt Twp., ca. 5 mi w of S Extension Rd. on Birchwood Rd., or ca. 8 mi e of Pellston, 10 Jul, *Stuckey 1060* (OS).

Disturbance: A culvert had been placed in the ditch and covered with soil. The plants were growing on this exposed soil near each end of the culvert. *R. islandica* was not found in the ditch beyond this culvert.

LOCALITY 10 (var. *fernaldiana*)

CHEBOYGAN CO.: One plant on gently sloping bank of roadside ditch, s edge of SW$\frac{1}{4}$ Sec. 15, Aloha Twp., 10 Aug, *Stuckey 1355* (OS).

Disturbance: The plant was growing at the edge of exposed soil which had been pushed off the road toward the bottom of the ditch by the highway department.

LOCALITY 11 (var. *fernaldiana*)

CHEBOYGAN CO.: Five plants in deep drying roadside ditch, n edge of N$\frac{1}{2}$ Sec. 20, Burt Twp., ca. 6 mi s e of Pellston, 23 Jul, *Stuckey 1194* (OS).

Disturbance: Water erosion created some exposed soil.

LOCALITY 12 (var. *fernaldiana*)

EMMET CO.: Numerous plants in shallow drying roadside ditch, NE$\frac{1}{4}$ of NW$\frac{1}{4}$ Sec. 15, McKinley Twp., ca. 4.0 mi n of Pellston on U.S. 31, 14 Jul, *Stuckey 1099* (MICH, OS).

Disturbance: Water erosion created some exposed soil. In comparison to the amount of disturbance in the previous 11 localities, this site appeared to be the least disturbed.

LOCALITY 13 (var. *hispida*)

EMMET CO.: Several plants on slope of roadside ditch bank along n edge of C Sec. 26, Wawatam Twp., ca. 4.8 mi s w of Mackinaw City, 28 Jul, *Stuckey 1268* (MICH, OS).

Disturbance: Soil quite sandy and easily eroded by wind and water.

LOCALITY 14 (var. *hispida*)

CHEBOYGAN CO.: Several plants near Carp Lake along edge of Mud

Creek in very wet black soil, c of n edge of Sec. 19, Hebron Twp., ca. 7 mi s of Mackinaw City, 29 Jun, *Stuckey 990* (OS).

Disturbance: Exposed soil resulting from higher water during the spring.

LOCALITY 15 (var. *hispida*)

CHEBOYGAN CO.: One plant in roadside ditch just w of Bessey Creek near mouth where it empties into Douglas Lake, along e edge of E$\frac{1}{2}$ Sec. 18, Munro Twp., ca. 4.5 m n e of Pellston, 7 Jul, *Stuckey 1051* (OS).

Disturbance: No recent disturbance noticed.

LOCALITY 16 (var. *hispida*)

CHEBOYGAN CO.: One plant along w bank of Crumley Creek, near Indian River, s edge of Sec. 24, Tuscarora Twp., at the town of Indian River, 13 Jul, *Stuckey 1083* (OS).

Disturbance: This plant was growing in soil that had been scraped by a bulldozer.

LOCALITY 17 (var. *hispida*)

CHEBOYGAN CO.: Numerous plants along sandy n shore of Burt Lake, Sec. 3, Burt Twp., ca. 6 mi e of Pellston, 6 Jul, *Stuckey 1068* (MICH, OS), 21 Jul, *Stuckey 1178* (OS).

Disturbance: Wind and water erosion on the beach provided exposed soil.

LOCALITY 18 (var. *hispida*)

CHEBOYGAN CO.: One plant on sandy beach at Grass Bay on Lake Huron, NE$\frac{1}{4}$ Sec. 25, Benton Twp., ca. 3.0 mi e of e city limits of Cheboygan, 21 Jul, *Stuckey 1176* (OS).

Disturbance: Wind and water erosion on the beach provided exposed soil.

LOCALITY 19 (var. *hispida*)

CHEBOYGAN CO.: Several plants along moist sandy e shore of Devereaux Lake, Sec. 29, Aloha Twp., ca. 11 mi s of Cheboygan, 3 Jul, *Stuckey 1013*, 26 Jul, *Stuckey 1246* (both OS).

Disturbance: Wind and water erosion on the beach provided exposed soil.

LOCALITY 20 (var. *hispida*)

PRESQUE ISLE CO.: Five plants in small old beach pool in sandy soil along Lake Huron beach, NE$\frac{1}{4}$ Sec. 23, Bearinger Twp., ca. 3.5 mi s e of Cheboygan Co. line, 7 Aug, *Stuckey 1340* (OS).

Disturbance: Wind and water erosion on the beach provided exposed soil.

LOCALITY 21 (var. *hispida*)

CHEBOYGAN CO.: Several plants on moist sandy beach in corner of NW$\frac{1}{4}$ Sec. 34 at Duncan Bay, Benton Twp., ca. at e city limits of Cheboygan, 7 Aug, *Stuckey 1346* (OS).

Disturbance: Wind and water erosion on the beach provided exposed soil.

THE RELEVÉ METHOD FOR DESCRIBING VEGETATION[1]

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The relevé method is an efficient, easily learned procedure for obtaining and presenting information on the species composition and structure of vegetation. The system of notation is widely understood. After 20 years or more of use in Europe the method was introduced in the United States about 30 years ago (Conard, 1935) and recently it has been put to increased use in Canada (Jurdant, 1964; Damman, 1964) and the United States (Becking, 1957; Tomaselli, 1958). For nearly 50 years the relevé method has been the most common system for detailed description of vegetation in most other parts of the world. A paper based on a slightly modified relevé method for surveying moss and lichen communities on tree trunks was published in Volume 1 of *The Michigan Botanist* (Bevis, 1962), and an application of relevés to reveal habitat differences for two varieties of a species of *Rorippa* appears in this issue (Stuckey, 1966). The aim of this account is to make the notations and practices of the relevé method understandable and usable for a wider group of readers.

The relevé (French for "list") is simply a list of all the macroscopic species making up the vegetation on a measured area. Usually vegetation of a sample plot is surveyed because it is representative of a somewhat larger stand that is recognizable as a unit of vegetation, i.e., a parcel of vegetation distinguishable by reason of its species (floristic composition) or the arrangement and growth forms of its species (structure) or both. When the list is being recorded at the survey site, the observer writes beside each species name a pair of symbols representing the abundance or cover value of the species and the manner of grouping of its individuals (the "sociability" or gregariousness). The observer also notes gross stratification of foliage (i.e., ground, field or herb, shrub, and tree strata). In addition he records at least the salient features of the habitat: topographic situation, slope and exposure, kind of soil, drainage conditions, litter and humus, evidence of former vegetation different from the present, and other features that seem significant for characterization of the site.

Unfortunately there are few instructions on the elementary steps of the relevé method available in the literature. Most ecologists or phytosociologists have learned by assisting a person experienced in the method. There are several good accounts in German (Ellenberg, 1956; Knapp, 1958) and at least one popular account in French (Carles,

[1]Experience and sample data used in this paper accrued largely during research supported by National Science Foundation Grant GB-2102, "Phytosociological Analysis of Two Forest Community Complexes."

1948). The works of the acknowledged originator and master of the relevé method (and of the "Zürich-Montpellier School" of phytosociology) fail to explain the practical aspects of making a relevé and manipulating relevés in tables (Braun-Blanquet, 1932; 1964). An intensive evaluation of Continental European phytosociological methods based on relevés was published in the British *Journal of Ecology* (Poore 1955a, 1955b, 1955c, 1956). Criticism was leveled at the subjective selection of sampling sites and the construction of elaborate formal hierarchical classifications of plant communities, a large part of the effort of Braun-Blanquet and his followers. The usefulness of relevés and phytosociological tables is generally acknowledged.

In practice the most difficult step in making a relevé is the initial one of selecting a sample area or quadrat having vegetation representative of that to be described. Evaluation of stand homogeneity and sample representativeness improves with experience in a given kind of vegetation. A sample plot is marked by corner stakes or string, and should be large enough to include the characteristic and constant species. Obviously plots must be larger for forest vegetation (usually at least 400 m^2) than in meadows (1 - 8 m^2) or moss communities (0.1 - 1.0 m^2). A list is made of all macroscopic species, usually while cruising back and forth over the larger forest plots or while crawling about on hands and knees in meadow plots. The species list is commonly recorded in order of successively lower strata. Species that cannot be identified in the field by reason of complex diagnostic characters or immaturity of the plants should be collected for precise determination at a later time.

The species list having been completed, each species is evaluated for its *cover-abundance* according to the following scale:

5 covering more than 3/4 of the sampled area
4 covering 1/2 to 3/4 of the sampled area
3 covering 1/4 to 1/2 of the sampled area
2 with any number of individuals covering 1/20 to 1/4 of the sampled area, or very numerous individuals but covering less than 1/20 of the area
1 numerous, but covering less than 1/20 of the sampled area, or fairly sparse but with greater cover value
\+ sparse and covering only a little of the sampled area
r rare and covering only a very little of the sampled area (usually only 1 example)

It will be noted that the values at the lower end of the scale — r, + (always spoken "cross"), and 1 — may be used to indicate either cover percentage or the relative numbers of individuals. The *sociability* is estimated for each species in terms of another scale:

5 in large solid stands; very dense populations
4 in small colonies or larger mats; rather dense populations
3 in small patches or polsters; distinct groups
2 in small groups or clusters or tufts
1 growing singly

TABLE 1. Relevés made by Lynn J. Rorabacher on 4×4 m plots in 10 cornfields in western Wayne County, Michigan, 29 Sept. to 3 Oct. 1965. Species (i.e. rows) ordered according to presence.

Total vegetation cover (5)	75	90	95	75	70	40	10	60	40	25
Total number of species	9	12	5	8	9	5	7	7	9	11
Relevé number	1	2	3	4	5	6	7	8	9	10
Zea mays (planted)	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Agropyron repens	r.1	+.3	+.2	r.3	r.1	.	+.1	2.2	+.1	+.1
Ambrosia artemisiifolia	+.1	1.2	.	r.2	+.2	r.1	.	+.1	1.1	+.1
Amaranthus retroflexus	r.1	.	2.2	r.1	1.2	r.2	r.1	.	1.1	r.1
Setaria glauca	r.2	+.2	.	.	.	1.2	r.1	2.3	+.1	+.1
Chenopodium leptophyllum	3.2	.	2.2	r.1	.	+.2	.	+.1	+.1	+.1
Daucus carota	.	2.3	.	.	r.1	.	r.1	.	+.1	+.2
Cirsium sp.	.	1.1	.	+.1	.	.	r.1	.	+.1	+.1
Chenopodium album	.	r.1	.	r.2	.	.	.	+.1	.	.
Portulaca oleracea	.	.	.	.	+.2	.	r.2	.	.	r.2
Digitaria sanguinalis	2.2	.	3.3	.	1.2	.	.	.	.	.
Panicum capillare	r.2	r.2	.	.	.	.	.	.	+.2	.
Plantago cf. major	.	r.1	.	.	.	.	.	.	.	r.1
Equisetum arvense	.	r.1	.	.	+.3	.	.	.	.	.
Xanthium chinense	.	.	.	.	.	.	.	2.2	.	.
Amaranthus sp.	.	r.1	.	.	.	.	.	.	.	.
Polygonum pensylvanicum v. laevigatum	.	r.2	.	.	.	.	.	.	.	.
Taraxacum officinale	.	.	.	r.1	.	.	.	.	.	.
Panicum dichotomiflorum (typical)	.	.	.	.	+.3	.	.	.	.	.
Echinochloa crusgalli	.	.	.	.	.	.	.	.	.	r.1
Echinochloa pungens v. microstachya	r.2	.	.	.	.	.	.	.	.	.

Placed above columns of the "presence-ordered" table this "dictation strip" indicates column positions in the new "differential" table

10	4	9	5	8	1	7	2	3	6

TABLE 2. Ten cornfield relevés of Table 1 reordered by columns to make the differential species evident. Three different weed communities (with two variations of one) are suggested, but more extensive sampling would be necessary to resolve this question.

Total vegetation cover (%)	40	60	40	90	75	25	10	70	95	75
Total number of species	5	7	9	12	8	11	7	9	5	9
New running number	1	2	3	4	5	6	7	8	9	10
Relevé number	6	8	9	2	4	10	7	5	3	1
Zea mays (planted)	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Agropyron repens	.	2.2	+.1	+.3	r.3	+.1	+.1	r.1	+.2	r.1
Ambrosia artemisiifolia	r.1	+.1	1.1	1.2	r.2	+.1	.	+.2	.	+.1
Amaranthus retroflexus	r.2	.	1.1	.	r.1	r.1	r.1	1.2	2.2	r.1
Setaria glauca	1.2	2.3	+.1	+.2	.	+.1	r.1	.	.	r.2
Chenopodium leptophyllum	+.2	+.1	+.1	.	r.1	+.1	.	.	2.2	3.2
Daucus carota	.	.	+.1	2.3	.	+.2	r.1	r.1	.	.
Cirsium sp.	.	.	+.1	1.1	+.1	+.1	r.1	.	.	.
Chenopodium album	.	+.1	.	r.1	r.2	.	.	.	.	.
Portulaca oleracea	.	.	.	.	.	r.2	r.2	+.2	.	.
Digitaria sanguinalis	.	.	.	.	.	.	.	1.2	3.3	2.2
Panicum capillare	.	.	+.2	r.2	.	.	.	.	.	r.2
Plantago cf. major	.	.	.	r.1	.	r.1	.	.	.	.
Equisetum arvense	.	.	.	r.1	.	.	.	+.3	.	.
Xanthium chinense	.	2.2	.	.	.	.	.	.	.	.
Amaranthus sp.	.	.	.	r.1	.	.	.	.	.	.
Polygonum pensylvanicum v. laevigatum	.	.	.	r.2	.	.	.	.	.	.
Taraxacum officinale	.	.	.	.	r.1	.	.	.	.	.
Panicum dichotomiflorum (typical)	.	.	.	.	.	.	.	+.3	.	.
Echinochloa crusgalli	.	.	.	.	.	r.1	.	.	.	.
Echinochloa pungens v. microstachya	.	.	.	.	.	.	.	.	.	r.2

"Sociability" is a poor but traditional term for this estimate of the predominant manner of occurrence of the stems of each species. It provides a crude but useful description of the manner of aggregation of individuals or of separate stems in a clone. The cover-abundance estimate and the sociability estimate are grouped together with a period between, as 4.2, +.3, etc. The complete list, in which these estimates are associated with the species names, constitutes the relevé proper. It is usual practice to append the kinds of additional information about the vegetation structure and site conditions mentioned above, but at least the percentage cover of the several strata, the proportion of cover by bryophytes and by lichens (if present), the plot size, the precise location, and the date must be recorded.

Further symbols relating to the *condition* and *vitality* of the individual species, as those below, may be recorded beside the cover-abundance and sociability estimates.

oo	very poor and especially not fruiting (e.g., $+^{oo}$ or 2^{oo})	no notation	normal growth
o	poor vitality (e.g. 1^{o})	•	luxurious growth (e.g. 4•)
g	germinating plant	e	being driven out (by other plants)
Y	young plant	d	dying
st	sterile	def	defoliated
bu	budding	dd	above-ground organs dead or dried out
bl	blooming	s	present only as seed
fr	fruiting	#	specimen collected

Some phytosociologists elaborate the sociability estimate by adding a solid underline to ranks 3, 4, or 5 to show solid packing, or a dotted line beneath the number to indicate "loose" arrangements or other species coming up within the patch or crowd.

Relevés may be readily compared one with another when grouped into a tabular array, species arranged in rows, relevés in columns. A table can be rearranged to group species of similar occurrence, or relevés of like composition, and so on to demonstrate the floristic characters and relationships of the vegetation units represented. The first step is to copy relevés into columns of a table without regard for special order, hence a "raw table." One then calculates the *presence* (number or percentage of occurrences) of each species in all the relevés. From this a new table is written with the species listed in order from the one of highest to the one of lowest presence. In the "presence table" one can discover similar patterns of occurrence for two or more species, patterns that permit marking out groups of "differential species." The table may be increasingly refined by reordering the sequences of both rows and columns until the array shows clearly the relationships that are to be demonstrated.

In reordering a table it is simple to number the species in the new order of rows desired. Reordering the columns or relevés involves placing the total estimate values in the different column positions and is best achieved by use of a "dictation strip," especially when rows and columns are being reordered in one transcription. This is a strip cut from the same kind of square-ruled or quadrille paper (4 or 5 lines to the inch) on which the tables are written. The number of each column as it will be in the new table is written on the strip held in place across the columns of the existing table. One person dictates the data from the old table row by row but in the new table sequence of columns, while a second person writes the data into each row of the new table from left to right. The reordering of the simple Table 1 into Table 2 illustrates these steps.

By assembling a table of similar relevés, each representing a sample from a stand a mile or more from any other stand of the same kind of vegetation, one can generalize upon the floristic composition and develop an abstract concept of species composition in this vegetation unit. Character species are those that occur in about 60% or more of the samples and/or occur exclusively or preferentially in the unit. The former quality is termed constancy; the latter, fidelity. The use of fidelity as a criterion for defining abstract communities is criticized and questioned by some ecologists. Some species show significantly higher constancy, vigor, and even dominance in certain subdivisions of major kinds of vegetation but have low fidelity because they occur in a number of differently constituted vegetation units. These are often useful as "differential species," especially for distinguishing sub-associations, which differ usually only in the presence of two or three species but do reflect different site conditions or history.

It is still a moot question whether we can construct a very formal and hierarchical classification of the vegetation of North America and whether, if we did, its usefulness would be proportional to the effort required. The relevé method will nevertheless remain a convenient, uniform system for making and keeping records of vegetation and of the occurrence of species at definite points in space and time. The fundamental importance of this information to biogeography, ecology, and eventually to land management is incontestable.

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NOTES ON THE DISTRIBUTION OF *ARISAEMA DRACONTIUM* IN MICHIGAN

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One of the plants of flood plains in northeastern America is Green Dragon, *Arisaema dracontium*. A member of the Arum family (Araceae), Green Dragon occurs in "Rich or alluvial woods, thickets and swales, Fla. to Tex., n., locally, to s. N.H., Vt. and sw. Que., s. Ont., Mich. and Wisc." (Fernald, 1950). The plant blooms from late May through late June.

As far as I have been able to determine, studies of *Arisaema dracontium* in Michigan are scarce. The only study of any significance was done by the late Emma J. Cole. She made careful observations of plants which she transplanted to a garden and cultivated for a number of years. Her studies resulted primarily in descriptions of growth habits (Cole, 1962).

For the past two years I have studied the distribution of this plant in Michigan, particularly in the Saginaw River drainage. In the process of my investigations I have located colonies previously unreported in Michigan. Until these discoveries, only a few manuscript records and sightings existed as to Green Dragon's presence in the Saginaw watershed. The most northern collection in the state was made by G. M. Bradford in 1896 from Bay County. The late R. R. Dreisbach found it at various localities along the Chippewa River in Midland County. Frederick W. Case, Jr., has observed the plant in river-bottom woods along the Pine River near Riverdale in Gratiot County. On June 15, 1964, I found colonies of Green Dragon, the first Saginaw County

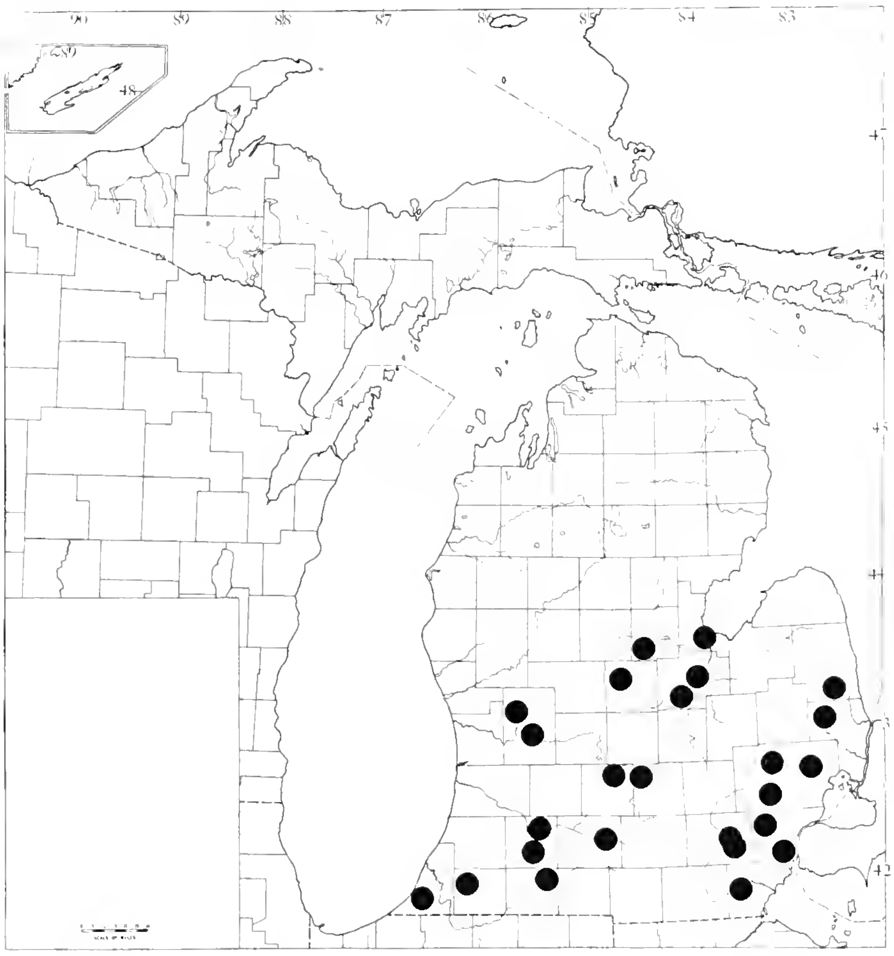

Fig. 1 (above). Distribution of *Arisaema dracontium* in Michigan.

Fig. 2 (left). *Arisaema dracontium* at junction of Cass and Saginaw Rivers, Saginaw Co., Michigan. Note characteristic elongate inflorescence. Photo May 22, 1965.

record, at the junction of the Cass and Saginaw Rivers along the line between sections 3 and 10, R. 4 E., T. 11 N. A herbarium voucher for this locality will be placed in the University of Michigan herbarium. In late spring of 1965, James D. Coppenger and I found a small colony of the plant near my original discovery in Saginaw County. In the early summer of 1965, Frederick W. Case, Jr., and James D. Coppenger found a very large, vigorous, colony of Green Dragon in woods along the Bad River near St. Charles, Michigan, approximately ten or twelve miles from my discoveries, thus adding a third record for Saginaw County and suggesting a possible widespread occurrence here.

In our area, I have observed Green Dragon (Fig. 2) as a frequenter of mature, flood plain forests of Silver Maple, *Acer saccharinum*, and American Elm, *Ulmus americana*, occurring in association with Giant Ragweed, *Ambrosia trifida*, Poison-ivy, *Toxicodendron radicans*, and Stinging Nettle, *Urtica dioica*. It is especially frequent along river banks, even colonizing small levees formed by flooding of the river. It is less frequent in the areas of the forest away from the river's edge.

In Saginaw County, the soil types on which *Arisaema dracontium* grows are Genesee very fine sandy loam and Griffin clay loam (Moon, et al., 1938). These soil types occur in the larger stream flood plains in all parts of the county. The greater amounts of these soil types, however, lie along the Shiawassee, Flint, and Tittabawassee Rivers, especially in the area known locally as the "Shiawassee Flats"—the area of confluence of the Shiawassee, Flint, Cass, and Tittabawassee Rivers. This area is poorly botanized.

It appears from previous herbarium records, as well as my more recent collections, that *Arisaema dracontium* probably occurs in almost every county in the southern part of the Lower Peninsula of the state. Absence of any records or reports north of the Saginaw-Grand River drainage suggests that Green Dragon's distribution in Michigan is restricted or at least much limited by the presence of the high glacial moraine country to the north, with its assorted colder temperatures and different soils.

ACKNOWLEDGMENTS

I would like to express my gratitude to Frederick W. Case, Jr., for his patience, suggestions, and critical examination of this manuscript; to Dr. Warren P. Stoutamire, Michigan State University, Dr. Edward G. Voss and Professor Warren H. Wagner, Jr., University of Michigan, for their aid in herbarium work. For their help and suggestions I thank Carl L. Altenhof, Richard Northrup, Nicholas Purichia, Martin R. Samoiloff, and Dr. L. H. Tunstall, all of Delta College. I would also like to thank James D. Coppenger for his companionship in the field.

The map (Fig. 1) is based on specimens examined from the following counties in the herbaria at the University of Michigan (MICH), Cranbrook Institute of Science (BLH), Michigan State University (MSC), and Wayne State University (WUD): Bay (MSC), Berrien (MICH, WUD, MSC), Calhoun (MICH), Cass (MSC), Eaton (MSC), Ingham (MSC), Kalamazoo (MICH, BLH), Kent (MICH, BLH, MSC), Macomb (MSC), Midland (MICH), Monroe (MICH, BLH), Oakland (BLH), Sanilac (MSC), St. Clair (MICH, MSC), St. Joseph (WUD), Washtenaw (MICH, BLH), Wayne (MICH, WUD, BLH).

The Gratiot County record is based on an observation made at the Pine River near Riverdale by Frederick W. Case, Jr., in 1957.

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AN UNDESCRIBED BOLETE IN THE *B. RUBELLUS* GROUP

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Species complexes in the boletes as for other fungi typically show the same gamut of character combinations. The group of boletes represented by the names Singer (1947, p. 45) has cited under the binomial *B. rubellus* is a typical complex. One way of attacking the further elucidation of the taxonomy of this group is to search for previously unused characters of a positive nature among its members. In the course of our studies on the boletes of Michigan we have discovered such a feature in a local population in this group. Smith, Thiers, and Miller (1965) called attention to Imler's (1950) paper on Melzer's reactions with boletes, a paper mostly ignored by Singer (1963), and added some observations of their own. The present study represents a continuation of this approach. The following species is one which can be distinguished immediately in the *B. rubellus* complex by the presence of dark-violet rods, granules, or larger particles in the cells of the epicuticular hyphae of the pileus.

BOLETUS FLAVORUBELLUS sp. nov.

Pileus 2.5-4 cm latus, convexus, siccus, subtomentosus demum areolatus, laete latericius demum flavus. Tubulis flavis tactu olivaceo-caeruleis. Stipes 3-5 cm longus, 5-8 mm crassus, intus flavus, rubro-variegatus; extus rubro-pruinosus. Sporae 10-13 × 4-5 × 4.5-7 μ. Hyphae epicuticularum cum detritis amyloidiis. Typus: Smith 62872 (MICH).

Pileus 2.5-4 cm broad, convex to pulvinate, becoming broadly convex; surface dry and subtomentose, soon deeply areolate exposing yellow context; the margin fertile; color Brick Red (Ridg.) to Hay's Russet (Ridg.) (a deep red), gradually paler and in age finally chrome yellow. Context bright rich yellow (flavous), slowly changing to greenish-blue when cut, with KOH turning ochraceous tan, with $FeSO_4$ grayish; taste mild, odor none.

Tubes sharply depressed at the stipe, 4-5 mm deep, flavous staining greenish-blue when bruised; mouths small, 2-3 per mm, angular to round, flavous, staining greenish when bruised.

Stipe 3-5 cm long, 5-8 mm thick, equal, solid, flavous within, streaked with red over exterior, often red around larval tunnels, slowly staining greenish where cut; surface with reddish pruina near apex, flavous below, tinged red in the midportion.

Spore deposit dark olive; spores compressed to some degree, 10-13 × 4-5 × 4.5-7 μ, in face view ventricose to ovate, in profile subelliptic to inequilateral, wall slightly thickened, outline irregular on some spores, with a minute apical discontinuity (callus ?), dingy ochraceous in KOH, in Melzer's sol. a dull yellowish-tan with a slight greenish-gray shadow when first mounted.

Basidia 4-spored, 20-25 × 8-10 μ, clavate, yellowish in KOH. Pleurocystidia scattered, 30-40 × 9-12 μ, fusoid-ventricose, apex obtuse, nearly buried in hymenium and content merely yellowish in KOH and Melzer's sol. Tube trama somewhat gelatinous, hyphae slightly divergent from central area (or nearly parallel as revived). Cutis of pileus a trichodermium of short-celled hyphae, cells 12-20 μ broad and 2-3 times as long but some globose, thin-walled, yellow in KOH and dingy yellowish in Melzer's sol. except for containing aggregations of dark-violet rods, granules, and particles, some of this material present in almost every cell. Clamp connections absent.

Scattered on wet earth, Ann Arbor, Michigan, Aug. 11, 1960. Smith 62872.

In this species the distinctive combination of characters is the slightly compressed spores, the inflated cells in the pileus trichodermium, and the amyloid content of its cells. Material identified as *B. sanguineus*, *B. rubeus* and *B. rubellus* does not show these features.

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Reviews

A FLORA OF NORTHEASTERN MINNESOTA. By Olga Lakela. Univ. of Minnesota Press, Minneapolis. 1965. xv + 541 pp. $10.00.

This long-awaited flora covers St. Louis and Lake counties, Minnesota, said to be 9,229 square miles and (contradictorily) said to be greater than Vermont. The eastern and western limits are both stated approximately 45 minutes of longitude west of their true location. In the absence of any location map, one may be slow to recognize that the area covered extends along the north shore of Lake Superior and from Duluth about 45 miles inland, north to the International Boundary (excluding Cook Co. at the tip of the "Arrowhead"). The distribution maps apparently plot for all of the species their known occurrence in this vast wilderness. If the full descriptions do reflect accurately the range of variation in the region covered, they too will prove to be a valuable contribution to knowledge.

The keys are unimaginative, and often fail to take into account any exception to the "typical." For example, in the key to grass genera of the tribe Agrostideae, *Muhlenbergia* runs only in the opposite lead to "Rhizomes not scaly; glumes awnless" although *M. uniflora* lacks scaly rhizomes and has blunt glumes. (Furthermore, this species is said to produce "axillary buds" from the lower sheaths, whereas one of its most interesting features is the formation of buds *below* the nodes.) *Sporobolus* and *Brachyelytrum*, in addition to the good character of whether or not the lemma is awned, are further distinguished by whether or not the grain separates from the pericarp—certainly a far less useful character to the average botanist than whether the ligule consists of a membrane or a fringe of hairs or whether the spikelets are less than 4 or more than 8 mm long. To identify any *Potamogeton* (except *P. alpinus*), one must know whether the species ever produces floating leaves. The key to angiosperm families works only if one knows the number of cotyledons and arrangement of vascular tissue in jack-in-the-pulpit, skunk-cabbage, and duckweed.

Despite the weakness of its keys, this flora is likely to prove useful in northern Michigan and northern Wisconsin as well as the adjacent region of Ontario (even though there are some characteristic species of the Lake Superior region, such as *Empetrum*, which do not range far enough west to be included), simply because there is no other manual centered in this large area.

BOTANICAL ESSAYS FOR HUMANISTS. By Kenneth L. Jones. George Wahr Publ. Co., Ann Arbor. 1966. 333 pp. $4.50.

This is the kind of book in which one dips for knowledge, in the broadest sense, rather than facts. For the particular facts it contains are not as essential as the point of view which they illustrate—that an understanding of plants is important to man's completeness, and that man is not the only creation on the face of the earth. Antibiotics, the marvelous process of flowering, plant tissue culture, the gene, the species from Linnaeus onward—all these and other topics are touched upon and illuminated with anecdotes both ancient and modern. Out of his experience teaching a popular course called "Plants and Man," the author (formerly chairman of the Botany Department at the U. of M.) has produced a book guaranteed to interest every reader, including all members of the Michigan Botanical Club.

The hemlock which did in poor Socrates was evidently *Conium*, not *Cicuta* (p. 154), but this trifle of identification does not affect the fascinating notion that the nectar of some poisonous plants yields delightful honey. One learns that the elms (now doomed?) on the central campus of the University of Michigan were planted by no less distinguished a personage than Andrew Dickson White. Finally, not the least of the pleasant discoveries in this volume are the sprightly drawings by Mrs. Jones, which adorn the beginning of each chapter.

—E.G.V.

Nature education feature --

MUSHROOM COLLECTORS - WHAT ARE THEY DOING?

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Because of my having had some formal training in the area of mycology dealing with the higher fungi (mushrooms) I was requested by Michigan State University Extension personnel in various areas of the state to conduct educational, interpretive programs for beginning (amateur) mushroom collectors. The first problem to be faced was that of determining the level of knowledge of the people who attended our meetings.

To explore this problem a very simple questionnaire was designed, including these questions: Have you eaten wild mushrooms? Which ones have you eaten? Do you preserve mushrooms? How? How do you tell if mushrooms are poisonous or good to eat? Do you use books to help in identification? If so, what books? People were asked to fill out the form upon their arrival at the meetings.

Two groups were sampled. One group attended a session held in the Upper Peninsula with an international naturalists group sponsoring the meeting. The other was in the Lower Peninsula and was sponsored by a smalltown chamber of commerce.

One hundred and sixteen questionnaires were filled out, each one representing (in most cases) a man and wife combination.

From answers to the question, "Have you eaten wild mushrooms?" this is what we learned:

Over half the people indicated they had eaten wild mushrooms.

We must remember, however, that these meetings attracted only those interested in mushrooms.

Most people ate several species, two to five.

One individual from the Lower Peninsula indicated he had eaten (spelling has been corrected):

Marasmius oreades
Several Pleurotus
Several Lactarius
Several Lepiota
Morels - Puffballs - Clitocybe
Coprinus comatus - Armillaria mellea
Coprinus atramentarius - Several Tricholoma
Several Boletus - Several Agaricus
(Oh, heck! - Over 100, I'd say.)

Morels were by far the most popular. A total of 61 named "morels": 35 from the Lower Peninsula group, and 26 from the Upper Peninsula group.

"Coral" mushrooms were consumed by 21 in the mid-state group (only four from the upper-state group).

"Puffballs" were equally popular, with seven in both areas for a total of 14.

"Inky Caps" were mentioned only in the northern group, with seven indicating they had eaten them.

"Fairy Rings" were eaten by three in the northern group and four in the southern group.

From there on the species varied greatly—at least by the localized identification jargon.

The habitat, season, rainfall, etc., vary in the two areas. The southern area is primarily oak and pine country. The northern area includes farming and hardwood country with a smattering of sandy pine plains.

Following is a list of the mushrooms said to be eaten, with the number of times cited (in parentheses) in each area. (Spelling has been corrected when possible to guess what was meant.)

The southern area: Morels (35), Coral (21), Stumpies (13), Stumper (5), Stump (2), Beefsteak (8), Puffballs (7), Fairy Rings (4), Snake Head (3), Goat's Beard (3), Pinies (3), Meadow (3), Boletus (2), Red Caps (2), Red Tops (2). Also, (1 each) Elephant Ears, Kellmeitier, Budavekies, Spongies, Honeydew, Jimmies, Shaggy Mane, Oyster, *Marasmius oreades*, *Lepiota*, *Lactarius*, *Clitocybe*, *Tricholoma*, *Armillaria mellea*, Leather Tops, Cauliflower, Honey Tops, and Sticky Tops.

Three stated that they didn't know the names of the mushrooms they were eating.

The northern area: Morels (26), Shaggy Mane (19), Puffballs (7), Inky Caps (7), *Coprinus* (3), Inky Coprinus (2), Oyster Pleurotus (3), Oyster (2), Coral (3), Pasture Mushroom (3), Fairy Rings (3), Horse Mushrooms (3). Also one each of the following: *Calvatia gigantea*, Field Mushrooms that are pink underneath, buttons pink underneath, Field, *Lepiota naucina*, *Coprinus comatus*, *Coprinus micaceus*, *Coprinus atramentarius*, *Agaricus edulis*, Fairy Caps, *Clavaria*, *Cantharellus*, *Lactarius deliciosus*, Morchellas, Buttons, Morchells, Inkies, Beefsteak, *Helvella*, Brown *Gyromitra*, Beef Mushroom, Truffles, Common mushroom.

Among the remaining answers were three who ate many kinds but didn't know the names: "don't know English names, pink beneath, pink beneath and peelable, and others."

When we asked the questions, "Do you preserve wild mushrooms" and "How?" this is what we learned:

There was a decided difference between the northern and southern groups.

In the southern group, more than half (30 out of 52) indicated that they preserved mushrooms.

Freezing was the most popular method of preservation. Of the 30 who preserved, 20 froze, 10 canned, 7 dried, and one pickled them. Most folks used several different methods of preservation, depending on the species.

In the northern group, only 12 (of the 64) said they had preserved mushrooms.

Freezing again proved the most popular, with 11 using this method. Seven dried mushrooms, four canned them, one salted them, two canned them in oil and spices. Again, some preserved them in more than one way.

One man (from Canada) made this contribution: "My grandmother was a famous ketchup maker (Yorkshire, England). I believe [she] cut up the mushrooms small and sprinkled with salt. They soon became a mush. Sieve the mixture and boil down to half the bulk. The secret of the fame was in the spices added. What were they?"

To total the two groups of answers related to preserving, 31 froze mushrooms, 16 canned them, 14 dried them, one salted them, and one pickled them.

The question "How do you tell if they're poisonous or good to eat?" provided some most interesting answers.

The mid-state group provided these answers (no attempt has been made to classify the answers):

"The hired man said so."
"Been told by my husband."
"Everyone knows a morel." (3)
"I've been shown." (3)
"My parents showed me." (2)
"My friends showed me." (2)
"By firmness."
"Can't eat morels anymore."
"Know only morels."
"No way to tell."
"Experience."
"Just pick the ones I know."
"Just have to learn 'um."
"From natives and books."
"Don't know." (3)
"Get a mushroom book."
"Try eating them."
"Advice of other people."
"I was given some."
"Know-how and where they grow."
"Eat what we know."
"Years of picking."

"I've been shown and know by experience."
"I pick only those I know others have eaten many times." (2)
"Information from folks who have eaten them."
"If I'm still alive in the morning."
"Have other hunters or friends identify them."
"Put a half dollar in the cooking water."

The group from the Upper Peninsula provided the following answers: (Again they are listed as they appeared on the filled-out questionnaire with no attempt at classification.)

"I pick the ones I know." (2)
"Only use two I know." (3)
"Previous knowledge."
"Key them out." (3)
"I know the ones I eat." (3)
"Boil with garlic."
"By identification."
"I know them."
"Observation."
"Refer to Smith's Field Guide."
"Reference books."
"I don't trust friends."
"Can't tell."
"Am a botanist."
"On other's say so."
"Ask my friends."
"Don't know." (9)
"My husband knows two kinds."

"Boil with a silver coin. If the coin turns black, they're poisonous."

"Depend on the good intentions of my friends."

"Poisonous ones have a veil beneath cap and cup in which the stem rests."

"I've been told only pink ones are good."

"I don't pick them, my husband does. I'm concerned for his safety; that's why I'm here."

"I'm sure if I ate one I'd get sick from being scared."

When we asked if they used books or references to help with identification, the answers were as follows:

A total of 25 of the 116 said "yes": 15 from the Lower Peninsula and 10 from the Upper Peninsula group.

Twenty-four said "no," they used no books: eight from southern group and 16 from northern group.

These were the references listed by the northern group, with the exception of the botanist, who said he had about the same ones as were brought to the meeting for reference:

Mushroom Hunter's Field Guide (Smith)	10
Some Common Mushrooms of Michigan's Parks & Recreation Areas (Smith) (40 were purchased at the meeting)	5
Mushrooms of Eastern Canada and U.S.A. (Pomerleau)	1
Field Book of Common Mushrooms (Thomas)	1

In the southern group one man listed Ramsbottom, Christensen, W. S. Thomas, and three others. The remainder of the listings included.

Smith's Field Guide	14
Smith's Parks and Recreation Areas	1
Twenty Common Mushrooms (George Caffin)	1
Michigan Automobile Magazine	1
Our Wonderful World Encyclopedia	1
Field Book of Common Mushrooms (Thomas)	1
Wonder Book	1
Mushrooms and Other Fungi (Cranbrook) [Common Edible and Poisonous Mushrooms of Southeastern Michigan (out of print)]	1
Government Bulletin	1
National Geographic	2

CONCLUSIONS

The most obvious conclusion is the desperate need for an educational program to protect mushroom hunters in the field against their own mistakes.

There certainly is need for a universal language, as evidenced by the terminology used to designate species being eaten. In spite of the reluctance on the part of the public, this will almost have to be the botanically correct name with genus and species epithet.

Remarkable as it may seem and as alarming to us would-be-educators, the methods used by these people to distinguish the poisonous from the edible species have worked for them so far. They were still around to attend the meetings.

There is authentic literature available, but the public is apparently not aware of it, as evidenced by the lack of references used at the amateur level.

There seems to be a gap in knowledge and a need for training at the level between the time interest is evidenced and the time when printed literature can be used effectively. On the site, in the field, training is elementary to an interpretation of the written word.

It is just as important to protect a person from poisoning himself with mushrooms as it is to protect him from a car accident, hunting accident, etc. We must not be afraid to continue to work on this problem with a sound educational approach. We need to reach the people who are in the woods picking mushrooms.

Publications of Interest

HUNTIA. A Yearbook of Botanical and Horticultural Bibliography. Vol. 2. 1965. 304 pp. $7.50 (paper) or $8.50 (cloth). Huntia has rapidly become an important publication source for articles in the fields of botanical and horticultural bibliography, biography, and history. The present volume is strong on articles about horticultural writers and their books, with representative pages reproduced from some of the great old volumes. There are also explanations of some bibliographical terminology and practices; biographical notices and recollections; a series of portraits of British botanists and gardeners, with notes; and brief accounts of important Hunt Library accessions. Those interested in botanical ''biobibliography'' are finding Hunt Library publications not only valuable additions to their libraries but also beautiful works of craftsmanship. (Although it is surprising to find in a volume from an institution which prides itself on bibliographic accomplishment that a short four-title list of references (p. 116) omits the year of publication for one and misspells an author's name (Henrichs) in another — not to mention ''bretheren'' in the Table of Contents.) Single copies or standing subscriptions may be ordered from the Hunt Botanical Library, Carnegie Institute of Technology, Pittsburgh, Pennsylvania 15213.

CATALYST. A Quarterly Publication of the Belle W. Baruch Foundation. Vol. 1, No. 1, dated Fall, 1965 (but copyright 1966), launches a new periodical ''designed to stimulate education and research in the broad fields associated with conservation, development and use of flora and fauna.'' The title is explained in that ''by serving as a kind of transmittal belt to relay news of who is doing what in these fields — particularly 'success stories' and significant 'frontier developments' we may be a catalytic influence in getting the relevant knowledge and skills put to practical use.'' A unique feature in this first number is a column reporting recent grants (from a total of 36 foundations, trusts, etc.) related to conservation. A special insert describes the 17,000-acre plantation in South Carolina, which the late Bernard Baruch retained in its natural state for the past half century. Copies may be obtained without charge from Catalyst, Editorial Office, 333 East 46th St., 6L, New York, N.Y. 10017.

MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

B. BOOKS, BULLETINS, SPECIAL REPORTS, AND MISCELLANEOUS

Bakuzis, E. V., & H. L. Hansen. 1965. Balsam Fir. Univ. Minn. Press, Minneapolis. 445 pp. $9.50. [A summary, based on thorough survey of the literature, of the ecology, microbiology, entomology, reproduction, growth, and utilization of *Abies balsamea*; a considerable amount of the data are from Michigan stands.]

Clark, Raymond M., & John W. Andresen. 1961. Forest Trees of the Lake States. Mich. State Univ. Prof. Series Bull. No. 53. 92 pp. $1.75. [Designed as an aid for teachers (especially high school) who include forestry units in their programs, this paper-bound guide includes photos of trees in winter, with closer views of bark, twigs, leaves, and fruit; winter and summer keys; information about each species; and very general statement of distribution in Michigan, Wisconsin, and Minnesota. Although not all trees of the area are included, it should prove helpful for identification.]

Graham, Samuel A., Robert P. Harrison, Jr., & Casey E. Westell, Jr. 1963. Aspens Phoenix Trees of the Great Lakes Region. Univ. Mich. Press, Ann Arbor. 272 pp. $7.50. [A survey of the history of aspen in Michigan, its ecology, growth and management, enemies (insect, fungal, and other), and relations to wildlife such as deer and beaver. The introduction errs in stating that four poplars, including the two aspens, are native to Michigan, omitting a fifth, the swamp cottonwood, long known locally in the southern part of the state. Despite the implication of its title, the book draws its data almost solely from original work in Michigan. By contrast, the balsam fir monograph (Bakuzis & Hansen, above) is more generally devoted to the entire range of the species but is largely a survey of literature. Except for photographs (75 excellent ones on aspen, 2 on fir), the reader gets a great deal more for his money in the fir book (38% more type per page, and more pages, resulting in about 226% as much material for 127% of the price of the aspen book), suggesting either that the University of Minnesota Press operates more economically than the University of Michigan, or that it has a greater confidence in its book and printed many more copies, or that the acknowledged support for publication differed drastically, or that pricing policies differ considerably.]

Hesler, L. R., & Alexander H. Smith. 1965. North American Species of Crepidotus. Hafner Publ. Co., New York. 168 pp. $12.50. [Most of the species are cited from Michigan, including several new species. 33 photographs in the text are repeated on glossy paper at the end. The publisher has inverted the photo on the dust jacket, with the remarkable result that a fungus appears to have gills on its upper surface.]

Piehl, Martin A. 1965. The Natural History and Taxonomy of Comandra (Santalaceae). Mem. Torrey Bot. Club 22 (1). 97 pp. [A single species, *C. umbellata,* is recognized, of which only the typical subspecies is in Michigan. Most of the natural history observations, including insect relations, were made in Michigan (Ann Arbor and U. of M. Biological Station).]

Rudolf, Paul O., & John W. Andresen. 1965. Botanical and Commercial Range of White Spruce in the Lake States. Lake States Forest Exp. Sta., U. S. Forest Serv. Res. Note LS-73. 4 pp. [Includes a detailed distribution map—which incidentally points out the need for herbarium specimens which would more accurately and completely document the distribution of such plants as the conifers, which are often ignored by collectors.]

Rudolf, Paul O. 1965. Botanical and Commercial Range of Black Spruce in the Lake States. Lake States Forest Exp. Sta., U. S. Forest Serv. Res. Note LS-74. 4 pp. [Includes distribution map.]

Smith, Carole Greer. 1966. Some Effects of Daucus carota on Germination and Growth. Occas. Pap. Adams Ctr. Ecol. Stud. 14. 9 pp. [Material tested came from an abandoned field northeast of Kalamazoo.]

Tubbs, Carl H. 1965. Influence of Temperature and Early Spring Conditions on Sugar Maple and Yellow Birch Germination in Upper Michigan. Lake States Forest Exp. Sta., U. S. Forest Serv. Res. Note LS-72. 2 pp.

C. JOURNAL ARTICLES

Iltis, Hugh H. 1965. The genus Gentianopsis (Gentianaceae): Transfers and phytogeographic comments. Sida 2: 129-154. [The 'phytogeographic comments' on the fringed gentians include Michigan implications, and there are distribution maps of two species which occur here. The dot for *G. crinita* at Grand Traverse Bay, however, is presumably copied from an erroneous dot on the map in an earlier monograph by Gillett.]

Iverson, Grace Blanchard. 1963. Karyotype evolution in the leafy liverwort genus Frullania. Jour. Hattori Bot. Lab. 26: 119-170. [Michigan material studied (and cited by county) of four species.]

Johnson, Miles F., & Hugh H. Iltis. "1963" [1964]. Preliminary reports on the flora of Wisconsin No. 48. Compositae I—Composite family I (Tribes Eupatorieae, Vernonieae, Cynarieae, and Cichorieae). Trans. Wis. Acad. 52: 255-342. [Distribution maps of *Cirsium pitcheri* and (for comparison) *Calamovilfa longifolia* in North America include Michigan stations and are presented with an interesting discussion of the problem of Great Lakes endemics. From the *Cirsium* map should be deleted a dot inland in southwestern Michigan and to the *Calamovilfa* map should be added a Lake Superior record at the Huron Mountain Club.]

Philcox, D. 1965. Contributions to the flora of tropical America: LXXIV Revision of the New World species of Buchnera L. (Scrophulariaceae). Kew Bull. 18: 275-315. [Cities *B. americana* from Michigan, as collected by 'Jackson' and without locality. The specimen (at Kew) was almost certainly collected *at* Jackson, presumably in July of 1838 by John Wright, on Houghton's First Geological Survey of Michigan, during which specimens were found in Kalamazoo and Calhoun counties (MICH). This interesting species has not since been found in Michigan.]

Pohl, Richard W., & Wm. W. Mitchell. 1965. Cytogeography of the rhizomatous American species of Muhlenbergia. Brittonia 17: 107-112. [Includes citation of *M. frondosa* f. *commutata* from Jackson Co., n = 20; and *M. glomerata* aneuploids from Clare, Crawford, & Cheboygan cos.]

Shinners, Lloyd H. 1965. Holosteum umbellatum (Caryophyllaceae) in the United States: Population explosion and fractionated suicide. Sida 2: 119-128. [Discussion of spread of this weed, inspired by the recently published first reports from Michigan.]

Shaffer, Robert L. 1964. The subsection Lactarioideae of Russula. Mycologia 56: 202-231. [Six taxa, including types of 3 new ones, are cited from Michigan localities.]

Smith, Alexander H., & S. M. Zeller. 1966. A preliminary account of the North American species of Rhizopogon. Mem. N. Y. Bot. Gard. 14(2): 1-177. [This is the monograph of "false truffles" promised in a summary in Mich. Bot. 3: 13-19. 1964. Of the 137 species included, most are new to science; the type locality of one new one (*R. baxteri*) is Ann Arbor; two others (*R. pseudoroseolus* and a var. of *R. rubescens*) are also cited from Michigan.]

Wells, James R. 1963. A taxonomic study of Polymnia (Compositae). Brittonia 17: 144-159. [*P. canadensis* said to occur in southern Michigan.]

PROGRAM NOTES

May 27-30: Michigan Botanical Club, Spring Campout, Bruce Peninsula.

"Wilderness Canoe Trips, Inc.," again offers weekly trips June 18-August 13, into the Algoma District wilderness of Ontario. Prices have been considerably lowered this year (each person providing his own transportation as far as Ranger Lake). For information write George Merring, 4351 Bluebird, Rt. 1, Union Lake, Michigan 48085.

Editorial Notes

IMPORTANT NOTICE TO ALL PAST AUTHORS: Authors of articles which have appeared in past issues of THE MICHIGAN BOTANIST should advise the editor if they wish to have their original manuscripts and/or art work returned. All manuscripts, photos, etc., not already returned to authors are still on file, but some must be discarded soon to conserve space.

The March number (Vol. 5, No. 2) was mailed March 10, 1966.

Publications of Interest

(Continued from page 124)

PLANTS OF BOTTINEAU COUNTY NORTH DAKOTA. By Orin Alva Stevens. North Dakota Forest Service & North Dakota School of Forestry, Bottineau. 1966. 37 pp. Six pages of introduction are followed by a briefly annotated list of vascular plants, including some records from adjoining counties and presumed occurrences. Although there is scarcely a page without at least one typographical error, the list is an interesting account of the flora of a large county on the center of the state's Canadian border, largely prairie except for the lakes and woods of the Turtle Mountains.

BOTANICAL LATIN. History, Grammar, Syntax, Terminology and Vocabulary. By William T. Stearn. Nelson, Edinburgh, 1966. 566 pp. 105s [= $14.70; also handled in the U. S. by Stechert-Hafner at $16.75]. As the distinguished author of this monumental volume summarizes his introductory part: "Botanical Latin is best described as a modern Romance language of special technical application, derived from Renaissance Latin with much plundering of ancient Greek, which has evolved, mainly since 1700 and primarily through the work of Carl Linnaeus (1707-78), to serve as an international medium for the scientific naming of plants, in all their vast numbers and manifold diversity." Fifty pages of historical introduction are followed by presentations (with copious botanical examples) of the parts of speech; descriptions and diagnoses; terms applied to geography, colors, habitats, parts and shapes, etc.; abbreviations; Greek alphabet and word elements; and a combined Latin-English and English-Latin vocabulary, keyed to sample declensions and explanations.

The work is intended to be useful for understanding and preparing Latin descriptions of all kinds of plants, with examples drawn from many groups; several pages are devoted to Fries' color terms for fungi and to chemical reactions of algae and fungi. The clarity and utility of presentation make this a book which must be on every taxonomist's personal reference shelf.

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(On the cover: Flowering Dogwood, Cornus florida, photographed in Michigan by Carl B. Obrecht.)

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THE MICHIGAN BOTANIST

May, 1966

A PRELIMINARY ACCOUNT OF THE NORTH AMERICAN SPECIES OF *LECCINUM*, SECTION *LECCINUM*

Alexander H. Smith, Harry D. Thiers, and Roy Watling

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Articles and notes dealing with any phase of botany in the Upper Great Lakes Region may be sent to the editor in chief. The attention of authors preparing manuscripts is called to "Information for Authors" (Vol. 4, p. 38, and also available from the editor).

Editorial Board

THE MICHIGAN BOTANICAL CLUB

Membership in the Michigan Botanical Club is open to anyone interested in its aims: conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on the plant life of the State; sponsorship of legislation to promote the preservation of Michigan native flora and to establish suitable sanctuaries and natural areas; and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

Dues are modest, but vary slightly among the chapters. In all cases, they include subscription to THE MICHIGAN BOTANIST.

A PRELIMINARY ACCOUNT OF THE NORTH AMERICAN SPECIES OF *LECCINUM*, SECTION *LECCINUM*

Alexander H. Smith, Harry D. Thiers, and Roy Watling
University Herbarium and Department of Botany,
The University of Michigan, Ann Arbor;
Department of Biology, San Francisco State College,
San Francisco, California; and
Royal Botanic Garden, Edinburgh, Scotland

The species of this group of boletes have long been popular as edible fungi, and since they are among the safest boletes for the table, it is important to inventory the group for North America, especially from a modern approach to the anatomical study of the basidiocarp, so that accurate identifications can be made. Since these fungi are notorious for their variability it is pertinent to review the pattern of speciation in the genus as a whole. The present contribution is a step in this direction.

The ensemble of features which distinguishes the section as recognized here is: (1) The pileus margin extending as a sterile membrane beyond the tubes and becoming divided into segments (Fig. 9). (2) The ornamentation of the stipe, which consists of scabrosities which are typically pallid at first but undergo changes through buff to brown or finally become black. (3) The pallid to ochraceous to orange, ferruginous, dark red, red-brown, pinkish cinnamon or rarely dark gray-brown pileus. (4) The hymenophore typically white when young and becoming gray-brown by maturity, rarely with an intermediate yellow stage. (5) The spore deposit as air dried being typically dark yellow-brown ("bister" to "cinnamon-brown" or "snuff-brown") but varying in some species to olive, olive-brown or cinnamon to "wood-brown" (a gray-brown).

We recognize *Leccinum aurantiacum* as the type species, and this group is therefore the type section of the genus.

For years it has been assumed that there were relatively few species belonging to this section in North America but no continent-wide search for them has ever been systematically made to ascertain the patterns of combinations of characters identifying the variants, or their distribution in the area. The flora of the Great Lakes area is apparently one of the richest in the world for species in this group. Since the number of "new" species proposed here may seem large to some, a few comments on the features used in defining taxa in this group are pertinent.

It has always been assumed, for instance, that the color of the pileus in *L. aurantiacum* was exceedingly variable through a series of tints from white to ferruginous to dark red or red-brown and even dull cinnamon. We have found that the pigments of a given tint such as ferruginous fall into two categories, those which withstand drying and cause the dried pileus to have a reddish tone, and those which break down in drying to such an extent that the dried pileus is dull brown to grayish-brown. This is a major difference between stirps *Aurantiacum* and stirps *Insigne*. The pigment in *L. aurantiacum* will not develop, and that of *L. insigne* only to a slight extent, if the pileus has been covered in any way during its development, whereas *L. atrostipitatum* and the fungus which has been called *L. testaceoscabrum* in Europe develop their pigment regardless of external factors. It was found on further study that in stirps *Insigne* when the epicuticular hyphae were revived in Melzer's solution[1] the pigment in the cells became granular or remained in solution (appearing homogeneous) but that in stirps *Aurantiacum* it became aggregated into pigment balls.[2] These globules are typically orange-brown to orange-red and may take the form of numerous droplets giving the hypha the appearance of being filled with beads, or only a few large ones may be present in a cell. They do not necessarily form in every hypha. In *Leccinum* these globules are characteristically within the hypha, but in *Rhizopogon* and in *Chroogomphus* they may be both inter- and intracellular.

Although the study of the histology of Californian boletes by Yates (1916) was inconclusive, he did indicate a future approach to the study of the boletes, i.e., the hyphal anatomy of the epicutis. Singer (1938) extended this to distinguish certain European members of the genus *Leccinum* (as *Kromholzia*). We have followed this character through our present study, but have found it much more useful in the *L. scabrum* group than in the present section. However, the anatomy of the epicuticular hyphae, particularly that of the end-cells in *L. insigne* and related species, furnishes an additional important set of differences to distinguish stirps *Insigne* from stirps *Aurantiacum*. The tendency for the cells of the epicuticular hyphae to disarticulate (become free of each other) was commented upon by Groves & Thompson (1955). We have followed this feature also and find it almost absent in *L. fibrillosum*, but present to some degree in most other species; apparently it is connected with aging and gelatinization of the hyphal wall as it is most pronounced in mature or old somewhat viscid basidiocarps. It is a most important feature as far as understanding of the changes that take place in a cap from youth to old age, but we have not been able to use it effectively in distinguishing taxa. It does explain, however, why a pileus can be dry and fibrillose when young and glabrous and viscid in age.

Since the genus is based primarily on the features of the ornamentation of the stipe, the yellow-brown color of the spore deposit, and the pallid hymenophore when young, divergencies from this basic

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[1]In the text simply referred to as Melzer's.

[2]A term first used by Morten Lange (1956) in ***Rhizopogon*** and further elaborated upon by Smith in Smith & Zeller (1966).

pattern have been given recognition in our classification. *L. imitatum* develops pale-yellow tubes before maturity, as does *L. insigne* var. *luteopallidum*. The stipe ornamentation in *L. aurantiacum* var. *pallidipes* scarcely darkens whereas that of *L. atrostipitatum* is dark from the very beginning. *L. discolor* has wood-brown spores in deposit, *L. laetum* has an olive tone in the spore deposit, etc. Certain odd features have also come to light in the present study, such as the membranous veil in *L. potteri*. The color changes when cut surfaces of the basidiocarp are exposed to air (oxidation reactions) presented a difficult problem. However, we have used two as features of major importance because from field observations the color changes to gray, fuscous, or blackish and that to yellow were constant. The change to blue in the stipe, however, appeared to be the most erratic and one most likely to be associated with age of the basidiocarp. Hence it does not even appear in our key though in the descriptions it has been recorded where observed. We have noted differences which depend on age in certain color changes in carpophores, as we have with color reactions produced by the application of $FeSO_4$; these differences are noted in the descriptions.

Spore width is another important feature. We find that in section *Leccinum* generally the spores are narrow (3-5 μ wide) whereas in the *L. scabrum* and *L. holopus* groups 5-7.5 μ is more typical. As our present account shows, however, wide spores are known for section *Leccinum* also. We shall have more to say on this matter when our study of the genus is complete.

Since it has been clearly shown that boletes in general form mycorrhiza with forest trees we assume that the fungus-tree associations we have observed are based on this relationship. In this respect some species seem to show a wide range of adaptability, and others appear to be narrowly restricted. We found in the course of our study that before we could speak with any authority on such relationships, some revised taxonomic concepts were essential.

The field work has been carried on incidental to other projects as time permitted. Generous support from the Faculty Research Fund of the University of Michigan financed much of the senior author's early work. In more recent years support from the National Science Foundation (Grants G-2313 and GB-2902) has been of great help and is acknowledged with pleasure. Through an arrangement with the Royal Botanic Garden, Edinburgh, Scotland, Dr. H. R. Fletcher, Regius Keeper, and with expenses from National Science Foundation Grant G-13282 to the University of Michigan Herbarium, Dr. Watling spent four months in the University Herbarium studying a backlog of collections of the Bolbitiaceae, and followed this with two months at the University of Michigan Biological Station where we all three concentrated on *Leccinum* since it was a good season for these fungi. We are happy to acknowledge the help given by way of facilities and the cooperation extended by Prof. A. H. Stockard, Director, in furthering our study. The Biological Station is an ideal location for the study of *Leccinum*. Funds covering excess pagination were furnished by N.S.F. Grant G13282.

Since a monograph of the genus is planned, the usual discussion of taxonomic features is not given here. Drawings of the microscopic features and lists of all the material examined are omitted. All color names within quotation marks are taken from Ridgway, *Color Standards and Color Nomenclature*, Washington, D.C., 1912. Types are deposited at the University of Michigan Herbarium, but where additional material was available, it has been deposited at the Royal Botanic Garden, Edinburgh, and in the Herbarium of San Francisco State College. The photographs are by A. H. Smith.

KEY TO SPECIES OF SECTION LECCINUM

1. Pileus white to dingy white, when mature buff to pale crust brown; stipe clavate (up to 7 cm at base when young); bruised tube mouths olive-yellow darkening to dull brown . . . . *L. clavatum*
1. Pileus more highly colored when mature 2
   2. Young tubes pale yellow 3
   2. Young tubes pallid, white, or olive-pallid 4
3. Spores 5-7 μ wide . . . . *L. imitatum*
3. Spores 4-5 μ wide . . . . *L. insigne* var. *luteopallidum*
   4. Pileus dark gray-brown ("hair brown") . . . . *L. obscurum*
   4. Pileus some other color 5
5. Young pileus with flat irregular patches representing remains of an outer membranous veil . . . . *L. potteri*
5. Not as above 6
   6. Cut context in pileus and stipe-apex turning from pallid to yellow . . . . *L. sublutescens*
   6. Cut context either not staining or becoming reddish to gray 7
7. Spores (10-15 x 4-5 μ) 17-25 x 5-6 (34 x 6) μ; pleurocystidia up to 20 μ broad . . . . *L. solheimii*
7. Not as above 8
   8. Cut context of pileus and stipe apex unchanging or not staining gray to fuscous 9
   8. Cut context finally stained gray to fuscous 11
9. Pileus orange-tan to clay-color; stipe ornamentation concolorous with the pileus . . . . *L. subfulvum*
9. Pileus much darker ferruginous to dark red 10
   10. Spores 3.5-4.5 μ wide . . . . *L. vulpinum*
   10. Spores 4.5-6 μ wide . . . . *L. ponderosum*
11. Cuticular hyphae as mounted in Melzer's showing pigment balls or globules in some of the cells 12
11. Cuticular hyphae in Melzer's with homogeneous to granular pigment . . 14
   12. Young tube mouths cinnamon-brown; pileus liver-brown . . . . *L. subtestaceum*
   12. Not as above 13
13. Many cuticular hyphae asperulate (as in *L. insigne*); mouths of tubes yellowish-green when bruised; stipe clavate and 4-8 cm broad near base . . . . *L. fallax*
13. Not as above . . . . *L. aurantiacum*

14. Spore deposit olive; stipe viscid at base when fresh . . . . *L. laetum*
14. Not as above 15
15. Spore deposit fuscous moist (wood brown air-dried); pileus orange-brown to dark yellow-brown; spores 5-6 (7) μ wide. . . *L. discolor*
15. Not as above. 16
16. Pileus basically yellow (or with a faint overcast of gray fibrils) . . . . *L. ochraceum*
16. Not as above; pileus with more red, orange or flushed apricot, buff to tawny 17
17. End-cells of epicuticular hyphae up to 20-30 μ broad; pileus pale rose pink. . . . . *L. barrowsii*
17. End-cells less inflated or if up to 20 μ broad then pileus more strongly pigmented 18
18. Pileus dark liver-brown and typically rather coarsely fibrillose. . . . . *L. fibrillosum*
18. Pileus orange to ferruginous-tan, cinnamon or vinaceous 19
19. Stipe when young with conspicuous black ornamentation; pileus pale orange-buff to apricot but slowly becoming orange-brownish and spotted with aggregations of fibrils . . . . *L. atrostipitatum*
19. Stipe ornamentation pallid when young though often soon becoming brown to blackish at least over lower half of stipe 20
20. Pileus cinnamon-buff to cinnamon, cinnamon-brown to incarnate . . 21
20. Pileus orange to ferruginous (may be duller in age) 22
21. Pileus cutis with hyphae often up to 22 μ wide, with bullet-like end-cells, walls often asperulate; pileus dull cinnamon . . . . *L. cinnamomeum*
21. Pileus cutis of broad (6-11 μ) tubular hyphae nearly always smooth; pileus vinaceous to vinaceous-cinnamon . . . . *L. incarnatum*
22. Epicutis of hyphae 3-6 μ diam.; context hyphae revived in Melzer's orange-red near subcutis. . . . . *L. boreale*
22. Epicutis of pileus with numerous hyphae 8-15 μ diam.; context hyphae not colored as above in Melzer's . . . . *L. insigne*

Leccinum clavatum sp. nov.

Pileus 8-20 cm latus, convexus demum late convexus, ad marginem appendiculatus, siccus, demum subviscidus, impolitus demum subsquamulosus, pallidus, ad centrum tarde pallide alutaceus. Tubulis albidis demum avellaneis, tactu brunneis. Stipes 4-8 cm longus, sursum 1.5-3 cm crassus, deorsum bulbosus (-7 cm crassus), albidus, squamuloso-scabrosus; squamulae albidae tarde brunneae; sporae 14-18 × 4-5 μ. Typus: Smith 15961 (MICH).

Pileus 8-20 cm broad, convex becoming broadly convex, margin appendiculate as in *L. aurantiacum*, surface typically dry, when old and moist somewhat viscid, appressed fibrillose-tomentose, the fibrils becoming aggregated into small appressed squamules over all in age, areolate, color white to pallid ("tilleul-buff") young, gradually becoming pale tan ("pinkish-buff" to "cinnamon-buff") on disc or over all in age. Context 2-3 cm thick, white, soft and spongy, turning bluish-gray in young specimens when cut, unchanging in old pilei, odor faintly fragrant, taste mild to nutty.

Tubes 1-2 cm long, depressed, whitish when young, soon dingy avellaneous, changing to brownish where bruised; mouths small (2 per mm), round, not stuffed, whitish, with thin dissepiments, gradually yellowish or if bruised sordid olive-yellow, when young quickly changing to brownish where bruised.

Stipe short, 4-8 cm long, 1.5-3 cm thick at apex, bulbous base up to 7 cm thick, solid, white within except for the yellowish to greenish-yellow base in old specimens, surface white at first, densely scabrous, scabrosity slowly darkening to a dull brown, in old specimens surface may appear coarsely fibrillose with the fibrils toward the base dark brown, staining blue where cut or handled ("light methyl blue"); note that young buttons did not give this change but in time changed to pinkish.

Spore deposit "Mars brown" (dark rusty brown). Spores 14-18 (19) × 4-5 μ, narrowly subfusoid in face view, narrowly and obscurely inequilateral in profile, smooth, yellowish hyaline to dingy ochraceous revived in KOH, in Melzer's yellowish or a few reddish tawny, wall relatively thin.

Basidia 28-34 × 8-10 μ, 4-spored, very delicate and soon collapsing, yellowish to hyaline in KOH and Melzer's. Pleurocystidia scattered, 34-46 × 8-12 μ, fusoid-ventricose with tapered curved neck and subacute apices, thin-walled, smooth, hyaline to yellowish or darker as revived. Cheilocystidia similar to pleurocystidia but neck less elongated. Caulocystidia clavate to fusoid-ventricose or mucronate, 36-57 × 10-16(20) μ, content pale ochraceous, walls thin and smooth. Caulobasidia and basidioles 18-33 × 7-12 μ, content ochraceous, often merely in the form of unenlarged hyphal tips but mostly clavate. Cutis of pileus a matted-down aggregation of fibrils with content yellowish to yellowish-brown when revived in KOH and yellowish hyaline in Melzer's, the end-cells 5-15 μ diam. and tubular to narrowly clavate, hyphal cells tending to disarticulate in mounts from old pilei, walls smooth, thin, and hyaline. Context of interwoven hyaline hyphae 10-15(20) μ diam. and yellowish hyaline to pale orange when revived in Melzer's. Clamp connections none.

Gregarious under spruce and fir, near Lick Creek Summit, Idaho National Forest, McCall, Idaho, Aug. 3, 1941. Smith 15961, type.

The diagnostic features of this species are the whitish pileus which finally becomes the color of pale toast on the disc, the young injured tube mouths staining brown when injured severely, the base of the stipe staining methyl blue on mature basidiocarps, the white stipe-ornamentation slowly becoming brown as the basidiocarps age, and the clavate-bulbous stipe. The pileus margin is frequently intergrown with the stipe in the manner of a *Gastroboletus*. The spores are longer than for *L. percandidum* (Vassilk.) Watling, and that species has quite a different habitat.

Leccinum imitatum sp. nov.

Pileus 6-10 cm latus, convexus vel late convexus, demum subplanus, siccus, fibrillosus, sordide rufus demum cinnamomeus, ad marginem appendiculatus. Tubulis luteis; orificiis luteobrunneis. Sporae 14-18 × 5-7 μ. Hyphae epicuticularum levis. Typus: Smith 66706 (MICH).

Pileus 6-10 cm broad, convex to broadly convex or finally nearly plane, surface dry and matted-fibrillose, becoming more conspicuously fibrillose in age, color when young evenly dingy rufous, becoming duller and in age or when dried dull cinnamon (near "Sayal brown"), margin appendiculate at first. Context white, firm, becoming soft, slowly bluish-gray to fuscous when cut, odor and taste not distinctive, with $FeSO_4$ greenish.

Tubes pale yellow in young specimens with the mouths dull yellow-brown ("bister" to "snuff-brown"), depressed around the stipe in age, 1.5 cm long in ventricose part, becoming grayish to near wood-brown at maturity; mouths small, round, concolorous with the sides in age.

Stipe 6-12 cm long, 1-2 cm thick, equal to evenly enlarged downward, solid, white, within finally staining blackish when cut or in drying, weakly yellowish in basal area in some as dried, staining blue in base when fresh; surface whitish with blackish ornamentation to apex.

Spore deposit dull rusty brown ("cinnamon-brown"). Spores 14-18 × 5-7 μ, smooth, wall thickened, in KOH dingy ochraceous to brownish-ochraceous, in Melzer's dingy yellowish to pale tan, rarely a few dextrinoid; shape in face view subfusoid, in profile inequilateral, suprahilar depression broad.

Basidia 23-38 × 10-12 μ, 4-spored, short-clavate, hyaline to yellowish in both KOH and Melzer's. Pleurocystidia abundant, 38-52 × 10-15 μ, fusoid-ventricose, the apices subacute to obtuse, wall thin and smooth, content hyaline in some both in KOH and Melzer's. Caulocystidia clavate to a few mucronate or fusoid-ventricose, 9-22 μ wide, content bister in KOH, walls thin and smooth. Tube trama of hyphae somewhat divergent from a central strand. Pileus cutis a tangled layer (not a trichodermium) of hyphae 4-9 μ diam. the end-cells usually tapered somewhat and rarely inflated in the midportion; in KOH the content orange-brown to dingy pale ochraceous brown and homogeneous to granular, when revived in Melzer's the content reddish and homogeneous at first but slowly becoming paler and somewhat granular; walls thin and smooth. Context hyphae next to cutis with orange to orange-red content as revived in Melzer's. Clamp connections none.

Under aspen, Pellston Hills, west of Pellston, Michigan, June 21, 1963. Smith 66706, type.

The distinguishing features of this species are the wide spores, the tubes yellow at first and with their mouths dark yellow-brown when young. The pileus colors are intermediate between the ferruginous and the dull cinnamon species. The spores are wider than in

L. aurantiacum and the Melzer's reaction of the content of the epicuticular hyphae is also different.

Leccinum potteri sp. nov. Figs. 1 & 3

Pileus 4-12 cm latus, convexus demum late convexus, pallide areolato-squamulosus, sublateritius, ad marginem appendiculatus. Tubulis albidis demum griseobrunneis, tactu subluteis. Stipes 5-10 cm longus, 1-2.5 cm crassus, aequalis, scabrosus; deorsum in siccatis sulphureus. Sporae 13-16 × 4-5 μ. Typus: V. Potter 12480 (MICH).

Pileus 4-12 cm broad, convex becoming broadly convex, surface at first coated with a thin submembranous pallid outer veil which soon breaks up into small areolate patches that gradually disappear, margin with sterile flaps of cutis as in *L. aurantiacum* and some veil material adhering to outer surface of these, the surface beneath the veil remnants more or less matted-fibrillose and dull brick-orange to dingy pale orange-tawny, evenly colored. Context pallid, when cut turning vinaceous then lavender and then gray, staining blue in base when cut; odor slight, taste not distinctive, $FeSO_4$ bluish, KOH yellow on tubes.

Tubes white when young, becoming wood-brown at maturity, yellowish then brownish when mouths are bruised, mouths pallid when young, small, round.

Stipe 5-10 cm long, 1-2.5 cm thick at apex, equal or enlarged downward slightly, solid, white and scabrous when fresh, base slowly bluish and scabrosity becoming finally near blackish-brown ("Mummy brown") but usually more nearly dark yellowish-brown, when dried the surface over basal part lime-green to sulphur-yellow, not so yellow in the interior, upper parts drying pallid to grayish except for the dark ornamentation.

Spore deposit tawny brown (Potter), olive-brown (Smith 72506). Spores 13-16 × 4-5 μ, smooth, narrowly fusoid in face view, in profile narrowly subinequilateral, suprahilar depression broad but shallow, when revived in KOH dingy ochraceous and in Melzer's pale tawny to tawny, no "fleeting amyloid" reaction present.

Basidia 4-spored, 18-22 × 8-11 μ, hyaline in KOH. Pleurocystidia none found. Cheilocystidia 18-36 × 4-9 μ, clavate to elongate-fusoid or fusoid-ventricose, mostly ochraceous in KOH, soon gelatinizing. Caulocystidia in fascicles, clavate to ellipsoid or balloon-shaped, 40-90 × 12-20 μ, with smoky-brown content in KOH, walls smooth and thin. Tube trama very soon gelatinizing in KOH and hyphal arrangement could not be accurately interpreted. Pileus cutis a trichodermium which collapses, the elements with clavate end-cells 7-12 μ diam. when young but in age many of them show a tapered neck, some with roughened and some with smooth walls; with a tendency for cells to disarticulate at the septa, cell content in KOH lemon-yellow to dingy brownish ochraceous, in Melzer's the content merely yellowish and homogeneous or in a few hyphae red pigment globules present in small numbers. Context hyphae hyaline in KOH, thin-walled, interwoven, hyphae 9-12(15) μ diam., as revived in Melzer's with masses of pinkish-red granular material in some of the cells of some hyphae, remaining hyphal cells in a filament hyaline to yellowish. Veil material lemon-yellow in KOH from dissolved pigment, hyphae interwoven, thin-walled and 4-10 μ diam. Clamp connections absent. All hyphae inamyloid.

Scattered on the ground in mixed woods, especially with large-toothed aspen; type from the State Game Area, Edgewood, Mich., Oct. 4, 1959, V. Potter 12480. It was not uncommon under large-toothed aspen in Washtenaw County during September, 1965, as well as in Cheboygan and Emmet counties.

This fungus has passed as a variant of *L. aurantiacum* for years in Michigan, but is constant in the KOH reactions, in the veil features, and the greenish-yellow stipe base which is often quite intensively colored when dried. Specimens of *L. aurantiacum* attacked by the common white bolete mold may at times have some of the white mold on the pileus as patches or along the pileus margin, but basidiocarps so infected seldom mature properly and do not have the above mentioned features. The white fragments of mycelium on *L. aurantiacum* can be cultured readily whereas the veil remnants on *L. potteri* cannot, a further indication that the two are in no way homologous. The KOH reaction of the cuticular hyphae will separate this species from *L. aurantiacum* if veil material is lacking.

Leccinum sublutescens sp. nov.

Pileus circa 7 cm latus, convexus, ad marginem appendiculatus, siccus, demum areolato-squamosus, aurantio-cinnamomeus. Stipes circa 8 cm longus, 8-10 cm crassus, atropunctatus, intus lutescens. Sporae 12-15 × 3-4.5 μ. Typus: Smith 72765 (MICH).

Pileus about 7 cm broad, convex, margin appendiculate, surface dry and conspicuously areolate from separation of the cutis, orange-cinnamon and drying orange-brown, pallid context showing in cracks. Context when cut slowly yellowish in both pileus and in the stipe apex, in the apex pale vinaceous-buff to dull pinkish-tan downward and lower two-thirds white and remaining so even when dried.

Tubes about 1 cm long, depressed around stipe, white becoming dull cinnamon in drying; mouths small, round, pallid at first, staining ochraceous when lightly bruised and this progressing to olivaceous.

Stipe about 8 cm long and 1 cm thick, nearly equal, solid, (for color changes see context), surface whitish beneath a fine sparse blackish ornamentation which fades out upward to the pallid only faintly ornamented apical region.

Spores 12-15 × 3-4.5 μ, narrowly subfusoid in face view, narrowly inequilateral in profile, smooth, pale ochraceous in KOH, pale tan in Melzer's.

Basidia 4-spored, clavate, hyaline in KOH, 18-24 × 9-10 μ, large hyaline globule frequent in interior in KOH. Pleurocystidia 34-45 × 8-12 μ, ventricose below, apex flexuous and subacute, 2-4 μ diam., varying to subfusoid with pointed apex; content smoky brownish to hyaline. Cheilocystidia clavate to subfusoid, 22-32 × 6-10 μ, content hyaline to smoky brown in KOH. Caulocystidia 36-60 × 10-17 μ, clavate mucronate or fusoid-ventricose, content finally smoky brown but caulobasidioles and supporting hyphae typically lemon-yellow in KOH. Pileus cutis of appressed hyphae 5-12 μ diam., the cells disarticulating to some extent, walls smooth to rarely obscurely asperulate, content of cells orange-brown to ochraceous brown in KOH and dark orange-brown in Melzer's and in the latter medium large orange-brown to dull brown pigment globules forming in many cells, cells mostly more than five times as long as wide; hyphae of subcutis interwoven, subgelatinous, lemon-yellow in KOH, nearly same color in Melzer's. Context hyphae with hyaline to pale yellow content when revived in Melzer's. Clamp connections absent.

Solitary in mixed hardwood-conifer area, Mackinaw City Hardwoods, Mackinaw City, Mich., Oct. 2, 1965. Smith 72765, type.

The distinctive features appear to be the areolate pileus, general lack of gray stains when fresh basidiocarp is sectioned (though the context is very pale gray as dried), the yellow staining of the cut context of pileus and stipe apex, and the bright yellow color of the hyphae of the subcutis. The yellow stains and KOH color-change of the subcutis clearly distinguish it from *L. vulpinum*. The hyphae supporting the stipe ornamentation and the elements themselves when young are lemon-yellow in KOH when revived. The narrow spores and KOH reactions relate the species to *L. potteri* but no masses of red pigment were found in any of the hyphae of the context.

Leccinum vulpinum Watling

Pileus 7-10 cm broad, flat when expanded, the surface dry and obscurely roughened but not squamulose; color dark brick red ("ferruginous" or darker), when dried dull vinaceous-brown; margin appendiculate when young. Context pallid when cut and scarcely changing or merely slightly brownish in pileus, with a dark olive watery line above the tubes, when dried mostly pallid but with some gray streaks or patches, with $FeSO_4$ bluish olive.

Tubes pallid becoming avellaneous, slightly depressed around the stipe; mouths pallid staining yellow and finally yellowish brown, when severely bruised not becoming fuscous or vinaceous gray, when dried dingy cinnamon.

Stipe 10-13 cm long, 1-1.5 cm thick at apex, nearly equal, solid, fibrous, pallid within and when cut slowly very pale vinaceous in places, soon staining rich indigo blue in base; surface pallid above beneath the dull brown ornamentation, extreme apex whitish, lower down the ornamentation moderately coarse and brown (but drying blackish), surface flushed yellowish to greenish in mid-portion and drying with these tones evident as in *L. potteri*.

Spore deposit dingy clay-color air-dried, but on standing darkening to dingy cinnamon. Spores 14-17(19) × 3.5-4.5 μ, smooth, wall scarcely thickened, narrowly subfusoid in face view, narrowly inequilateral in profile, suprahilar depression broad and shallow, in KOH clay-color, in Melzer's yellowish brown.

Basidia 4-spored, 16-20 × 8-10 μ, yellowish hyaline in KOH and Melzer's. Pleurocystidia none seen. Cheilocystidia mostly clavate, 20-30 × 7-9 μ, ochraceous in KOH to hyaline, walls thin and soon gelatinizing. Caulocystidia 34-50(60) × 9-15 μ, clavate to fusoid-ventricose, apex obtuse, content smoky ochraceous to brownish in KOH. Pileus cutis of tangled hyphae 5-8(12) μ diam., cells 30-70 μ long or longer, end-cells not distinctively differentiated, walls smooth, thin, no disarticulation of cells noted, content dull orange in KOH, in Melzer's the content soon forming minute granules, very few refractive thickenings seen against interior wall surfaces. Subcutis of interwoven gelatinous hyaline hyphae 2.5-5 μ diam., not colored in KOH or Melzer's. Context hyphae hyaline, interwoven, 6-15 μ diam., lacking colored contents in Melzer's or refractive content in KOH. Clamp connections absent. No colored pigment balls present in mounts in Melzer's.

Solitary in mixed woods with pine, Cheboygan and Barry counties, Mich., in the fall. The description is from Smith 72725, collected by Sam Mazzer in Barry County, Sept. 25, 1965.

This is a distinctive species related to *L. potteri* in the narrow spores and the color of the stipe especially as dried, but the cuticular hyphae were not lemon-yellow in KOH and no veil material was found. There was no change to gray on the fresh specimens when cut, though some shows on the dried specimens.

Leccinum subfulvum sp. nov.

Pileus 6-12 cm latus, convexus, siccus, fibrillosus, subaurantiacus demum argillaceus. Caro immutabilis. Stipes 5-10 cm longus, 1-2 cm crassus, clavatus, argillaceo-scabrosus, immutabilis. Sporae 13.5-17 × 4.5-5.5 μ. Typus: Smith 40334 (MICH).

Pileus 6-12 cm broad, convex to broadly convex, surface dry and with distinct appressed fibrillose squamules which in age allow the pallid context to show, color pale orange but soon orange-tan and at maturity and as dried dull clay-color. Context white, when cut unchanging, when dried whitish.

Tubes 1-2 cm long, depressed around stipe, dingy yellowish-brown as dried, mouths concolor and apparently not staining (when dried paler than in any other species).

Stipe 5-10 cm long, 1-2 cm thick at apex, 3-4 cm thick at or near base, pointed below, solid, white, unchanging when cut and drying whitish or pallid, ornamentation in form of squamules below and points above and concolorous with cutis of cap as dried. No blackening anywhere.

Spores 13.5-17 × 4.5-5.5 μ, smooth, fusoid in face view, inequilateral in profile, in Melzer's a fair number dextrinoid, mostly merely yellowish-tan, in KOH hyaline to ochraceous, suprahilar depression prominent.

Basidia 23-28 × 8-11 μ, hyaline, 4-spored, clavate. Pleurocystidia 36-48 × 7-12 μ, hyaline in KOH and Melzer's sol., fusoid-ventricose with long often flexuous neck and obtuse to subacute apex. Cheilocystidia clavate to narrowly fusoid, 26-30(38) × 5-10 μ, ochraceous in KOH, thin-walled. Caulocystidia 10-25 μ diam., ellipsoid to fusoid-ventricose, content pale ochraceous. Pileus cutis of hyphae 5-10(12) μ; cells very readily disarticulating, cells usually 5 times as long as wide or more, tubular or the degree of inflation very slight, a few bullet-shaped end-cells present but mostly no significant differentiation noted; walls roughened in many (revived in KOH) and pale pinkish-buff to pinkish-buff, slowly becoming hyaline, in Melzer's the content homogeneous and pale orange fading to yellow and a few granules present (rarely of medium size). Context hyphae with orange to red content when revived in Melzer's. Clamp connections absent.

Under *Pinus contorta*, Powerhouse area, Mt. Rainier Nat'l Park, Sept. 29, 1952. Smith 40334, type.

This species is distinct by the clay-colored squamulose pileus at maturity, the unchanging flesh when cut, the dull clay-colored ornamentation of the stipe which does not blacken in age or on drying, and lack of pigment globules in the cutis hyphae when revived in Melzer's.

Leccinum solheimii sp. nov.

Pileus 10-25 cm latus, convexus, ad marginem appendiculatus, subfibrillosus, lateritius. Caro immutabilis. Stipes 4-10 cm longus, 2-3 cm crassus, clavatus, solidus, intus albidus, subsquamulosus, squamulis brunneis. Sporae (10-15 × 4-5 μ) 17-25 × 4-5 μ (34 × 6 μ). Typus: Solheim 6241 (MICH).

Pileus 10-25 cm broad, convex becoming broadly convex, the margin appendiculate, surface granular-roughened to appressed fibrillose; dark brick-red drying dark red-brown. Context thick, punky, where cut not showing any distinct color change when dried.

Tubes about 2 cm long, depressed around the stipe, dingy yellow-brown when dried; mouths minute, in some areas discolored dark brown, under the microscope the cheilocystidia ochraceous indicating a possible yellow stain of fresh tube mouths.

Stipe 4-10 cm long, 2-3 cm thick at apex, clavate, solid, white within, merely dingy buff when dried except for a lemon-yellow flush at base inside and out; surface ornamented by sepia to bister appressed-fibrillose ornamentation over a yellowish ground color (as dried), apex pallid.

Spores (10-15 × 4-5 μ) 17-25 × 5-6 μ (34 × 6 μ), very variable in size and shape, typical range in shape narrowly subfusoid to obscurely angular-elongate in face view, in profile angular-elongate to narrowly subinequilateral in Melzer's slowly dextrinoid, in KOH hyaline in young material and ochraceous to clay-color in old pilei.

Basidia 2- and 4-spored, 10-12 μ diam., with a hyaline large globule in many. Pleurocystidia 40-65 × 12-20 μ, hyaline or with dull brown content in KOH or Melzer's, ventricose-rostrate to fusoid-ventricose. Cheilocystidia clavate to subfusoid, 23-32 × 5-10 μ, ochraceous in KOH, apex with a refractive narrow wall-thickening. Caulocystidia mostly clavate, some fusoid-ventricose, 30-55 × 9-15 μ, the hyphae of the fascicle with very short cells and in some showing a tendency to inflate (as subhymenial cells in *Rhizopogon* often do); content of cystidia dingy ochraceous to smoky brown, numerous hyaline refractive interior wall thickenings in the epicuticular hyphae of the stipe. Cutis hyphae as in *L. aurantiacum*, in Melzer's with pigment globules orange to red; in KOH content dingy reddish to dull ochraceous; hyphae 5-11 μ, smooth to rarely with slightly roughened walls, cells five times as long as wide or longer, some cells disarticulating, end-cells not distinctively differentiated. In KOH mounts of the stipe cutis much lemon-yellow pigment diffusing into the mounts. Context hyphae when revived in Melzer's with ochraceous to orange content or merely hyaline, no refractive thickenings seen against interior wall.

Under *Pinus contorta*, at bridge over Nash Creek, Medicine Bow Mountains, Albany County, Wyoming, Sept. 16, 1961. Solheim 6241, type.

The pattern of spore variation here is that observed by Smith (Smith & Zeller, 1966) for spores in some species of *Rhizopogon* and which to some degree has been observed in such genera as *Psathyrella* and *Inocybe* in the agarics. This pattern involves a tendency to angularity of the spore and extreme variation in length, or both combined. Along with this one encounters a small percentage of spores versiform in shape and deviating markedly from what might be termed typical. The pigment in the hyphae of the epicutis of the pileus aggregates into pigment balls in Melzer's as in *L. aurantiacum*, but the pleurocystidia are the largest we have seen in the section. The tendency for some of the subhymenial cells in the fascicles of stipe ornamentation to enlarge appears to be an unusual feature in the genus, as is the presence of a large number of local hyaline refractive interior wall thickenings in hyphae of the stipe epicutis.

Leccinum ponderosum sp. nov. Fig. 4

Pileus 10-30 cm broad, convexus demum late convexus, subviscidus, ferrugineo-brunneus. Caro immutabilis. Stipes 8-16 cm longus, 2-3 cm crassus, clavatus, tactu subcaerulescens, subsquamulosus. Spore 14-17 × 4.5-5.5(6) μ. Typus: Smith 55718 (MICH).

Pileus 10-30 cm broad, obtuse to convex when young, with appendiculate margin, expanding to broadly convex to nearly plane with the margin spreading somewhat, surface subviscid when young, becoming more viscid in age, glabrous to appressed fibrillose, ferruginous-red ("Kaiser-brown" to "vinaceous-rufous" or "rufous") and when dried pale dull brick red. Context white when cut and not changing appreciably, but as dried mostly merely buff-color throughout pileus and stipe but with a few gray streaks.

Tubes 1-2 cm long (in young caps), adnate-subdecurrent, dingy clay-color as dried; mouths minute, pallid to avellaneous when young, staining ochraceous where lightly bruised.

Stipe 8-16 cm long, 2-3 cm thick at apex, evenly enlarged downward to 5-9 cm, solid and hard, merely pale buff within when dried; surface ornamented with avellaneous to fuscous points and squamules arising from a pallid cottony rather well-developed under-layer, where handled staining blue (entire base finally) and in drying becoming yellow to olive-yellow, the ornamentation drying near "snuff brown" and appearing as irregular patches of appressed material, apex pale buff, when fresh often flushed reddish like the pileus.

Spores 14-17 × 4.5-5.5(6) μ, smooth, ochraceous in KOH, tan in Melzer's, fusoid in face view, inequilateral in profile.

Basidia 4-spored, 18-24 × 9-12 μ, often with a large hyaline globule. Pleurocystidia 36-45 × 8-13 μ, fusoid-ventricose with neck often irregular, apices acute to subacute, content hyaline or brownish. Cheilocystidia clavate to clavate-mucronate, 20-32 × 7-12 μ, ochraceous in KOH. Caulocystidia mostly clavate (30)40-70 × (8)10-18 μ, content smoky ochraceous in KOH. Pileus cutis with hyphae of epicutis 4-12 μ diam., the end-cells not distinctively differentiated (at most merely somewhat cystidioid), walls smooth or very rarely minutely asperulate, cells readily disarticulating, cells mostly more than 5 times longer than wide, content brownish in KOH and pigment separating in rather indistinct globules, in Melzer's with large medium and small pigment globules red to orange-red in color. Context hyphae near subcutis with yellow to orange content when revived in Melzer's. Clamp connections none.

Solitary to scattered under *Pinus ponderosa* and *P. lambertiana* near Grants Pass, Ore., Nov. 16, 1956. Smith 55718, type.

This is the monster of all the large western species of *Leccinum* but is close to *L. aurantiacum* in pileus color and was identified as that species in the field. Its distinctive features as a species are: The stipe staining blue so readily when handled, the brown stipe-ornamentation as dried and its smeared appearance, the lack of a clear-cut change to gray or fuscous when the context is cut, and spores centering around 5-5.5 μ wide. The latter is a fine distinction but possibly of some merit, for in *L. aurantiacum* and *L. vulpinum* they center around 4 to 4.5 μ.

Leccinum subtestaceum sp. nov. Figs. 5, 6, & 7

Pileus 4-12 cm latus, convexus vel late convexus, ad marginem appendiculatus, obscure ferrugineus vel subtestaceus (''Hay's russet''), fibrillosus. Tubulis orificiis cinnamomeo-brunneis. Sporae 11-15 × 4-5 μ. Hyphae epicuticularum 4-10(12) μ diam. in ''Melzer's'' cum globulis aurantiis. Typus: Smith 67243 (MICH).

Pileus 4-12 cm broad, convex to broadly convex, surface dark ferruginous to liver color (''Hay's russet'') and glabrous to finely fibrillose, in age becoming obscurely areolate, sterile margin soon broken into segments. Context white, changing to vinaceous gray to slate color, soon blue in base of stipe, odor and taste mild; $FeSO_4$ greenish-blue.

Tubes whitish becoming gray to wood-brown, 1-2 cm long, depressed around the stipe in age, adnate at first, slowly vinaceous-gray when cut; mouths small round and ''cinnamon-brown'' when young, paler in age.

Stipe 7-12 cm long, 2-3 cm thick at apex, equal or evenly enlarged downward, solid, white within, staining vinaceous-slate when cut, bluish in and around the base in some; surface white but overlaid with a black reticulate scabrous coating of lines and points.

Spores 11-15 × 4-5 μ, smooth, walls thickened slightly, narrowly subfusoid in face view, in profile inequilateral-elongate, brownish-ochraceous to ochraceous when revived in KOH, and in Melzer's ochraceous tan (rather pale and dingy).

Basidia 4-spored, clavate, 22-27 × 8-11 μ, hyaline to yellowish in KOH. Pleurocystidia none seen. Cheilocystidia 23-24 × 5-9 μ, subfusoid with obtuse apex to clavate, dingy ochraceous in KOH. Caulocystidia mostly fusoid-ventricose or clavate-mucronate, some remaining clavate, thin-walled, smooth, content dark smoky-brown as revived in KOH. Pileus cutis of appressed interwoven hyphae 4-10(12) μ diam., the end-cells mostly narrowly clavate to cylindric, tips obtuse, content in KOH orange-brown to orange-ochraceous, in Melzer's the content breaking up into pigment balls or masses so that end-cells often simulate a tube filled with beads. Context hyphae lacking a highly colored content when revived in Melzer's. Clamp connections absent.

On soil under aspen, University of Michigan Biological Station, Aug. 19, 1963. Nancy Jane Smith collector, A. H. Smith 67243, type.

The base of the stipe shows some yellowish stain. The diagnostic features are the Melzer's reaction on the pigments of the cuticular hyphae, the cinnamon-brown tube mouths when young, and the very dull reddish pileus.

Leccinum fallax sp. nov.

Pileus 6-20 cm latus, obtusus vel convexus demum late convexus, ad marginem appendiculatus, siccus, fibrillosus, rubro-ferrugineus. Stipes 6-14 cm longus, 1-4 cm crassus, clavatus, deorsum 5-8 cm crassus, demum subequalis, deorsum tactu olivaceo-luteus. Sporae 14-17 × 3.2-4.5 μ. Hyphae epicuticularum asperulatae, cum globulis aurantiis in "Melzer's." Typus: Smith 15962 (MICH).

Pileus 6-20 broad, obtuse to convex expanding to broadly convex, margin appendiculate from sterile portions of over-grown pileus margin, surface dry, matted-fibrillose under a lens, evenly rufous over all ("dragon's blood red," "ferrugineous," or "rufous"), orange color remaining distinct in dried material. Context thick and soft, white slowly staining dingy grayish vinaceous where bruised or cut; odor and taste mild.

Tubes 1-2 cm long, depressed around the stipe, whitish slowly becoming pale avellaneous, finally near wood-brown, mouths small round, pallid to grayish staining slowly when bruised to yellowish green and then brownish or at times merely olive-yellowish.

Stipe 6-14 cm long, 1-4 cm thick above, clavate bulb up to 8 cm, becoming nearly equal in age, solid, white within, staining reddish slowly when cut and finally going to blackish, staining bluish-green in and around the base when handled or damaged, surface white at first, scabrous-roughened, the scabrosity gradually staining dark brownish but not blackish even when dried.

Spores 14-17 × 3.2-4.5 μ, smooth, narrowly subfusoid in face view, in profile narrowly subinequilateral, in KOH yellowish, in Melzer's pale to bright tan.

Basidia 4-spored, 26-37 × 8-10 μ, hyaline in KOH and merely yellowish in Melzer's. Pleurocystidia scattered 44-60 × 9-15 μ, fusoid-ventricose, obtuse to subacute, thin-walled, smooth, hyaline or with ochraceous content. Cheilocystidia clavate to subfusoid, 18-30 × 5-8 μ, dull ochraceous in KOH. Caulocystidia mostly clavate and 9-14 μ broad but some up to 20 μ broad, mostly not with a projecting neck, content hyaline to yellowish in KOH, walls thin and smooth. Pileus cutis of appressed hyphae 4-11 μ diam. and with dull orange-brown content in KOH, in Melzer's the content orange-cinnamon to orange-red and aggregating into pigment balls much as in species of *Rhizopogon*, cells not or only slightly constricted at the septa, end-cell nearly equal in width throughout or narrowly clavate to a short-tapered apex, walls thin and many hyphae with asperulate walls. Context hyphae orange to red when revived in Melzer's. Clamp connections none. All hyphae inamyloid.

Gregarious under spruce, Lick Creek Summit, Idaho National Forest, Idaho, Valley County, Aug. 2, 1941. Smith 15962, type.

The distinctive features of this species are the pigment masses that form in Melzer's, the dark red pileus, the stipe ornamentation that does not turn black, and the conspicuously clavate-bulbous stipe. It differs further from *L. aurantiacum* in the much more conspicuously roughened cuticular hyphae. When dried the basidiocarps of the type collection somewhat resemble those of *L. subfulvum* but the latter is not dark red on the pileus when fresh and sectioned basidiocarps do not darken.

KEY TO VARIETIES OF *LECCINUM AURANTIACUM*

1. Stipe ornamentation pallid or merely becoming faintly brownish at maturity . . . . *L. aurantiacum* var. *pallidipes*
1. Ornamentation of stipe soon brown to blackish 2
   2. Cut flesh staining gray to fuscous directly . . . . *L. aurantiacum* var. *intermedium*
   2. Cut flesh staining pink to vinaceous before going to gray. 3
3. Stipe readily staining red around base but yellow and blue stains often evident also . . . . *L. aurantiacum* var. *aurantiacum*
3. Hyphae of subcutis when revived in KOH showing hyaline blisters or warts on the wall; base of stipe staining brownish to reddish but not multicolored as above . . . . *L. aurantiacum* var. *pinicola*

Leccinum aurantiacum (Fr.) S.F.Gray var. aurantiacum Fig. 9

Pileus 5-15(20) cm broad, convex to broadly convex, finally plane or broadly convex with an upturned margin, rarely with a low umbo, margin at first with a sterile band of tissue breaking up into segments; surface dry and uneven, roughened or appressed-fibrillose, in age more or less glabrous and subviscid; color bright to dull ferruginous-red but often with a pallid area where covered by leaves or debris. Context thick, white, when cut slowly staining vinaceous then grayish and slowly fuscous, with $FeSO_4$ very pale bluish; in the stipe when cut pallid at first but staining to fuscous in upper part, sometimes staining caerulean blue in the base and in places strongly reddish to red-brown.

Tubes 1-2 cm long, depressed around the stipe to nearly free, pale olive-buff slowly becoming darker ("wood brown"); mouths minute, olivaceous-pallid, when lightly bruised staining olive to olive-brown but where severely bruised stained avellaneous.

Stipe 10-16 cm long, 2-3 cm thick, dry, narrowly clavate to fusiform becoming equal, solid, fibrous and hard lower down, pallid within, when cut staining as indicated above, surface scabrous-roughened, pallid to whitish at first but ornamentation soon staining brown and finally blackish at least over basal half, apex often remaining pallid, in places yellowish but ground color mostly pallid to white, when dried often yellow over the base.

Spore deposit dark yellow-brown to dull cinnamon. Spores 13-16 (18) × 3.8-4.5(5) μ, smooth, in face view subfusoid, in profile narrowly somewhat inequilateral, in KOH pale ochraceous brown, in Melzer's merely yellowish-brown.

Basidia 4-spored, 8-9 μ broad, clavate. Pleurocystidia rare to scattered, hyaline in KOH to merely yellowish, 35-50 × 8-12 μ, apices obtuse. Cheilocystidia clavate to subfusoid, 18-26 × 5-8(10) μ, ochraceous to brownish in KOH. Caulocystidia mostly clavate, 9-30 μ diam., a few cylindric, smooth, content dingy yellowish in KOH. Cutis of pileus of appressed interwoven hyphae 5-12(15) μ diam., cells elongate (mostly more than 5 times as long as broad), walls thin, smooth to minutely roughened, the cells disarticulating to some extent; the end-cells narrowly clavate to tubular or near apex slightly tapered, the content yellow to orange-buff in KOH (in young caps distinctly reddish), in Melzer's the content orange-brown and forming globules of various sizes often filling the cell. Context hyphae hyaline in Melzer's. Clamp connections absent.

Scattered under pine and aspen, not uncommon during summer and fall throughout the state where aspen and pine grow; Smith 71887 is considered typical.

This species is well illustrated and described by Romagnesi (1958, pl. 136). As we have observed it in Michigan the cuticular hyphae are relatively smooth in contrast to those of *L. insigne* which is the common species under aspen in June. In the dried material the red pigment in the pileus of *L. aurantiacum* is more stable than in *L. insigne* and this is reflected in a distinct color difference between dried specimens. In *L. insigne* the stipe is ornamented with black ornamentation very soon whereas in *L. aurantiacum* it is not uncommon to find specimens with the stipe nearly white or with the ornamentation orange-tan to browner and only in age fuscous. In North America *L. aurantiacum* often fruits in mixed aspen-pine woods so it is impossible to be sure of the tree associate. The species is variable in the Great Lakes region and we have aberrant single specimens usually with one striking difference, such as the stipe ornamentation not coloring at all, etc. It is possible that *Boletus sanguinescens* Vel. should be segregated from the residuum still included in the type variety, although in recent British collections some variation within a wide population was noted which joined the type variety through intermediates to Velenovsky's fungus.

Leccinum aurantiacum var. pallidipes var. nov.

Pileus circa 10 cm latus, appendiculatus, rufus; stipes pallido-scabrosus; sporae 12-15 × 4-5 μ. Typus: Smith 72696 (MICH).

Pileus 10 cm broad, convex, margin appendiculate, surface obscurely fibrillose, subviscid to the touch, color dull orange-cinnamon to orange-rufous and vinaceous tan ("pecan brown") as dried. Context white, when cut staining blue-gray then fuscous, with $FeSO_4$ olive-blue.

Tubes 1.5 cm long, depressed around stipe, pallid, darkening to wood-brown; when young the tube mouths gray, staining olive if lightly bruised, when severely bruised avellaneous to wood-brown.

Stipe 11 cm long, 1.5 cm thick at apex, solid, equal, when cut the pallid surface soon flushed vinaceous then bluish and finally blackish; surface scabrous-ornamented and ornamentation coarse and white, scarcely becoming brownish on standing two days but in drying slightly grayish-brown in mid-portion; base dry hard and almost woody, basal area as dried olive-ocher.

Spore deposit near cinnamon-brown. Spores 12-15 × 4-5 μ, smooth, yellow in KOH, groups of spores pale tawny in KOH, face view narrowly subfusoid, in profile narrowly subinequilateral, in Melzer's merely pale tan.

Basidia 4-spored, often with large hyaline globule within. Pleurocystidia 35-50 × 8-14 μ, fusoid-ventricose, apices subacute, content hyaline to pale brownish in KOH. Cheilocystidia 20-30 × 4-8 μ, clavate to subfusoid, ochraceous as revived in KOH. Caulocystidia 38-63 × 13-20 μ, fusoid-ventricose, content hyaline to dingy ochraceous and in KOH not reviving readily; many caulobasidioles and slightly larger clavate cells also present and mostly hyaline in KOH. Pileus cutis with hyphae 4-9(12) μ diam., cells with dingy ochraceous content in KOH, orange-brownish in Melzer's and aggregating into pigment balls, cells usually 5 times or more as long as broad, walls smooth or minutely asperulate, no appreciable number of refractive bodies seen. Context hyphae lacking highly colored contents when revived in Melzer's. Clamp connections none.

Collected near Marquette, Michigan, by Mrs. Ingrid Bartelli, Sept. 21, 1965. Smith 72696, type.

This variant is worth recording because of the pallid stipe with the ornamentation scarcely changing color, the preponderance of fusoid-ventricose caulocystidia and gray tube mouths when young.

Leccinum aurantiacum var. pinicola var. nov.

Pileus 6-12(15) cm latus, convexus, aurantiacus vel lateritius; hyphae subcuticularum verrucosae; sporae 12-15 × 3.2-4.5 μ. Typus: Smith 72698 (MICH).

Pileus 6-12(15) cm broad, convex, expanding to broadly convex, margin appendiculate; surface at first dry to touch and appressed fibrillose, in age nearly glabrous and subviscid; colors dull brick red to dull reddish-orange ("Mars-orange," "burnt-sienna" to "auburn"), as dried dark vinaceous brown ("bone-brown"). Context pallid, when cut slowly staining fuscous, with $FeSO_4$ pale bluish, in stipe lower down changing to pale vinaceous and then fuscous when cut.

Tubes up to 2 cm long, depressed to nearly free, pallid becoming wood-brown where cut; mouths minute, pallid at first, slowly grayish, staining olive-brownish where bruised.

Stipe 8-14 cm long, 2-3 cm thick, equal, dry throughout, solid (for color changes see under context), surface coarsely ornamented from a cottony layer breaking up into squamules and points and finally forming an indistinct reticulum which is pallid at first but soon brownish in mid-portion and gray above (including cottony layer), base whitish but staining reddish to brown in places.

Spores 12-15(16) × 3.2-4.5 μ, smooth, narrow, walls slightly thickened, in face view narrowly subfusoid, in profile narrowly subinequilateral, suprahilar depression broad and shallow, in KOH pale buckthorn brown (yellow-brown) in mass, ochraceous singly, in Melzer's about the same color as in KOH (no deposit obtained on white paper but on one old stipe-apex the color was near bister).

Basidia 4-spored, 8-10 μ broad, brownish to hyaline in KOH, yellowish in Melzer's. Pleurocystidia scattered, 34-50 × 10-16 μ, fusoid-ventricose, thin-walled, content hyaline or hardly colored in KOH and Melzer's. Cheilocystidia clavate to almost globose-pedicellate, 18-26 × 7-11 μ, hyaline to slightly ochraceous in KOH. Caulocystidia 33-62 × 9-15(22) μ, clavate, obventricose, some fusoid-ventricose to clavate mucronate, content wood-brown in KOH, wall thin and smooth. Cutis of pileus a tangled mass of hyphae 5-10(15) μ diam.; the cells not or only slightly enlarged, end-cells narrowly clavate or tapered to a blunt apex, cell length typically over 50 μ; walls smooth or some developing slight irregularities, content in KOH ochraceous to pale tawny-ochraceous, in Melzer's orange-brown and quickly separating into globules within the cells causing the latter to appear somewhat like uniseriate asci but the globules soon breaking down into minute orange-brown granules at least in part. Subcutis of hyphae 3-9 μ diam., hyaline to yellowish in KOH, soon gelatinizing and many cells developing distinct warts (as a result of swelling in KOH?). Clamp connections none. Hyphae of context lacking a distinctive content in either KOH or Melzer's.

Abundant under *Pinus banksiana* near Marquette, Mich., Sept. 21, 1965. Ingrid Bartelli, Smith 72698, type.

This variety is distinct by the features used in the key. Its tree associate is definitely jack pine.

Leccinum aurantiacum var. intermedium var. nov.

Pileus 5-17 cm latus, convexus, ferrugineus; stipes albidus tactu tarde fuscus; sporae 14-17 × 4-5 μ; hyphae epicuticularum 5-10 μ diam. Typus: Smith 71867 (MICH).

Pileus 5-17 cm broad, convex, margin appendiculate, surface dry and obscurely appressed fibrillose, color distinctly rufous-red (redder than "ferruginous"). Context pallid, with $FeSO_4$ scarcely (and slowly) bluish, when cut slowly changing to bluish fuscous (no red tinge present); odor and taste not distinctive.

Tubes depressed, about 1 cm deep, olive-pallid, avellaneous when cut or broken but dull cinnamon-brown when dried; mouths small, olive-pallid when young, staining olive-yellowish when lightly bruised, "wood-brown" if severely bruised.

Stipe up to 15 cm long, up to 3 cm thick, equal, pallid within, staining blackish in places but mostly gray when cut; surface pallid, ornamented with blackish lines and squamules to somewhat reticulate, with dark lines, base whitish and as dried grayish pallid, no green or red stains present.

Spores 14-17 × 4-5 μ, narrowly subfusoid in face view, narrowly inequilateral in profile, pale dingy ochraceous-cinnamon in KOH, isolated spores in a mount merely dull yellowish, in Melzer's pale ochraceous tan, smooth, wall slightly thickened.

Basidia 4-spored, hyaline to yellowish in KOH, 8-11 μ broad. Pleurocystidia 38-52 × 8-14 μ, fusoid-ventricose, hyaline in KOH and Melzer's or a few smoky brown, thin-walled, lacking incrustations, apex subacute. Cheilocystidia 18-26 × 4-8 μ, clavate to subfusoid, pale ochraceous in KOH. Caulocystidia 40-80 × 12-20 μ, pedicels mostly narrow (3-5 μ), clavate, ovate, obventricose, to somewhat fusoid-ventricose, content smoky brown in KOH. Cutis of pileus of uninflated hyphae for most part 5-10 μ diam., the end-cells mostly 40-120 × 9-14 μ, rarely bullet-shaped, smooth or obscurely roughened, content reddish-brown in KOH and more so in Melzer's, in the latter medium pigment globules forming in some cells, disarticulation of cells rather frequent, very few hyphal cells 2-4 times as long as broad, mostly over 5 times as long as broad. Context hyphae near cutis with ochraceous to orange pigment in some when revived in Melzer's. Clamp connections none.

Near Swamp Lake, Luce County, Mich., July 25, 1965. Smith 71867, type. *Pinus resinosa*, *P. banksiana*, and *Populus grandidentata*, along with two species of *Betula*, were present in the area so no conclusions in regard to a mycorrhizal associate appear justified.

This variant has the following *L. aurantiacum* features: Spores seldom over 4.5 μ wide, cuticular hyphae mostly under 10 μ diam., cells of the cuticular hyphae smooth to very inconspicuously roughened, the pleurocystidia of undamaged areas of the hymenium without much color, and the dried cap is decidedly reddish.

Its *L. insigne* features are: Some short cells in the epicuticular elements of the pileus, a tendency for the cells to become roughened, occasional bullet-like end-cells on cuticular filaments, and a tendency of the epicuticular hyphae to disarticulate.

Odd features worthy of note are that the base of the stipe is grayish to pallid as dried with no sign of yellow, there were no red or green stains anywhere on fresh material, and when cut the color change was to gray to fuscous directly with no red showing.

Leccinum discolor sp. nov.

Pileus 8-12 cm latus, convexus vel late convexus, ad marginem appendiculatus, glaber, brunneo-aurantiacus demum cinnamomeus. Tubulis pallidis demum avellaneis. Stipes 7-9 cm longus, 1-2 cm crassus, albidus, atropunctatus. Sporae in cumulis fuscis, 15-19.5 × 4.5-6(7) μ. Typus: Smith 67848 (MICH).

Pileus 8-12 cm broad, convex to broadly convex the margin appendiculate at first, surface glabrous but dull, becoming faintly areolate-rimose, color evenly dull orange-brown to orange-cinnamon and slowly becoming dull cinnamon ("Sayal brown"), when dried near bister ("Saccardo's umber"). Context white, when cut slowly vinaceous to lilac-brown and finally grayish, bluish-gray where touched with KOH, odor and taste not distinctive.

Tubes up to 3 cm deep, becoming depressed around the stipe, pallid becoming avellaneous, staining near bister when cut, mouths round, small (about 2 per mm) grayish when young.

Stipe 7-9 cm long, 1-2 cm thick at apex, solid, equal or nearly so, white, when cut staining vinaceous-lilac in upper part, KOH producing a yellow basal line in the sectioned stipe, walls of larval tunnels slowly becoming dark brown, stipe base when cut turning faintly olive-yellow before changing to lilac-gray, $FeSO_4$ no reaction; surface white with blackish ornamentation overall, at base yellowish-gray.

Spore deposit fuscous when moist, near "wood-brown" air-dried. Spores 15-19.5 × 4.5-6(7) μ, subfusoid in face view, narrowly inequilateral in profile, smooth, wall slightly thickened, brownish-ochraceous to ochraceous in KOH, in Melzer's dingy tan, smooth.

Basidia 4-spored, 22-26 × 10-13 μ, hyaline to yellowish in KOH, dingy yellow in Melzer's. Pleurocystidia abundant 38-56 × 10-18 μ, broadly ventricose-mucronate to fusoid-ventricose with the neck short and apex obtuse to subacute, near tube mouths more rostrate, in KOH the content yellow-brown to smoky-ochraceous, in Melzer's rusty brown to red-brown (somewhat dextrinoid). Cheilocystidia ventricose-rostrate to clavate, 23-28(34) × 7-10 μ, ochraceous in KOH. Caulocystidia with smoky ochraceous content when revived in KOH, mostly ventricose mucronate to fusoid-ventricose with acute to subacute apices, 40-70 × 10-25 μ, smaller clavate cells with smoky content also present in the fascicles. Pileus cutis of matted hyphae the end-cells of which are equal throughout their length or nearly so and the apices rounded, with content ochraceous to smoky ochraceous as revived in KOH, when revived in Melzer's the content homogeneous and reddish to orange-brown, no pigment balls or masses present but in a few hyphae some granulation present. Cutis hyphae lacking incrusting pigment but hyphae may be asperulate, the cells tending to disarticulate. Context hyphae near cutis with orange to bright red content when revived in Melzer's. Clamp connections absent.

Near aspens and pine, Priest River Experimental Forest, Priest River, Idaho, Sept. 22, 1964. Coll. Lisa Miller (Smith 67848), type.

This species has passed as *L. aurantiacum* in northern Idaho, but differs in the color of the spore deposit, the lack of pigment globules in the cuticular hyphae when revived in Melzer's, and in the wider spores, which actually are more like the spores of most species in the *L. scabrum* group.

Leccinum barrowsii sp. nov.

Pileus 10-20 cm latus, late convexus, ad marginem appendiculatus, siccus, fibrillosus, laete roseus. Caro tactu fuscus. Stipes 6-11 cm longus, 1-2 cm crassus, clavatus, albidus, demum brunneo-punctatus. Sporae 14-18.5 × 4-5 μ. Typus: Chas. Barrows 1717 (MICH).

Pileus 10-20 cm broad, broadly convex in oldest, hemispheric in youngest, margin appendiculate, surface dry and appressed-fibrillose, color a beautiful pale rose-pink, fading in drying to grayish pallid, no pink remaining. Context white, staining blackish in drying where cut. Tubes white, adnate (but all young); mouths white. Stipe 6-11 cm long, 1-2 cm thick (estimated), evenly enlarged downward, solid, white within, cut surface blackening; staining greenish-blue at base, surface white including the ornamentation which in drying became dark gray and was present mostly as streaks rather than points or squamules.

Spores 14-18.5 × 4-5 μ, elongate-subfusoid in face view, elongate-inequilateral in profile, suprahilar depression usually distinct, when revived in KOH smoky-ochraceous and in Melzer's hyaline or with a grayish cast (hence dull).

Basidia hyaline to yellow in KOH, 4-spored, 26-30 × 8-11 μ, hyaline to yellow in Melzer's. Pleurocystidia abundant, 28-42 × 8-12 μ, fusoid-ventricose, content in Melzer's bister and granulose, in KOH the content snuff-brown and homogeneous to reticulate. Cheilocystidia 24-35 × 5-9 μ, fusoid-ventricose with acute apex or ventricose-rostrate and neck about 2 μ wide, ochraceous in KOH. Caulocystidia both clavate and fusoid-ventricose, 8-15 μ diam., content dingy ochraceous, occasional giant cells present. Pileus cutis of matted fibrils, hyphae (4)6-12(15) μ diam., cells constricted at cross walls, frequently disarticulating at septa, upper and terminal cells often inflated to ellipsoid and 12-25 μ diam., at times 100 μ or more long and 20-30 μ wide, tapered to obtuse apex (cystidioid); content smoky ochraceous in KOH, yellowish to brownish granular in Melzer's or hyaline, walls thin and smooth. Context hyphae when revived in Melzer's mostly lacking colored content but a few with some reddish granular material. Clamp connections absent.

Under conifers, Santa Clara Canyon, Santa Fe, New Mexico, Aug. 1964. Chas. Barrows 1717, type.

The distinguishing features are the rose-pink pileus which dries a dingy pallid, the greatly inflated ultimate and penultimate cells of some of the cuticular hyphae of the pileus, and relatively inconspicuous ornamentation of the stipe.

Leccinum laetum sp. nov. Fig. 10

Pileus 5-15 cm latus, convexus, ad marginem appendiculatus, siccus, fibrillosus, glabrescens, aurantiacus demum aurantio-ochraceus; stipes atropunctatus vel atrosquamulosus, ad basin viscidus; sporae 13-16(17) × 4-5 μ, leves. Hyphae epicuticularum saepe asperulae. Typus: Smith 72567 (MICH).

Pileus 5-15 cm broad, oval to convex, expanding to broadly obtuse to broadly convex, margin appendiculate; surface dry and appressed fibrillose-squamulose, becoming glabrous; color when young and fresh orange to orange-ochraceous but becoming dull ochraceous, the appressed fibrils or squamules yellow-brown ("buckthorn brown"), glabrescent and in age subviscid and at this time with olive tones on margin and disc dingy ochraceous to dull orange-brown. Context pallid, when cut soon staining vinaceous then gray and then fuscous; in the stipe staining in addition both blue and yellow and reddish (in different areas), $FeSO_4$ blue; KOH on cutis no reaction to slightly rusty-brown; odor none, taste mild to slightly acid.

Tubes 1-2 cm deep, depressed around stipe to nearly free, white staining avellaneous when cut; mouths minute, round, white to olive-white when young, staining olive when slightly bruised, but when severely bruised staining near grayish vinaceous brown ("wood-brown").

Stipe 8-16 cm long, 1-2.5 cm thick, equal, solid, when cut changing color as noted under context above, soon fuscous-black around the worm holes; surface faintly ornamented by pallid then brownish and finally darker points lines or squamules, apex pallid, viscid over base when young as in *Boletellus russellii*.

Spore deposit olive when wet and olive-brown when air dried (dark "olive-buff" to "olive-brown"). Spores 13-16(17) × 4-5 μ, smooth, wall slightly thickened, shape in profile somewhat elongate-inequilateral with a broad shallow suprahilar depression, in face view subfusoid, pale ochraceous in KOH, in Melzer's a few dextrinoid, the rest pale yellow-brown (in mounts made from hymenial tissue when revived in Melzer's showing a faint suggestion of the "fleeting amyloid" reaction).

Basidia 4-spored, 17-23 × 8-11 μ, hyaline in KOH. Pleurocystidia abundant, 40-60 × 10-15 μ, fusoid-ventricose with blunt apices but neck often elongated and flexuous, thin-walled, hyaline in KOH at first but when revived in KOH having a dingy yellow-brown content, and in Melzer's dark yellow-brown. Cheilocystidia 23-34 × 6-11 μ, mostly fusoid-ventricose with narrow necks (about 2 μ diam.), and subacute apices, ochraceous in KOH. Caulocystidia a mixture of ventricose, mucronate and clavate cells 27-40 × 8-12 μ and larger ones up to 15-20 μ diam. scattered in each fascicle, their content pale brownish in KOH. Cutis of pileus a tangled layer of epicuticular hyphae with ochraceous content in KOH and a hyaline more or less gelatinous subcutis of interwoven hyphae. The coarse fibrils of the epicutis composed of hyphae 8-15 μ broad with cells 40-120 μ or more long and some of these with minutely roughened walls, the end-cells often ovate-pointed (bullet-shaped), no pigment balls present in Melzer's, the colored cells with content amorphous-reticulate and orange-brown, the cells tending to disarticulate in age and at this time more of them showing slight wall irregularities. Context of hyaline hyphae in KOH and Melzer's. Clamp connections absent.

Scattered in an aspen thicket which had a ground cover of willow, Highlands Recreation Area, Oakland County, Mich., Sept. 12, 1965. Smith 72567, type.

This species is near *L. insigne* by virtue of the features of the broad epicuticular hyphae, but is distinct by the olive-colored spore deposit, by the viscid stipe base, the relatively weak stipe ornamentation, and the basically ochraceous to orange-ochraceous pileus color. About 50 basidiocarps were collected in the one locality and were constant as described. It appears that the fibrils which are conspicuous on the fresh pilei are composed to a fairly large extent of broad hyphae and that as the cells of these disarticulate and become lost the pileus becomes glabrous and also somewhat viscid from the gelatinous subcutis which is then more exposed. The habitat close to *Salix* spp. needs further study, but if proved constant the character would be unique for the group.

Leccinum atrostipitatum sp. nov. Fig. 11

Pileus 6-13(18) cm latus, convexus, demum late convexus, ad marginem appendiculatus, siccus, fibrillosus vel subsquamulosus, obscure persicinus vel obscure aurantio-ochraceus. Stipes 8-15 cm longus, sursum 1-2.5 cm crassus, deorsum 3-4 cm crassus, siccus, in juventate conspicue atropunctatus. Sporae 14-17(19) × 4-5 μ. Hyphae epicuticularum leves vel asperulae. Typus: Smith 78885 (MICH).

Pileus 6-13(18) cm broad, hemispheric becoming broadly convex with the margin exceeding the tube line by 5 mm or often more and this band soon breaking up into segments; surface dry and appressed fibrillose, becoming obscurely to distinctly appressed squamulose by maturity, the outer fibrils often grayish; color pale dull orange-buff ("pale apricot buff"), slowly becoming pale orange-brownish and finally a dingy pinkish-tan, the squamules finally merely brownish.

Context white, when cut soon vinaceous buff and this progressing to violaceous-fuscous; with $FeSO_4$ bluish-gray, NH_4OH bluish, color changes in stipe same as in pileus but sometimes staining blue-green in addition.

Tubes 1-1.5 cm long, adnate-seceding, olivaceous-pallid when young, then dingy honey-brown and finally wood-brown; mouths minute, staining olive to olive-brown and if severely bruised avellaneous or darker.

Stipe massive, 8-15 cm long, 1-2.5 cm thick at apex and up to 4 cm thick at base, clavate becoming equal in age, solid, consistency hard and fibrous, white throughout, when cut staining pinkish avellaneous to violaceous-fuscous, finally toward the base staining bluish green in some either within or on surface; surface with coarse black ornamentation in the form of points and squamules from button stages to maturity and from base to apex, with a cottony-fibrillose layer beneath this, dry at base in young specimens.

Spore deposit dull yellow-brown (''snuff-brown''). Spores 13-17 × 4-5 μ, smooth, wall slightly thickened, in face view subfusoid, in profile very obscurely inequilateral, suprahilar depression broad and shallow, pale yellow-brown in KOH and not changing much in Melzer's.

Basidia 4-spored, 8-12 μ broad, hyaline in KOH. Pleurocystidia scattered, 30-40 × 8-12 μ, fusoid-ventricose, with dull yellow-brown content when revived in KOH or in Melzer's, smooth, thin-walled. Cheilocystidia 26-35 × 6-10 μ, fusoid-ventricose to clavate, ochraceous in KOH, soon gelatinizing in KOH. Caulocystidia 40-120 × 10-25 μ, clavate to fusoid-ventricose, content bister in KOH. Cutis of pileus of tangled filaments, the hyphae with lemon-yellow content in KOH when fresh, yellow to nearly hyaline when revived in KOH and in Melzer's the content granular to homogeneous and yellowish (no pigment globules seen); the hyphae with cells tubular to somewhat inflated, mostly 6-11 μ diam., some rather short, finally disarticulating, the end-cells tubular to either narrowly clavate or tapered to apex, walls smooth to minutely asperulate. Context hyphae when revived in Melzer's with orange to red content in a few. Clamp connections absent.

Solitary to scattered in the hardwood forests of the Great Lakes area; birch has been present in all areas checked by us. In one locality only *Betula papyrifera* was found in the area near the carpophores. It is not uncommon during wet seasons. Sugar Island, Michigan, July 27, 1965. Smith 71885, type.

This is one of the most distinctive species in the genus by virtue of its pale rather dull colored pileus which typically appears patchy in age from appressed aggregations of fibrils, the black ornamentation covering the entire stipe except possibly the extreme base, and medium-sized spores. It closely resembles some illustrations passing under the name *L. testaceoscabrum* and has undoubtedly been referred to the latter species in North America. However, the use of the latter name for a birch-associated species is questionable. Under *Boletus testaceus scaber* Secretan (1833) specifically states in the original description "... sous les hêtres et les chênes" and describes the pileus as "rouge de tuile." Singer stated (1938) under the name *L. testaceoscabrum* (Sec.) Singer that this species has rather rare sphaerocysts in the pileus cutis and that it grows under *Betula* and is characteristic of the north. Watling (1961) under the same epithet and following recent European tradition, reported on the common orange-capped northern birchwood bolete which possesses a filamentose cuticle lacking sphaerocysts. We do not understand the rationale which is involved in the change in ecology of *B. testaceus scaber* from what must have been relatively low elevations under beech and oak to a fungus of high elevations and northern distribution growing under *Betula*. The original description by definition is "right" as far as positive features observed by the describing author are concerned and cannot be emended unless overwhelming proof for emendation is evident. Under the circumstances we simply cannot accept Singer's statement (1947): "This is a northern-Alpine species growing with various species of *Betula*, and being especially abundant in the tundras of Europe and Asia"[3] *L. boreale* has a conspicuous pinkish-orange stage in the color pattern of the cut flesh as compared to vinaceous buff in *L. atrostipitatum*. In the latter the spores are dull yellow-brown in deposit and measure 4-5 μ broad. In *L. boreale* they are olive-brown and measure 5-6 μ broad. In *L. atrostipitatum* very few hyphae of the context are brightly colored when revived in Melzer's whereas this is a conspicuous feature in *L. boreale*. The latter is associated with cottonwood whereas *L. atrostipitatum* appears to be associated with birch.

Leccinum cinnamomeum sp. nov. Fig. 12

Pileus 6-12(18) cm latus, convexus, ad marginem appendiculatus, siccus, glaber vel fibrillosus, sordide cinnamomeus. Stipes 8-10 cm longus, 2-2.5 cm crassus, brunneo-squamulosus vel scabrosus. Sporae 12-15 × 4-5 μ. Hyphae epicuticularum saepe asperulae. Typus: Smith 71564 (MICH).

Pileus 6-12(18) cm broad, convex, broadly convex and finally nearly plane; margin curved in at first and soon appendiculate as the sterile band divides into segments; surface dry and unpolished,

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[3]Singer (Mycologia 57: 672. 1965) has been fit to comment on the observations of Smith and Thiers on mycorrhizal relationships as follows: "Observations on mycorrhizal relationships between certain Suilli and certain trees in Smith & Thiers are generally scarce, superficial and inconclusive since these authors do not believe in or use ecological methods." The reader can draw his own conclusions in regard to Singer's "ecological methods."

glabrous to appressed-fibrillose, or squamulose from spotlike squamules, subviscid in older material and then glabrous or nearly so; colors dingy cinnamon over the center (over all in buttons) and grayish-cinnamon-buff toward the margin (disc "Sayal brown") margin grayish pinkish buff, in age dingy alutaceous with olive reflection along the margin if wet. Context firm, hard and white, soft in age, when cut staining quickly to vinaceous then to violaceous fuscous, with $FeSO_4$ blue-green, KOH no reaction in or on stipe base but on tubes pale cinnamon.

Tubes pallid to olivaceous-yellowish and on maturing becoming avellaneous to wood-brown, about 1.5 cm long, depressed around stipe, mouths minute, olive-whitish when young and soon staining yellowish if lightly bruised but sepia if severely bruised.

Stipe 8-10 cm long, 2-2.5 cm thick, solid, firm, hard, and fibrous, but pithy in center, when cut slowly changing to fuscous; surface white, ornamented with fuscous-brown squamules and points, slowly staining brownish around base from handling.

Spore deposit between cinnamon-brown and bister. Spores 12.5-15 × 4-5 μ, smooth, walls thickened slightly, fusoid with blunt ends in face view, inequilateral in profile, suprahilar depression often broad and distinct, dingy ochraceous in KOH, yellowish in Melzer's.

Basidia 4-spored, clavate, 8-9 μ broad, hyaline in KOH and yellowish in Melzer's. Pleurocystidia 37-56 × 9-14 μ, fusoid-ventricose, apices obtuse, thin-walled, content pale cinnamon in KOH, darker cinnamon when revived in KOH, and near sepia in Melzer's. Cheilocystidia 24-33 × 6-10 μ, clavate to ventricose-rostrate or fusoid-ventricose, ochraceous in KOH, soon gelatinizing. Caulocystidia varying from clavate to fusoid ventricose, the content sepia in fresh material, all smooth and thin-walled.

Pileus epicutis of tangled hyphae (5)7-12(22) μ diam., many slender hyphae 5-10 μ diam., tubular, with end-cells tapered slightly, walls thin and smooth to minutely roughened, content dingy ochraceous to orange-brown in KOH, content reddish-brown and granular in Melzer's; the broader hyphae (10-22 μ) with short cells (15-60 μ long), walls smooth or roughened and cells tubular to inflated but not sphaerocyst-like, end-cells often short and bullet-shaped; subcutis of hyaline hyphae in either KOH or Melzer's, smooth, finally subgelatinous. Context of hyaline smooth interwoven hyphae both in KOH and Melzer's. Clamp connections none.

In a low woods of white birch and aspen, near Mackinaw City, Mich., June 29, 1965. Smith 71564, type. It is not an uncommon species in the Upper Peninsula of Michigan during the summer.

Mounts of the epicutis in Melzer's show aggregations of orange-brown pigment as globules within some cells within an hour, but much dextrinoid granular material remains also. The broad hyphae with the bullet-shaped end-cells are most numerous on young specimens showing appressed fibrils and squamules. No appreciable amount of disarticulation of cells was noted, but some does undoubtedly occur as the pilei may finally become glabrous.

The dull cinnamon pilei of immature specimens separate the species in the field from both *L. aurantiacum* and *L. insigne* with either of which it is not infrequently found fruiting.

Leccinum boreale sp. nov.

Pileus 4-10 cm latus, convexus vel late convexus, ad marginem appendiculatus, glaber, demum subsquamulosus, siccus demum subviscidus, rufus vel aurantio-rufus, in siccatis subochraceous. Tubulis pallidis cum orificiis pallidis. Stipes 4-12 cm longus, 10-15 mm crassus, scabro-reticulatus, squamulis obscure brunneis. Sporae 14-18 × 4.5-6 μ. Typus: Wells & Kempton, Aug. 12, 1963 (MICH).

Pileus 4-10 cm broad, convex with an appendiculate margin, expanding to broadly convex or nearly plane, surface glabrous at first but in age the cutis separating to form obscure to distinct spotlike scales, dry at first but becoming subviscid in age, color rufous to orange-tan and when dried dull tan with scarcely any red showing. Context white, when broken or cut in young pilei changing quickly to pinkish-orange, the rapidity of the reaction lessening in old basidiocarps, finally slowly violaceous drab to fuscous; with $FeSO_4$ slowly to slate-blue in old basidiocarps, but blue-green immediately in young ones, no change in pileus context or apex of stipe with NH_4OH.

Tubes 1-2 cm deep, depressed around stipe to nearly free, white to pale olive-buff, slowly changing to fuscous when wounded, becoming near wood-brown as spores mature; tube mouths small and round, 2-3 per mm, whitish at first, becoming avellaneous to wood-brown as spores mature.

Stipe 4-12 cm long, 10-15 mm thick at apex, 1-2 cm thick at base, equal, white within, when cut staining pinkish-orange then fuscous above, bluish-green in or around base, with NH_4OH the base immediately lemon-yellow; surface basically white but scabrous-reticulate from dark brown to blackish elements of the ornamentation.

Spores olive-brown in a thin deposit, 14-18(20) × 4.5-6 μ, smooth, in face view subfusoid, in profile elongate-inequilateral, suprahilar depression shallow and inconspicuous, in KOH subhyaline to ochraceous, in Melzer's slowly becoming dextrinoid in some but majority remaining merely pallid brownish, walls relatively thin as seen in mounts in Melzer's.

Basidia 4-spored, 23-28 × 9-12 μ, yellow in Melzer's, to nearly hyaline, in KOH hyaline to yellowish. Pleurocystidia scattered to rare, fusoid-ventricose, 28-37 × 10-14 μ, content dingy yellowish when revived in KOH, in Melzer's bister or paler, or merely hyaline in both media, smooth, walls thin. Cheilocystidia 27-34 × 7-10 μ, clavate to fusoid-ventricose, ochraceous in KOH. Caulocystidia 40-70 × 12-20 μ, saccate to elongate-clavate to fusoid-ventricose, apex usually obtuse, content smoky-brown in KOH. Pileus cutis consisting of a tangled mass of flexuous hyphae or hyphal ends, 3-6 μ diam. and subgelatinous, with yellow to brownish pigment in KOH, in Melzer's orange-buff, pigment balls not forming; cells mostly lacking constrictions at the septa, smooth, thin-walled, on standing some amyloid intercellular debris showing along with scattered dark violet blackish pigment masses (here regarded as extraneous). Context hyphae 8-15 μ diam., with what appears to be colloidal content and reviving perfectly in KOH (very clearly defined), and in Melzer's with orange-red homogeneous content. Clamp connections none.

Under cottonwood, Portage Glacier Road, Seward Highway from Anchorage, Alaska, Aug. 12, 1963. Wells and Kempton, type.

In Melzer's the content of the context hyphae remained homogeneous. This species was assumed to be *L. aurantiacum* in the field but the iodine reaction of the hyphae of the pileus context and the difference in width between the cuticle elements and those of the pileus context are distinctive, as are the wide spores and habitat under cottonwood. The dark violet pigment masses were found in some mounts and not in others. For the present we regard this reaction as anomalous, perhaps due to some contamination, but further work will be needed to check this conclusion.

Leccinum insigne sp. nov. Fig. 13

Pileus 4-15 cm latus, convexus, demum late convexus, ad marginem appendiculatus, siccus, fibrillosus vel fibrilloso-squamulosus, glabrescens, ferrugineus. Stipes 8-15 cm longus, sursum 1-2 cm crassus, deorsum siccus et 2.5-3 cm crassus, atrofurfuraceus vel atrosquamulosus. Sporae 12-16 × 4-5.5 μ. Hyphae epicuticularum saepe asperulatae. Typus: Smith 71730 (MICH).

Pileus 4-15 cm broad, convex, becoming broadly convex, margin exceeding the tubes by over 1 mm when young and this tissue soon broken up into segments causing margin to be appendiculate, surface dry when young and then minutely granular to obscurely appressed fibrillose or distinctly fibrillose-squamulose, especially near the margin, glabrescent and in age soft and subviscid; color bright ferruginous ("ferruginous") when in full color but buttons sometimes pallid where covered by leaves, at maturity or when old orange-cinnamon to dingy orange-brown with olive tones near the margin if wet. Context white, thick, firm becoming soft, when cut staining vinaceous gray going to fuscous or to gray directly with no reddish tinge, with $FeSO_4$ bluish, taste slight, odor mild to slight fragrant.

Tubes 1.5-2 cm long, depressed, pallid becoming olivaceous-pallid, turning wood-brown when cut, in age more or less wood-brown with a yellowish-tan tint over the pore layer; tube mouths whitish staining slowly to dingy yellow to yellow-brown, olive-brown or olive finally, but when severely injured staining avellaneous to fuscous, in age where not injured with a dingy yellowish-cinnamon tone.

Stipe 8-12 cm long, 1-2 cm thick near apex, evenly enlarged to the base where it is 2.5-3 cm thick, often tapered to a point below, solid, pallid when cut, but soon darkening to fuscous on cut surface, KOH usually yellow on the cut base; surface whitish and ornamented with brown punctate dots or squamules which darken to blackish by maturity or age, the surface underlying the ornamentation cottony and uneven to obscurely reticulate, base dry.

Spore deposit dark yellow-brown ("snuff-brown" to "amber-brown"). Spores 13-16 × 4-5.5 μ, pale ochraceous in KOH, lemon-yellow in Melzer's but a few tawny, duller in both KOH and Melzer's when revived, in profile somewhat inequilateral, in face view sub-fusoid, smooth, wall slightly thickened.

Basidia 4-spored, clavate, hyaline in KOH. Pleurocystidia 42-56 × 10-15 μ, fusoid-ventricose with subacute apices, thin-walled, hyaline in KOH fresh, with dark brown content when revived in KOH. Cheilocystidia similar to pleurocystidia but neck often shorter and varying to clavate, those in bruised areas with smoky ochraceous content. Caulocystidia clavate to ventricose-mucronate and often resembling pleurocystidia in size, but giant cells also present (70 × 20 μ more or less), with smoky-brown content in KOH. Pileus cutis of hyphae mostly 4-8 μ diam., and end-cells tubular but some hyphae 12-20 μ wide, most numerous on young pilei, with either smooth or minutely roughened walls, hyphal cells of the large hyphae short (often only 20-80 μ long) and the end-cells frequently bullet-shaped, with a distinct tendency for the cuticular cells to disarticulate, the layer a tangled appressed mass of hyphae; content of cells ochraceous to brownish in KOH and in Melzer's more ochraceous-orange and the content soon forming minute granules but no large pigment globules; when revived in Melzer's the hyphae of the subcutis yellow to orange from a colored content. Context hyphae hyaline in Melzer's. Clamp connections none.

Common under large-toothed aspen (*Populus grandidentata*) on low ground in June and early July in Michigan. Smith 71730, type.

This species, commonly mistaken for *L. aurantiacum* in North America, is distinguished by the following features: the ferruginous pileus soon becoming rather dull, the honey-tan color of the pore-surface at maturity where undamaged, the numerous short cells in the pileus cutis, and the pilei when dried lacking the reddish to orange-brown color of *L. aurantiacum*.

Leccinum insigne var. luteopallidum var. nov.

Pileus circa 8 cm latus, convexus, ad marginem appendiculatus, siccus, fibrillosus, obscure ferrugineus; tubuli pallide lutei; stipes circa 13 cm longus, 2 cm crassus, atrosquamulosus; sporae 12-15 × 4-5 μ; hyphae epicuticularum saepe asperulatae. Typus: Smith 71745 (MICH).

Pileus about 8 cm broad, convex, margin appendiculate, surface dry, near margin with appressed fibrils, elsewhere merely uneven; color dull ferrugineus ("cinnamon-rufous") to orange-tan, drying to a dark wood-brown (gray-brown). Context pallid, when cut soon flushed with fuscous streaks in stipe-apex and black when dried; with $FeSO_4$ bluish, with KOH brownish; odor mild; taste acid then mild.

Tubes about 1 cm long, depressed around stipe, pale yellow young ("ivory-yellow" or slightly brighter), with KOH dull cinnamon, dull brown where cut; mouths minute, yellowish, slowly staining snuff-brown when lightly bruised, when severely bruised violaceous-fuscous.

Stipe about 13 cm long, 2 cm thick, equal or at first evenly enlarged downward, pallid within, when cut showing greenish-blue streaks, slowly staining fuscous generally, with NH_4OH or KOH yellow in the base; surface pallid, with this mostly covered by an ornamentation or blackish points and lines.

Spores 12-15 × 4-5 μ, smooth, fusoid in face view, in profile elongate inequilateral, suprahilar depression broad and shallow, ochraceous in KOH, in Melzer's pale tawny-yellowish to nearly hyaline.

Basidia 23-27 × 8-9 μ, clavate, 4-spored, hyaline in KOH. Pleurocystidia abundant, 33-50 × 8-14 μ, fusoid-ventricose with acute apices, smooth, thin-walled, content hyaline to smoky-brown in KOH. Cheilocystidia 24-33 × 5-9 μ, clavate to fusoid-ventricose or obventricose-mucronate, yellow-brown in KOH. Caulocystidia clavate to mucronate, both large and small types present, content smoky-brown. Pileus cutis of hyphae 4-15(20) μ broad, the wider ones often with asperulate walls and bullet-shaped apical cell, cells disarticulating, content dingy brownish in KOH, many cells 60-150 μ long. Context hyphae when revived in Melzer's lacking yellow or orange-red contents. Clamp connections none.

In a hardwood slashing (*Betula lutea* present), Emerson, Mich., July 14, 1965. Smith 71745, type.

It is important to place this variety on record as it introduces pale-yellow tubes to the *L. insigne* group.

Leccinum ochraceum sp. nov. Fig. 8

Pileus 5-12 cm latus, convexus demum lato convexus, ad marginem appendiculatus siccus, fibrillosus, ochraceus demum pallide obscure cinnamomeus; stipes 11-15 cm longus, 12-25 mm crassus, pallidus, atrosquamulosus vel subreticulatus; sporae 14-16 × 4.5-5.5 μ; hyphae epicuticularum saepe asperulatae. Typus: Smith 72837 (MICH).

Pileus 5-12 cm broad, convex becoming broadly convex, the margin appendiculate at first; surface dry and unpolished to appressed fibrillose, in some with appressed fibrillose squamules near margin;

color varying from ochraceous-yellow with grayish overtones from fibrils to a dingy tan ("pinkish-buff") over disc, or becoming pinkish-cinnamon to pale dingy cinnamon. Context thick, white, when cut changing to vinaceous then avellaneous and finally violaceous-fuscous, with $FeSO_4$ bluish; odor and taste not distinctive.

Tubes 1-1.5 cm long, adnate at first, becoming depressed, pallid olivaceous, dull brown where cut; mouths minute, olivaceous-pallid, staining dark brown where severely bruised but olive-yellowish where lightly bruised.

Stipe 11-15 cm long, 12-25 mm thick, solid, fibrous, hard, pallid within, when cut slowly staining fuscous in streaks, no blue or red stains developed on specimens observed; surface whitish with coarse blackish reticulation and squamules or points, when dried with an overall grayish-ground color.

Spores dark yellow-brown ("snuff-brown") in deposits, 14-16 × 4.5-5.5 μ, subfusoid in face view, in profile inequilateral (often rather ventricose), suprahilar depression broad; walls slightly thickened, color in KOH dingy brownish ochraceous, not much different in Melzer's.

Basidia 4-spored, 18-22 × 9-10 μ, clavate, hyaline in KOH and Melzer's. Pleurocystidia 38-52 × 9-14 μ, fusoid-ventricose, content usually brownish to bister in KOH and bister to violaceous-bister in Melzer's, large bister to violaceous-bister laticiferous elements present in mounts revived in Melzer's. Cheilocystidia 30-45 × 5-9 μ, clavate to fusoid-ventricose, ochraceous in KOH. Caulocystidia voluminous, up to 60 × 20 μ, clavate to obclavate or mucronate, more rarely fusoid-ventricose, content bister in KOH. Hyphae of pileus cutis olivaceous when first revived in KOH but quickly fading to brownish at times with some cells with dingy brown walls as seen in KOH, hyphae commonly disarticulating; hyphal width, cell size, and ornamentation as in var. *insigne*. Context hyphae when revived in Melzer's typically orange to red but also with a few fuscous (amyloid ?) masses or particles. Clamp connections absent.

Solitary to scattered, Sugar Island and at Tahquamenon Falls State Park, Chippewa County, Mich., July to Sept., 1965. Smith 72837, type.

The pilei dry to an olive-gray. The fresh pilei are ochre-yellow to paler at first with a gray shadow from the surface fibrils, but gradually get duller as they mature. When old they resemble those of *L. cinnamomeum*. It differs slightly from *L. insigne* to which we at first attached it as a variety, by the pileus color and the KOH reaction of the content of the cuticular cells.

Leccinum incarnatum sp. nov.

Pileus 5-15 cm latus, convexus demum late convexus, siccus, fibrillosus, incarnatus vel subincarnatus. Tubulis pallidis, orificiis avellaneis. Stipes 4-8(12) cm longus, 2-2.5 cm crassus, deorsum circa 4 cm latus, subsquamulosus, squamulis griseo-vinaceis. Sporae 13-16 × 3-4.5 μ. Typus: Smith 69628 (MICH).

Pileus 5-15 cm broad, convex becoming broadly convex, surface dry, when young matted-fibrillose as in many *Agaricus* spp.; margin appendiculate, color evenly "light pinkish-cinnamon" when young, but when mature even more distinctly vinaceous, young specimens often with an overcast of avellaneous fibrils, in age areolate over disc or at times deeply rimose. Context white, odor and taste mild, when cut slowly becoming vinaceous-buff and finally darker smoky vinaceous-gray; with $FeSO_4$ blue on white context.

Tubes 1.5 cm long, depressed around stipe, pallid to grayish or finally wood-brown; mouths minute, 2-3 per mm, round, pale wood-brown or a dark avellaneous when the sides of the tubes are still pallid, staining a dingy yellow-brown when bruised.

Stipe 4-8(12) cm long, 2-2.5 cm thick above, up to 4 cm below, clavate to fusoid, solid, pallid within; vinaceous buff when cut and pea-green in the base, surface scabrous-roughened (with cottony tissue between the squamules) white when young, scabrosity vinaceous-buff becoming near wood-brown but not blackening on drying, pea-green around the base in places.

Spore deposit not obtained. Spores 13-16 × 3-4.5 μ, narrowly subfusoid in face view, narrowly and distinctly inequilateral in profile and some "sway-backed," in KOH brownish ochraceous, in Melzer's weakly yellowish or a few finally dark red-brown.

Basidia 4-spored, 23-30 × 8-11 μ, yellowish in KOH and Melzer's but with some refractive globules in KOH. Pleurocystidia none found. Caulocystidia clavate to mucronate, 10-20 μ broad, hyaline or with dark yellow-brown content; caulobasidia numerous, in KOH hyaline to dark yellow-brown. Tube trama mostly of parallel hyphae when revived in KOH and Melzer's (an artifact ?). Pileus cutis of a tangle of matted-down hyphae the end-cells clavate to narrowly fusoid, hyphae 6-11 μ diam. and tubular, in Melzer's the content homogeneous and yellowish (neither granular nor with globules). Hyphae of subcutis hyaline. Context hyphae orange to red near subcutis when revived in Melzer's. Clamp connections none. All hyphae inamyloid.

Gregarious under white-bark pine (*P. albicaulis*), Cougar Mt., McCall, Idaho, Aug. 22, 1964. Smith 69628, type.

This is a vinaceous-colored species drying a pinkish-tan, in which the cutis has a strong tendency to break up into small squamules appressed as seen on dried specimens. The tube mouths stain yellow-brown when bruised and the spores are rather narrow in profile view. Also, the ornamentation on the stipe is weakly colored. The hyphae of the epicutis typically are tubular and broad, and the content in Melzer's is homogeneous and exceptionally pale.

Leccinum fibrillosum sp. nov. Fig. 14

Pileus 8-25 cm latus, convexus demum late convexus, siccus, fibrillosus, demum fibrilloso-squamulosus, obscure testaceus. Tubulis pallide cinereis; orificiis cinereis tactu luteobrunneis. Stipes 4-12 cm longus, 2-5 cm crassus, atrosquamulosus. Sporae 14-18(20) × 3.8-5 μ. Typus: Smith 66337 (MICH).

Pileus 8-25 cm broad, convex becoming broadly convex, in age the surface becoming uneven in some, surface dry and matted-fibrillose, the fibrils becoming aggregated into appressed coarse squamules or the latter slightly recurved at the tips, margin irregularly appendiculate from the sterile extensions of pileus cutis; color very dark dull testaceous (''Hay's brown,'' ''Natal brown,'' or ''bone brown''), with an overcast of gray from the fibrils and squamules. Context pallid becoming reddish-vinaceous (''vinaceous-buff'' to ''onion-skin pink'') and finally through vinaceous gray to purple drab, with $FeSO_4$ greenish-blue in pileus and stipe; odor and taste mild.

Tubes 1-2 cm deep, depressed to nearly free, grayish pallid, when cut staining like the context of pileus, wood-brown or darker in age; mouths 1-2 per mm dingy buff and staining brown (''snuff-brown'') where bruised.

Stipe 4-12 cm long, 2-5 cm thick, equal or narrowed above, solid, staining blue to greenish in or around the base, surface white and densely coated with a wooly-scabrous layer breaking into squamules which soon blacken, apex pallid.

Spores 14-18(20) × 3.8-5 μ, in face view narrowly subfusoid, in profile narrowly subinequilateral and some with a medial shallow dorsal depression (sway-backed); in KOH ochraceous, in Melzer's pale dull tawny to tawny; smooth, wall thickened appreciably.

Basidia 23-27 × 8-11 μ, clavate, 4-spored, hyaline to yellowish in KOH, yellowish in Melzer's. Pleurocystidia scattered, fusoid-ventricose with narrow sometimes curved neck and a subacute apex, thin-walled, hyaline to dark yellow-brown in KOH from colored content, smooth. Cheilocystidia similar to but smaller than the pleurocystidia, varying to clavate. Caulocystidia variable in size 23-60 × 8-18 μ, ovate-pointed or with a slight neck, hyaline or with colored context in KOH.

Pileus cutis of hyphae 6-12 μ diam., in a tangled mass or squamules radially arranged, the end-cells often narrowly fusoid but varying to almost uninflated, content dingy orange-ochraceous to dull brownish in KOH, in Melzer's with fine brownish granules in interior but no large globules; of equal diameter throughout or constricted at the septa but no disarticulation evident in the type. Context hyphae when revived in Melzer's with bright red to orange content. Clamp connections none. All hyphae inamyloid.

Gregarious under mixed conifers (lodgepole pine present), Payette Lakes, Idaho, Aug. 31, 1962. Smith 66337, type.

This is a dark liver-brown hairy species the flesh of which becomes decidedly reddish when cut, a wooly scabrous stipe which in some dried specimens shows olive-yellow over basal area and the white tubes soon grayish with mouths which stain brown

Leccinum obscurum sp. nov. Fig. 2

Pileus circa 7 cm latus, convexus, ad marginem appendiculatus, siccus, glaber, subspadiceus. Stipes 14 cm longus, 2.5 cm crassus, atrofurfuraceus. Sporae 12-16(19) × 4.5-5.5(6) μ. Hyphae epicuticularum saepe asperulae. Typus: Smith 72566 (MICH).

Pileus about 7 cm broad, convex, incurved margin breaking into sterile segments as in *L. aurantiacum;* surface dry, glabrous, uneven (no fibrils on immature pileus); color near "hair brown" (much like that of a dark *L. scabrum*), drying dark gray-brown. Context pallid, when cut staining vinaceous then violaceous-fuscous, similar changes occurring in the stipe, in addition near the stipe base staining blue in some areas and red in others, with $FeSO_4$ bluish fuscous, KOH yellow in base of stipe.

Tubes white, slowly staining pinkish when cut, deeply depressed around the stipe; dull cinnamon-brown when dried; mouths pallid, staining vinaceous to fuscous when bruised in young specimens.

Stipe about 14 cm long, 2.5 cm thick, equal, solid (see under context for color changes); surface pallid, stained red over the base, ornamentation coarse and blackish to the pallid apex.

Spore deposit none obtained. Spores 12-16(19) × 4.5-5(6) μ, subfusoid in face view, obscurely elongate-inequilateral in profile, wall slightly thickened, dingy ochraceous in KOH, in Melzer's pale dingy tan, smooth, wall slightly thickened.

Basidia 4-spored, hyaline to yellowish in KOH and Melzer's, 16-20 × 7-9 μ, clavate. Pleurocystidia 34-48 × 8-13 μ, scattered, hyaline in KOH and Melzer's, fusoid ventricose, subacute at apex. Cheilocystidia similar to pleurocystidia but many with brown content in KOH. Caulocystidia in large patches of caulobasidia, 36-56 × 9-18 μ, a fair number fusoid-ventricose but many clavate to mucronate, with dull brown walls; caulobasidia numerous and sporulating, 2-, 3-, or 4-spored, dull brown in KOH; spores from them 8-10 × 4-5.5 μ, ellipsoid to ovoid, hyaline to slightly colored (very different from those borne on hymenophore). Pileus cutis of tangled hyphae with hyaline to brownish bands of incrusting material on some hyphae but mostly as in *L. insigne* with some cells merely asperulate, content smoky brown in KOH from homogeneous content, in Melzer's dingy orange-brown and homogeneous to reticulate-coagulated, no pigment balls seen, the hyphae tubular to the inflated-fusoid end-cells or end-cells bullet-like, the enlarged cells up to 20 μ diam., some cells disarticulating, walls variously ornamented but a minority smooth; amyloid particles scattered in the mount in places. Context hyphae hyaline or with yellowish walls in Melzer's, the content not distinctively colored. Clamp connections none.

Solitary under aspen, Haven Hill, Oakland County, Mich., Oct. 12, 1965. Smith 72566, type.

This was a perfectly developed basidiocarp which is worth placing on record because it establishes the appendiculate pileus margin as occurring in combination with pileus colors of a dark *L. scabrum*. It is a species in its own right because it is one of the few in the genus with some of the roughness on the cuticular hyphae actually representing pigment deposits. It appears to be most closely related to *L. cinnamomeum*.

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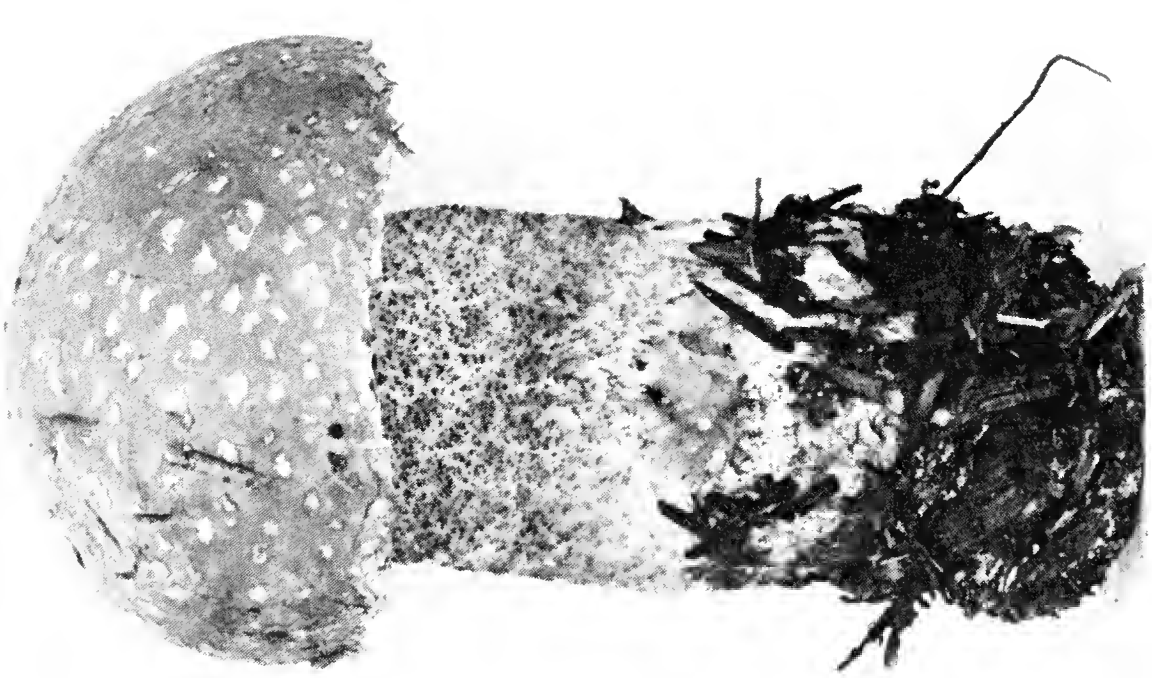

Fig. 1. *Leccinum potteri* ×1 Smith 64492

Fig. 2. *Leccinum obscurum* ×1 Smith 72566

Fig. 3. *Leccinum potteri* ×1 Smith 72529

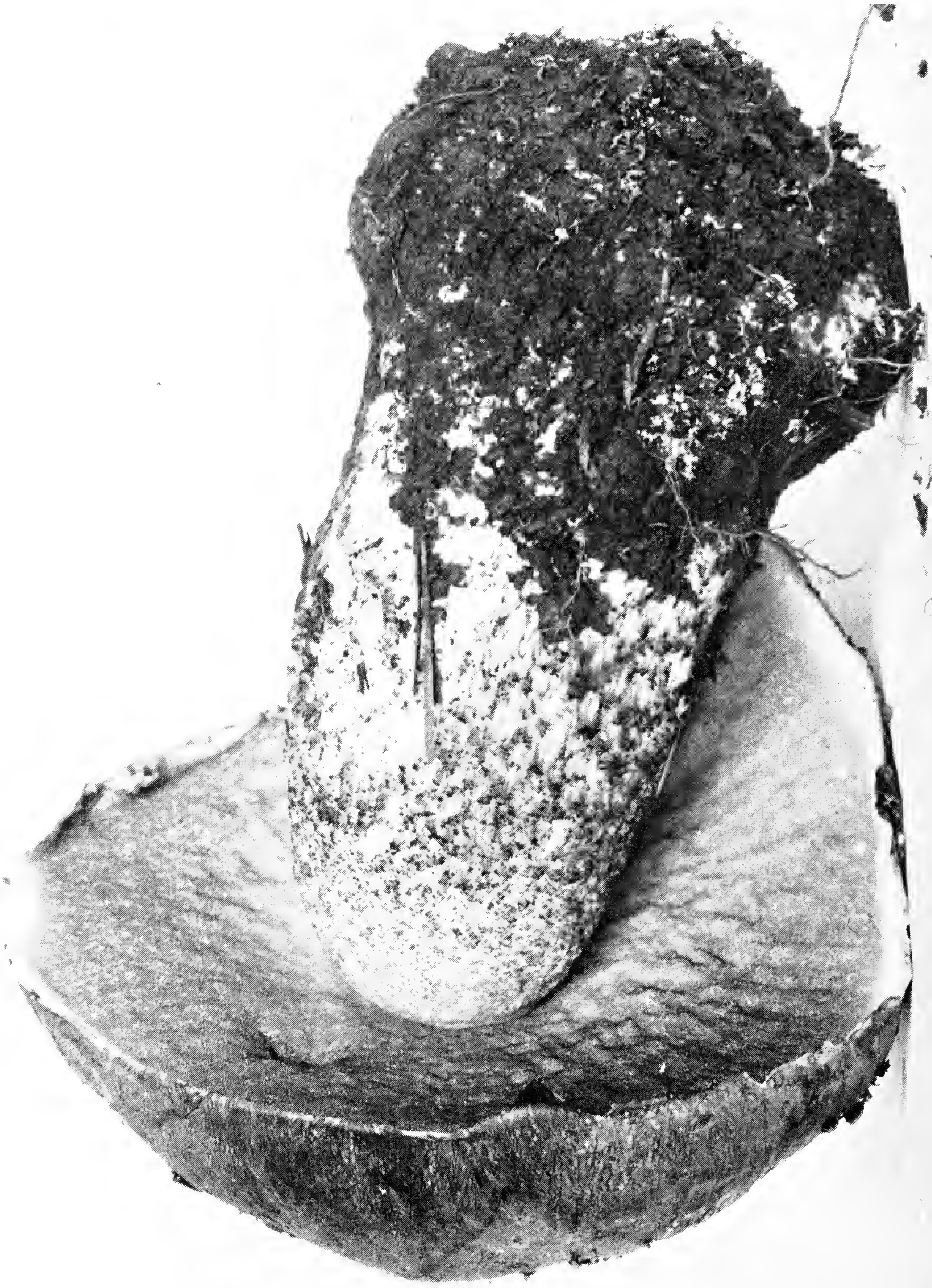

Fig. 4. *Leccinum ponderosum* ×1 Smith 55718

Fig. 5. *Leccinum subtestaceum* ×1 Smith 58018

Fig. 6. *Leccinum subtestaceum* x1 Smith 65886

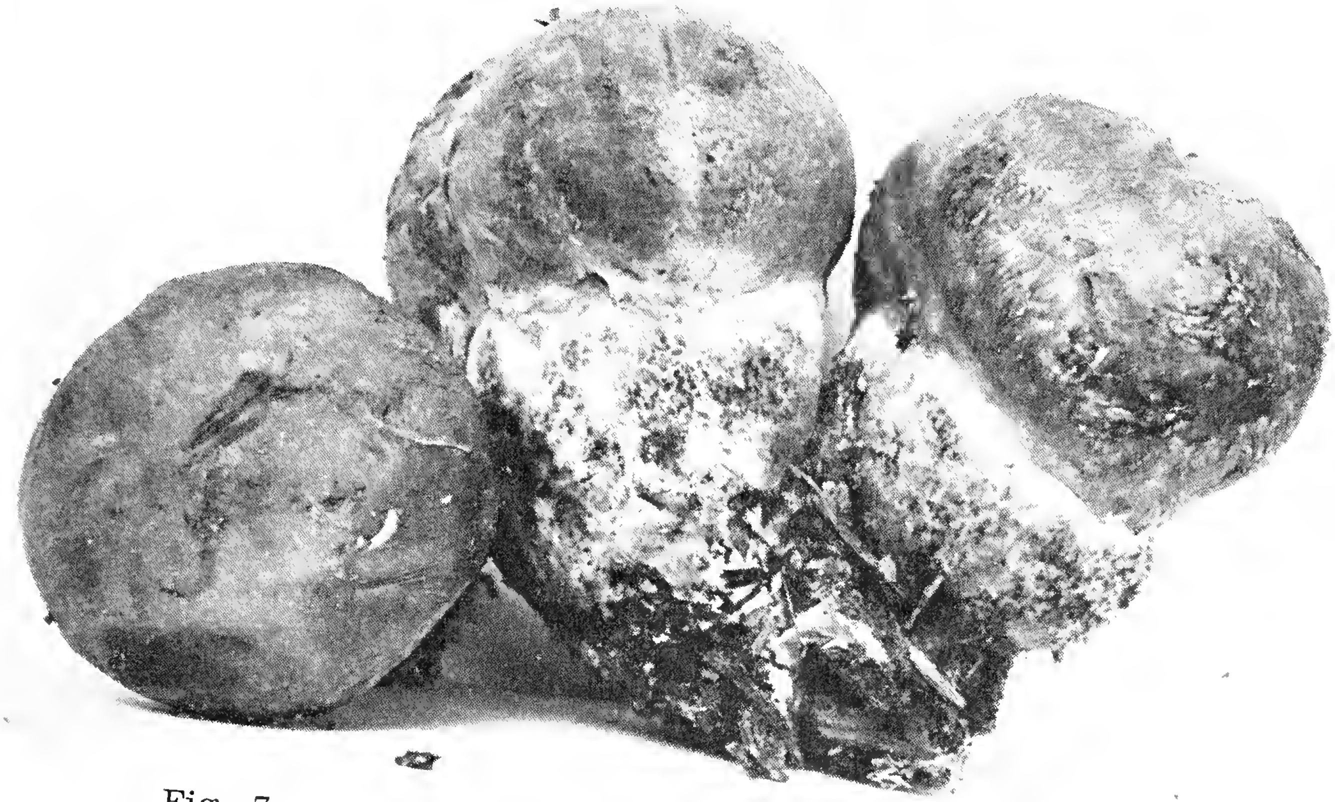

Fig. 7. *Leccinum subtestaceum* ×1 Smith 66337

Fig. 8. *Leccinum ochraceum* ×1 Smith 72411

Fig. 9. *Leccinum aurantiacum* var. *aurantiacum* x1 Smith 62435

Fig. 10. *Leccinum laetum* x1 Smith 72567

Fig. 11. *Leccinum atrostipitatum* x1 Smith 71855

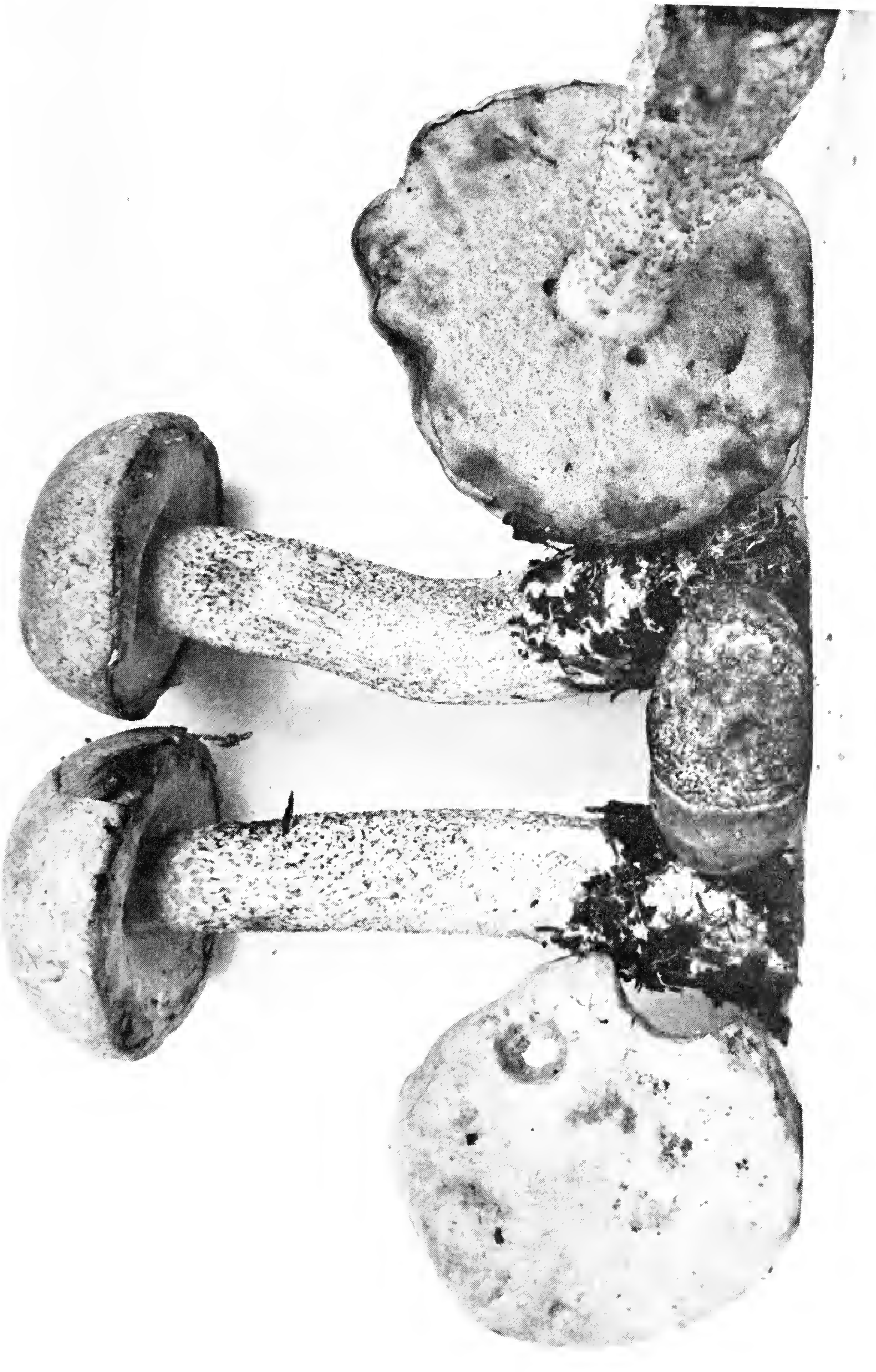

Fig. 12. *Leccinum cinnamomeum* ×1 Smith 66832

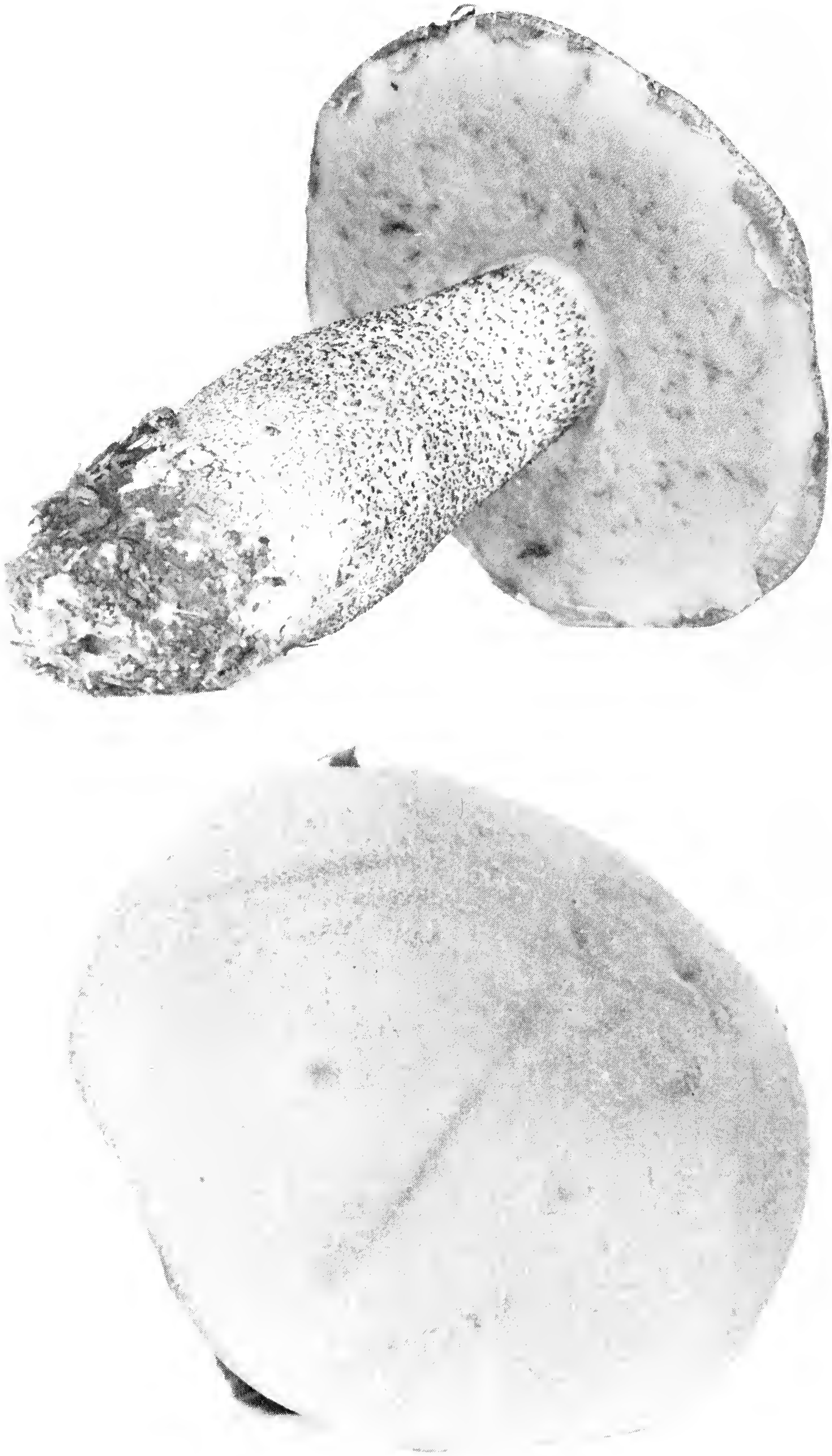

Fig. 13. *Leccinum insigne* × 3/4 Smith 71569

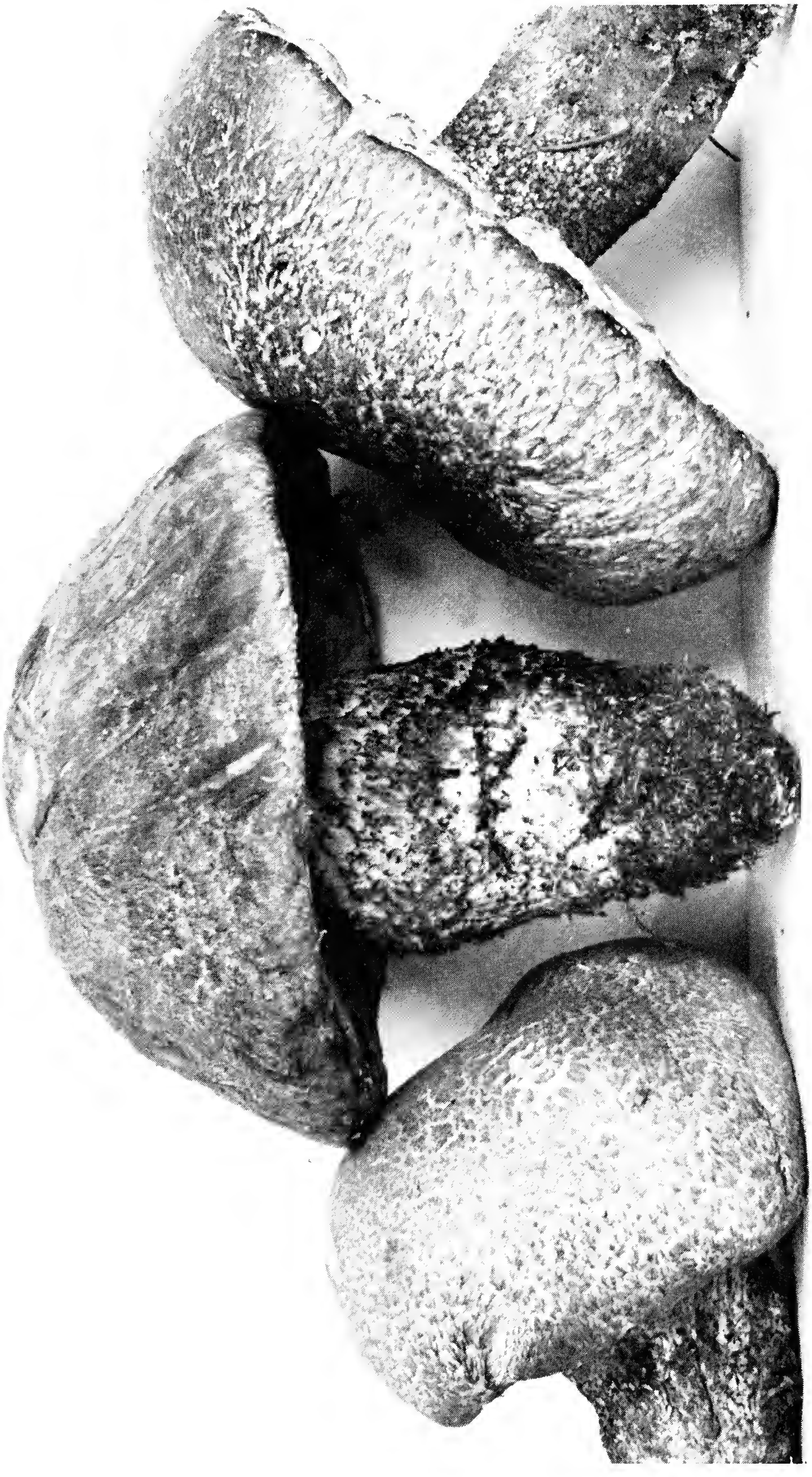

Fig. 14. *Leccinum fibrillosum* × 1/2 Smith 66337

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(On the cover: Flowering Dogwood, Cornus florida, photographed in Michigan by Carl B. Obrecht.)

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Articles and notes dealing with any phase of botany in the Upper Great Lakes Region may be sent to the editor in chief. The attention of authors preparing manuscripts is called to "Information for Authors" (Vol. 4, p. 38; reprints available from the editor).

Editorial Board

THE MICHIGAN BOTANICAL CLUB

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Dues are modest, but vary slightly among the chapters. In all cases, they include subscription to THE MICHIGAN BOTANIST.

WINIFRED CHASE, INTREPID SPIRIT

Kenneth L. Jones
Department of Botany,
The University of Michigan, Ann Arbor

Early in the 1950's, exactly when I do not recall, I found on my desk two boxes of 3-1/4 x 4-1/4 lantern slides. One, superb tinted photographs of natural populations of wild flowers growing in southeastern Michigan, the other, black-and-whites of an expedition to New Zealand and the South Seas, circa 1910. There was no identification except the initials "E. W. B. C." or "Leland" on the South Seas collection. Some pencilled notes used years ago for a talk before a general audience were chucked into the South Seas box. The slides were cached away with other of my paraphernalia for a decade.

Quite apart, I became aware of a University of Michigan Endowment Fund designated *The W. B. Chase Fellowship for Botanical Exploration*, established in 1954, to be administered by the Director of the Botanical Gardens. The late Harley Harris Bartlett, then Director, was more than likely involved in the arrangements.

On inquiry at the Business Office of the University, I discovered that the original donors were Miss Bernice Leland and Miss Harriet W. Thomson, residing at the latter's home in Eugene, Oregon. Miss Leland gave a hint of the career and interests of Miss Chase in her stipulation:

> The proposed appointments would be designed to aid the research programs of students in systematic botany, plant geography and other phases of botany requiring study in the field in this country or abroad or personal accumulation of plant materials for garden, herbarium or laboratory investigation in Ann Arbor.

Miss Thomson added a warm personal note:

> Without tying any strings on the proposed fund it is hoped that it may sometime provide for completion of work undertaken jointly by Miss Chase and the late C. A. Weatherby of Harvard but never completed, on the flora of Grand Manan [an island some fifteen miles long off the northernmost coast of Maine, but politically, New Brunswick] . . . . This is in memory of my girl friend and college "pal" at Michigan in our undergraduate days. I wish it could be many times more.[1]

---

[1] "A List of the Vascular Plants of Grand Manan, Charlotte County, New Brunswick," by C. A. Weatherby and John Adams, was published in October, 1945, as Contributions from the Gray Herbarium of Harvard University, No. 158. On p. 14, the authors note, among various visitors who have made small collections on Grand Manan: "Prof. E. W. B. Chase, of Wayne University, Detroit, spent a month in the islands in 1938 and made collections with a view to studying plant associations; her material has never been worked up." The authors further noted that they had seen the specimens of all collectors except those of Prof. Chase. —Editor's note.

Well, there came a day, propitious to the clearing in my own mind of just who Miss Winifred B. Chase was and what she did. To effect this, I agreed to talk on April 20, 1966, before the Ann Arbor Garden Club, on "Winifred Chase, Intrepid Spirit." I first proceeded to the Alumni Records Office of The University of Michigan Alumni Association. Promptly there was placed before me for unhurried perusal a folder designated: *Miss Ethel Winifred Bennett Chase A.B. University of Michigan '03, M.A. 1915.* The folder included several official registration cards of Summer Session attendance; questionnaires answered "gladly" to which were appended lively letters; and finally, the inevitable obituary notice.

Ethel Winifred B. Chase

A former botany professor and women's adviser at Wayne University, Miss Chase died Friday at the Northville convalescent home after a long illness [August 26, 1949]. She was 71.

Services will be at 2:30 P.M. Tuesday at the Wm. R. Hamilton Co. Chapel. Burial will be in Evergreen Cemetery [how apt].

She began her 45-year career as a science teacher at McMillan School in Delray. Since her retirement two years ago, Miss Chase had lived at Novi. Four cousins survive.

---that was all!

The Alumni Records Office now had a Detroit address for Miss Bernice Leland. There followed a quick exchange of letters between us—most cordial—including information that Mrs. O. H. Clark of Ann Arbor, A.B. University of Michigan, 1917, had also been a close friend of Winifred's. A telephone call to Mrs. Clark proved a pleasant entree into the life story of the "intrepid spirit." She had known Winifred as a loyal alumna of the Tri Delta sorority. Winifred's relationship to Mrs. Clark began on the level of teacher to student, as the former was on the staff of The Detroit Junior College, and Mrs. Clark (née Genevieve Gladys Rowe) was an undergraduate in the Literary College at the University, majoring in German and English. Winifred came out from Detroit on week ends to visit the girls and to plan the new house, in fact she personally did the landscaping. *Δ Δ Δ* was a first love and hobby with her. She served for twelve consecutive years, actively, on the national council and furthermore was one of the state founders of the international honor society of Delta Kappa Gamma, and a charter member of its Alpha Chapter.

Apparently Winifred delighted in enlivening her younger "sisters" with the sportiveness of her own college days. Mrs. Clark remembers Winifred's rollicking account of being "called up" before the Dean for driving a pair of frisky white horses around the campus. She says Winifred had so many friends that it is difficult to single out particular ones but certainly Bernice Leland, Harriet Thomson, Marian Stowe (then Head of the Department of Speech at Michigan

State Normal College), and herself, were in the inner circle. It was Mrs. Clark and Bernice Leland, together, who dismantled Winifred's museum-like apartment after her demise and distributed the effects—various books, etc., to the Clements Library of the University and lantern slides to the Department of Botany.

It was my good fortune on April 11, 1966, to visit Bernice Leland and Harriet W. Thomson at the Eventide Residence in Detroit, where they live on the eleventh floor in adjoining rooms. Though this venerable building lies in downtown Detroit between Cass and Woodward, "just beyond the miserable excavation being made for the new Freeway," it is serene within itself. In its secluded garden Winifred's name appears on a roll of honor, "as a fine woman with basic interests in people and the great outdoors."

Bernice Leland, born in Fenton, Michigan, April 25, 1882, received her B.S. degree from the University of Pennsylvania and her M.A. from The University of Michigan in 1932. She first became acquainted with Winifred in about 1905 in Delray, Michigan, where they taught in separate schools under the late Frank Cody. They met purely by chance during lunch time, soon became fast friends and were "family" to one another until Winifred's death in 1949. Bernice retired from a high position on the staff of the Detroit Psychological Clinic in 1951. Her long and productive career was devoted to teaching of children retarded in reading during an era when this was rugged pioneering.

Harriet Waterbury Thomson, born at Port Sanilac, September 16, 1879, was the college "pal" of Winifred's undergraduate days at Michigan. Together they worked on an ecological study of the Huron River. Actually another girl, Pearl Blanche Taylor (A.B. '03), and Harriet were doing this for "10 hours academic credit" under Professor Volney H. Spalding, Head of the Department of Botany. The other girl became ill. It was a vigorous undertaking to determine all of the plants (and consider their inter-relationships) from the crest of the hillsides to the middle of the Huron River itself. A day's work often began at 4 a.m., even in inclement weather. Winifred came to Harriet's rescue and worked with her—although the other girl returned—until the project was completed. Quite in character, she did this for the fun of it and received no academic credit. The study must have been performed thoroughly as it landed Harriet an appointment with the Federal Government in Washington, D.C., as a Scientific Aid, sans the usual Civil Service examination. However, she soon forsook government employment for a teaching position at the University of Oregon, a career which was to span fifty years. Beginning in 1921, she was Director of the Women's Gymnasium, a superbly equipped establishment with rooms for corrective work of many kinds. Though a Professor of Physical Education, Harriet Thomson was a born naturalist and became an expert on shells.

I learned subsequently through the Alumni Records Office that the Detroit *News* for Sunday, March 25, 1962, ran a feature article on Harriet W. Thomson, with an excellent photograph of her at work—peering contentedly through a microscope. She is probably the oldest active member of the National Malacological Union. The *News* article told of her owning a sample of sand used surreptitiously by chocolate-bar manufacturers to give weight to their bars. She showed me this specimen but had such a twinkle in her eye that I thought she was stringing me along. I felt comfortable enough, on first acquaintance, to tell her so! However, printed word is never (or almost never) to be denied and the *News* says the sand "is mined near Eugene, Oregon, and is tasteless, harmless, but gives weight and body to candies." Harriet more or less grew up a geologist as her family owned a salt company near Port Sanilac, Michigan. She is still interested in the home country—in fact asked if I might prod a University professor to write to her about the two shells she recently sent him from a 700-foot well drilled near the Port.

Now we should return to Winifred. She was born at LaPorte, Indiana, December 19, 1877, the only child of Henry A. and Helen McCormick Chase. As a mere infant Winifred lost her mother. Her father remarried and departed from the Midwest. Winifred's succinct words tell us:

> Because of mother's death I grew up in home of maternal grandparents who had been pioneers in 1846. Grandfather worked on survey of state and county, later became extensive landowner and was one of first men to import thoroughbred livestock from Europe for breeding purpose, also active politically. Superior cultural background for an avid minded and rather lonely little girl.

Her high school days at LaPorte were marked by a great earnestness in the study of science and a firm desire for higher education. The late Ruth Willoughby, music teacher at Detroit Western High School, was then at LaPorte High School. Her inspiration and friendship became a potent factor in Winifred's decisions and furthermore introduced her to great music. The high school years were not to be without sorrow and unusual responsibility for a teen-aged girl, as her beloved grandfather sickened and became blind. She assumed the task of helping him in his business affairs. He died during her senior year in high school, and her grandmother a few years later. This was a painfully shattering experience; nevertheless she clung firmly to her determination to seek a scholarly career and at the age of twenty-two entered the University of Michigan.

> A bright new world of natural beauty and intellectual opportunity opened before her there. She loved the rolling hills of Washtenaw County, the blue sky, the birds, the trees, and flowers. It was all music and poetry to her. Most of all she loved the Huron River which she explored for its

rich beauty and for serious scientific purposes as well. Firm friendships with fellow students, with townspeople, and with the members of the university faculty were established during these college years, to be maintained and treasured to the end of her life.

Those were the days of the May Festival under the direction of Professor Albert Stanley; of Schumann-Heink and Homer, and many others who brought the inspiration of their great talents to the student body. Their influence upon Winifred's intellectual and emotional life cannot be measured. They contributed a substantial part of the background for her later deep appreciation of the theatre, of fine literature, music and especially poetry and grand opera. She was thus spared the fate of becoming a scientist of narrow concerns and restricted outlook. Her book shelves, crowded with volumes on a great variety of subjects, gave testimony to the breadth of her interests. . . [From Bernice Leland's article of 1957.]

Winifred was not influenced by her professors at Michigan to become a botanist—she had already made up her mind to this before entering the University and throughout her days, whenever out-of-doors, she was botanizing—no particular group of plants or environment—*but all plants, everywhere, deeply interested her.*

In her undergraduate days, the Botany Department occupied all four rooms of the fourth floor of the South Wing of University Hall. The ends of the corridors were partitioned off for offices and storerooms. Living plants had to be grown in the windows. "This situation was remedied in 1903 to some extent, by the renting of a small space in Cousins and Hall's greenhouse on South University Avenue." Her teachers in Botany were Volney M. Spalding, Frederick Charles Newcombe, James Barkley Pollock, Julia W. Snow, and George P. Burns. Something of the mind-set of her principal teacher, Volney M. Spalding, may perhaps be conveyed by a note, "To The Student," in his popular textbook:

Cultivate self-reliance, but not self-sufficiency. Study things themselves rather than book descriptions of them, but habitually use the books you are referred to, comparing point by point your own observations with what the authors have to say. The writers may or may not be right; they are more likely to be than you are; but both of you may be wrong.

During the year '01-'02, Winifred was at the J. B. Stetson University in DeLand, Florida, as Assistant Botanist and Instructor in Physical Education. She returned to Ann Arbor the following year as Senior Assistant in Botany and earned her A.B. degree. Then followed a ten-year teaching stint at Delray McMillan High School, interrupted only by an expedition to the South Seas in 1909-1910. From 1913 until her retirement in 1947 she taught in Detroit, in turn at Central High School (1913-15), Detroit Junior College (1915-1922), and the College of the City of Detroit which evolved into Wayne University and then Wayne State University through the mutagenic action of intrepid spirits like her own.

The joys of teaching, which only a born teacher knows, did not deter Winifred from a vigorous career as a field botanist. She never settled on one group of plants or a particular ecological setting; all plants everywhere were her fascination. Summers were spent at Biological Stations: Woods Hole, Massachusetts; Minnesota Seaside on Vancouver Island; Mountain Lake in Virginia; and Friday Harbor, San Juan, Washington. She wrote the Director of the Michigan Alumni Association that these summers were *not* spent "for credit to be applied on the Ph.D.!" She botanized a season on Grand Manan Island, New Brunswick, and another near Raymond, Maine, not far from the Sebago Lake district.

The summer in Vancouver was noteworthy as there she and Bernice Leland struck up a happy acquaintance with one of the instructors, Josephine ("Joe") Tilden, renowned algologist. There is extant a poetic caricature of Winifred made by a fellow student that summer at Vancouver:

An athletic young woman named Chase
Who was always first in the race
Put a log on her shoulder
Stepped from boulder to boulder
And said, "I can keep up the pace."

"Joe" Tilden invited Winifred and Bernice, at their own expense, to accompany her and her mother and mother's sister on a venture to the South Seas (1909-1910). The party left San Francisco on the good ship *Mariposa*, one of the first oil-burning passenger boats to ply the Pacific. The trip was a brutal one in turbulent weather—a Yale professor aboard declared, "The Pacific was God's mistake!"

Miss Tilden, filled with romantic longings, was quite entranced by everything: the algae fringing the several islands, the friendly natives, and the South Pacific itself. She really hadn't much concern for "guiding" the botanical endeavors of Bernice and Winifred who were consequently thrown on their own to collect and mount anything and everything of the land flora. This they did avidly with little or no foreknowledge of what they were accumulating as specimens, which were to grace, or at least enrich, the Herbarium of The University of Minnesota.

Judging from the lantern slides, the New Zealand venture to the North Island, in particular, was a rewarding personal experience to the ladies, as a botanical and anthropological wonderland. Tree ferns and kauri pine were then magnificent. They witnessed "the dying" Maori civilization. T. F. Cheeseman, director of the museum in Auckland, took great pride in the Maori collections of *pas* (fortresses), dwellings, feathered clothing, graceful masks, exquisite carvings, and weaponry.

In the days of the University of Minnesota Expedition of Josephine Tilden, the fate of the Maoris was unresolved. Winifred must have been deeply concerned with these people, as individuals, and with a record of their past, if we may judge from the numerous lantern slides left in her collections.

Winifred and Bernice botanized in the Society Islands of Raratonga and Tahiti. In Tahiti they dwelt in one of the French-type "bird houses" at Papeete. The open structure of these flimsy dwellings gave air circulation not provided by the solid-walled, unhealthful mansions of more affluent Europeans. "Joe" found the entire milieu at Tahiti idyllic. The young Chief Salmon of Papyra took the party on a junket across the 33-mile island and they were guests at his home.

"You see these natives are a curious mixture of their natural inclinations and teaching which the missionaries brought to them," so read the pencilled notes in the box of lantern slides at my disposal. The slides show splendid males carrying bananas and shaping canoes from crude tools deep in the rain forest. The women, poor things, are clad in Mother Hubbard dresses and mail-house straw hats.

> Sweet tempered always kind, helpful, very curious, indolent of course and very lovable. Brown skinned and brown eyed, soft voiced and bearing no resemblance physical or otherwise to our negro as has been suggested. The women are beautiful. One of the happiest memories of these people singing native songs far away among cocoanut groves in soft sweet voices at edge of evening. Back away from road are native thatched houses of poorer sort. At end of first day we stopped in Papyra at home of Chief Salmon. We ate on back porch of his home overlooking sea where waves broke on reef and natives played about in their canoes.

A picture of the entourage led by Chief Salmon shows Winifred standing next to another Chief of great fame, Ori a Ori, the Tevan Chieftain who with Princess Moë, some nineteen years earlier, nursed the dying Robert Louis Stevenson back to health. The six-foot three-inch Ori a Ori was in 1909 a magnificent human specimen; dignified, noble of bearing, and kindly.

Stevenson wrote, "The best fortune of our stay [nine weeks] in Tautira was my knowledge of Ori himself, one of the finest creatures extant." He was made a member of the Teva tribe in a ceremony culminated by the exchanging of names, Louis took the name "Teriitera" and Ori, "Rui" (Rui rather than Lui as there is no equivalent of the letter "l" in the Tevan dialect).

"Joe" stayed on for some time in the South Pacific but for Bernice and Winifred there was no choice but to return to their teaching positions in the States at Detroit—a prospect which was inviting in many ways.

In her prime, Winifred was indeed a forceful, scintillating, ingenuous, and altogether lovable person—to meet her was to remember her. A student confessed, "We do not remember her so much for what she taught as for herself." Physically she was rather short (5'4") and stocky; blue-eyed, large-jawed, and blessed with lush, glistening brown hair. Her countenance was animated and one had better be prepared for a quick wit and a straightforward onslaught of strong opinions.

Even the lowly questionnaire bristled with her answers. One such sent from the Michigan Alumni Office in 1932 asked the innocuous question—"Date of Departure [from University]." She wrote in, "*Never did leave!*" Then she gave the Director the full treatment in the following letter which she appended to the form:

> My Dear Mr. Goodrich:
>
> Easter greetings even though a bit late. These intimate little questionnaires that the Alum office wants makes us feel a bit older than we are and as though they expected us to shuffle off any minute now. Well we all thought last year that J. Herbert Russell was going to do it in an untimely hurry by a unique method. He managed to be sleeping in a room where the ceiling fell and developed a nasty case of infection but after six months rest he is back on the job in City College as good as ever. Miss Orpha Worden is on the faculty of the Teachers College in the same building and Grace Smith and her sister Edna have started a wool shop at their summer home in Amherstberg, Ont. where they sell beautiful Canadian woolens under the sign of the wooly lamb—and teach in Detroit during school year. Since Detroit is in a bad way financially and has not been able to pay its teachers their full salaries, I think the girls are smart. I hear now and then from Harriet Thomson who was with us four years but was graduated with '04 because of illness. She is in the womens gymnasium Univ. of Oregon, has her own home in Eugene and spends part of her summers driving the western wilderness with a son of Rin Tin Tin as special body guard. He has managed to make quite a row with a few western bears but so far Harriet has never been involved in the fight.
>
> I am still teaching botany and trying to "dean" girls but since we are so overcrowded 10,000 in a building planned for 2,000—that I no longer have even an office, my efforts seem to be mostly hall interviews and about as effective as a cordial hail and farewell on a main highway.
>
> I have no idea as to how much class dues are. I paid up in full at last class meeting. Helped to make up some kind of deficit then and I have never had notice of dues since. May I have a statement if there are any. Best of luck hope to see you at next session.
>
> Cordially,
> Winifred Chase.

Winifred botanized intensively in Wayne, Oakland, Washtenaw, Huron, and Sanilac Counties. Bernice Leland says:

> Much of her botanizing was informal, wherever we went, on roadsides hither and yon as we tramped, or drove in later years. She was obliged to collect her own materials for her classes to study first hand. We spent many a week-end on that. The fields out Michigan Ave. were wide open spaces then and we scoured them all. Later years opened up areas of roads in the lakes area. We went *to* or *into* most of them.

She was a key person on the committee appointed by Dean McKenzie to plan science courses for premedical students and others looking forward to entrance into higher professional schools; she set standards in her own classes which soon gained recognition in schools of medicine, dentistry, and pharmacy.

She took the initiative to encourage the women students to participate in student government and originated an efficient system of student personnel records, and a counseling service which developed out of the need, *expressed by the students themselves, for her advice and guidance*. It was she who inspired and helped them create a stable student loan fund for women, initiating this by an annual student bazaar. Speaking of the first $500 raised in this way in 1922 she said:

> I never deposited money with greater satisfaction. It represented opportunity for some worthy woman to complete her course elsewhere.

During all this time she carried a full-time program of teaching, and had no secretarial service. She was never officially a "dean."

President David Henry, in behalf of Wayne State University, and out of great personal regard, gave the following citation on her retirement:

> Professor Chase, knowing plants and people, simply combined them to form a career which must be satisfying to her, and which is invaluable to the university and to the city, now and forever.

From Bernice Leland, devoted friend of forty-five years, should come the last words. These she has written to me in a personal communication:

> Winifred's sturdy health began to decline; she retired, hoping for free years in which to pursue her many interests. But that was not to be.
>
> She spent the last several months of her life in a perfect spot—a convalescent home in the country. She looked out of her window to the wide, wide fields beyond, of clover, birds and trees. She loved it.
>
> Pictures of her—I have many of them. The formal ones by professionals *do not show her* as she *really* was. My most favorite one is of a snap-shot enlarged. It was taken at Pine Lake and shows her *coming forward* her arms *full* of autumn branches.

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PRESETTLEMENT FOREST PATTERNS IN MONTCALM COUNTY, MICHIGAN

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INTRODUCTION

Accurate delineation of the distributional limits of native trees and reconstruction of the composition of the forest primeval have occupied the interest of many North American ecologists since Sargent's distribution data were published 75 years ago (Sargent, 1884, 1891-1902).

In an early paper, Transeau (1905) recognized two major centers of forest distribution in eastern North America: the Northeastern Conifer Center and the Deciduous Forest Center. Subsequent attempts by several authors to delimit more adequately the forest types are summarized by Nichols in 1935. Recently a rather detailed map of the potential vegetation of the conterminous United States has been published (Küchler, 1964).

One feature common to all of these descriptions of the natural forest associations was the recognition of a vegetational transition near the center of the Lower Peninsula of Michigan. Quick (1924) pointed out the character of the forest transition in central Michigan and suggested that postglacial migration rates were important factors in explaining present distribution of forest associations. Potzger (1948) later described this region as an ecological "tension zone" and conducted pollen analysis on sediments from several bogs in central Michigan. As did Nichols (1935), Potzger concluded that eastern hemlock (*Tsuga canadensis*) was of particular significance in delimiting the boundaries between the mixed deciduous forest region and the pine-hemlock-northern hardwood region which extends northward. The postglacial pollen record from lakes and bogs in the area shows that the basic floristic composition of the central Michigan forests was established about 7500 (C-14) years ago with the migration of beech and finally hemlock into the region; there were subsequent fluctuations in the pollen frequencies of pine and hardwoods which suggest that climatic changes resulted in vegetational shifts in this transition zone (Gilliam, et al., in press).

---

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The present paper contributes data from Montcalm County, Michigan, which allow more accurate characterization of the original forest communities in this transition zone. The botanical data from General Land Office Survey (G.L.O.S.) records ("witness trees" blazed to permit relocation of survey stakes, notations about boundaries of plant communities, and description of forest types) adds distributional data for certain tree species and permits the preparation of a presettlement forest cover map (Fig. 1).

Soil survey information aided in defining some boundaries on the map of original forest types, and the frequency of occurrences of certain common tree species on the major soil types is discussed. Patterns of extant and postglacial drainage systems, glacial deposits, and particularly the major soil groups have been used previously by Veatch (1932, 1959) in reconstructing presettlement forests. An analysis of the relationship between tree species and soil types in presettlement Indiana has recently shown that depth of soil horizons, percentage of nitrogen, and percentage of clay are the most influential soil attributes (Crankshaw, et al., 1965). Such a detailed analysis would be informative in central Michigan, but is beyond the scope of this study. The virgin forests are briefly compared with the second-growth forests of the county in the last section of the paper.

Analysis of pollen from subrecent sediments in bogs and lakes provides an indirect record of the components of the presettlement forests. Pollen analysts are currently attempting to determine whether it is possible to relate characteristic pollen spectra to specific forest types. The objective of establishing such coincidences between forests and the pollen mixture produced by the trees is to improve the accuracy of interpretations of postglacial pollen diagrams, permitting paleoecologists to clarify the changes in forest communities over the past several thousand years. Pollen spectra from three localities (located in different forest types) in Montcalm County are presented in this paper. The possibility of using G.L.O.S. data as a basis for interpreting pollen spectra is discussed.

ANALYSIS OF SURVEYORS' RECORDS

As early as 1907, C. A. Davis utilized General Land Office Survey data in reconstructing the original forests in northern Michigan. Subsequently Sears (1925), Shanks (1937), Lutz (1930), Finley (1951), Blewett and Potzger (1950), and Kilburn (1959) have used surveyors' records to reconstruct the presettlement forests in parts of Ohio, Indiana, Pennsylvania, Wisconsin, and Illinois. Similar studies in Michigan include those of Kenoyer (1930, 1934, 1940, 1943) for southwestern Michigan, Dick (1937) for Wayne County, and unpublished reports by Hartesveldt (1951) and Merk (1951) for Jackson and Washtenaw Counties. Bourdo (1956) reviewed surveyors' instructions and summarized the quantitative techniques by which survey data may be used in reconstructing virgin forests.

Surveyors' Techniques

The original survey of Montcalm County was completed in the period 1832-1839 and although there were minor alterations in the survey instructions, the technique of selecting witness trees was sufficiently uniform to permit use of the data in this study. The surveyors were instructed to mark two witness trees, closest to the corner post and in a different quadrant, at every section and quarter section corner. The tree species, their diameters in inches, and the direction and distances in links from the corner posts were recorded in notebooks which are retained at the county courthouse. In addition, the surveyors usually placed a double blaze on each tree intersected by a section line; the identities and estimated diameters of two or three of these "line trees" were usually recorded in the notebooks. While there must have been variations in the accuracy of tree identification by different surveyors, the internal consistency of the data recorded from small areas by subsequent survey teams suggests that determinations were consistent in Montcalm County. The recorded abbreviations of the vernacular names of the witness trees were deciphered with the aid of botanical manuals published during the survey era; all scientific names have been brought into agreement with usage in Gray's Manual of Botany, 8th edition. The following trees were recorded as witness trees; in each case the surveyors' notation is given in parenthesis following the scientific name:

Acer saccharinum (W. maple)
Acer saccharum (Sugar)
Acer rubrum (Maple)
Alnus rugosa (Alder)
Betula papyrifera (W. birch)
Betula spp. (Birch)
Carya spp. (Hickory)
Celtis occidentalis (Hackberry)
Fagus grandifolia (Beech)
Fraxinus americana (W. Ash)
Fraxinus nigra (B. Ash)
Fraxinus pennsylvanica
var. subintegerrima (G. Ash)
Fraxinus sp. (S. Ash or Swp. Ash)
Fraxinus spp. (Ash)
Juglans cinerea (Butternut)
Juglans nigra (Walnut)
Larix laricina (Tamc or Tamk)
Ostrya virginiana (Ironwood)
Picea mariana (Spruce)
Pinus strobus (Pine)[1]
Platanus occidentalis (Sycamore)
Populus deltoides (Cottonwood)
Populus spp. (Aspen)
Prunus spp. (Cherry)
Quercus alba (W. Oak)

[1]The surveyors' notes record "pine" without indication of the species; microscopic examination of wood from stump fences and *in situ* stumps in Richland Twp. (T12N, R5W) has revealed only *Pinus strobus*. This direct evidence is not conclusive, however, since red pine wood disintegrates more rapidly than white pine. Distributional information (Rudolf & Andresen, 1965) suggests that *Pinus resinosa* was probably not encountered by the surveyors in Montcalm County; we conclude that virtually all pines marked as witness trees in this county were *Pinus strobus*.

Q. bicolor (Swp. Oak or Swp. White Oak)
Q. macrocarpa (Br. Oak)
Q. muhlenbergii (Y. Oak)
Q. palustris (Span. Oak)
Q. rubra (Red Oak)
Q. velutina (B. Oak)
Quercus spp. (Scrub Oak)
Salix nigra (Willow)
Thuja occidentalis (Cedar)
Tilia americana (Lynn)
Tsuga canadensis (Heml. or Hemlock)
Ulmus americana (W. elm)
Ulmus spp. (Elm)

Evaluation of Surveyors' Bias

The establishment of a square grid pattern of sections and the placement of corner posts in the government land survey provided a series of systematically placed sample points in the original forests. The identities and distances of witness trees therefore approximate a random sample of these former forests.

There are a few known cases of gross fraud and falsified notebooks in the G.L.O.S.; the records from Montcalm County appear to be valid, however, and many of the original witness trees were relocated in subsequent survey work.

The existence of varying degrees of bias in the selection of witness trees by the surveyors has been discussed by Bourdo (1956). Unless the trees were actually the nearest to the corner post and selected without regard to species, size, soundness, bark character, etc., they would not represent a systematic and unbiased sample of the original forest. The survey instructions at various times stated that bearing (witness) trees should be "alive and healthy and not less than five inches diameter" or "the soundest and most thrifty in appearance, and of the size and kinds of trees which experience teaches will be the most permanent and lasting" (Bourdo, 1956, p. 760). There was a tendency to select medium-sized trees which were easier to blaze, rather than either small or very old trees which were likely to be cut during subsequent lumbering. There was also a tendency to select an uncommon species near the post because relocation was made easier. Such short-lived trees as aspen (*Populus*) were usually avoided. While different selection biases of the several surveyors in a county may have partially offset one another, there can be little doubt that the selection of witness trees was not strictly random. We must therefore evaluate the importance of bias in order to utilize these data.

Bourdo (1956) discusses several tests for evaluating bias in the surveys, including use of stand tables and evaluation of bias by quadrants. He also describes a technique by which surveyors' preferences with regard to species selection and tree size can be determined by computing the mean distance from the corner posts to the witness trees. We have used this technique to evaluate the preferential selection of trees by determining the mean distances from the corner posts for each of the dominant species.

Bourdo (1956, p. 762-3) states the rationale for this technique: "In a timber type which contains two or more dominants, the location of each with respect to the corner post depends on the density of trees of that species. . . . *However, mean distances from the post for each species and for every diameter class in it should be the same* [italics added]. This is wholly true only when the different kinds of trees are well distributed throughout the type. . . . the degree of random choice cannot be computed with equal accuracy for all species. It will be most closely approximated for the ones which are commonest, and especially for those, like sugar maple and beech, whose tolerance and habitat requirements also are similar."

The bias test was conducted for each of the more or less homogeneous forest types (beech-maple, oak, beech-pine-mixed hardwood) which were mapped. Since there is considerable site heterogeneity within the mapped units (because it is impossible to segregate microhabitats from surveyors' notes or resolve them at the scale

TABLE I. Mean distance in links (and range) from the commonest trees to the corner post in the three major presettlement forest types in Montcalm County. The chi-square analysis tests the hypothesis that the selection of tree species and distance from post were independent variables.

Species	Beech-Maple Type			Oak Type			Beech-Pine-Mixed Hardwoods		
	No.	Mean	Range	No.	Mean	Range	No.	Mean	Range
Fagus grandifolia	87	24.1	(3-65)	11	15.8	(0-26)	288	24.5	(0-75)
Acer saccharum	59	25.5	(0-88)		-		30	21.4	(0-54)
Acer rubrum		-		8	16.6	(0-34)	81	24.7	(0-60)
Fraxinus americana	3	24.0	(8-40)		-		8	25.7	(13-50)
Tilia americana	3	23	(9-34)		-		10	24.6	(0-65)
Pinus strobus		-		18	20.3	(0-55)	95	21.6	(0-68)
Ulmus spp.	12	34.1	(5-66)	10	19.1	(3-44)	21	29.4	(0-71)
Fraxinus nigra	5	33.2	(5-65)	3	29	(17-40)	17	31.5	(9-83)
Populus spp.		-		10	60.4	(15-200)	5	45.4	(26-73)
Quercus alba	3	24.7	(4-47)	255	82.6	(0-475)	46	42.1	(0-60)
Quercus velutina		-		25	89.8	(0-410)		-	
Quercus macrocarpa		-		10	125.5	(6-320)		-	
Quercus muhlenbergii		-		30	125.6	(0-440)		-	

Chi-square Analysis	Beech-Maple Type	Oak Type	Beech-Pine-Mixed Hardwoods
x^2 =	0.35	0.93	4.08
d.f. =	4	3	6
probability	.98 > .99	.80 > .90	.50 > .70

of mapping), less than perfect agreement of mean distances is expected.

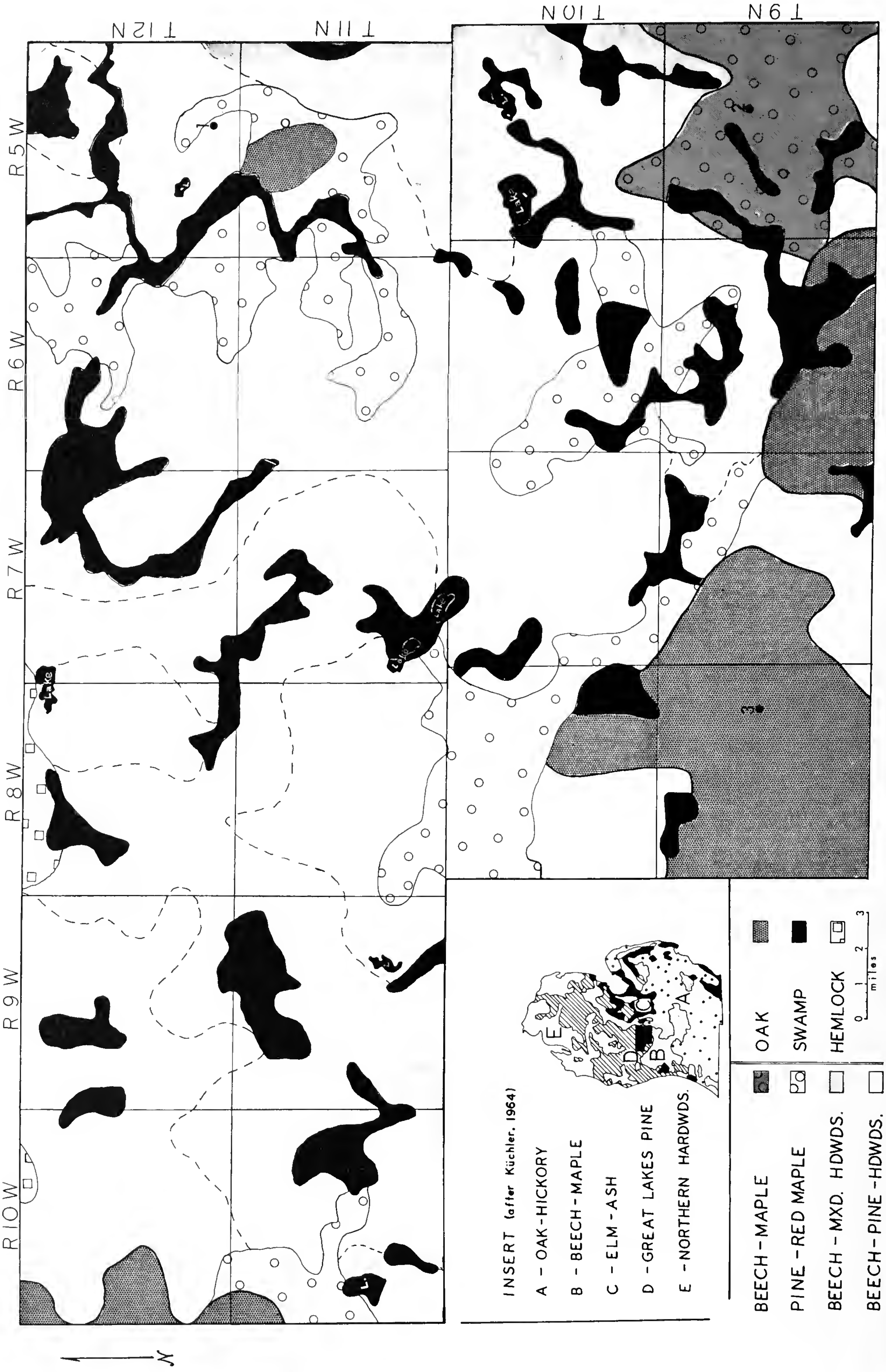
Table I gives the mean distances in links to the survey post (and the ranges) for each of the major species. Inspection of the means for the beech-maple type shows a high degree of similarity between those species with similar site requirements. The larger means for *Ulmus* and *Fraxinus nigra* indicate that some swamp forest is included in the beech-maple type, as mapped, and that the density of trees (at least those appropriate for selection as witness trees) was lower in the elm-ash stands.

Casual inspection of the data from the oak or beech-pine-mixed hardwood types in Table I does not permit evaluation of bias. The lack of similarity of means could be due to selection bias and/or greater heterogeneity of sites and stands within the mapped units. To test the validity of the hypothesis that selection of tree species and distances to posts were independent variables, two-way classification (contingency) tables were computed for each of the major forest types and the chi-square statistic obtained for each category. Differences as large as those observed (0.35) in species selection in the beech-maple forest could be due to chance with a probability of 98%; therefore bias is not significant. Similarly, while the chi-square value is slightly larger (0.93), species selection in the oak area could be due to chance at least 8 out of 10 times. Analysis of selection in the beech-pine-mixed hardwood type shows that differences as large as observed (4.08) could be due to chance with a 50 to 70% probability. There does not appear to have been important bias in selection of species of witness trees in Montcalm County.

RECONSTRUCTION OF ORIGINAL FORESTS FROM G.L.O.S. DATA

A map of the county was constructed in which every section and quarter section witness tree was plotted. Line trees were not included in the analysis because these need not have been at systematically selected points. Subsequently, the distribution maps for several prominent and interesting species were analyzed, permitting the preparation of a forest type map (Fig. 1). The distribution patterns of several species are shown in Fig. 2; pine, red maple, and several others which had a wide or scattered distribution are not plotted in this figure. The majority of oaks and sugar maples were found in circumscribed areas and suggest approximate geographic limits of the beech-maple and oak forest types. It can be noted that yellow oak (*Quercus muhlenbergii*) reached its northern distributional limit among the oak openings in Eureka Twp. (T9N, R8W). The southern limit of continuous distribution of hemlock was approximately the northern boundary of Montcalm County.

Each of the major forest types, as mapped in Fig. 1, is discussed and characterized below.


T 12 N
T 11 N
T 10 N
T 9 N
R 5 W
R 6 W
R 7 W
R 8 W
R 9 W
R 10 W
Lake
INSERT (after Küchler, 1964)
A - OAK-HICKORY
B - BEECH-MAPLE
C - ELM-ASH
D - GREAT LAKES PINE
E - NORTHERN HARDWDS.
A
B
C
D
E
BEECH-MAPLE
PINE-RED MAPLE
BEECH-MXD. HDWDS.
BEECH-PINE-HDWDS.
OAK
SWAMP
HEMLOCK
0 1 2 3
miles
N

Oak Type

The mean distance to the survey posts for the oaks in the southwestern part of the county was exceptionally high (85-125 links), indicating patches of low density forest or non-wooded areas. Large mean distances (125 links) for *Quercus macrocarpa* and *Q. muhlenbergii* probably reflected the tendency of these species to grow in or near oak openings. The historical records of the county (Schenck, 1881) also mention prairie openings in the oak forests of Eureka (T9N, R8W) and Fairplain (T9N, R7W) townships. Dry prairies in Michigan have been discussed by Veatch (1928), who published a map of the 39 major prairies known in the state. None of these mapped prairies occurred in Montcalm or adjacent Ionia counties, but southwestern Montcalm County lies in a zone where oak openings might be expected.

The oak forest type was dominated by white oak (*Quercus alba*) with lesser amounts of yellow (*Q. muhlenbergii*), bur (*Q. macrocarpa*), and black (*Q. velutina*) oaks. There was one record of Spanish oak (apparently *Quercus palustris*) on the southern county line, within the oak forest type. The Flat River passed through the oak forest of Eureka Twp. (T9N, R8W) and on the moister sites of the floodplains and adjacent habitats, white pine, red maple, elm, and beech were found. This oak forest area (Fig. 1) was predominantly a mixed oak forest with *Q. alba* and *Q. velutina* occupying a broad ecological spectrum and *Q. macrocarpa* and *Q. muhlenbergii* restricted to drier sites, often near or within oak openings. *Populus* spp. were found admixed with the oaks in low frequency. In the southern part of the county the oak forest type was interrupted in central Fairplain Twp. (T9N, R7W) by beech-pine-mixed hardwood forests. The eastern sector of the oak forest is limited at its easterly extent by the beech-maple forest type, and northward by beech and mixed hardwoods. In this area more beech, pine, sugar maple, and red maple were interspersed among the oaks. The criterion used for mapping the limits of the original oak forest (i.e., oak equivalent to at least 50% of the witness trees recorded for each section) permitted the mapping of a small area dominated by white oak in north-central Ferris Twp. (T11N, R5W).

An oak forest type of somewhat different composition occurred in the northwestern part of the county. The type was here restricted to Grayling sand and included pine and some scrub oak. Since clearing and subsequent fires, this section of primeval oak forest has

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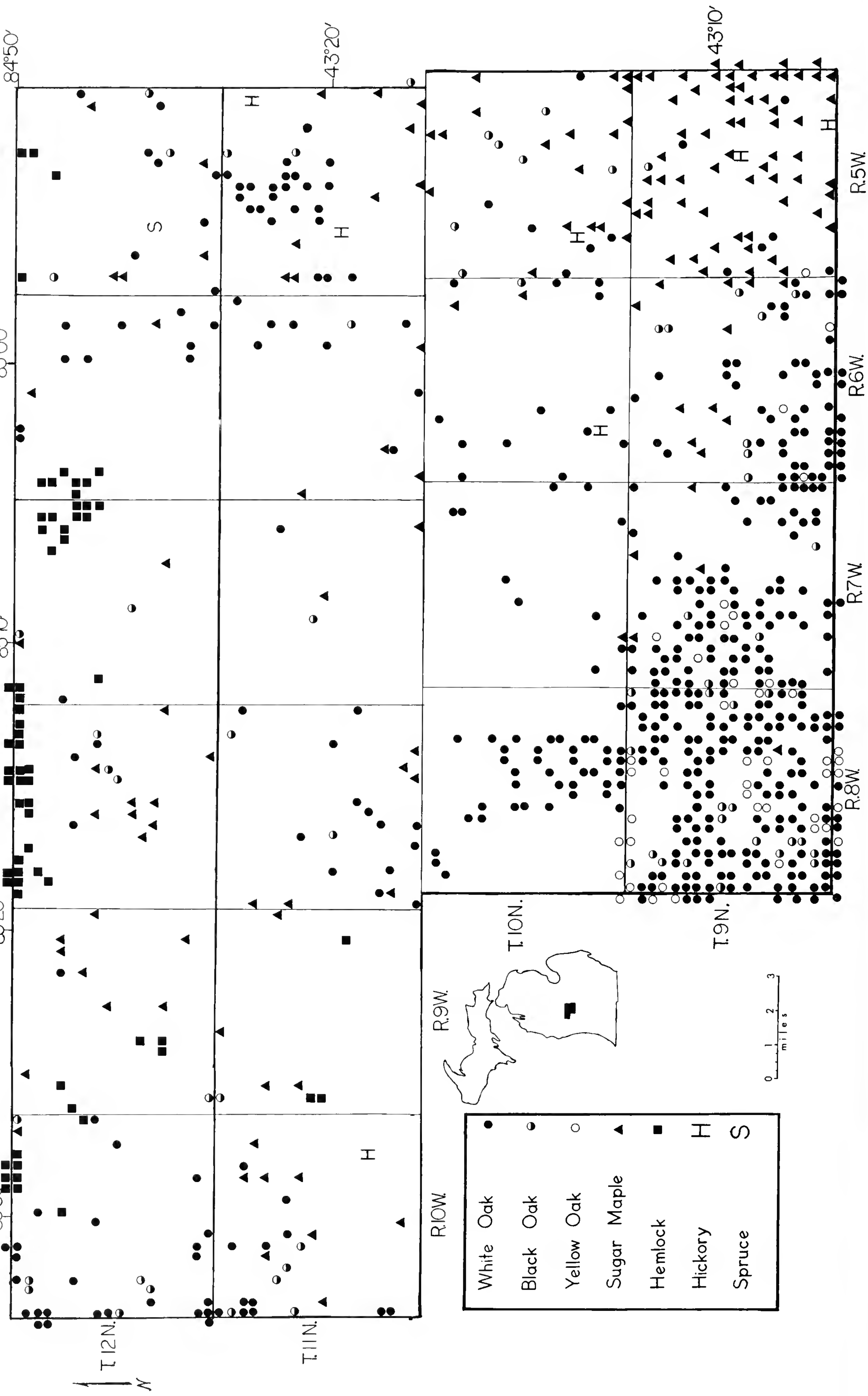
Fig. 1. Presettlement forest types of Montcalm County, Michigan, reconstructed from records of the General Land Office Survey. Boundaries are based partly on the extent of the major soil types. Pollen analysis sites: #1 (T12N, R5W) - Vestaburg Bog, Richland Twp.; #2 (T9N, R5W) - McCracken's Pond, Bloomer Twp.; #3 (T9N, R8W) - Manoka Lake, Eureka Twp.


84°50'
85°00'
85°10'
85°20'
85°30'
43°20'
43°10'
T.12N.
T.11N.
T.10N.
T.9N.
R.10W.
R.9W.
R.8W.
R.7W.
R.6W.
R.5W.
N
0 1 2 3
miles
White Oak
Black Oak
Yellow Oak
Sugar Maple
Hemlock
Hickory
Spruce

reverted to jack pine (*Pinus banksiana*) and scrub oak, and is continuous with similar forests in Newaygo County.

Beech-Sugar Maple Type

In presettlement times, the southerly beech-sugar maple forest extended into southeastern Montcalm County and apparently was almost completely restricted to Bloomer Twp. (T9N, R5W). The continuous distribution of sugar maple (i.e., at least 33% of the witness trees recorded for each section), with associated beech, was the criterion for delimiting the mapped extent of the beech-sugar maple type. Pine was completely absent from the survey notes for the southeastern corner of the county, and basswood (*Tilia americana*) was more abundant here than in other areas. Sugar maples extended into other parts of the county (Fig. 2), but the boundaries of the small, discontinuous stands of beech-sugar maple cannot be resolved with this sampling technique.

Mixed Coniferous-Hardwood Type

Most of Montcalm County was originally covered with a complex and variable mosaic of forest associations, characterized by abundant beech and white pine. Four subtypes have been distinguished and mapped (Fig. 1): the pine-red maple, beech-mixed hardwood, hemlock-pine-mixed hardwood, and beech-pine-mixed hardwood subtypes.

The broad ecological tolerance of white pine, beech, and red maple appears to explain the prominence of these species in the ecological transition zone of central Michigan. The occurrence of the three species on various soil types was analyzed using the surveyors' notes and the detailed soil map (Schneider, 1960) of the county. The analysis of the relative density (percent occurrence) and relative dominance (percent of total basal area) for the major species in the presettlement forest of 30,000 acres in Richland (T12N, R5W) and eastern Home (T12N, R6W) townships is shown in Fig. 3. White pine and red maple occurred in abundance on soils with very different moisture characteristics and with variable organic content, although both reached peaks of dominance and density on well drained sands and loamy sands. Beech exhibits a narrower, but substantial, tolerance for varied edaphic conditions. It was absent from peat and muck soils, and reached its peak performance in mesic sites on sandy loam soils.

Density and dominance analysis for the other major species (Table II) permits a generalized reconstruction of the relationships between soils and forest species in the presettlement forest.

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Fig. 2. Locations of several species of witness trees in Montcalm County. Beech, pine, red maple, and several other species which had a wide or scattered distribution are not plotted. Data mapped directly from notes of the original survey.

The low fidelity (degree to which species are confined to certain communities) of *Acer rubrum* in the forest associations of Wisconsin was noted by Curtis (1959). He observed that red maple now attains maximum presence (degree of representation; a species is counted present if it occurs, even infrequently, within a stand) in the "northern-dry mesic forest." Curtis (1959, p. 207) further comments that red maple exhibits a bimodal curve of ecological presence, occurring abundantly on both dry and wet sites.

It has been possible to delimit and map a *pine-red maple subtype* of the mixed coniferous-hardwood forest (Fig. 1). This forest community was characterized by the dominance of the two species for which it is named and by the virtual absence of beech. The subtype in some localities (e.g., T12N, R6W and T11N, R5W) was primarily an extension of the swamp forest onto better drained sites. In such areas both species, but particularly red maple, extended into the swamp forests as minor components. In other parts of the

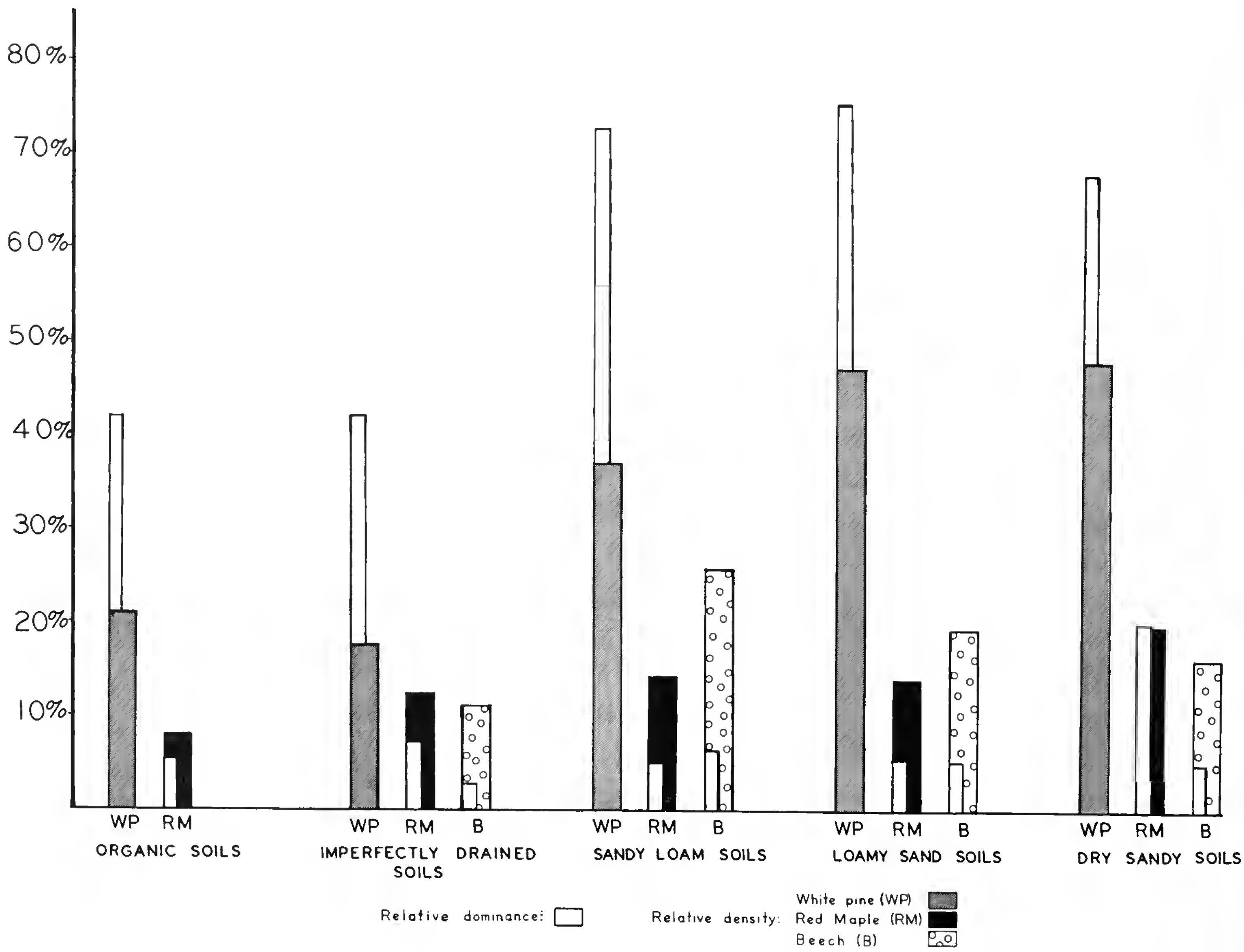


Fig. 3. Comparison of density and dominance of white pine (WP), red maple (RM), and beech (B) on the five major soil types. Percentage scale refers to the percent occurrence of each species compared with the total number of witness trees encountered (relative density) and the percent of total basal area of all witness trees (relative dominance).

TABLE II. Relation of Tree Species to Soil Type (Schneider, 1960) in the Presettlement Forest (Richland and Home Twps.). Note: Density percentages are based on total number of trees on each soil type; dominance percentages are based on the sum of the basal areas (in square inches) of all trees.

SPECIES	ORGANIC SOILS (Carlisle and Edwards muck; Rifle, Tawas, Greenwood, and Dawson peats)		IMPERFECTLY DRAINED (Alluvial soils; Ensley and Edmore fine sand; Gladwin loamy sand, Palo sandy loam)		SANDY LOAM (McBride, Isabella, Montcalm, and Newaygo sandy loams)		LOAMY SAND (Mancelona and Montcalm loamy sand)		DEEP DRY SAND (Grayling sand)	
	Density (N = 62)	Dominance (Σ = 14,554)	Density (N = 63)	Dominance (Σ = 18,943)	Density (N = 143)	Dominance (Σ = 50,158)	Density (N = 220)	Dominance (Σ = 81,607)	Density (N = 25)	Dominance (Σ = 7,185)
Larix laricina	14.5	8.6								
Thuja occidentalis	6.4	4.8								
Picea mariana	3.2	0.4								
Betula lutea	9.7	7.0								
Fraxinus nigra	16.1	4.2	14.3	12.1						
Ulmus spp.	16.1	14.3	17.5	19.6	2.1	1.0				
Tilia americana			11.1	5.2	2.8	1.2				
Tsuga canadensis			6.3	2.2						
Pinus strobus	20.9	42.6	17.5	42.0	36.1	72.9	47.3	75.5	48.0	67.9
Acer rubrum	8.0	5.2	12.7	7.3	14.7	5.1	14.1	5.1	20.0	19.8
Fagus grandifolia			11.1	3.0	25.8	7.4	19.5	6.1	16.0	4.4
Acer saccharum					4.9	1.6	1.4	0.8		
Quercus alba					9.8	8.8	9.5	7.3		
Quercus spp. (Bur & Red)							2.8	2.6		
Fraxinus americana							1.8	0.5		
Ostrya virginiana							1.8	0.2		
Betula papyrifera									12.0	13.5

county (e.g., T10N, R8W) the red maple-white pine subtype was found on well drained sands.

The beech-mixed hardwood subtype (Fig. 1) was characterized by the prominence of beech and virtual absence of white pine. White and black oak, a few sugar and red maples, American ash, and some other hardwoods were often associated with this subtype. The northern extent of this subtype in the southeastern part of the county marked the approximate southern distributional limit of pine.

The hemlock-pine-mixed hardwood subtype (Fig. 1) was restricted to small areas along the northern boundary of the county. Here the eastern hemlock (*Tsuga canadensis*) occupied mesic sites in a forest of beech and white pine. The areal extent of this subtype in the county was inadequate to permit a full characterization of the forest composition from surveyors' notes. In addition, hemlock occurred in the large area of swamp forest mapped in T12N, R6W and T12N, R7W.

The beech-pine-mixed hardwood subtype (Fig. 1) extended over wide areas in central and northwestern Montcalm County. Beech and white pine were clearly the dominant trees in this subtype, although a minor component of oak, maple, and ash was present. The structure of this forest was apparently a mosaic of dense pine stands and pine-hardwood communities. This subtype was the chief source of pine timber and was of great economic importance during the period of lumbering. Contagion in distribution of pine was evident from surveyors' records and other historical notes. The dense pineries were often on river banks and these sites have been least satisfactory for profitable pursuit of agriculture. Such pinelands were repeatedly burned during and after clearing (Schenck, 1881), as is evident upon examination of stump fences and *in situ* white pine stumps.

Swamp Forest Type

Swamp forest existed on floodplains and in poorly drained depressions where peat or muck soils were predominant. In some localities such swamp forests were almost exclusively tamarack (*Larix laricina*). Cedar (*Thuja occidentalis*) was most abundant in floodplains in the northern tier of townships. Usually the swamp forests contained a strong representation of deciduous species, notably black ash (*Fraxinus nigra*), elm (*Ulmus* spp.) and red maple (*Acer rubrum*). The tamarack-cedar element was much less prominent in the swamp forests of the southern parts of the county; hemlock occurred occasionally in the lowland forests of the northern townships.

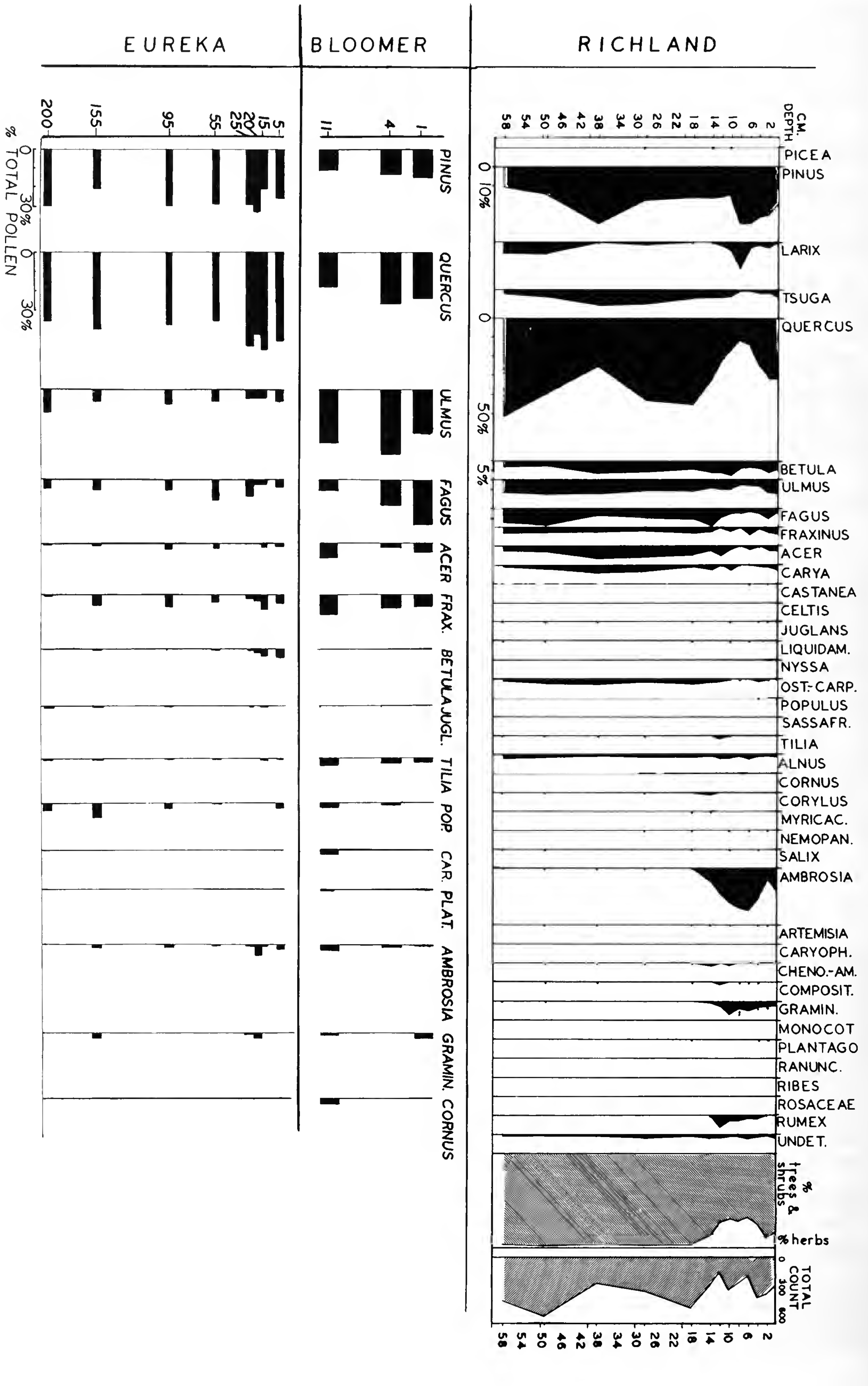
POLLEN REPRESENTATION OF THE PRESETTLEMENT FORESTS

The uncertain nature of the relationship between the composition of a forest and its pollen production is an enigma which detracts from the accuracy of pollen analysis (Potter, 1962); only within the last decade have there been systematic attempts to relate modern vegetation and modern pollen rain in North America (Davis & Goodlett, 1960; Potter and Rowley, 1960). McAndrews (in press), working in Minnesota, has studied the relationship of pollen rain to several vegetation types; Benninghoff (1960) has compared modern pollen deposition in different communities near Inverness Mud Lake Bog in northern Michigan. Alterations of the structure of the vegetation by deforestation, reforestation, and introduction of exotic species make it likely that correction factors based on modern vegetation and pollen rain will not be entirely applicable to presettlement pollen records. Kilburn (unpublished manuscript) has suggested that comparisons between surveyors' records and contemporaneous pollen spectra might be useful to students of vegetational history; we have attempted to evaluate this approach as an adjunct to this study of presettlement forests.

Localities and Results

Analysis of the pollen content of shallow sediments from lakes and ponds in three presettlement forest types has been attempted in Montcalm County. Fig. 4 presents data from three parts of the county, each from a different presettlement forest type. The Richland diagram is from the upper 60 cm of sediments in Vestaburg Bog (NW$\frac{1}{4}$NE$\frac{1}{4}$, Sec. 34, T12N, R5W); the area was in the beech-pine-mixed hardwood presettlement forest. The Bloomer diagram is from a small woodland pond (NE$\frac{1}{4}$, Sec. 15, T9N, R5W) within the beech-maple presettlement forest area. The Eureka diagram is from calcareous Manoka Lake in the village of Greenville (SE$\frac{1}{4}$NE$\frac{1}{4}$, Sec. 16, T9N, R8W) within the presettlement oak forest area.

The Richland diagram shows the presettlement pollen rain below 18 cm. Deforestation is demonstrated in the percentage pollen spectra by decreases in frequency of *Quercus*, *Fagus*, *Acer*, *Carya*, *Tsuga*, and to a lesser extent *Betula* and *Ulmus*. Remarkably, even though pine was the most abundant timber tree removed from the hills surrounding Vestaburg Bog, the pollen percentage of *Pinus* increased after deforestation. It is evident that higher percentages of *Pinus* and *Larix* in the upper 10 cm of sediments is the result of heavy overrepresentation of the few pines and tamaracks remaining in the lake basin. Succession of the forests after initial timber removal is evidenced in the pollen diagram by recovery of the percentages of the hardwood trees, and simultaneous decline in percentages of the locally overrepresented pollen of pine and tamarack. The upland second growth forests of the area are now dominated by white oak, red maple, and species of *Populus*. Evidence of settlement and agriculture is the sharp rise in ragweed (*Ambrosia*) pollen and other herbaceous plants of open fields (e.g. Gramineae, Chenopodiaceae-Amaranthaceae, and *Rumex*).


EUREKA
BLOOMER
RICHLAND
% TOTAL POLLEN
PINUS
QUERCUS
ULMUS
FAGUS
ACER
FRAX.
BETULA
JUGL.
TILIA
POP.
CAR.
PLAT.
AMBROSIA
GRAMIN.
CORNUS
CM. DEPTH
PICEA
PINUS
LARIX
TSUGA
QUERCUS
BETULA
ULMUS
FAGUS
FRAXINUS
ACER
CARYA
CASTANEA
CELTIS
JUGLANS
LIQUIDAM.
NYSSA
OST.-CARP.
POPULUS
SASSAFR.
TILIA
ALNUS
CORNUS
CORYLUS
MYRICAC.
NEMOPAN.
SALIX
AMBROSIA
ARTEMISIA
CARYOPH.
CHENO.-AM.
COMPOSIT.
GRAMIN.
MONOCOT
PLANTAGO
RANUNC.
RIBES
ROSACEAE
RUMEX
UNDET.
% trees & shrubs
% herbs
TOTAL COUNT

The pollen spectrum for the presettlement forest in Richland Twp. is:

Pine	20%	Hickory	1%
Oak	45%	Walnut	trace
Birch	5%	Hemlock	5%
Elm	6%	Aspen	trace
Beech	5%	Sycamore	trace
Ash	3%	Ragweed	trace
Maple	5%	Grasses	trace

Depositional basins are small, infrequent, and often disturbed in Bloomer Twp. (T9N, R5W). A small pond was sampled which yielded a meter of muck, gyttja and clay. This is a woodland pond near the edge of a well-managed stand of mature beech, maple, basswood, elm, and ironwood which today has physiognomic characteristics of a virgin beech-maple stand. There is no evidence of an increase in ragweed (*Ambrosia*) or agricultural weed pollen in the surface sediments, probably because the basin is within the woodlot and does not receive much pollen from surrounding farmland. We believe that the three pollen spectra from the deposit reflect the pollen contribution of the beech-maple association, whether derived from the presettlement era or the modern surrounding woodlots. The average of the pollen spectra from the beech-maple forest type in Bloomer Twp. is:

Pine	13%	Hickory	trace
Oak	24%	Walnut	trace
Birch	trace	Hemlock	trace
Elm	29%	Aspen	trace
Beech	14%	Sycamore	trace
Ash	8%	Ragweed	1%
Maple	5%	Grasses	1%

Data from the presettlement oak region of Eureka Twp. are also presented in Fig. 4. The rise in the ragweed (*Ambrosia*) curve in the upper samples is believed to record deforestation; consequently the pollen spectrum from the 55 cm level is considered to have been from presettlement times; it has the following composition:

←

Fig. 4. Pollen diagrams from short cores collected from sites located within three different presettlement forest types in Montcalm County. The Richland Twp. site is within the original beech-pine-mixed hardwood type; the Bloomer Twp. site within the beech-sugar maple forest; and the Eureka Twp. site within the original oak forest. Abbreviations: Ost.-Carp. = *Ostrya-Carpinus*; Cheno.-Am.= Chenopodiaceae-Amaranthaceae; Frax. = *Fraxinus*; Jugl. = *Juglans*; Pop. = *Populus*; Car. = *Carya*; Plat. = *Platanus*.

Pine	26%	Hickory	1%
Oak	40%	Walnut	1%
Birch	0.5%	Hemlock	trace
Elm	9%	Aspen	4%
Beech	5%	Sycamore	4%
Ash	5%	Ragweed	2%
Maple	2%	Grasses	1%

Discussion

There is a general agreement between the virgin forest types (as reconstructed and mapped above) and the pollen rain of the presettlement era. It should be noted that certain trees such as maple, basswood, tamarack, and poplar tend to produce pollen grains in low numbers, disperse it poorly, or produce pollen susceptible to degradation. These types are generally underrepresented in the pollen rain. Some other types, notably pine and oak, produce excessive quantities of pollen and are disproportionately abundant in pollen spectra.

Within the range of pine in Montcalm County, the pine pollen percentage was 20-26%, while outside its range, a distance of 5-6 miles, pine pollen frequency was only 13% (Bloomer Twp.). Conversely oak contributed about 40% to the pollen spectra in Eureka and Richland Townships, while within the beech-maple forest of Bloomer Twp. the oak percentages were about one-half that value. Maples were virtually absent from the surveyors' notes of Eureka Twp. and the pollen percentages are low (2%). In Bloomer and Richland Twps., maple pollen accounts for 5% of the spectra, probably due to concentrations of sugar maple in the former area and red maple in the latter. Beech pollen reached high percentages in the beech-maple region (14%), while a background contribution of about 5% would appear to be expected in the regional presettlement pollen rain in central Michigan. Hemlock pollen was present (5%) in the deposits near the northern edge of the county, and virtually absent at sites 15 miles south, beyond the southern limit of continuous distribution. Hemlock pollen is apparently not widely disseminated from its source. Paper and yellow birch trees were frequent only in the northern part of the county and the pollen spectra reflect the distributional pattern.

These data will facilitate the interpretation of postglacial pollen records in central Michigan; refinement of the correlations between presettlement forests and pollen rain in this and other areas should be of value to pollen analysts.

FOREST REGENERATION AFTER CLEARING

Subsequent to lumbering and the associated burning which occurred chiefly in the years 1850-1875, most of the county was put into agricultural production. Sandy areas of low fertility and regions of steep slopes and bottomlands, especially in the northern parts of the county, were permitted to regenerate to woodland immediately after lumbering, or after a period of unprofitable agricultural activity. The extensive pineries of the north and central parts of the county were supplanted by second growth forest of oak (mostly *Q. alba*) and aspen; where a few native white pines survived the axe, as near Vestaburg Bog in Sec. 34 of Richland Twp., young seedlings and saplings of that species are now developing under the canopy of the second-growth hardwoods. The capacity and present tendency for white pine to regenerate in the second-growth oak and mixed hardwood forests of the county requires further investigation. Some well managed woodlots in Bloomer Twp., within the original beech-maple forest type, were not clearcut or burned and appear to have retained the structure of a mature beech-sugar maple-basswood forest.

An inventory of the timber resources of Montcalm and other central Michigan counties was completed in 1949 (Chase, 1953). At that time 55% of the forests of Montcalm County were second-growth oak woodland. The southeastern and northcentral parts of the county (about 30%) had regenerated to a mixture of beech-maple and northern hardwoods. The remainder of the wooded portion of the county was lowland hardwood forest, although this type has been altered from its presettlement composition by selective removal of cedar, tamarack, and ash.

SUMMARY

The notes of the original land survey of Montcalm County, Michigan, have yielded botanical data which were utilized in the preparation of a presettlement forest map of the county. Each of the original forest types (as mapped) is characterized and discussed. The northern limits of distribution of *Quercus muhlenbergii* and *Q. palustris* were in southwestern Montcalm County and the southern extent of the continuous ranges of *Pinus strobus* and *Tsuga canadensis* also lie within the county. Comparison of the distribution of the surveyors' witness trees with the major soil types has permitted some generalizations about edaphic requirements of certain forest species.

Pollen analysis was completed on short sediment cores from three sites within the county; each site was located in a different presettlement forest type. Differences in composition of the original forest can be detected in the contemporaneous pollen records. These comparative data will aid in interpretation of regional postglacial pollen diagrams, especially facilitating the detection of vegetational shifts in the ecological tension zone of central Michigan.

ACKNOWLEDGMENTS

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THE NATURAL OCCURRENCE OF A HYBRID HONEYSUCKLE (*LONICERA x BELLA*) IN OHIO AND MICHIGAN[1]

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Recent floristic work in northeastern Ohio (see reports by Amann, 1961; Hawver, 1962; & Hauser, 1965) and throughout Michigan has yielded several collections of *Lonicera* x *bella* Zabel. This honeysuckle is regarded as a hybrid between the well-known Tartarian Honeysuckle (*Lonicera tatarica* L.) and the Morrow Honeysuckle (*L. morrowii* Gray). The hybrid was named by Zabel in 1889 (Gartenflora 38: 525) and has often arisen unintentionally in cultivation.

[1]Based on a paper presented at the 69th Annual Meeting of the Michigan Academy of Science, Arts, and Letters, held at The University of Michigan, Ann Arbor, March 19, 1965.

In Gray's Manual, Fernald (1950) states that *L. × bella* is found as an escape from cultivation, Maine to New York, New Jersey, and Pennsylvania; the western Great Lakes region would be excluded from this statement of range. The occurrence of both parent species, but not the hybrid, in Ohio is mentioned by Braun (1961); all three are included by Hauser (1965). *Lonicera tatarica* is accepted by Billington (1949) as established in Michigan. Both it and *L. morrowii* are reported by Hanes and Hanes (1947) from southwestern Michigan; Voss (1957) mentions *L. × bella* and *L. morrowii* from northern Michigan.

Lonicera morrowii and *L. tatarica* are both indigenous to Asia, where they are isolated geographically. As indicated by Rehder (1903) and Bailey (1949), the native distribution of *L. tatarica* is from central Asia to South Russia (from the Altai to the Ural Mountains and to the Volga), whereas *L. morrowii* occurs only in Japan. In North America both species have been cultivated and have escaped. In our region, they can both be considered as naturalized, as defined by Lawrence (1951, p. 279). Here no geographic barrier exists and apparently where both species occur together, hybrid plants (*L. × bella*) may be found. The evidence for the hypothesis that the hybrids are spontaneous rather than having themselves escaped from cultivation comes mainly from observations and field studies in northeastern Ohio.

SOURCES OF SUPPORTING DATA

Habitat. The most recently discovered stations of *L. × bella* in Ohio are in the northeastern portion of the state. Here a profound revolution in land usage has taken place during the last three decades. Rapid and large-scale suburbanization of the area adjacent to large cities, e.g., Akron and Cleveland, has occurred. Land investment companies have consumed large acreage of farms. As land costs, taxes, and zoning requirements have increased, it has become economically unfavorable to use this area for agricultural purposes. As a result, much of the farmland has been abandoned, creating over a period of years many new marginal habitats, such as artificially treeless open field areas. These and previously existing fencerows, grazed pastures, railroad embankments, and roadsides represent favorable habitats for these honeysuckles.

Undoubtedly, plants of *L. morrowii* and *L. tatarica* have escaped from cultivation into these easily available habitats. Hanes and Hanes (1947) indicate that *L. morrowii* and *L. tatarica* apparently are disseminated by birds. Seed analysis studies (conducted by Professors R. W. Dexter and Clinton Hobbs at Kent State University) of bird digestive tracts support this assumption.

An important factor influencing the distribution of these honeysuckles is their ability to become established under a wide range of unstable conditions. Generally, the habitats occupied by these plants are exposed and may be either wet or dry. Often they are adjacent to one another, e.g., roadside, fencerow, and open field. Weedy plants such as *Brassica nigra*, *Dipsacus sylvestris*, *Lepidium virginicum*, and *Solidago* spp. are common herbaceous associates. In open fields, competition may occur with other woody plants, such as those of the following genera: *Cornus*, *Crataegus*, *Lindera*, *Prunus*, *Rhus*, *Pyrus*, and *Viburnum*. For example, in the Lake Rockwell area of Portage County, Ohio, *L. morrowii* and *L.* × *bella* have been found as understory shrubs under a canopy of mature trees of *Prunus serotina*.

Phenology. The general flowering period for these honeysuckles in Ohio and Michigan is from May 1 to May 31. The formation and opening of the flower buds occur at approximately the same time on plants of all three taxa in the same area. Plants of all three can be found in anthesis on the same day in the same area. These observations are supported by the collections of Battles, Foldesy, Gillis, and Hauser (cited below). Certainly flowering period is no barrier to hybridization.

Pollination. The principal pollinating agents are bumblebees (*Bombus* spp.). Thus, pollination between plants some distance apart is possible when these wide-ranging insects are present. My collections in the Lake Rockwell area of Ohio are interesting in that many juvenile plants of the hybrid were found with mature plants of *L. morrowii*. The nearest collecting site for *L. tatarica* was about one-half mile away. Data on the collections of Gillis (in Michigan) and others also indicate the presence of *L. morrowii* in the immediate vicinity of the hybrid. These observations would suggest that *L. tatarica* is the pollen parent of the hybrid.

Cytology. Chromosome numbers for *L. tatarica*, *L. morrowii*, and their hybrid reported in Darlington & Wylie (1955) indicate that all three are homoploid (2n = 18). In lactophenol--cotton blue tests for fertility, the hybrid exhibits about 30% abortive pollen. Thus, it is probable that it produces a large amount of viable pollen, indicating high genetic compatibility between the parental species.

Morphology. As indicated by Stebbins (1950, p. 27), most interspecific hybrids tend to express an intermediate morphology. The morphological intermediacy of the honeysuckle hybrid is not readily apparent from casual observation, nor even from critical study. In fact, the hybrid is noteworthy in that a number of characters are not intermediate between those of the parent species, e.g., bracts, bractlets, petioles, and peduncles all tend to be longer. Although Fernald (1950) and Gleason (1952) note a few distinguishing characters of the hybrid, a more complete list is given in Table I.

TABLE 1. Diagnostic characters of *L. tatarica*, *L. morrowii*, and their hybrid (*L.* × *bella*).

Character	*L.* × *bella*	*L. tatarica*	*L. morrowii*
1. Leaf vesture (undersurface)	pubescent to glabrate	glabrous	tomentose
2. Petiole length (cm)	2.5 - 4.5	1.7 - 3.2	1.8 - 3.5
3. Petiole vesture	pubescent	glabrate	densely pilose
4. Bractlets	ciliate, as long as or longer than the ovary	eciliate, less than half the length of ovary	ciliate, about 3/4 ovary length
5. Peduncle length (mm)	longer than 10	less than 10	about 10
6. Peduncle vesture	sparsely pilose	glabrous	densely pilose
7. Corolla color*	pink to purple-red	pink	white
8. Corolla tube length (mm)	4.1 - 4.3	2.8 - 3.5	4.0 - 6.6
9. Corolla lip length (mm)	6.2 - 6.6	5.3 - 6.7	6.4 - 8.6
10. Corolla tube vesture (outside)	sparsely pubescent	glabrous	pubescent
11. Sepals	with few cilia near apex	eciliate	with many cilia near apex
12. Bracts	pubescent	glabrous or with few cilia	densely pubescent

*Spectrophotometric and chromatographic analysis of the corolla pigments in all three taxa indicate that the differences are quantitative and not qualitative. *L. morrowii* produces very small amounts which generally are not visible. The pigments have been identified as flavones.

PREVIOUS WORK

Rehder (1903, pp. 202-203), in his "Synopsis of the Genus Lonicera," offers additional documentation on the occurrence of honeysuckle hybrids:

> Spontaneous hybrids are apparently very rare in the genus *Lonicera;* . . . A great number of hybrids, however, have originated in cultivation, particularly in the subsections Ochranthae and Tataricae and between them and also in the subgenus Periclymenum. All were raised unintentionally without artificial aid in gardens and nurseries where the different species grew close together and seeds were collected from them. So much inclined are some species of the subsection Ochranthae, especially . . . *L. Morrowii,* to hybridize with *L. Tatarica* that it is almost impossible to raise them true from seed if *L. Tatarica* grows near the mother plant; consequently, the typical species have become comparatively rare in gardens, while the hybrids are often met with. These hybrids fruit as profusely as the species and seedlings raised from their seeds show almost invariably a reversion to *L. Tatarica;* probably they are usually fertilized by the pollen of that species.

ANALOGOUS SITUATIONS

Situations similar to that postulated here in *Lonicera,* involving hybridization in woody plants, are well known. For example, Benson (1962, p. 63) cites hybridization between English oak (*Quercus robur*) and two native species, the white oak (*Q. alba*) and chestnut oak (*Q. prinus*). The English oak is cultivated in eastern North America, where it escapes and becomes established along roadsides and woodland borders, where hybrids are produced. "Thus genetic isolation is wanting or incomplete, and these species have been kept distinct for a long period of geologic time perhaps only through geographic separation. Each has evolved in its own way, but its independence has been due, at least in part, to the intervening Atlantic Ocean." (Benson, loc. cit.)

CONCLUSIONS

On the basis of the data presented, it seems reasonable to conclude that many of the hybrid honeysuckles collected are naturally occurring interspecific hybrids of *Lonicera morrowii* x *L. tatarica* (= *L.* x *bella*). Normally the two parent species are separated geographically in Asia. In North America, however, no geographic barrier exists when they are in cultivation. After escaping, they may hybridize. The close proximity of plants of the taxa considered at most collecting stations would suggest that follow-up studies of this group over a period of years should prove interesting, as conditions appear favorable for introgression.

ACKNOWLEDGMENTS

I wish to express my appreciation to the curators of the Kent State University (KE), Michigan State University (MSC), and University of Michigan (MICH) herbaria for providing the herbarium material examined in this study.

REPRESENTATIVE SPECIMENS

Lonicera tatarica L. Sp. Pl., p. 173 (1753).

MICHIGAN - Grand Traverse Co.: Steep bank below aspen-birch-beech woods, east side of East Bay (Sec. 3, T27N, R10W), 1 June 1957, *Dieterle 1968* (MICH); Houghton Co.: Canal Rd., w of Houghton, 5 July 1949, *Richards 2239* (MICH); Ingham Co.: Established in wet, aspen-box elder woods just east of Vernon St. in E. Lansing, T4N, R1W, Sec. 17, 18 May 1963, *Anderson 2339* (MSC); Marquette Co.: Growing between lake shore and RR tracks on n side of Lake Michigamme, 22 June 1950, *Richards 3229* (MICH); St. Clair Co.: In Pine Grove Park, City of Port Huron, escaping, 31 May 1913, *Dodge* (MICH). A permanent escape along St. Clair River, below city of St. Clair, plentiful, 7 June 1898, *Dodge* (MICH); Washtenaw Co.: Ypsilanti, 6 June 1919, *Walpole* (MSC); Wayne Co.: Along the river, Grosse Isle, frequent, 18 May 1913, *Dodge* (MICH).
OHIO - Ashtabula Co.: Windsor Twp., waste area along roadside of Rt. 534 n of Trumbull Co. line, 28 May 1961, *Hauser 422* (KE); Geauga Co.: Bainbridge Twp., roadside and along fencerow of pasture, 15 June 1961, *Hauser 450* (KE). Burton Twp., wooded grazed area along roadside of Gingerick Rd. near Rt. 87, 28 May 1961, *Hauser 424* (KE). Chesterland Twp., eastern portions of grazed pasture, 30 May 1961, *Battles 1* (KE); Lake Co.: Leroy Twp., wooded slope along roadside of Rt. 86, 28 May 1961, *Hauser 420* (KE); Portage Co.: Franklin Twp., roadside bank along open field area, 14 May 1964, *Hauser 1007, 1008* (KE). Streetsboro Twp., roadside thickets along Rt. 43, 23 May 1961, *Hauser 416, 417* (KE); Summit Co.: Hudson Twp., roadside of Prospect Rd., 11 May 1963, *Foldesy 5, 6* (KE). Hudson Twp., roadside Rt. 303 at Stow St., 11 May 1963, *Foldesy 7* (KE).

Lonicera morrowii Gray. In Perry, Narr. Exp. China & Japan 2: p. 313 (1856).

MICHIGAN - Cass Co.: Driskol Lake, 17 May 1952, *Rapp 444* (MICH); Emmet Co.: In deciduous woods evidently once used as a dump, at w edge of Petoskey (w edge Sec. 6, Bear Creek Twp.), 14 July 1953, *Voss 1674* (MICH); Gogebic Co.: Well-established, rocky woods, NE$\frac{1}{4}$, Sec. 9, T47N, R45W, ca. 1 mi. ne of Wakefield, 30 May 1958, *Voss 6230* (MICH); Kalamazoo Co.: T1S, R9W, Sec. 8, wet roadside abundant with *L.* × *bella*, 24 May 1960, *Gillis 3592* (MSC); Livingston Co.: Green Oak Twp., Island Lake Recreation Area, near pond, an occasional escape along roadsides, 15 June 1947, *Lynch* (MSC); Oakland Co.: Royal Oak, moist woods (city park), 22 May 1939, *Marshall* (MSC).
OHIO - Cuyahoga Co.: Bentleyville Village, dry wooded slopes along road bordering Chagrin River, 23 May 1961, *Hauser 418, 419* (KE). Solon, waste area along edge of woods and open field area, 30 May 1961, *Hauser 426* (KE); Geauga Co.: Bainbridge Twp., in rich soil along edge of woods near open fields, 15 May 1960, *Hauser 148* (KE); Lake Co.: Leroy Twp., wooded slopes along roadside of Rt. 86, 28 May 1961, *Hauser 421* (KE); Portage Co.: Kent, dry open railroad ballast along Mogadore Rd. 1/2 mi. n of Rt. 261, 14 May 1964, *Hauser 1001, 1003, 1005* (KE). Between Kent and Twin Lakes, dry open banks of gravel pit along road side of Rt. 43, 23 May 1961, *Hauser 413* (KE). Lake Rockwell Rd. ca. 1-1/2 mi. n of Lake Rd. just over 1st bridge, edge of dry open roadbank, 14 May 1964, *Hauser 1001* (KE, MSC). Lake Rockwell area, steep banks of roadside, 14 May 1964, *Hauser 1016, 1020* (KE, MSC); Summit Co.: Hudson Twp., roadside of Prospect Rd., 11 May 1963, *Foldesy 7, 9* (KE).

Lonicera x *bella* Zabel. Gartenflora 38: 525 (1889). (*L. tatarica* x *L. morrowii*)

MICHIGAN - Eaton Co.: Established in mixed deciduous woods on steep slopes of south banks of Grand River, n of Willow Highway near east edge of Grand Ledge, T4N, R4W, Sec. 12., 15 May 1963, *Anderson 2311* (MSC); Iron Co.: In aspen woods by road n of Basswood Pond, e edge of NE$\frac{1}{4}$, Sec. 25, T44N, R37W, ca. 3 mi. se of Elmwood, 21 June 1959, *Voss 8598* (MICH); Isabella Co.: Edge of swampy woods (by road) near center n edge of Sec. 34, Isabella Twp., ca. 3.5 mi. n of Mt. Pleasant, 1 June 1959, *Voss 8510* (MICH); Kalamazoo Co.: T1S, R9W, Sec. 8., wet roadside, abundant with *L. morrowii*, 24 May 1960, *Gillis 3594* (MSC); Livingston Co.: Oak-hickory woods, n side of Woodland Lake, near center s edge sec. 18, Brighton Twp., ca. 2 mi. n of Brighton, 22 May 1965, *Voss 11843* (MICH); St. Clair Co.: Pine Grove Park, Port Huron, 31 May 1915, *Dodge* (MICH).

OHIO - Cuyahoga Co.: Bentleyville Village, wooded slopes along roadside bordering Chagrin River, 23 May 1961, *Hauser 415* (KE); Geauga Co.: Chesterland Twp., east portion of grazed pasture, 30 May 1961, *Battles 2* (KE); Portage Co.: Between Kent and Twin Lakes, dry banks of gravel pit along roadside of Rt. 43, 23 May 1961, *Hauser 1013* (KE, MSC). Lake Rockwell Rd., open field area, 14 May 1964, *Hauser 414* (KE). Lake Rockwell Rd., steep south facing slopes, 14 May 1964, *Hauser 1017, 1018* (KE, MSC); Stark Co.: Plain Twp., Sec. 27 along Nimishillen Creek, moist woods, 7 May 1960, *Amann 87* (KE); Summit Co.: Hudson Twp., along railroad tracks, 11 May 1963, *Foldesy 4* (KE).

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ADDITIONAL SPECIES OF *CLITOCYBE* FROM MICHIGAN

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The genus *Clitocybe* is a large assemblage of closely related agaric species differing in relatively few features, such as the presence or absence of clamp connections, the presence or absence of encrusting pigments on the pileus cuticular hyphae, and the color of the spore deposit, which may be white, pinkish, or yellow. Mature basidiocarps typically have pilei which are depressed in the center and decurrent lamellae. The genus, like *Russula,* is relatively easy for the field naturalist to recognize, but comparatively few of its species can be accurately identified in the field.

Many interesting aspects of classification among agarics are brought into focus by a critical study of this genus, such as the fact that *Clitocybe,* like *Russula,* should not be regarded as a "white-spored genus." Once a critical study has been made, some of the species not known previously can be readily recognized in the field. Those presented here are in this category, and though the basidiocarps of none are known to be edible and desirable, they will be encountered by the collector on occasion and are apt to arouse his curiosity. These species are conspicuous elements in our mushroom flora at the peak of their fruiting cycle. Notes on them have been in our files for some time.

In the following descriptions the color terms in quotation marks are from Ridgway, *Color Standards and Color Nomenclature* (Washington, D.C., 1912). Material of all numbers cited is in the University of Michigan Herbarium, with additional material of some in the Herbarium of the University of Massachusetts.

Clitocybe martiorum Favre, Schw. Zeitschr. Pilzk. 34: 172. 1956. Fig. 1.

Pileus 2-6 cm broad, convex with an inrolled margin at first and remaining so for some time, finally broadly convex to plane with the disc shallowly depressed; margin often variously lobed, not striate; surface more or less hoary over all at first, glabrescent but hoariness usually persisting along the margin, rivulose at times, moist or sometimes watery-spotted, "light pinkish cinnamon" at first, becoming darker and near "sayal brown" at least in zones or areas, finally a brighter cinnamon; flesh moderately thick in disc, "light pinkish cinnamon" or if water-soaked then "sayal brown''; odor and taste farinaceous to rancid-farinaceous, fading with age.

Lamellae broadly adnate to short-decurrent, very crowded and narrow, not intervenose, forked at times, cocoa color (more vinaceous-cinnamon than ''sayal brown''); edges uneven to crenulate, pallid.

Stipe 2.5-5 cm long, 5-15 mm thick at apex, equal or with the base swollen, white mycelioid, and binding much debris, solid; interior watery, ''cinnamon'' to ''sayal brown''; surface canescent, concolorous with pileus beneath canescence.

Spores 4-6 × 2-3.5 μ, elliptical to nearly oblong at times, smooth, not amyloid, pink (''pale congo pink'') in deposit; basidia 18-25 × 3-5.5 μ, 4-spored; cheilocystidia present on some lamellae, rare or abundant, filamentous, projecting up to 50 μ and $\pm$ 2.5 μ in diameter, or basidioid and often with a rostrate apex, with yellowish contents at times, smooth; pileus surface yellowish and somewhat gelatinous in KOH but not a true pellicle; pigment dilute in cell contents of some hyphae, surface hyphae at times projecting as pilocystidia or soon appressed, hyphae cylindrical, 1-5 μ in diameter, yellowish refractive hyphae present in places; pileus trama hyaline except for thin brownish area just above lamellae, at times floccose in center but always compact next to lamellae, the hyphae cylindrical to inflated, 5-12 μ in diameter, clamp connections present; hyphae of gill trama regular to subparallel but slightly diverging near subhymenium, mostly cylindrical, 2-7 μ in diameter but with a central strand of larger slightly inflated hyphae 5-12 μ in diameter.

Gregarious to cespitose in arcs on needles under white pine or Scotch pine. September to November.

Michigan material examined: Bigelow 788, October 16, 1952, 1594, September 27, 1953, 2915, November 16, 1955; Smith 20792, September 30, 1945, 21341, October 9, 1945—all from Saginaw Forest, Ann Arbor, Washtenaw Co.; Smith 38916, October 10, 1951, 51172, November 3, 1955, 64778, October 27, 1961--all from Stinchfield Woods, Dexter, Washtenaw Co.; Smith 43563, September 28, 1953, Wilderness State Park, Emmet Co.

Although we have collected quantities of this agaric in the pine plantations of southeastern Michigan over the years, only recently did we identify it as *Clitocybe martiorum*. Previously, the colored spore deposit had led to some confusion with other taxa in *Clitocybe* or related genera.

Clitocybe martiorum is well described in the literature of Europe (Favre, 1956; Bouteville & Josserand, 1961; Romagnesi & Margaine, 1964), but apparently our report here is the first under this name for North America. However, Smith (1958, 1963) has illustrated this agaric, with brief notes, as ''*Clitocybe* sp.'' Smith's colored figure (1963, no. 103) presents mature specimens, while the painting of Margaine (Romagnesi & Margaine, 1964) shows an earlier stage.

Fig. 1. *Clitocybe martiorum* × 1 Smith 64778

The colors appear to darken considerably with a loss of the hoary coating on cap and stipe.

Through the courtesy of M. Marcel Josserand, of Lyon, France, we have been able to compare authentic dried material of *C. martiorum* (Switzerland, Lise & Francois Marti, Nov. 3, 1960) with the Michigan specimens; and we have found very close agreement on all observable characters. While we did not find cheilocystidia on the Swiss specimen, their absence is not disturbing. Romagnesi & Margaine do not describe them, but Favre did note "petits poils" in his original description. Bouteville & Josserand confirm the presence of filamentous cheilocystidia in their study. Various basidiocarps in the Michigan collections show considerable variability in the development of these structures, as do different lamellae in the same basidiocarp. The few minor differences in field characters of European and North American material are not of sufficient magnitude to indicate the existence of two taxa.

Clitocybe bartelliae sp. nov. Fig. 2.

Pileus 10-16 cm latus, convexus, demum distortus, glaber, hygrophanus, albidus vel pallide lilaceus vel pallide vinaceus, demum cinnamomeo-alutaceus tum fulvus; caro crassa, mollis; odor gravis, acre; sapor mitis; lamellae adnatae, subdistantes, latae, pallide lilaceae, demum vinaceo-alutaceae, dein griseo-vinaceae; stipes 5-8 cm longus, ad apicem 2-3 cm crassus, ad basim usque ad 6 cm crassus, solidus, pallidus, lineatus, sursum scabroso-punctatus, demum tomentosus; sporae 5.5-8 × 3-4.5 μ, asperulatae et subreticulatae, in cumulo pallido roseo-alutaceae. Cespitosus, in scobis.

Typum legit I. Bartelli (A. H. Smith 66389), Marquette, Michigan, September 29, 1962, in Herb. Univ. Mich. conservatum.

Pileus 10-16 cm broad, broadly convex with an inrolled margin, becoming broadly convex and misshapen from mutual pressure; surface glabrous, moist, hygrophanous, whitish to pale lilaceous or vinaceous-pallid when young and fresh, soon fading to dull white, then slowly becoming dingy cinnamon buff to darker yellow-brown; trama thick, soft, pallid to tinged lilac-gray; odor very pronounced, pungent, recalling green corn or hay; taste mild; KOH - O; $FeSO_4$ - O.

Lamellae adnate, subdistant, broad, lilaceous pallid, becoming pale dingy vinaceous-buff, finally rather dark grayish vinaceous; edges even and concolorous.

Stipe 5-8 cm long, 2-3 cm thick at apex, up to 6 cm thick at the enlarged base, solid (white inside with watery pallid streaks, finally yellowish in base); surface pallid and streaked at first; apex whitish scabrous-punctate, becoming somewhat mycelioid on standing; base developing a pale lilac mycelium after standing over night.

Spores 5.5-8 × 3-4.5 μ, elliptical, finely roughened by minute warts connected in places to form a fine reticulum (seen under oil immersion lens), not amyloid, "pale pinkish buff" to "vinaceous-buff" in deposit; basidia 23-31 × 5.5-7 μ, 4-spored; cystidia not differentiated; pileus cuticle hyaline and appearing subgelatinous in KOH, the hyphae cylindrical, 1.5-4.5 μ in diameter, some refractive, tramal hyphae cylindrical to slightly inflated, 5.5-12 μ in diameter, clamp connections present; hyphae of gill trama regular to subparallel, cylindrical to slightly inflated, 4-10 μ in diameter.

Cespitose on sawdust. September.

Michigan material examined: Smith 6689 (type), September 29, 1962, Marquette, Marquette Co., collected by Ingrid Bartelli; Smith 67411, September 4, 1963, 67619, September 15, 1963, both Rifle River Area, Rose City, Ogemaw Co.; Bartelli, September 19, 1963, Marquette.

In the field, basidiocarps of *C. bartelliae* are easily recognized by their size, cespitose growth on sawdust, and characteristic strong odor. This odor can be detected even in herbarium specimens several years old.

The rough spores, colored in deposit, may prompt some investigators to place *C. bartelliae* in *Lepista* (or *Rhodopaxillus*). We are describing this species as a *Clitocybe* to emphasize the close affinity with species like *C. nebularis*, *C. robusta*, *C. catervata*, *C. odora*, etc., which have colored, smooth spores. With the variability in spore characters and gill attachment shown by many typical *Lepista* (i.e., *L. nuda*, *irina*, *sordida*), we fail to find any combination of characters which provide a sound basis for separating *Lepista* from *Clitocybe*.

Basidiocarps of *C. bartelliae* taste mild when fresh, but when cooked are most disagreeable and hence unfit for human consumption. This is important because most relatives of "Blewits" are fine for the table.

Clitocybe leucopaxilloides sp. nov.

Pileus 3-6 cm latus, convexus, nonnumquam umbonatus, glaber, hygrophanus, vinaceo-brunneus demum alutaceus; caro crassa, mollis, pallida; sapor farinaceus; lamellae adnatae demum decurrentes, angustae, confertae, pallide alutaceae, saepe brunnescens; stipes 3-5 cm longus, 10-18 mm crassus, aequalis, solidus, mollis, glaber, albidus; sporae 4-6 × 2-3 μ, in cumulo pallido roseo-alutaceae; hyphis defibuligeris.

Typum legit A. H. Smith 61390, Pike Lake, Luce Co., Michigan, August 15, 1959, in Herb. Univ. Mich. conservatum.

Pileus 3-6 cm broad, convex with an inrolled margin, expanding to broadly convex, at times with slight umbo; surface glabrous, opaque, moist and hygrophanous, near "verona brown" or "russet," fading to near "pinkish buff"; trama thick, soft, pallid; odor mild; taste farinaceous, rancid at times.

Fig. 2. *Clitocybe bartelliae* × 1/2 Smith 67619

Lamellae adnexed or adnate to short decurrent, narrow, crowded to close, pale grayish buff, pale vinaceous-buff to pinkish buff, often stained brownish in injured areas.

Stipe 3-5 cm long, 10-18 mm thick at apex, equal or nearly so, solid, soft and soon eaten by larvae, glabrous, pallid or white.

Spores 4-6 × 2-3 μ, elliptical to nearly oblong, smooth in KOH, some appearing very slightly roughened in Melzer's reagent, not amyloid, "pale pinkish buff" in deposit; basidia 21-27 × 4-6 μ, 4-spored; cystidia not differentiated; pileus surface somewhat gelatinous in KOH, the cuticle pale dingy yellowish in KOH, pigment soluble in KOH or water, the hyphae cylindrical or slightly inflated, 1.5-7.5 μ in diameter, walls sometimes rather sinuous, tramal hyphae cylindrical to inflated, 2-15 μ in diameter, clamp connections absent, refractive hyphae present; hyphae of gill trama subparallel, cylindrical to somewhat inflated, 3-10 μ in diameter; $FeSO_4$ - O.

Scattered on sandy soil in open conifer woods or under hardwoods. July and August.

Michigan material examined: Smith 61390 (type), August 15, 1959, Pike Lake, Luce Co.; Smith 71749, July 14, 1965, Emerson, Chippewa Co.; Smith 72081, August 12, 1963, Tahquamenon Falls State Park.

This species is distinctive by the combination of the pileus color, the farinaceous taste, the absence of clamp connections, and the faintly colored spores. The few other species of *Clitocybe* which lack clamp connections are quite different in field characters and have a white spore deposit. *C. leucopaxilloides* is most abundant along roads through hardwood slashings where piles of lignicolous debris have been left.

Clitocybe crispa sp. nov. Fig. 3.

Pileus 4-10 cm latus, convexus demum planus, saepe lobatus, ultimo elatus, glaber vel aliquantum canus, hygrophanus vel subhygrophanus, brunneus tum alutaceus; caro concolor, lenta; odor acerbus aliquando; sapor mitis vel subpiperatus; lamellae adnatae dein decurrentes, confertae, angustatae, primum pallide alutaceae, demum brunneae; stipes 3-7 cm longus, apicem 6-15(-20) mm crassus, fere aequalis, basi mycelio-rhizoideo, solidus, lentus, primum pallidus et fibrillosus, demum glaber et brunnescens.

Typum legit A. H. Smith 64342, Pinckney, Michigan, September 17, 1961, in Herb. Univ. Mich. conservatum.

Pileus 4-10 cm broad, broadly convex with an incurved and inrolled margin, expanding to plane, shallowly depressed at times; margin becoming elevated and often scalloped or lobed, very irregular in age; surface hygrophanous or subhygrophanous, glabrous or somewhat canescent, brown (dingy "cinnamon buff" to "snuff brown") fading to dull alutaceous or dingy buff; flesh thin, watery

Fig. 3. *Clitocybe crispa* about × 1 Smith 64431

"snuff brown," fading to dingy buff or pallid, pliant, tough; odor fungoid to pungent; taste mild or slightly pungent; KOH - O; $FeSO_4$ - O.

Lamellae adnexed, adnate, or short decurrent, close, narrow, readily separable from pileus trama, "pale pinkish buff" to "pinkish buff" at first, gradually becoming "cinnamon-buff" to "snuff brown."

Stipe 3-7 cm long, 6-15(-20) mm thick at apex, equal or narrowed downward, solid, tough, the surface pallid from coarse appressed fibrils, somewhat glabrescent and then brownish, dingy yellow-brown within; base with heavy, white, coarse mycelium and numerous rhizomorphs, strigose or tomentose at times.

Spores 4-5.5 × 2-2.5 μ, elliptical, smooth, not amyloid, white in deposit; basidia 18-23 × 4-5.5 μ, 4-spored; basidioles irregular in shape at times; cystidia not differentiated; pileus cuticle light yellow-brown in KOH, pigment in slightly thickened but smooth walls or very finely encrusted on cuticular hyphae, the hyphae mostly cylindrical, 3-5.5 μ in diameter, sometimes irregularly inflated and contorted, the trama hyaline, hyphae cylindrical to inflated, (2.5-)5.5-9(-12) μ, walls often sinuous-thickened, clamp connections present; hyphae of gill trama regular to subparallel, cylindrical to inflated, 2.5-15 μ in diameter.

Gregarious on soil and needles under juniper; also found once under locust. September and October.

Michigan material examined: Homola 1787, October 11, 1965, Stinchfield Woods, Dexter, Washtenaw Co.; Smith 64431, September 25, 1961, Stinchfield Woods; Smith 64342 (type), September 17, 1961, 72550, September 8, 1965, both Pinckney Recreation Area; Smith 72609, September 16, 1965, Waterloo.

The basidiocarp shape of this *Clitocybe* recalls many illustrations of *C. incilis* known in Europe. *C. crispa* differs by the darkening lamellae, smaller spores, and absence of a farinaceous odor. Although *C. crispa* has hygrophanous pilei, the shape of the expanded basidiocarps, the thin pileus flesh, and the presence of encrusting pigments probably indicate that the species belongs in section *Infundibuliformes*.

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Editorial Notes

Limitation of space in this issue forces postponement of many listings of new literature; "Michigan Plants in Print" should be up to date again in the January number.

The May number (in two sections, Vol. 5, No. 3, and No. 3A) was mailed May 26, 1966.

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(*On the cover: Indian-Pipe,* Monotropa uniflora, *photographed in Tahquamenon Falls State Park, Michigan, by Gottfried Hogh, July 1963.*)

Vol. 6, No. 1

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Dues are modest, but vary slightly among the chapters. In all cases, they include subscription to THE MICHIGAN BOTANIST.

STUDIES IN THE GENUS *AGARICUS* - I. *AGARICUS CRETACELLUS* AND ITS RELATIONSHIPS [1]

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In this series of studies I shall attempt to bring together nomenclatural, taxonomic, and literary data for a revision of the North American species of the genus *Agaricus*. This first paper serves a dual function as an introduction to my continuing studies of this genus and to a discussion of a rather unusual and interesting species of *Agaricus*.

This is, of course, the genus containing some of the finest edible mushrooms including the well known mushroom of commerce (*Agaricus edulis* Bull. ex St. Amans, 1821, non *A. campestris* α *edulis* Vitt. 1835; = *A. bisporus* (J. Lange) Pilat, 1951, *A. hortensis* (Cooke) Konrad & Maublanc, 1937, *A. brunnescens* Peck, 1900, etc.) and the field mushroom (*A. campestris* Linn. ex Fr. 1821.). The edibility of *A. cretacellus* is, to my knowledge, as yet not clearly established and thus the usual precautions ought to be followed in testing such a species.

The genus *Agaricus* is one of the more natural genera in the Agaricales, yet its species are problematic from a taxonomic standpoint. Perhaps the most obvious reason for this is that there are few of the micro-anatomical characters available that have been employed with such success in genera as *Mycena*, *Galerina*, *Inocybe*, and *Marasmius*. One can scarcely say, however, that there are no utilizable characters at hand. It is, rather, that most of the diagnostic characters are observable only in freshly collected basidiocarps. This is certainly true of the macrochemical tests, the structure of the veils, and the coloration of the basidiocarp and its flesh.

One is faced with another difficulty as there is no modern North American treatment of *Agaricus* where one may identify the many species that occur here. On this continent papers by such authors as Peck (1872, 1884, 1897), Murrill (1918, 1922), Hotson and Stuntz (1938), Coker (1928), and Smith (1940) have been primarily concerned with descriptions of new taxa, or with redescriptions of poorly understood species. Smith's studies (1940) are particularly noteworthy for he examined holotypes of North American species and pointed out the particular usefulness of sporal dimensions in taxonomic work in *Agaricus*.

[1] I should like to thank Mr. Stanley Smith of the New York State Museum, Albany, New York, for the opportunity to study the Peck types of *Agaricus* and Dr. R. P. Korf of the Department of Plant Pathology, Cornell University, Ithaca, New York, for the loan of the holotype of *Agaricus cretacellus* Atk. The photographs (Fig. 1) are used through the courtesy of Dr. A. H. Smith.

Similarly, Hotson and Stuntz (1938) brought attention to the possible taxonomic importance of the cystidial hyphae on the lamellar edge of certain species of *Agaricus* (see also Lange, 1926).

While North American authors have been primarily concerned with descriptions of new and interesting taxa, several European authors have made important contributions to our understanding of the classical European *Agaricus* species and have also suggested the use of new or scarcely utilized characters in the delimitation of taxa in this genus. These authors include Schäffer (1933), Schäffer and Møller (1938), Møller (1950, 1952), Pilat (1951), and most recently Heinemann (1956a, 1961).

One of the largest and most frequently encountered groups within *Agaricus* is section *Sanguinolenti*. The diagnostic characters of this section are as follows: negative Schäffer reaction,[2] presence of cheilocystidia and cheilocatenulae[3] on the lamellar edge, the slender often small spores, and the tendency for the basidiocarp of many species to undergo changes of coloration due to oxidation when the flesh is cut or bruised. The flesh characteristically assumes hues that are rosy, reddish, or vinaceous, though a number of species slowly turn dull brownish if the flesh is cut.

Agaricus cretacellus was placed by A. H. Smith (1940, p. 115, 120) in the series of species most closely related to *Agaricus arvensis* Schaeffer ex Secr. However, I have concluded that *A. cretacellus* ought to be referred to section *Sanguinolenti*. The remainder of this paper is devoted to presentation of data which support this conclusion

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[2] The Schäffer reaction requires two reagents, 20% aq. nitric acid and 10% alc. anilin (these solutions are considerably more dilute than those that have been customarily suggested, e.g., Schäffer, 1933). One uses a glass rod to apply the chemicals, preferably to the pileal surface. A streak of anilin is first applied, followed by a streak of nitric acid at right angles to the first. In a positive reaction the intersectional area becomes scarlet to orange immediately or within 10 minutes. This area may first become chrome yellow, then slowly turn orange to scarlet at the rim where the chemicals have mixed. In a negative reaction the intersectional area slowly becomes brown or shows no color change. Heinemann (1961, p. 231) has introduced the term "Schäffer microreaction" for a procedure where a tiny fragment from an exsiccated specimen is placed on a microscope-slide for 10 minutes in 10% anilin; then a minute drop of 20% nitric acid is introduced under the cover slip, and the fragment is observed under low magnification. The same colors as mentioned in the above discussion occur when the reaction is positive, a negative reaction showing no color change.

[3] The term cheilocatenula (cheilo- Gr. edge, lip, or rim; -catenula L., a little chain, fem.) is suggested here for a hypha found on the lamellar edge of certain species of *Agaricus* (in sect. *Arvenses* and *Sanguinolenti)* that forms strands. Each uniseriate strand is chain-like, elongate, and multicellular; being comprised of cells that are generally globose, oval, oblong, or elliptical. The upper portions of such strands may be anastomosed and fasciculate. Cheilocatenulae appear to be modified derivatives of the subhymenium and lamellar trama (see fig. 2f).

and to a discussion of the more unusual features of this very interesting agaric. A full redescription of the species follows[4]:

Agaricus cretacellus Atkinson. J. Mycol. 8: 110. 1902. (Holotype. CUP! No. 5359. Growing in leaf mold, woods, Cascadilla Creek, Ithaca, New York, Sept. 7, 1900). Fig. 1, 2d-i.

Agaricus magnificus Peck. Bull. Torr. Bot. Club 26: 67-68. 1899. (Holotype. NYS! Loc. Mt. Gretna, Pa. Leg. C. McIlvaine. Aug. 1899). Non *Agaricus magnificus* Fries. 1838. Epicrisis, p. 10. Fig. 2a-c.

Agaricus magniceps Peck. Bull. N. Y. St. Mus. 94:36. 1905. Nom. nov., ≡ *A. magnificus* Peck.

Psalliota cretacella (Atk.) Kauffman. Agar. Mich. 1:234. 1918.

Pileus 40-150 mm broad; shape oval to conical, then becoming pulvinate, finally broadly convex to plane; disc slightly umbonate to flattened, in age becoming slightly depressed, areolate-cracked in dry weather; pileal surface dry and appressed-fibrillose, becoming very minutely fibrillose-squamulose near the margin, marginal area often decorated with wart-like fragments of velar tissue, rarely the entire pileus diffracted-scaly if weathered, staining very slightly yellowish or turning tan to rusty brown if bruised, often not changing color at all if bruised; pileal color silvery white at first, often becoming chalky white in time, the disc often pinkish buff ("pale pinkish buff"), squamules this color if present, or at times disc and squamules crust brown ("cinnamon-buff"); pileal flesh white, very slightly tinged pink when cut, firm or soft, moderately thick; odor peculiar, similar to oil of bitter lemons, anise, or shoe-polish; taste mild to slightly bitter, nutty.

Lamellae free, approximate at first, finally remote, 3-8 mm broad; edges not pruinose, even or irregularly undulate; lamellar color white to buff ("light buff") in buttons, then pale pinkish pale vinaceous ("pale vinaceous-fawn," "cinnamon-drab"), then dark reddish brown to blackish ("Natal brown," "fuscous-black"); many specimens may retain persistently paler gills, dull pinkish flesh-color ("cinnamon-drab").

Stipe 50-150 mm long, 6-20 mm thick at apex, 10-30 mm thick at base; shape equal or enlarged downwards to a clavate or rounded-bulbous base, often markedly but evenly thickened downward; surface silky-shining above, appressed-fibrillose to fibrillose-squamulose downward, often densely floccose-tomentose near base; color white at first, becoming dingy buff below in age, or the entire stipe flushed with dingy grayish brown; interior solid at first, then with a silky

[4] Color citations in parentheses are from Ridgway, 1912.

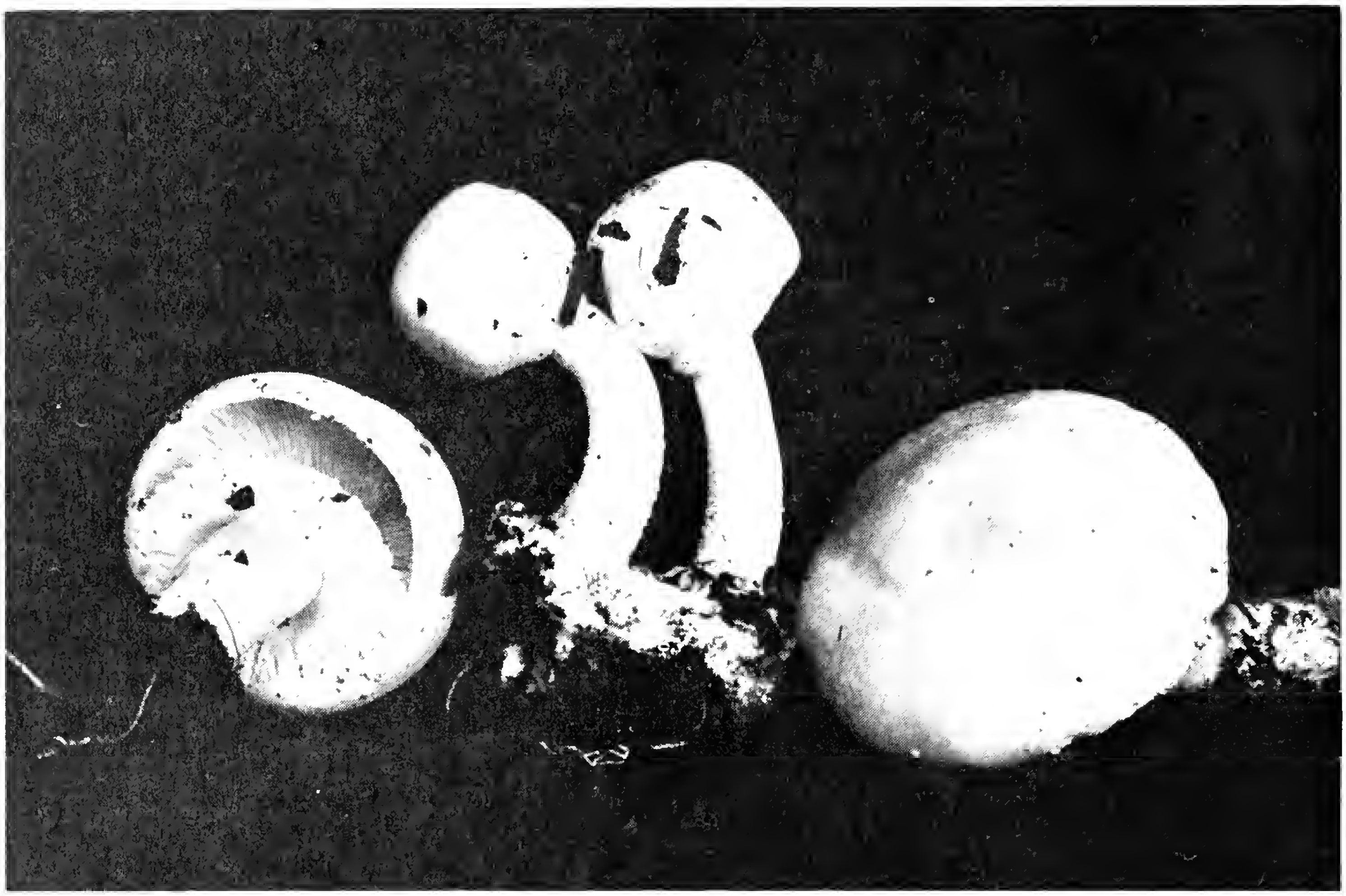

Fig. 1a. *Agaricus cretacellus* Smith 72588 x 1/2

Fig. 1b. *A. cretacellus* Smith 42357 x 3/4

pith and narrow fistula, at length often hollow, the flesh faintly flushing flesh-color when cut; mycelium white.

Annulus at first ascending and attached to pileal margin for some time, superior to median, frequently rather fragile; undersurface with cottony, cream buff to buff patches; upper surface white, smooth and silky, often chocolate-brown tinted from spores.

Chemical reactions (pileal surface): Schäffer reaction buff, then umber brown, negative. 10% anilin alc. pale buff to yellowish orange. Anilin-oil tan. 20% nitric acid aq. pale yellow. 2% potassium hydroxide not reacting. 10% ferric chloride not reacting. Phenoanilin rosy around droplet. P-cresol tan with a purplish halo. P-phenylenediamine blue at first, then vinaceous to grayish, finally black. Alc. gum guaiac blue on stipe.

Spores 4.5-6.5 × 3.0-4.0 (-4.5) μ; shape narrowly amygdaliform to narrowly oval in profile, narrowly oval to very occasionally oblong-elliptical in face view, somewhat compressed dorsiventrally; surface smooth, germinal pore absent; apiculus rather inconspicuous, or thick and beak-like, hyaline; color pale reddish brown to snuff brown in NH_4OH. Spores in deposit dark neutral brown ("snuff brown," "bister").

Basidia 16-25 (-30) × 5-8 μ; 1-, 2-, 4-spored; shape cylindro-clavate to narrowly clavate; color hyaline or partially filled with an umbrinous content; sterigmata 3-4 (-7) μ long, aculeate. Cheilocystidia present, but often collapsed and difficult to demonstrate, 15-24 (-30) × 10-15 μ; shape mostly broadly clavate to saccate, thin-walled; hyaline. Cheilocatenulae short, the terminal cells 11-20 × 7-14 μ; shape globose, oval, or oblong; color of lamellar edge hyaline to brownish, not yellow, edge with occasional basidia.

Lamellar trama subregular; hyaline or slightly tan; a few oleiferous hyphae present. Subhymenium 20-30 μ broad; pseudoparenchymatous; hyaline. Pileal surface a dense layer, somewhat loosely interwoven; the cells 3-6 (-10) μ wide; cell shape slender and elongate, color hyaline or slightly yellowish. Pileal trama loosely interwoven; cells 5-13 μ wide, inflated somewhat, thin-walled and often collapsed. All hyphae without clamp connections.

Habit, habitat, and distribution. Single to gregarious under hardwoods or occasionally under mixed deciduous and coniferous trees. Fruiting from late August to early October. This species is known from Alabama and Florida in the southeastern United States to Michigan and to Ontario in Canada.

Material studied. Alabama: R. P. Burke. Aug. 1942. Canada, Ontario: E. Groves and C. A. Loveland. Sept. 18, 1951 (MICH). Florida: Isaacs 2467. W. A. Murrill. Nov. 2, 1941 (FLAS 17421). Kansas: C. T. Rogerson 3737 (MICH). Michigan: Isaacs 2601, 2603. C. H. Kauffman, Sept. 21, 1905; Aug. 23, 1909. V. Potter 3550, 3798, 10130, 10142, 10592, 10596b. A. H. Smith 5044, 26036, 32980, 36133, 42509, 42763, 64387, 64522, 72587, 72588. H. D. Thiers

4325 (all MICH). New York: C. H. Atkinson Sept. 7, 1900. Holotype of Agaricus cretacellus (No. 5359, CUP!). C. H. Kauffman, Aug. 1903 (MICH). North Carolina: C. H. Kauffman, Aug. 21, 1924 (MICH). Pennsylvania: C. McIlvaine, Aug. 1898. Holotype of Agaricus magnificus Peck (NYS!). Tennessee: L. R. Hesler 5338, 7932, 12207, 12836, 12854, 12896, 24499 (all TENN). L. R. Hesler 16365 (MICH). A. H. Smith 10271, 10367 (MICH).

Before discussing holotypes studied in conjunction with the synonymy previously cited, microscopical diagnoses are furnished here for the holotypes of *Agaricus cretacellus* and *A. magnificus*. These diagnoses may then be compared with the general description given previously for *A. cretacellus*.

Data from holotype of *Agaricus cretacellus*. (See fig. 2g-i.)

Spores 5.0-6.0 × 3.5-4.0 μ; shape narrowly amygdaliform in profile, in face view narrowly oval to oblong-elliptical, very occasionally oval; smooth, germinal pore absent; apiculus small, not beak-like, hyaline; color rather pale brown ("snuff brown," "Verona brown") in NH_4OH. Basidia 18-22 (-30) × 6-8 μ; 4-spored; shape clavate to cylindro-clavate, hyaline; sterigmata 3-4 μ long, aculeate. Cheilocystidia 15-24 × 10-13 μ; mostly small and broadly clavate to saccate, thin-walled; hyaline. Cheilocatenulae 11-15 × 7-14 μ, in short chains; shape of terminal cells oval, elliptical, or oblong; color hyaline. Lamellar edge hyaline or slightly brownish, furnished with occasional basidia.

Lamellar trama subregular; cells elongate and interwoven; pale yellowish in NH_4OH; no oleiferous hyphae seen. Pileal surface a dense layer, loosely interwoven; the cells 2-11 μ wide; shape narrowly cylindrical; hyaline in NH_4OH. Pileal trama filamentous; cells cylindrical and elongate as in dense layer; hyaline or faintly brownish; no oleiferous hyphae seen. Subhymenium 10-15 μ broad; pseudoparenchymatous; cells angular; color pale yellowish tan. Schäffer microreaction negative.

Data from holotype of *Agaricus magnificus*. (See fig. 2a-c.)

Spores 5.0-6.5 × 3.5-4.0 μ; shape narrowly oval to oblong-elliptical in both profile and face views; smooth, germinal pore absent; apiculus 3-4 μ long, or prominent and beak-like, up to 7 μ long, small; hyaline; color either weakly pigmented and light brown ("Sayal brown"), or more strongly pigmented, reddish brown ("Verona brown") in NH_4OH. Basidia 16-20 × 6-7 μ; 4-spored; shape clavate; color hyaline; cells not reviving well. Cheilocystidia and cheilocatenulae present, but not reviving well. Pileal surface a dense layer; the cells 4-7 μ wide; cell shape elongate and slender; color light yellowish in NH_4OH. Pileal trama mostly collapsed; the cells somewhat inflated, 5-13 μ wide; color slightly yellowish; oleiferous hyphae present. Subhymenium pseudoparenchymatous, reviving poorly. Schäffer microreaction negative.

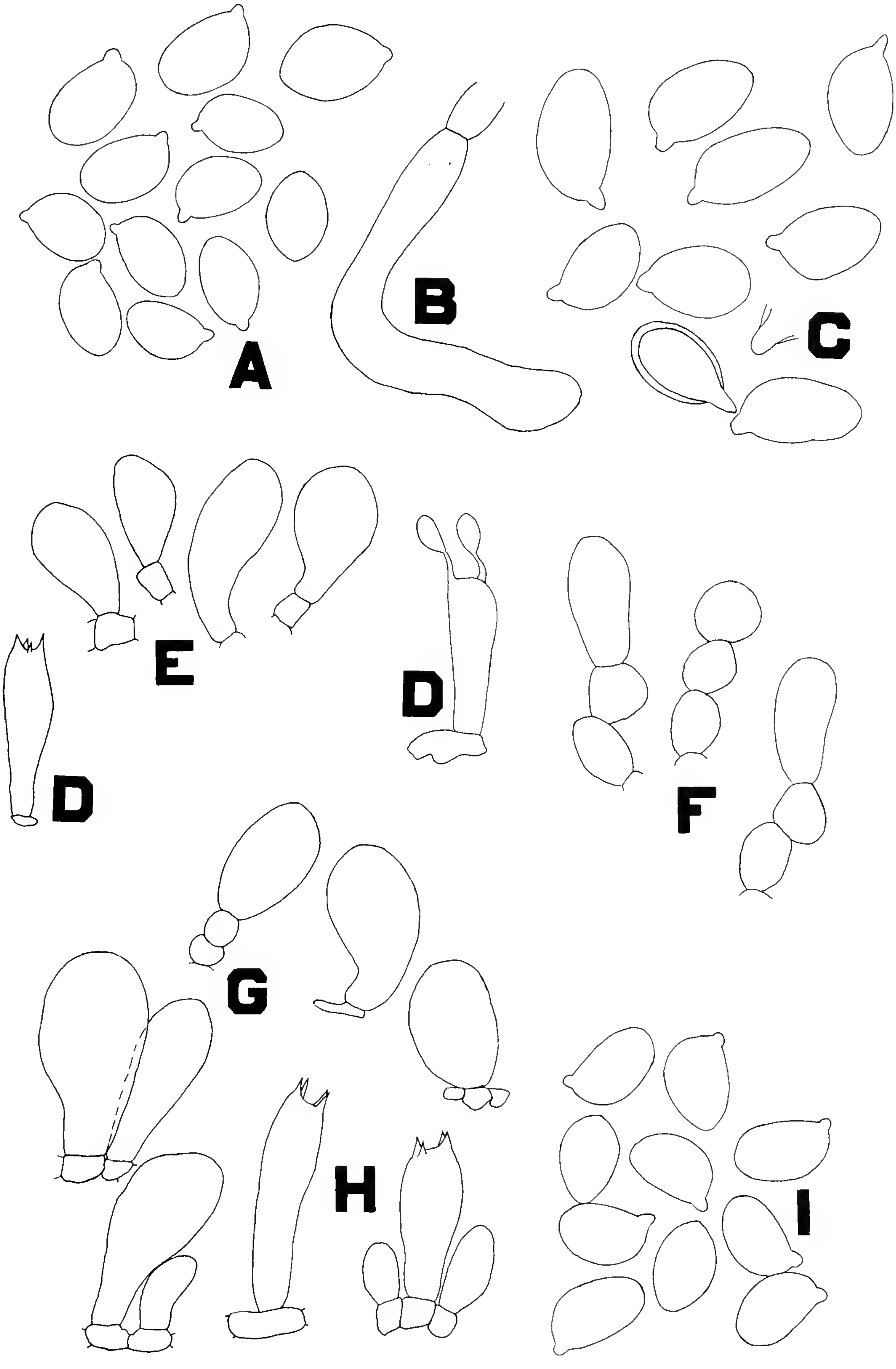

Fig. 2. A-C. *Agaricus magnificus.* holotype. A. normal spores. B. Oleiferous hypha. C. Beaked spores. D-F. *A. cretacellus*, Smith 42509. D. Basidia. E. Cheilocystidia. F. Cheilocatenulae. G-I. *A. cretacellus*, holotype. G. Cheilocystidia. H. Basidia. I. Spores. All spores 1880×; other fig. 780×.

Some justification for referring *Agaricus magniceps* Peck to synonymy with *A. cretacellus* seems in order, in view of the report and description of this latter species furnished by A. H. Smith (1940). The striking features of *A. magniceps* are the large size of the basidiocarps and the beaked spores it may manifest (see fig. 2c). The holotype of *A. cretacellus* shows no beaked spores. However, I was able to demonstrate variable percentages of these beaked spores in both undetermined collections and those determined as either *A. cretacellus* or *A. magniceps* (e.g., A. H. Smith 5044, 26036, 64522, Isaacs 2603).

It is of interest to note that in the above-cited collections there were also varying numbers of one-, two-, and four-spored basidia. Isaacs 2603 had a very high percentage of beaked spores (i.e., those having thickened apiculi) (percentage about 30-40%) and this collection had been lightly frosted previous to its collection. Møller (1950, p. 35; 1952, p. 155) has mentioned thickened apiculi and other abnormalities in sporal morphology in certain species of *Agaricus* and has also attributed such characteristics to effects of cold and temperature change.

Another related feature in *A. cretacellus* that is noteworthy is the tendency of the lamellae to remain pallid grayish flesh-color even after the basidiocarps have become old. In certain instances the lamellae are also found to be incised, with patches of pallid coloration intermixed with areas of normal pigmentation. This odd characteristic is reminiscent of P. R. Day's report (in Fincham and Day, 1963, pp. 230-231) that in cultures of *Coprinus "lagopus"* (= *C. cinereus* (Schaeff. ex Fr.) S. F. Gray acc. to P. D. Orton, 1960, p. 37) there is a mutant form called "pale gill" where the density of tetrads on the lamellae is reduced by 80%. As in Day's fungus, our species seems to have normally pigmented spores, but such spores are much less frequent in microscopical preparations than would normally be expected. Also, spore-deposits are uniformly thin when prepared from these pallid gilled specimens. Such similarities in these two species of agarics are of interest, but the evidence for a mutant form in *Agaricus cretacellus* is of course only circumstantial and requires experimental confirmation.

The small, narrow spores, negative Schäffer reaction, presence of cheilocystidia and cheilocatenulae on the lamellar edge, and occurrence in woods are characters in this species which are all indicative of section *Sanguinolenti*. However, there is scarcely any change in the color of the flesh when basidiocarps are cut and the pileus is unreactive to anilin-oil (unlike many species in this section). In fact, the placement of this *Agaricus* next to its most nearly related neighbor in section *Sanguinolenti* presents a problem. *Agaricus hondensis* Murr. is similar in that the latter species is unreactive to the standard reagents (i.e., KOH, anilin, and Schäffer reagents), possesses narrow, small spores, and is also whitish colored.

However, *Agaricus hondensis* has a markedly marginate-bulbous stipe-base, the pileus may assume by maturity nut-brown to vinaceous brown tints on the disc and squamules (if latter present), and the lamellar edge is sparsely furnished with cheilocystidia. The annulus of *A. hondensis* is a thick flaring limb that is often pendant, thus contrasting markedly with the funnel-shaped, erect annulus of *A. cretacellus*. Other species resembling *A. cretacellus* are *Agaricus deylii* Pilat and *A. depauperatus* (Møll.) Pilat, both of which possess whitish basidiocarps. *Agaricus deylii* is markedly different from our species in having large spores, 9.5-11.0 x 5.5-6.0 μ, rosy lamellae in youth, a cylindrical stipe, rubescent flesh, and occurrence under spruce. *Agaricus depauperatus* (Møll.) Pilat is much like *A. deylii* in having large spores, 7.5-8.5 (-10) x 4-5 μ and in having rubescent flesh. The pileus of *A. depauperatus* is described as being ("tilleul buff") when young and ("avellaneous") later, with ("light drab") squamules. Also, the young lamellae of *A. depauperatus* are grayish flesh color. *Agaricus benesi* is readily distinguished from *A. cretacellus* in having strongly rubescent flesh, a pileal surface that is imbricate-squamulose, and the basidiocarp reacts markedly to anilin-oil, turning vinaceous red immediately.

Another species that has been confused with *Agaricus cretacellus* is *A. subponderosus* Murr. As in *A. cretacellus* this species has small spores, 4.5-5.5 (-6.0) x 3.5-4.0 (-4.5) μ; the basidiocarp also being white to pale tan. However, *A. subponderosus* has a strongly positive Schäffer reaction (sect. *Arvenses*!) and the pileus turns lemon yellow where 15% KOH is applied. This latter species also has vesciculose to clavate cheilocystidia, seemingly lacking cheilocatenulae.

Perhaps one of the most unusual characteristics of *Agaricus cretacellus* is that it has often been found growing lignicolously. Collections have been made repeatedly of this species growing on old maple sawdust (e.g., Isaacs 2601, A. H. Smith 64837, 72587, 72588) and on twigs of deciduous trees (V. Potter 3550, 10596b). It is noteworthy that in no case that I have encountered has this species been found growing exclusively under conifers. Although the species is widespread, having been collected from Ontario in Canada to southern Florida, it has been associated predominantly with deciduous forests such as live oak (*Quercus virginiana* Mill.) in Florida, while in Michigan it is frequently to be found under trees such as red maple (*Acer rubrum* L.) and American elm (*Ulmus americana* L.), or in the northern part of the state under yellow birch (*Betula lutea* Michx. f.) and white spruce (*Picea glauca* (Moench) Voss). In Tennessee *Agaricus cretacellus* is to be found under mixed woods of deciduous trees and hemlock (*Tsuga canadensis* (L.) Carr.).

This report, it is hoped, will serve to stimulate others to look for this common, yet little recognized species in order that we obtain a more accurate picture of its variations and ecology.

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THE STATUS OF SOME REPORTS OF VASCULAR PLANTS FROM MICHIGAN[1]

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Some sort of detective work may arise in almost any line of endeavor, but it is especially frequent in study of the local flora. Fernald[2] pointed out some years ago, in discussing the slow and exacting task of completing the 8th edition of Gray's Manual, the unsatisfactory nature of floras which are merely quick compilations of the work of others, without original synthesis and verification. In the present instance, the question is sometimes as simple as whether or not there is an authentic specimen, preserved in a herbarium somewhere, to support a published record of the occurrence of a species in the state. But sometimes, and even more demanding of "detective" work, the question is whether the data associated with such a specimen can be relied upon or have been correctly interpreted.

The few "case histories" presented here are typical of the kinds of investigation which become necessary before one can even prepare a reasonably accurate list of the flora of the state — and they may serve as a continued warning that statements of distribution in a manual (or even a monograph) must often be taken with the proverbial grain of salt. Errors of both commission and omission are repeated over and over again as a result, presumably, of uncritical copying; this problem exists for distributional information as well as for descriptive statements about the plants themselves[3] (not to mention bibliographic and nomenclatural details!). It is perhaps harder to lay ghosts to rest than to resurrect a few which are deserving, but the following examples may help to clarify the status of some species in our flora.

Potamogeton lateralis Morong

Morong (Mem. Torrey Bot. Club 3(2): 45. 1893) cited this rare species from "Bear Lake, Mich." as collected by E. J. Hill. When

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[1] Contribution from the Biological Station of The University of Michigan.

[2] Merritt L. Fernald, "How Soon Will the 'Manual' Be Done?" A Plea for Some Undisturbed Moments, Science 89: 329-332. 1939. See also H. E. Moore in Baileya (14: 13. 1966), quoting Fernald "that no one was to be trusted and that all references should be checked personally."

[3] See, for example, Edward G. Voss, Which Side Is Up? A Look at the Leaves of Oryzopsis, Rhodora 63: 285-287. 1961. I am happy to add that, eight editions of Gray's Manual, two editions of the Manual of Grasses, and many other manuals notwithstanding, at least one author *does* know "which side is up" and has described the leaves of *Oryzopsis asperifolia* as "dark-green on the back and pale-green above" (W. G. Dore & A. E. Roland, The Grasses of Nova Scotia, Proc. Nova Scotian Inst. Sci. 20: 177-288. 1942).

monographing the linear-leaved pondweeds, Fernald (Mem. Am. Acad. 17 [= Mem. Gray Herb. 3]: 98. 1932) referred to Morong's citation and mapped the species in the northern part of the Lower Peninsula of Michigan. It is not clear how Fernald decided which of the nearly 40 "Bear Lakes" in Michigan was meant by Morong. For some strange reason, he had not included among the 41 herbaria from which material was examined the herbarium of the University of Illinois, which since 1917 had included the specimens of E. J. Hill, one of the most active students of the pondweeds and whose material a monographer should surely have wanted to see. Dr. G. N. Jones, in 1959, generously sent me on loan all of Hill's numerous Michigan pondweeds, and his no. 54, collected July 23, 1872, from "Ponds, Bear Lake" is *P. lateralis* and the label is clearly headed Van Buren County, which is in the southwest part of the state, some 200 miles from the area indicated by the dot on Fernald's map.

It would be desirable to have an additional recent collection to confirm the continued presence of this species in the state, and it is not clear in what lake one ought to look. There are at least three possibilities in northern Van Buren County, more or less between Grand Junction and Bloomingdale: Great Bear Lake near Bloomingdale, Deer Lake (called "Bair Lake" on an old plat), and what Conservation Department maps call "Blair Lake" (called "Little Bair" on the old plat, and "Little Bear" by the U. S. Geological Survey). On September 12, 1959, I explored the latter body of water rather superficially, with the aid of a borrowed rowboat, and saw no unusual pondweeds (although *Naias guadalupensis* was fruiting nicely). Further search should be made for *P. lateralis*.

Sagittaria montevidensis Cham. & Schlect.

The North American representative of this typically South American species of "arrow-head" has long been segregated as *Lophotocarpus calycinus* (Engelm.) J. G. Smith or *Sagittaria calycina* Engelm.; it is here listed as treated in the recent monograph by Bogin (1955). It was first reported from Michigan in a monograph of *Lophotocarpus* by J. G. Smith in 1899 (Missouri Bot. Gard. Rep. 11: 147): "Michigan (J. Schneck, Grand Rapids, Aug. 24, 1881)." The same specimens were cited in the later monograph by Bogin (1955), and manuals have generally credited the species to southern Michigan.

Although the record in Smith's monograph was promptly recognized by Wheeler (1899, p. 89, as "Grand Rapids,—J. G. Smith"), quoted again by McAtee (1923, p. 160), it was, significantly, not included in Beal's "Michigan Flora" (1905). The cited specimens, collected by Schneck, are in the herbarium of the Missouri Botanical Garden, where I have examined them. At face value, these would appear to be acceptable records.

However, there is no evidence in any of Schneck's published notes that he ever visited Michigan. The labels on the specimens merely say "Grand Rapids," with no designation of state. "Michigan" has been written next to similar "Grand Rapids" labels for certain other Sagittarias in the hand of Dr. J. M. Greenman, who came to Missouri as curator in 1913. Schneck collected extensively in the Lower Wabash Valley of Indiana and Illinois, and published a list of the flora of that region in 1876; it does not include this species. Schneck's own annotated copy of his flora, with corrections and additions, came into the possession of C. C. Deam, who published in 1912 (Proc. Indiana Acad. 1911: 365-369) a list of additions from Schneck's annotations. These included one aquatic, *Zannichellia palustris*, "at Grand Rapids," but no mention of *Lophotocarpus*. However, this bit of evidence does suggest a "Grand Rapids" in the Lower Wabash Valley, an idea readily confirmed by consultation of old maps. An 1836 map of Illinois shows "Grand Rapids" in the Wabash River immediately above Mount Carmel, Schneck's home, and the U. S. Geological Survey topographic map for the area (Princeton Quadrangle, surveyed 1901) likewise shows it just above the mouth of the White River, which is opposite Mount Carmel.[4] Undoubtedly, the *Lophotocarpus* (or *Sagittaria*) came from this Grand Rapids of the Wabash River (Knox Co., Indiana, or Wabash Co., Illinois) and not from the southwestern Michigan city, despite the citations of two noted monographers and the manuals which have followed them.[5]

It is not, however, necessary to delete the species entirely from the list of state flora. It was apparently first collected, authentically, in Michigan in 1949 by Malcolm McDonald in the Pte. Mouillée State Game Area, Monroe Co. (McDonald 5594, MICH, MSC). I have found it along Lake Erie about three miles southeast of Erie (Voss 11831, MICH), in Sterling State Park, and on the banks of Swan Creek at Oldport — all in Monroe Co., the southeasternmost county in the state. The flowers are generally perfect, with a ring of stamens below the carpels, rather than unisexual as in typical Sagittarias.

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[4] It should be noted that the complete title of Schneck's report is "Catalogue of the Flora of the Wabash Valley Below the Mouth of White River, and Observations Thereon" (Ann. Rep. Geol. Surv. Indiana 7 (for 1875): 504-579. 1876). Since "Grand Rapids" is, according to the maps, just *above* the mouth of the White River, there would be no reason for Schneck to have mentioned the location or to have listed plants restricted to it, either in his original catalog or in his supplement (Bot. Gaz. 2: 83. 1877).

[5] Another example of the danger of jumping to geographic conclusions is in the locality "Highland Park." Once one is assured that a "Highland Park" specimen is indeed from Michigan, there are still at least three possibilities. I have encountered plant specimens not only from the Detroit area community of that name (Wayne Co.) but also from a park in the city of Grand Rapids (Kent Co.) and a resort area at Grand Haven (Ottawa Co.), each known as "Highland Park."

Echinodorus tenellus (Mart.) Buch.
var. *parvulus* (Engelm.) Fassett

This little relative of the arrow-heads has sometimes been said, in manuals, to range as far north and west as Minnesota. In the original description of *E. parvulus* (sometimes recognized as a species distinct from the typical South American *E. tenellus*), Engelmann merely gave the range as "Michigan to Illinois and westward" (in Gray's Man., ed. 2, p. 438. 1856). Robinson (Rhodora 5: 89. 1903), after referring to collections from the vicinity of St. Louis, cautiously observed: "There are also indefinite reports of its occurrence in Michigan and on the north shores of Lake Superior. These last records need substantiation and, in general, the rarity of the species is such that the discovery and record of new stations will have more than ordinary interest." Yet Small (N. Am. Fl. 17: 45. 1909) for some reason designated Michigan as the type locality (in the absence of any restriction in Engelmann's broad statement).

Fassett's monograph of the genus (Rhodora 57: 133-156; 174-188; 202-212. 1955) cites or maps no specimens closer to Michigan than from East St. Louis, Illinois. There are no specimens from this area in the herbarium of the New York Botanical Garden or the Gray Herbarium (according to Fassett's citations, also kindly checked for me by Dr. Arthur Cronquist and Dr. Carroll E. Wood, respectively), and I have confirmed that there are none at the Missouri Botanical Garden. The current Gray's Manual (ed. 8) does not include Michigan in the stated range, even though it had been designated by Small as the type locality, a point to which Fassett makes no reference at all.

A Michigan specimen has, fortunately, turned up in the University of Michigan Herbarium, previously misidentified as *Sagittaria subulata*. It was collected at White Pigeon (St. Joseph Co.), August 11, 1837, presumably by Abram Sager, the botanical and zoological assistant in 1837, during the first Geological Survey of Michigan, which was under the direction of Douglass Houghton. Like many of the First Survey plants, there is no "original" label, the oldest existing one in this instance being in the hand of Miss E. C. Allmendinger, an active Ann Arbor botanist of the 1870's, who erroneously labeled a number of First Survey plants with Houghton himself given as the collector. The label on the sheet here concerned also gives 1838 as the year, but the First Survey collections have been studied by Dr. Rogers McVaugh (unpublished), who has carefully worked out the dates, itineraries, etc., as they relate to the hundreds of plant specimens preserved, and it is clear that the date for this White Pigeon collection should be August 11, 1837. The species is not included in the published catalog of the First Survey (Mich. House Documents, 1839), and may never have been identified at the time.

Our specimen was presumably not seen by Engelmann or Small, and we can only guess whether there might once have been a duplicate at New York (perhaps ex herb. Torrey, with whom Houghton corresponded and to whom he sent specimens) or elsewhere which Small actually saw when designating Michigan as the type locality. Perhaps our specimen is a sole surviving type of some nature. At least it would seem that Michigan may be retained in the range (or former range) of this species and hence as the type locality.

Scirpus hallii Gray

Fernald (1950, p. 268) says of this rare little sedge: "Peaty and sandy shores, very local, Ga. and Fla. to e. Tex.; Winter P., Middlesex Co., Mass.; Athens, Menard Co., Ill.; s. Mo. and St. Louis, Mo. (formerly)." Other manuals, likewise, omit Michigan from the range, as does Beetle (N. Am. Fl. 18: 498. 1947). Mohlenbrock (Am. Midl. Nat. 70: 7. 1963) states that the species is known "from six states," of which Michigan is not one.

Yet the one and only complete (or so intended) list of Michigan vascular plants published in this century, Beal's "Michigan Flora" (1905, p. 52) cited *S. hallii* from Muskegon Co. — a record which there was no reason to reject, as the distinctive specimens have always been correctly identified in the Michigan State University Herbarium, where anyone could check the basis of the published report. The sheet was cited (with misquoted label) by Koyama (Canad. Jour. Bot. 40: 920. 1962) — apparently the first published awareness of the occurrence of this species in Michigan since the time of Beal. (Koyama, following some other authors, recognizes this as *S. supinus* L. var. *hallii* (Gray) Gray.)

The material was collected Aug. 22, 1900, by C. D. McLouth: "Vic. of Five Lake[s]. Habitat. Sand in slope of receding lake." I had already collected plants twice in the Carr Lake area, in Eggleston Township, Muskegon Co., before realizing that the group of five small lakes or ponds (now all without standing water except sometimes the largest, Carr Lake itself) were presumably the "Five Lakes" of McLouth. Some of McLouth's specimens of other interesting plants are labelled as from Carr Lake, and hence I had been encouraged to seek rarities there (Voss, 1957). Among the unusual plants of that vicinity are *Eleocharis melanocarpa*, *Fimbristylis autumnalis*, *Fuirena squarrosa* var. *pumila*, *Hemicarpha micrantha*, *Psilocarya scirpoides*, *Rhynchospora macrostachya*, *Scirpus purshianus* (*S. smithii* sens. lat.), *Stachys hyssopifolia*, and *Solidago remota*. So it was with high anticipation that I returned to this group of depressions on September 13, 1959, accompanied by Raymond McAdams and Stephen Koch. After much hands-and-knees combing of moist shores, I finally discovered a small colony of *Scirpus hallii* on the northwest shore of Carr Lake (Voss 9152, MICH, BLH, NY, GH, SMU). The plants were more prostrate in aspect and smaller than those of *S. smithii* (*purshianus*), which was a common species at the site. The achenes of *S. hallii* tend to be more persistent than their scales and are thus conspicuous; mature achenes are sometimes found at the very base of the plant. The distinctive strong cross-ribs on the achenes readily distinguish the species on closer examination. Dr. A. E. Schuyler, of the Academy of Natural Sciences of Philadelphia, has written me that he found *S. hallii* at Carr Lake in the summer of 1966, and evidently at a different spot from my colony, which he was attempting to relocate. So the species is not yet extinct in the state.

Sisyrinchium strictum Bicknell

This species of "blue-eyed-grass" seems to be of disputed taxonomic status. It was originally described by Bicknell (Bull. Torrey Bot. Club 26: 299-300. 1899) from Montcalm Co., Michigan. An apparent isotype, collected by C. F. Wheeler near Vestaburg June 22, 1898, is in the University of Michigan Herbarium. The species was accepted by Robinson and Fernald in the 7th edition of Gray's Manual (1908), but in the 8th, Fernald (1950) makes no mention of it whatsoever, even in synonymy. Alexander in Gleason (1952, 1: 451) asserts that it is "merely a form" of *S. montanum* with branched scapes "known only from a single collection." I have been unable to learn the basis for this statement. As noted in the original description and confirmed by the isotype and other collections cited below, *S. strictum* differs from *S. montanum*, in addition to the branched scape, in having narrower stems (not over 2 mm wide), slightly smaller capsules, and (perhaps most important next to the branching) subequal spathe bracts (16-22 mm long in our material) of which the inner one may even be a little longer and the outer one has margins fused for 4-5 mm basally. In *S. montanum* the outer bract is larger or even foliaceous, with the margins often fused for less than 4 mm. At least some of the pedicels in inflorescences of *S. strictum* are broadly wing-margined basally for more than half their length; the plants lack purple flush (except sometimes a little in the otherwise very pale capsules), and the margins of the stems and leaves are minutely serrulate or scabrous.

Plants thus described seem as distinct as many recognized species of *Sisyrinchium*, and are known in Michigan not only from the type collection but also from near Fallassburg in Kent Co. (Bazuin 1629, MICH; 4534, WUD) and near Upper (or Canyon) Falls of the Sturgeon River in Baraga Co. (sec. 19, T49N, R33W, ca. 1.5 mi. S of Alberta), where there is a large colony near a foot trail at the edge of rocky mixed woods (Voss 7658, MICH; 8865, MICH; 12264, 6 sheets to be distributed). The colony was thriving and in good fruit when last visited (July 29, 1966, with John S. Russell and Gary R. Williams), and has evidently been consistent in its characters over the past nine years (first collected in 1958, with Karl J. Stone).

While recognition of *Sisyrinchium strictum* in the flora of the state is more a matter of taxonomic opinion than uncertainty of records, it seems worthwhile to take this means of suggesting that it be maintained until (and unless) there is some definite evidence that it is not a good species.

Lychnis drummondii (Hooker) Watson

This rather inconspicuous western American relation of the common introduced white campion is attributed in Gray's Manual (Fernald 1950, p. 631) to "sw. Mich.," and various other manuals and wildflower books which must necessarily obtain their distributional data second-hand have evidently relied upon this statement. Maguire in Gleason (1952, 2: 134) was more critical, saying that the species "has been reported from" Michigan, and in the Gleason and Cronquist manual (1963, p. 296) the word is "reputedly" in southwestern Michigan.

Several years ago Dr. G. N. Jones, of the University of Illinois, inquired of me the possible basis for inclusion of Michigan in the range of this western species, and it was largely his encouragement to present the results of my search that has led to the present notes on it and other species of dubious status. There are no Michigan specimens in the herbarium of the New York Botanical Garden according to Dr. Maguire (in litt., 1961), who suggests that the tentative statement in the Illustrated Flora was probably based on references and notes assembled by Gleason and presumably no longer extant. Material from the Gray Herbarium was, at the time of my inquiry, on loan to Dr. Gilbert Bocquet of Geneva, but Dr. C. E. Wood advised that the geographic data on folders suggested no Michigan material. Dr. Bocquet, who was completing a monograph of that part of the genus, wrote me (1962) that although he had before him material of *L. drummondii* from many institutions there were no specimens known to him from Michigan. "This state is definitely outside the area of the species," he wrote.

Thus, there seemed to be no specimen basis for the Gray's Manual report. The only literature reference I can find, and it was presumably picked up by Fernald, is by the late W. L. McAtee (1923, p. 161). McAtee's paper was based chiefly on notes and letters inserted in C. F. Wheeler's personal interleaved copy of the Beal and Wheeler "Michigan Flora" of 1892. (McAtee was apparently unaware of the later "Michigan Flora" by Beal (1905), or else he chose to ignore that most of the records resurrected from Wheeler's [possibly tentative] marginal notes were not accepted by Beal.) The record of *Lychnis drummondii* is given as: "Niles, R. Ballard, In letter."

Identification of "R. Ballard" was a problem until discovery of a relevant letter in the papers of C. K. Dodge, whose herbarium came to the University of Michigan after his death in March of 1918. Dodge, in his last years, was working on a report on the flora of Berrien County, in the southwest corner of the state. Among Dodge's notes is a letter dated April 15, 1918, addressed to him from Ralph Ballard, of the Ballard Fruit and Dairy Farm, Niles, Michigan (in Berrien Co.). Accompanying this, Ballard sent to Dodge a list "of the plants that we know" prepared by himself and his wife. It is solely a list, with no annotations, and it covers only Pteridophytes to Ericaceae. *Lychnis drummondii* is not on it among the Caryophyllaceae. I would assume, therefore, that at some time between his writing to Wheeler and his writing to Dodge, Ballard realized that he had made a misidentification. The letter to Wheeler, cited by McAtee, though not confirmed by Beal (1905), must be the ultimate source of statements that *L. drummondii* occurs in Michigan. It is unfortunate that Fernald utilized such unevaluated and unsubstantiated second- or third-hand records in Gray's Manual — while rejecting perfectly good and well supported records from reliable sources (e.g., *Scirpus hallii*, discussed above).

Lysimachia × *producta* (Gray) Fern.

There is really no doubt that this hybrid loosestrife occurs in Michigan, which is, in fact, its type locality; but serious confusion surrounds citation of the type in the monograph by Ray (1956).

Now assumed to be a hybrid between "swamp-candles" (*Lysimachia terrestris* (L.) BSP., once known as *L. stricta* Ait.) and the whorled loosestrife (*L. quadrifolia* L.), this plant was described by Gray (Man., ed. 2, p. 272. 1856) without any statement of locality. Later (Syn. Fl. 2(1): 63. 1878), Gray said "New York and Michigan." It was pointed out by Fernald (Rhodora 1: 132. 1899) that "Gray's only specimen was collected in Michigan, but he refers to his variety a portion of Michaux's *L. racemosa* from New York." Furthermore, Fernald (p. 134) accurately cited the Michigan specimen as "without statement of locality and collector (Gray Herb.)."

This Michigan specimen, which can be taken as the type, must be the same one cited by Ray (1956, p. 76) with considerable data invented: "Michigan. Ingham [Co.]: Michigan State College, East Lansing, *Gray* (GH)." So far as I know, Asa Gray, who died in 1888, never collected in Michigan; and even if he had, he would have been remarkably prescient to have anticipated that, beginning in 1925 (over a third of a century after his death and 87 years after his brief visit to Michigan), the name "Michigan State College" would be applied to what had previously been known, since its founding in 1855, as the "Michigan Agricultural College."

A number of plants in the Gray Herbarium are labeled "Mich. State coll." in Gray's hand. But this does not mean they were collected by Gray, or at what was later called Michigan State College, at East Lansing, or anywhere else in Ingham County. The abbreviation "coll." stands for "collection," not "college," and the specimens are from the collection made by the first Geological Survey of Michigan, under the direction of Douglass Houghton.[6] Houghton himself collected some plants in 1839, or at least was present when they were gathered, but in 1837 and 1838, the first two years of the Survey, biological specimens were prepared by assistants working apart from Houghton, the State Geologist (chiefly Abram Sager in 1837 and John Wright in 1838).[7] (See comments under *Echinodorus*, above.) In 1838, Asa Gray was appointed the first professor at the University of Michigan after its relocation in Ann Arbor, and he visited the state briefly before sailing for a year in Europe; he was then on leave, without pay, until resigning in 1842 to accept appointment at Harvard. It is not surprising that Gray was sent specimens from the First Survey collections, although it is unfortunate that they were not more adequately labeled.

A presumed duplicate of the Gray Herbarium specimen, and hence isotype of *Lysimachia* × *producta*, in the University of Michigan Herbarium is from "Branch Co. (Sandy, damp woods) Aug. 1 [1837]." Ray's repeated references to "Michigan State College" under this species (including p. 76, twice on p. 77, and the legend of Plate III, which figures the type) are wholly erroneous anachronisms. (The same error of attributing specimens to Ingham Co., with Gray as collector, is made by Ray for *L. lanceolata* (p. 35) and *L. quadriflora* (1. 51); corresponding deletions would follow on distribution maps and the index to exsiccatae.) All this is an excellent illustration, incidentally, of the desirability, when citing specimens, of placing in brackets all material added to data from the original labels.

Verbascum phlomoides L.

In 1946, the late E. E. Sherff (Rhodora 48: 97-98) reported *V. phlomoides* from Michigan and referred to his collection no. 5023 made in 1945 in Barry County. No material of this species from the state was in the University of Michigan Herbarium in March of 1959, when Dr. Sherff kindly sent me some seeds freshly collected from plants in his garden, grown from seeds from his cited colony.

Not long afterward, on July 5, 1959, accompanied by Richard F. Willis, I collected a large *Verbascum* along the roadside by a field at the northwest corner of sec. 8, Penn Tp., ca. 4.5 mi. northwest of Vandalia, in Cass County, a county adjacent to Indiana and southwest of Barry County. Larger plants, with candalabrum-like inflorescence

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[6] I have previously related the data pertaining to the type of *Solidago houghtonii* Gray (Jour. Sci. Labs. Denison Univ. 44: 28. 1956).

[7] The history of the First Survey of Michigan has been described in several places. A standard reference is George P. Merrill, Contributions to a History of American State Geological and Natural History Surveys (U. S. Natl. Mus. Bull. 109). 1920. (Michigan on pp. 158-239.)

(as observed in Sherff's footnote) were seen in the adjacent field, and I supposed at the time that I had discovered another station for *V. phlomoides*. The fresh corollas were about 33 mm in diameter when fully open — distinctly larger than those of the common mullein, *V. thapsus*.

Upon further checking, however, I concluded that the Cass Co. collection (Voss 8809, MICH) was more likely to be *V. thapsiforme* Schrad. Added interest then attended the outcome of planting Sherff's seeds. Plants from the latter, grown both in Toledo, Ohio, and Mackinaw City, Michigan, by Mrs. David O. Voss, finally bloomed in the summer of 1963, aided in their growth by the addition of fertilizer. Tall plants, eventually attaining a height of as much as 10 feet, these bore handsome bright yellow corollas 40-50 mm broad. These plants, too, appeared to be *V. thapsiforme*. (Specimens were collected as Voss 11343, MICH, GH.)

In August, 1963, a large-flowered *Verbascum*, the largest plants with a much-branched candalabrum-like inflorescence, was noted as locally common on the grassy banks of an expressway interchange at the west edge of Ann Arbor, Washtenaw County. These plants (Voss 11371, MICH, MSC) appeared closer to *V. phlomoides* than either of the southwestern Michigan plants.

Previous reports of these species from North America have frequently commented on their similarity. Examination of the series of European collections of both in the herbarium of the Missouri Botanical Garden has helped to confirm my previous determinations, although the distinctions are not as clear as might be desired, especially (as noted by Murbeck, 1933, p. 90) in poorly developed individuals — the very ones which collectors are inclined to take for specimens. Murbeck's defense for recognizing the two species as distinct is that plants which are undoubted hybrids of the two are almost completely sterile. Further field observations on our Verbascums are clearly called for.

In what appear to be the most distinctive specimens of *V. phlomoides* (e.g., J. R. Churchill in 1909, Plainville, Mass., MO), the leaves are not decurrent at all. *V. thapsiforme* typically has strongly decurrent leaves, the wings on the stem extending from one node to the next.

Sherff's no. 5023 in the herbarium of the Missouri Botanical Garden ("Abundant in old field, N. of Pine Lake, N. W. quarter of Hope Township, Barry County, Mich.") consists of only the upper portion of a plant. The leaves are not as strongly decurrent as usual for *V. thapsiforme*, running for only about half the length of the internodes. However, the specimen is altogether a better match for European specimens of that species than of *V. phlomoides*. The plants grown from Sherff's seed and those collected in Cass County can readily be referred to *V. thapsiforme* by their strongly decurrent leaf bases; prolonged, acuminate or caudate lower bracts in the inflorescence; acuminate, or even caudate, tips on the upper cauline leaves; and distinctly crenate leaf margins.

The Washtenaw County material presents an aspect similar to Fl. Exsicc. Austr.-Hung. 1741 (Wettstein, MO), distributed as *V. kerneri (V. phlomoides* x *V. thapsus*). However, Murbeck (1933, p. 61) refers this number to *V. phlomoides* "mit etwas herablaufenden Blättern." On our specimens the leaves are crowded, somewhat decurrent, the margins scarcely crenate, the tips less prominently acuminate than in *V. thapsiforme;* and the lower bracts of the inflorescence are not prolonged. Anderson (Rhodora 49: 67-68. 1947) states that in Iowa sprouts from plants which have been cut clearly resemble *V. phlomoides* but that the healthy uncut plant is "*V. thapsiforme* in the sense of Hegi not of Murbeck." I do not see that Murbeck and Hegi (Ill. Fl. Mit.-Eur. 6(1). 1913) differ in their application of this name, Murbeck (pp. 53 & 86) merely noting that one of Hegi's figures labeled as *V. thapsiforme* is actually *V. phlomoides*. Descriptions of the Iowa plants suggest that they may indeed be *V. thapsiforme;* the *phlomoides*-like growth reported after cutting is a matter which should be investigated further. (None of the Michigan collections have any indications of prior cutting.) Anderson (Proc. Iowa Acad. 52: 91-92. 1946) found no evidence of hybridization in Iowa between *V. thapsus* and "*phlomoides*" even when they were growing together. Hybrids are widely known in this genus and should be sought in Michigan and elsewhere.

In summary, plants from Barry and Cass counties, Michigan, appear to be *V. thapsiforme*, a species first reported from North America by Weatherby (Rhodora 26: 39. 1924) on the basis of specimens collected at Westford, Massachusetts, in 1911. Plants from Washtenaw County, on the other hand, appear to be *V. phlomoides* with slightly more decurrent leaves than usual. Since the Indiana records reported by Deam (Fl. Indiana, pp. 824-825. 1940) were checked by Murbeck, they must be reliable *V. phlomoides*. Other records of *V. phlomoides* naturalized in North America may bear checking, since most manuals have not mentioned *V. thapsiforme* at all (Gleason, 1952, is an exception). Both species are undoubtedly more widespread in Michigan, and collectors should watch for them along roadsides and in old fields. They make striking garden plants, with a long blooming season; Murbeck observes under *V. phlomoides*: "In allen botanischen Gärten kultiviert."

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TWO ADDITIONAL GRASS SPECIES FOR SOUTHWESTERN MICHIGAN[1]

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Collections made by me during the summer of 1966 in the vicinity of Gull Lake, Michigan, included *Cynosurus echinatus* L. and *Leptochloa fascicularis* (Lam.) A. Gray. The former has not been previously reported from the state, and the latter only from Ypsilanti, Mich. (Farwell 1923, Walpole 1924).

Cynosurus echinatus was collected near the northern edge of Wintergreen Lake in the Kellogg Bird Sanctuary (R9W, T1S, S8; Kalamazoo Co., Mich.). The species is well established on a dry, west-facing slope overlooking a marsh which extends several hundred yards northwesterly from Wintergreen Lake. Scattered plants were also present adjacent to the marsh and along a work road extending to the eastern boundary of the sanctuary.

The species, an annual, is a native of Europe and a member of the tribe Festuceae. Hitchcock (1951) indicates a rather spotty distribution for it in North America, with a western segment extending from British Columbia to northern California, and a generally southern occurrence in the middle and eastern United States.

Leptochloa fascicularis was collected in a tree planting site between 42nd St. and Augusta Creek in the Kellogg Forest (R9W, T1S, S21; Kalamazoo Co., Mich.). The origin of the plants is questionable, but the circumstances surrounding their occurrence indicate that it is probably local, although the species was not found elsewhere. The collection site was recently disturbed by a road realignment project

[1] Contribution No. 133 from the W. K. Kellogg Biological Station, Michigan State University.

which left a bare soil strip approximately 30 m by 300 m parallel to Augusta Creek. The soil is a mixture of the underlying peaty muck and gravelly sand from the adjacent uplands where road fill was obtained. Apparently there was little or no importation of materials from beyond the immediate vicinity. The strip was planted in 1965 with aspen and larch seedlings. In August 1966, when the *Leptochloa* collection was made, the site was covered with a heavy growth of pioneer old-field plant species along with many species found in the adjacent lowlands. And, with the exception of *Eragrostis hypnoides* (Lam.) BSP. which is uncommon in the region (Hanes and Hanes, 1947), all of the associated plants were found elsewhere in the Gull Lake vicinity.

The circumscription of the genus *Leptochloa* by various authors differs greatly. Traditionally the genus is placed in the tribe Chlorideae. However, Fernald (1950) includes *L. fascicularis* as one of four species in the segregate genus *Diplachne* (which is placed in the Festuceae), as *D. fascicularis* (Lam.) Beauv. Two other of the four species (*D. acuminata* Nash and *D. maritima* Bickn.) are relegated to varietal rank under *Leptochloa fascicularis* by Gleason and Cronquist (1963). Hitchcock (1951) treats *D. maritima* and *D. acuminata* as synomyms of *L. fascicularis*.

According to Gleason and Cronquist (1963) *Leptochloa fascicularis* var. *maritima* (Bickn.) Gl. is an Atlantic coastal form, whereas var. *fascicularis* is generally south-central and southeastern in distribution and var. *acuminata* (Nash) Gl. is more northerly and western in distribution, with overlapping of the ranges probably from Illinois to Texas. Using the criteria of Fernald (1950) and Gleason and Cronquist (1963) a character analysis was made to determine the affinities of the two Michigan collections. Comparisons were based on 8 characters: (1) vesture of the inflorescence branches, (2) distance between spikelets, (3) length of first glume, (4) length of second glume, (5) length of first lemma, (6) length of awns, (7) color of lemmas, and (8) degree of development of apical teeth on the lemmas. Each character was given a weight of -1 if similar to var. *fascicularis* or +1 if similar to var *acuminata*. On the basis of this analysis the Walpole specimens (Cranbrook Institute of Science Nos. 14178 and 24467) with a $\Sigma = 0$ are intermediate between the two varieties. The Gull Lake specimens with a $\Sigma = +8$ are most similar to var. *acuminata*. The most obvious differences between the two collections were in (1) the general stature of the plants and length of the inflorescence, both of which may have resulted from environmental differences and/or age of individual plants; and (2) length of the 2nd glume (means $\pm$ 2 standard deviations: Walpole collection, 3.45 $\pm$ 0.4 (mm); Gull Lake collection, 4.13 $\pm$ 0.46; n=16). Other differences between the two collections were the generally longer awns of the Gull Lake collection; purple lemma coloration in the Gull Lake collection vs. apparent green coloration in the Walpole collection; and the more pronounced apical teeth on the lemmas in the Walpole collection.

Specimens of both *Cynosurus echinatus* (Kellogg-Gull Lake Bio. Station No. 01180) and *Leptochloa fascicularis* (Kellogg-Gull Lake Bio. Station No. 01319) have been placed in the Kellogg-Gull Lake Biological Station Herbarium and the Michigan State University Herbarium.

I wish to thank Dr. Richard W. Pippen of Western Michigan University for checking the Hanes collection; Dr. James R. Wells and the Cranbrook Institute of Science for the loan of *Leptochloa* specimens from the Walpole collection; and Dr. Edward G. Voss of the University of Michigan for checking collections in the University herbarium and for bringing to my attention the Walpole collection.

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MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

This section lists new literature relating to Michigan Botany under four categories: A. Maps, Soils, Geography, Geology (new maps and selected bulletins or articles on soils and geology as these may be of use to field naturalists and students of plant distribution); B. Books, Bulletins, etc., and C. Journal Articles (listing, respectively, all separate publications and articles in other periodicals which cite Michigan specimens or include research based on plants of wild origin in Michigan; —not generally including work on cultivated plants nor strictly economic aspects of forestry, conservation, or agriculture); D. History, Biography, Exploration (travels and lives of persons with Michigan botanical connections). When the subject matter or relation to Michigan is not clear from the title, annotations are added in brackets. Readers are urged to call to the editor's attention any titles (1960 or later) which appear to have been overlooked—especially in less well known sources.

A. MAPS, SOILS, GEOGRAPHY, GEOLOGY

The following topographic maps for Michigan have been published by the U. S. Geological Survey, Washington, D. C. 20242, since the previous listing in our March, 1966, issue. All are 7 1/2-minute quadrangles (scale of 1:24,000 or about 2 1/2 inches to a mile). Maps are supplied with green overprint showing wooded areas unless request is made to the contrary. NEW MAP PRICES went into effect October 1, 1966. Standard topographic quadrangle maps are now $ .50 each, and maps in the 1:250,000 series are now $ .75 each. The minimum retail order to which a 20% discount applies has been raised to $20.00.

Following the name of the quadrangle, the county or counties in which it primarily lies are added in brackets in the list below:

Albany Island [Chippewa]
Big Stone Bay [Emmet]
Brevort [Mackinac]
Burnt Island [Chippewa]
Cedarville [Mackinac]
Charles [Mackinac]
Crystal [Montcalm]
De Tour Village [Chippewa]
Drummond [Chippewa]
Drummond SE [Chippewa]
Epoufette [Mackinac]
Evergreen Shores [Mackinac]
Goetzville [Chippewa]
Goose Island [Mackinac]
Hessel [Mackinac]
Kenneth [Mackinac]
Lime Island [Chippewa, + Ontario]
Marble Head [Chippewa]
McGulpin Point [Emmet, Mackinac]
McRae Bay [Mackinac]
Meade Island [Chippewa]
Mecosta NW [Mecosta]
Moran [Mackinac]
Ozark [Chippewa, Mackinac]
Ozark NE [Chippewa, Mackinac]
Ozark SE [Mackinac]
Pickford SE [Mackinac, Chippewa]
Pointe aux Chenes [Mackinac]
Pontchartrain Shores [Mackinac]
Prentiss Bay [Chippewa, Mackinac]
Rexton [Mackinac]
Round Island [Mackinac]
Sherman City [Isabella, Mecosta]
St. Ignace [Mackinac, Emmet, Cheboygan]
St. Martin Island [Mackinac]
Stalwart [Chippewa]
Stanton [Montcalm]
Trout Lake [Mackinac, Chippewa]
West Branch [Ogemaw]
Whitney Bay [Chippewa]

Hack, John T. 1965. Postglacial Drainage Evolution and Stream Geometry in the Ontonagon Area, Michigan. U. S. Geol. Surv. Prof. Pap. 504-B. 40 pp. + map. $.75 (U. S. Gov. Printing Off.). [Folded topographic map of area, from Lake of the Clouds in the Porcupine Mts. east as far as Greenland and south as far as 3 miles north of Bergland, shows shorelines of glacial lakes. These, and the general information on climate and drainage, will be of interest to students of local plant distribution.]

Linn, Robert M., Robert G. Johnsson, & William W. Dunmire. 1966. Wilderness Trails. A Guide to the Trails in Isle Royale National Park. Isle Royale Natural History Assoc. & Natl. Park Serv. 44 pp.

Rakestraw, Lawrence. 1965. Historic Mining on Isle Royale. Isle Royale Natural History Assoc. & Natl. Park Serv. 20 pp.

(U. S. Natl. Arboretum) 1965. Plant Hardiness Zone Map. U. S. Dep. Agr. Misc. Publ. 814, revised. [8] pp. + map. $.20 (U. S. Gov. Printing Off). [County map of the 48 states, plus adjacent southern Canada, shows in color 10 zones of winter hardiness (expected minimum temperatures) for certain ornamental plants. (It must be remembered that nothing is indicated about "summer hardiness": colder climate plants will not necessarily grow everywhere that it is warmer, any more than warmer climate plants will grow where it is colder; the map will help with the latter problem.)]

B. BOOKS BULLETINS, SPECIAL REPORTS, AND MISCELLANEOUS

Bevis, Frederick B. 1964. Cladonia of the Western Upper Peninsula of Michigan, with a Checklist of Northern Michigan Lichens. Ford Forestry Center Bull. 11. 17 pp. [processed]

Bevis, Frederick B., & Richard J. Krueger. n. d. [1965]. Phytosociology of Lichen Vegetation on a Sandy, Glacial Outwash Plain in Northern Michigan. Ford Forestry Center Bull. 10. 13 pp. [processed] [Study of "reindeer-moss" in Baraga Co.; the nomenclature, though said to follow Hale & Culberson, does not do so.]

Clewell, Andre F. 1966. Identification of the Lespedezas in North America. A Selected Bibliography on Lespedeza. Bull. Tall Timbers Res. Sta. 7. 29 pp. ["Southern Michigan" included in stated distribution of *L. hirta.*]

Daubs, Edwin Horace. 1965. A Monograph of Lemnaceae. Ill. Biol. Monogr. 34. 118 pp. $3.50 (Univ. Ill. Press). [Includes keys to all taxa in the world, drawings, distribution maps, and citation of specimens. The citations give no more precise localities than state, and apparently were selected at random; two of the several species determined by the author as occurring in Michigan (*L. obscura* & *L. trinervis*, MICH, det. Daubs, 1961-62) are neither cited nor mapped from the state. Despite the statement in the introduction that "detailed maps of the geographic distribution" are included, the maps are in fact among the least detailed ever published and are nearly useless, though usually reliable enough to indicate the countries or continents from which each species is known. The documentation in general is extraordinarily careless and sketchy.]

Fowells, H. A. (compiler & reviser). 1965. Silvics of Forest Trees of the United States. U. S. Dep. Agr., Forest Service, Agr. Handb. 271 762 pp. $4.25 (U. S. Gov. Printing Off.). [Compiled from the series of papers on "silvical characteristics" of various forest trees, issued by the Forest Experiment Stations of the U. S. D. A., this useful volume includes rather detailed distribution maps of trees, often on a county map base, and occasionally other data and illustrations are from Michigan material.]

Gaiser, Lulu O., & Raymond J. Moore. 1966. A Survey of the Vascular Plants of Lambton County, Ontario. Plant Res. Inst., Canad. Dep. Agr. 122 pp. [Dr. Gaiser's work has been compiled posthumously by the junior author, and consists of an annotated list with introduction. The occurrence of a few species in adjacent Michigan is noted.]

Knapp, Rüdiger. 1965. Die Vegetation von Nord- und Mittelamerika und der Hawaii-Inseln. Gustave Fischer Verlag, Stuttgart. xl + 373 pp. DM 58 [$14.50 from Stechert-Hafner, New York]. [In addition to casual mention of Michigan in statements and inclusion in maps, original diagrams based on Michigan vegetation are on pp. 31, 49, & 85.]

Mech, L. David. 1966. The Wolves of Isle Royale. Fauna Natl. Parks U. S., Fauna Ser. 7. 210 pp. $1.00 (U. S. Gov. Printing Off.). [Includes general forest cover map of Isle Royale, brief remarks on vegetation, and observations on effect of moose on vegetation; many photos.]

Rickett, Harold William. 1966. Wild Flowers of the United States. Vol. I. The Northeastern States. N. Y. Bot. Gard. & McGraw-Hill, New York. 559 pp. (in two parts). $39.50. [Michigan included, not always correctly, in stated distribution of many species in this superbly illustrated work; 4 of the 49 photographers whose work is included (chief among them Bernard Horne, of Jackson) are currently Michigan residents, and although the photos are not geographically identified we can be sure that most (not all) of the pictures by these four were taken in Michigan. See review on p. 30 of this issue.]

Skilling, Darroll D., & Charles E. Cordell. 1966. Scleroderris Canker on National Forests in Upper Michigan and Northern Wisconsin. North Central

For. Exp. Sta., Res. Pap. NC-3. 10 pp. [This fungus disease widespread on red and jack pine in Ottawa and Hiawatha National Forests in Michigan.]

C. JOURNAL ARTICLES

Argus, George W. "1964" [1965]. Preliminary reports on the flora of Wisconsin. No. 51. Salicaceae. The genus Salix — the willows. Trans. Wis. Acad. 53: 217-272. [*S. syrticola* is mentioned from New Buffalo, Mich.]

Banks, Donald J. 1966. Taxonomy of Paspalum setaceum (Gramineae). Sida 2: 269-284. [Distribution maps show occurrence in Michigan of var. *stramineum* and var. *muhlenbergii*.]

Barkley, T. M. "1963" [1964]. Preliminary reports on the flora of Wisconsin No. 49. Compositae II—Composite family II The genus Senecio—the ragworts—in Wisconsin. Trans. Wis. Acad. 52: 343-352. [Includes statement on occurrence of *S. indecorus* on Keweenaw Peninsula and generalized distribution maps show *S. plattensis* and *S. pauperculus* in Michigan.]

Barr, Margaret E. 1964. The genus Pseudomassaria in North America. Mycologia 56: 841-862. [*P. lycopodina* cited from Mackinac Co.]

Bigelow, Howard E. 1965. The genus Clitycybe in North America: Section Clitocybe. Lloydia 28: 139-180. [Half of the 30 species are cited from Michigan, generally with no further locality data, including the type of one new species from Dexter.]

Britton, Donald M., & James H. Soper. 1966. The cytology and distribution of Dryopteris species in Ontario. Canad. Jour. Bot. 44: 63-78. [Distribution maps include a few Michigan records for some species.]

Bulmer, Glenn S., & Everett S. Beneke. 1964. Germination of basidiospores of Lycoperdon species and Scleroderma lycoperdoides. Mycologia 56: 70-76. [Material of the Lycoperdon species was collected near Lansing.]

Daoud, H. S., & Robert L. Wilbur. 1965. A revision of the North American species of Helianthemum (Cistaceae). Rhodora 67: 255-312. [This installment of a continuing monograph includes a few specimen citations and more ample distribution maps showing *H. canadense* & *H. bicknellii* in Michigan.]

Denison, William C. 1964. The genus Cheilymenia in North America. Mycologia 56: 718-737. [*C. coprinaria* cited from moose dung, Isle Royale.]

Dodson, Calaway H. 1966. Studies in orchid pollination Cypripedium, Phragmipedium, and allied genera. Bull. Am. Orchid Soc. 35: 125-128. [Includes photo of bee emerging from *C. arietinum* in Michigan.]

Gilbertson, Robert L. 1965. Resupinate hydnaceous fungi of North America V. Type studies of species described by Berkeley and Curtis. Mycologia 57: 845-871. [*Hydnum setulosum* cited from three Michigan localities.]

Groves, J. Walton. 1965. The genus Godronia. Canad. Jour. Bot. 43: 1195-1276. [Two species of these discomycete fungi are cited from one Michigan locality each.]

Kral, Robert. 1966. Eriocaulaceae of continental North America north of Mexico. Sida 2:285-332. [*E. septangulare* mapped from 17 Michigan counties-about half those from which it is known.]

Kral, Robert. 1966. Xyris (Xyridaceae) of the continental United States and Canada. Sida 2: 177-260. [Distribution maps show occurrence of *X. torta*, *X. montana*, and *X. difformis*—though from less than a fourth of the counties known.]

Larsen, Michael J. 1965. Tomentella and related genera in North America I. Studies of nomenclatural types of species of Hypochnus described by Burt. Canad. Jour. Bot. 43: 1485-1510. [*H. canadensis* cited from Kellogg Forest, Michigan.]

Long, Robert W. 1966. Biosystematics of the Helianthus nuttallii complex (Compositae). Brittonia 18: 64-79. [Distribution map for *H. maximiliani* includes Michigan localities.]

Review

WILD FLOWERS OF THE UNITED STATES. Vol. I. The Northeastern States. By Harold William Rickett. New York Botanical Garden & McGraw-Hill Book Co., New York. 1966. 559 pp. (in two parts). $39.50.

Lest one conclude that $39.50 is too much to pay for 559 pages, it should be proclaimed at the start that these two sturdily bound 10 × 13 inch volumes include over 1200 superb reproductions of color transparencies, and were it not for subsidies in preparation, they would cost a deservedly higher figure.

The color photographs are extraordinarily well reproduced, with remarkable faithfulness to the original slides, which seem to have lost nothing in the printing. Those few instances where the pictures are not up to par can almost certainly be attributed to unavailability of a good slide to begin with. The illustrations will be a joy to both amateur and professional botanists. The blues, so difficult to capture in color, are often (though by no means always) displayed with unusual brilliance. Inevitably, there can be some questions of identification. The flowering plant of "*Streptopus amplexifolius*" on pl. 6 is surely *S. roseus;* the two Nuphars on pl. 29 may be switched (or else both are *N. variegata*); "*Drosera intermedia*" on pl. 57 [at Hammond Bay, Mich.] is probably *D. linearis* × *D. rotundifolia* (the former also in photo); and "*Bidens connata*" on pl. 144 is certainly *B. cernua*. Most of these may perhaps be attributed to errors by the photographers. In at least one instance, error results from failure to accept the identification of the photographer: The original slide of "*Tragopogon porrifolius*" (pl. 170) was submitted as the hybrid of that species with *T. pratensis;* the plant was among others growing (by railroad station in Cheboygan, a well known site for the hybrids) with both parents and was clearly intermediate between them.

All grasses, sedges, rushes, pondweeds, etc., are omitted, and only a few woody plants are considered "wild flowers." Those of us more used to tradition than are some amateurs will be frustrated by certain features: the use of miscellaneous wordy and exception-ridden "groups," "guides," and so forth instead of the straightforward dichotomous simplicity of good keys; the absence of the metric system (admitted, many laymen cannot readily think in terms of millimeters, but are figures like 1/6, 4/5, 1 1/5 inch really that much more comprehensible?); and the various deviations from what is basically the Engler-Prantl sequence of families. Distributional data in the text evidently are lifted from manuals without much if any evaluation or correction. For example, *Iris lacustris* has not, to my knowledge, been found around Lake Superior; *Lychnis drummondii* has apparently not "been found in Michigan"; and *Viola blanda*, as now understood, does not range west to Minnesota and Wisconsin.

Local readers will note that some distinctive Great Lakes region plants like *Iris lacustris*, *Cirsium pitcheri*, and *Tanacetum huronense* are included but *Solidago houghtonii* rates only two lines of fine print. One of our most interesting native orchids, *Habenaria unalascensis*, is not mentioned at all, and *Listera auriculata* (not illustrated) is admitted to the U. S. only in New Hampshire, with no mention of Minnesota and Michigan. Both so-called species of *Comandra* are pictured, but not *Geocaulon* in the same family. The handsome photo of *Primula mistassinica* is evidently var. *novaboracensis* and not the common plant around the Great Lakes. *Filago arvensis* is pictured, but there is not even a mention of *Centaurea diffusa*, an even commoner weed in the state.

No trifling errors of commission or omission can seriously detract from the fact that this is the most complete and finest collection of color pictures of northeastern American wildflowers, accompanied by readable descriptions and comments in which technical terminology has been avoided with exceptional skill.

—E. G. V.

PROGRAM NOTES

February 11-20: Flower Show, Detroit Artillery Armory (near Northland).

March 17-18: Michigan Academy of Science, Arts, & Letters, 71st Annual Meeting, University of Michigan, Ann Arbor. The Botany Section will meet at the Botanical Gardens, with lunch Friday at the North Campus Commons.

April 9: Michigan Botanical Club, at University of Michigan Botanical Gardens:
10:00 Board meeting
12:00 State meeting
2:30 Huron Valley Chapter annual meeting

May 27-28: Annual spring campout, Michigan Botanical Club, this year at the University of Michigan Biological Station on Douglas Lake.

A southwestern Michigan chapter of the Botanical Club is being formed, with Kalamazoo as a center but extending to Muskegon, Grand Rapids, and Lansing to the extent that members are interested. For further information contact Dr. Harriette V. Bartoo, Department of Biology, Western Michigan University, Kalamazoo, Michigan 49001.

Editorial Notes

IMPORTANT NOTICE TO ALL PAST AUTHORS: Authors of articles which have appeared in past issues of THE MICHIGAN BOTANIST should advise the editor if they wish to have their original manuscripts and/or art work returned. All manuscripts, photos, etc., not already returned to authors are still on file, but some must be discarded soon to conserve space.

The October number (Vol. 5, No. 4) was mailed October 28, 1966.

News of Botanists

Briefly, we record these recent items of interest regarding botanists (or persons well known to many local botanists).

NEW APPOINTMENTS: Dr. Marion T. Hall, formerly botanist at Cranbrook and for a year acting director of the University of Michigan Botanical Gardens, most recently director of the Stovall Museum at the University of Oklahoma, has since September 27 been Executive Director of The Morton Arboretum, Lisle, Illinois. . . . Dr. James R. Wells, formerly at Old Dominion College, Norfolk, Virginia, is now staff botanist at the Cranbrook Institute of Science; the previous botanist, Dr. Warren P. Stoutamire, is now on the faculty of the University of Akron, Akron, Ohio.

RECENT DEATHS: Dr. Lulu O. Gaiser, formerly of McMaster University (Hamilton, Ontario), in retirement working on the flora of Lambton Co., Ontario (across from Port Huron), on April 7, 1965. . . . Florence N. Hanes, author with her late husband, Clarence, of the "Flora of Kalamazoo County, Michigan," on June 10, 1966. . . . Dr. A. E. Allin, active and hospitable amateur naturalist of Fort William, Ontario, on November 7, 1966. . . . Dr. A. H. Stockard, zoologist, director of the University of Michigan Biological Station for 26 years, on November 26, 1966.

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(On the cover: Snow on cat-tails, Typha *sp., at Rose Island on Wildfowl Bay, Huron Co., Michigan. Photograph by Clyde Allison, 1957, courtesy of Michigan Department of Conservation.)*

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THE MICHIGAN BOTANIST

March, 1967

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Vol. 6- (4 numbers, at $.75 each): $3.00

Subscriptions (from those not members of the Michigan Botanical Club) and all orders for back issues should be addressed to the business and circulation manager, who will assume that subscriptions received prior to the last number of a volume are intended to begin with the first number of that volume unless specified to the contrary.

Articles and notes dealing with any phase of botany in the Upper Great Lakes Region may be sent to the editor in chief. The attention of authors preparing manuscripts is called to "Information for Authors" (Vol. 4, p. 38; reprints available from the editor).

THE MICHIGAN BOTANICAL CLUB

Membership in the Michigan Botanical Club is open to anyone interested in its aims: conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on the plant life of the State; sponsorship of legislation to promote the preservation of Michigan native flora and to establish suitable sanctuaries and natural areas; and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

Dues are modest, but vary slightly among the chapters. In all cases, they include subscription to THE MICHIGAN BOTANIST.

President: Charles Barclay, 915 Mixtwood, Ann Arbor, Michigan 48103
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A VEGETATIVE KEY TO THE GENERA OF SUBMERSED AND FLOATING AQUATIC VASCULAR PLANTS OF MICHIGAN [1]

Edward G. Voss
Herbarium, The University of Michigan, Ann Arbor

INTRODUCTION

It is usually not difficult to learn to recognize at least the genera of true aquatic plants in sterile condition. Waterweed (*Elodea*), wild-celery (*Vallisneria*), pondweed (*Potamogeton*), coontail (*Ceratophyllum*), water-milfoil (*Myriophyllum*), bladderwort (*Utricularia*), water-lily (*Nymphaea*), and others are known, often by name, to fishermen and other outdoorsmen as well as to botanists. Other aquatic plants, such as *Subularia* and *Littorella*, may be very rare and of interest from an ecological and phytogeographical standpoint. Still others, although usually emergent, may have truly aquatic forms.

Although these plants are reasonably distinctive even when lacking flowers and fruit (which is usually the condition of many of them), most botanical manuals make their identification difficult by requiring a knowledge of reproductive parts which are at best obscure and more often missing completely. It ought not be necessary to decide first whether duckweed and watermeal (*Lemna* and *Wolffia*) are monocots or dicots in order to key them down. Coontail (*Ceratophyllum*) is absolutely distinctive even if one does not know the nature of the perianth (or, worse yet, the placentation, upon which many keys depend).

Within the limitations of scope described below, the key which follows should make more easy the identification of true aquatic plants in Michigan (and to a greater or lesser extent, in neighboring areas).

Scope: This is a key to strictly aquatic plants, with *all* leaves *submersed* or *floating* on the surface of the water (at most the inflorescences and bracts, not leaves, held above the surface). Rush-like plants (grasses, sedges, and rushes) with erect stems extending above the water should not be sought in this key unless they have definite limp aquatic leaves.

In the field (for which the key is largely designed), plants are usually readily recognized as being aquatic if one is not misled by a

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[1] Contribution from the Biological Station of The University of Michigan. If additional copies of this key are desired for field use by students, conservation workers, or others, they may be obtained postpaid (if prepaid) from Campus Publishers, 711 N. University Ave., Ann Arbor, Michigan 48104, at $.50 each (20% discount in quantities of 10 or more).

rise in water level to assume that an inundated plant is a normally aquatic species. In the herbarium, a proper label should record the habitat, but most of the larger true aquatics, even without complete data, can be recognized as such by the delicate structure of submersed stems and leaves, which are often extremely limp and flexible or divided into filiform segments; hence when dry they still convey the impression of having been supported by water. The presence of algae, other aquatic organisms, or marl incrustations is also a handy clue to an underwater source.

It is intended that all genera with species known to produce a normal aquatic form in Michigan be included. Many of these plants are always aquatic, while others (e. g., *Nelumbo*, *Marsilea*, *Zizania*) usually have above-water leaves. The key is not designed to include non-vascular plants, but notice has been taken of a few algae and bryophytes which are most likely to confuse the novice. It has not been possible to account for all seedling and juvenile forms (whether of included genera or not) which might be encountered in the water. Genera including one or more non-indigenous species are not designated in any special way.

Characters: Vegetative characters are stressed, including some which are easily seen only on fresh material. Sometimes obvious characters of inflorescences or flowers have been added. Basically, the key is carried out only to genera, since most manuals, especially illustrated ones, will work fairly well once one knows the genus. If we have only one species which is intended to key out at a particular place, its epithet is given in parentheses after the generic name. In two instances (couplets 27 & 30) the key is extended to distinctions between species in order to call attention to some vegetative characters apparently useful on sterile plants but not generally mentioned in manuals.

It should be stressed that some of the species considered are not always aquatic. When flowering or fruiting specimens are available along adjacent shores and can confidently be associated with nearby sterile aquatic forms, the fertile material may often be identified by better characteristics than the vegetative ones necessarily employed for the aquatic form.

As in all keys, both choices of a given couplet should be read very carefully and compared for understanding of terminology and nature of the distinctions made, before proceeding to the next choice.

In preparing this key, I have examined fresh aquatic material from Michigan of all 46 included genera except one (*Cabomba*, which is known to be established only in Kalamazoo and adjacent St. Joseph counties), and of 90% of the approximately 120 species of vascular plants which the key is designed to cover (at least in their aquatic forms).[2] I am indebted to Jarl K. Hiltunen for supplying abundant

[2] A mimeographed checklist of aquatic vascular plants of Michigan, including also marsh and emergent species, is available from the author.

fresh material of certain rarities, to several other botanical colleagues for advice, and to my students in "Aquatic Flowering Plants" during the past six years for much practical aid—some of it perhaps inadvertent during class exercises with keys. The excellent drawings, which illustrate some of the types of dissected leaves, venation, and other characters, are the skillful work of Edward M. Barrows, to whom I am especially grateful for this major contribution to clarity.

1. Plants without distinct stem and leaves, free-floating at or below surface of water (except when stranded by drop in water level), the segments (internodes) small (up to 15 mm, but in most species much smaller, often remaining attached where budded from parent plant)
  2. Plant body once to several times equally 2-lobed or 2-forked . . . . (Thallose liverworts, Ricciaceae)
  2. Plant body not consistently dichotomous
    3. Plants rootless, about as broad as thick (or even globose), less than 1 mm in greatest dimension[3] . . . . WOLFFIA
    3. Plants with rootlets (when intact), ± flattened, usually more than 1 mm in greatest dimension
      4. Individual segments each with several rootlets, solid dark purplish-red on under surface and often with a purple dot (from which radiate 5-7 or more obscure nerves) on upper surface above point of attachment of the roots; larger segments averaging 2.5-3.5 mm in breadth, rounded to obovate in outline . . . . SPIRODELA (polyrhiza)
      4. Individual segments each with a single rootlet, sometimes flushed with purplish but seldom solid dark colored beneath, with at most 1-3 very obscure nerves above, these not radiating from a main dark spot; segments either averaging less than 3 mm in breadth or not rounded in overall outline . . . . LEMNA
1. Plants with distinct stem and/or leaves, usually anchored in substrate, mostly larger
  5. Plants with floating leaves present (blades, or at least their terminal portions, floating on the surface of water, usually ± smooth and leathery in texture, especially compared with submersed leaves—or submersed leaves none)
    6. Blades of some or all floating leaves on a plant sagittate or deeply lobed at base, or compound, or peltate
      7. Floating blades compound (4-foliolate) . . . . . . MARSILEA (quadrifolia)
      7. Floating blades simple
        8. Floating blades (at least some of them) sagittate (the apex and lobes acute) [Caution: Do not try to key plants here with sagittate blades extending *above* the surface of the water.] . . . . SAGITTARIA (cuneata)[4]

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[3] *Nostoc,* a genus of algae, has several species which may occur in spherical or nearly spherical colonies ranging in size from that of *Wolffia* to over 1 cm; these are blue- or olive-green, in contrast to the bright or yellowish green of *Wolffia,* with which they may grow.

[4] This species is apparently the commonest (and perhaps the only) one of the genus to display the aquatic form described, but it is possible that some other species could simulate it. For safe identification, look for emergent plants with flowers or fruit.

8. Floating blades circular to ± elliptical in outline, peltate, or rounded at apex with deep sinus at base
  9. Floating leaves with deep sinus, the petiole attached at its depth, between the two basal lobes of blade
    10. Blades of floating leaves circular or nearly so in general outline, the lobes pointed; more pairs of veins radiating from base of midrib than from along midrib; basal submersed leaves none; flowers white . . . . NYMPHAEA
    10. Blades of floating leaves broadly elliptical in general outline (mostly about 1.5-2 times as long as wide), the lobes rounded; more pairs of veins arising from along midrib than radiating from its base; basal submersed leaves (early & mid-season) broad and membranous; flowers yellow . . . . NUPHAR
  9. Floating leaves peltate
    11. Submersed leaves dissected into thread-like divisions . . . . CABOMBA (caroliniana)
    11. Submersed leaves simple or none
      12. Leaves less than 1 (rarely 1.5) dm long, ± elliptical, often covered (as is stem) with a thick gelatinous coat, especially beneath; flowers maroon, less than 3 cm broad . . . . BRASENIA (schreberi)
      12. Leaves mostly more than 1.5 dm in diameter, ± circular, without gelatinous coat; flowers cream-colored, much larger . . . . NELUMBO (lutea)
6. Blades of floating leaves all unlobed (at most subcordate at base), simple, the petiole marginal or absent (if blade ribbon-like)
  13. Floating leaves small (less than 1 cm long), crowded in a terminal rosette; submersed leaves distinctly opposite . . . . CALLITRICHE
  13. Floating leaves larger, not in a rosette; submersed leaves alternate, basal, or absent
    14. Leaves narrow and ribbon-like, the blades many times longer than broad, without distinct petioles (though in some species a sheath surrounds the stem)
      15. Leaves ± rounded at tip (even if tapered), the floating portion smooth and shiny, somewhat yellow-green to bright green when fresh, sometimes keeled but midvein scarcely if at all more prominent than others; leaf not differentiated into blade and sheath, the submersed portion similar to the floating but more evidently with a fine closely checked pattern; flowers and fruit in spherical heads . . . . SPARGANIUM
      15. Leaves sharply acute at tip, the floating portion ± dull, rather blue-green when fresh, with midrib; leaf including a sheath around the stem and a membranous ligule at junction of sheath and blade; flowers and fruit in paniculate spikelets[5]

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[5] The grasses which most commonly produce elongate floating leaves in our area are manna grass, *Glyceria borealis* and *G. septentrionalis*, and young plants of wild rice, *Zizania aquatica*. Identification is assured by comparison with normal plants in the vicinity or by checking floral characteristics if spikelets are present (as they often are at the same time as floating leaves in *Glyceria*).

16. Floating blades minutely but densely pubescent or strongly papillose above; sheaths closed at least most of their length (margins connate to form tube around stem); plants rhizomatous . . . . GLYCERIA
16. Floating blades glabrous; sheaths open (split down one side nearly or quite to the node); plants loosely rooted, not rhizomatous . . . . ZIZANIA (aquatica)
14. Leaves (at least floating ones) with ± elliptical blades and distinct petioles
17. Leaves all basal[6] . . . . ALISMA (plantago-aquatica)
17. Leaves alternate or opposite on stem
18. Venation netted; flowers bright pink, in dense ovoid to cylindrical spike . . . . POLYGONUM
18. Venation parallel; flowers dull, in narrow cylindrical spike . . . . POTAMOGETON
5. Plants without any floating leaves, entirely submersed (except sometimes for inflorescences and bracts)
19. Plants with leaves (or leaf-like structures) all basal and simple
20. Leaves definitely flat, several times as broad as thick (widest about the middle or parallel-sided)
21. Leaf blades not over twice as long as broad . . . .(juvenile Nymphaeaceae: go back to couplet 9)
21. Leaf blades more than twice as long as broad
22. Leaves stiff and erect or somewhat outcurved, less than 20 cm long . . . . SAGITTARIA (graminea)[4]
22. Leaves limp, more than 20 cm long (tape-like or ribbon-like)
23. Midvein not evident: all veins of essentially equal prominence, with the tiny cross-veins giving a checkered appearance to the leaf, which is thus uniformly marked with minute rectangular cells about 1-2 mm long or smaller (fig. 2) . . . . SPARGANIUM
23. Midvein (and usually some additional longitudinal veins) evident, the veins not all of equal prominence, not dividing the entire leaf into minute rectangular cells
24. Leaves with the central third (or more) of distinctly different texture (more densely reticulate) than the two marginal zones (fig. 1); plants dioecious, the staminate flowers eventually liberated from a dense inflorescence submersed at base of plant, the pistillate solitary on a long ± spiraled peduncle which reaches the surface of the water . . . . VALLISNERIA (americana)
24. Leaves ± uniform in venation pattern, not 3-zoned (fig. 3); plants monoecious, with emergent inflorescence of white-petaled flowers (but these scarce on plants with submersed tape-like leaves) . . . . SAGITTARIA (cuneata)[4]
20. Leaves[7] filiform (thread-like) or terete or only slightly flattened (especially basally), elongate and limp to short and quill-like, less than twice as broad as thick

[6] Sometimes plants of *Sagittaria cuneata* may have leaves only of this sort (none projecting above the water, none sagittate). Comparison with other plants, especially if flowering, in the vicinity will confirm identification. Floating blades of *Alisma* tend to be more broadly elliptical than the elongate—lanceolate ones of *S. cuneata*.

[7] The conspicuous structures here called "leaves" for ease of identification are in some instances actually stems or sterile culms.

25. Major erect structures solitary, spaced along a simple or branched delicate rhizome, consisting either of rather yellowish stems bearing minute alternate bumps as leaves or of filiform leaves mostly buried in the substrate and with a few minute bladder-like organs[8]

26. Leaves minute alternate bumps on stem, these accompanied (especially at lower nodes) by pale or dark transverse lines circling stem, giving it a ± segmented appearance, but no bladders present; flowers sessile, usually in an emersed spike, inconspicuous, regular . . . . MYRIOPHYLLUM (tenellum)

26. Leaves filiform, mostly buried in substrate (only the green tips, circinate when young, protruding); minute bladders usually present on the delicate branching rhizomes and buried leaf bases; flowers on an emergent scape, 1-few, showy (yellow or purple), zygomorphic

27. Leaf-bearing nodes of rhizome each with 2 lateral rootlet-like runners when intact; flower solitary, purple . . . . UTRICULARIA (resupinata)

27. Leaf-bearing nodes of rhizome with 0-4 (not consistently 2) lateral rootlet-like runners; flowers usually 2 or more, yellow . . . . UTRICULARIA (cornuta)

25. Major erect structures solitary to densely tufted, consisting of filiform or quill-like leaves or culms (stems), with neither alternate bumps nor bladders

28. Leaves very limp (retaining no stiffness when removed from water and hence irregularly curved, sinuate, bent, or matted in herbarium specimens—though a stiffer straight culm may also be present), mostly more than 20 cm long, about 0.2-1 mm in diameter

29. Leaves (actually sterile culms) terete their entire length, not expanded basally nor sheathing each other, but each separate and closely surrounded at base for about (0.6) 1 cm or more by a very delicate membranous tubular sheath (this sometimes requiring careful dissection to distinguish); rhizome less than 2 mm in diameter; inflorescence (rare on plants otherwise entirely submersed) a single strictly terminal spikelet

30. Rhizome reddish, at least on older portions; leaves mostly over 20 cm long, very limp; fertile culm triangular in section on emersed portion, much larger in diameter than the leaves, but spikelet no thicker than culm ELEOCHARIS (robbinsii)

30. Rhizome whitish throughout; leaves sometimes shorter, usually stiffer; fertile culm no larger than leaves, but spikelet distinctly thicker than culm . . ELEOCHARIS (acicularis)

29. Leaves slightly expanded basally for about (0.7) 2-10 cm, sheathing the next inner leaf at least dorsally (usually the sheath continued ventrally as an almost invisible membrane), with tiny ligule or pair of auricles at the summit; rhizome various; inflorescence a lateral spikelet or terminal cyme

31. Leaf somewhat flattened or grooved ventrally for at least a few cm above the sheath (± crescent-shaped in section), with 1-5 longitudinal nerves evident, the tiny cross-veins

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[8]Occasional populations of *Utricularia cornuta* without buried bladders may be placed by the circinate (inrolled) tips of the young singly spaced leaves.

connecting between nerves but not extending entirely across the leaf (fig. 4); sheath with a tiny ligule at summit; rhizome less than 2 mm in diameter; inflorescence a solitary lateral spikelet on a stiff wiry culm just above or near the surface of the water . . . . SCIRPUS (subterminalis)

31. Leaf terete above sheath, with no evident longitudinal nerves, but numerous definite septa extending entirely across the blade (which shrinks between septa on drying); sheath with a minute pair of auricles at summit; rhizome about 2-5 mm thick; inflorescence an open cyme of many several-flowered heads on a very stout culm (several mm in diameter, over 50 cm tall). . . . . .JUNCUS (militaris)

28. Leaves usually firm (retaining stiffness when removed from water and hence straight or with an even curve in herbarium specimens), less (in most species much less) than 20 cm long, of various diameter

32. Leaves filiform throughout, not broader basally nor sheathing each other, solitary (rarely) or in small tufts along a filiform whitish rhizome, each leaf (actually a sterile culm) closely surrounded at its base for about 6 mm or more by a very delicate membranous tubular sheath (this sometimes requiring careful dissection to distinguish); inflorescence (rare on completely submersed plants) a single terminal spikelet . . . . ELEOCHARIS (acicularis)

32. Leaves linear or tapered from base to apex, or if otherwise uniformly filiform then sheathing or expanded at base, without individual tubular sheaths as described above; inflorescence various

33. Leaf in section appearing composed of 2 hollow tubes side by side (fig. 5), linear (±parallel-sided), broadly rounded at tip; flowers zygomorphic, in few-flowered raceme . . . . LOBELIA (dortmanna)

33. Leaf not (or rarely) of 2 hollow tubes, tapered and ± acute (or filiform); flowers regular and racemose, or solitary, or in a dense head or spike, or plant producing spores at base

34. Roots with prominent cross-septate appearance (checkered with fine transverse lines, fig. 6); inflorescence a small head of whitish or gray flowers (flowering in shallow water or on wet shores) . . . . ERIOCAULON (septangulare)

34. Roots not distinctly septate or cross-lined; inflorescence not as above

35. Leaves rather abruptly expanded at base to enclose sporangia, often dark green, composed of 4 hollow tubes (seen in section, fig. 7), surrounding a hard corm-like stem; plant always submersed (unless stranded), non-flowering . . . . ISOETES

35. Leaves gradually and slightly expanded or grooved on one side at a somewhat sheathing base but not composed of 4 tubes nor enclosing sporangia and no corm-like stem present; plants (except *Subularia*) not flowering when submersed but only on wet shores

36. Leaves somewhat flattened at least basally, widest at the base, gradually tapered to sharp apex; plants with buried rhizome or none

37. Plants connected by slender rhizomes (ca. 1 mm or narrower); sheathing basal portion of leaf (ca. 7 mm or more) with pale membranous borders abruptly terminating (or with minute auricles); leaves often 4 cm or more in length, somewhat flattened laterally below, with 2-3 conspicuous hollow tubes evident in section; inflorescence (not on wholly submersed plants) a spreading cyme of solitary to paired 3-merous flowers . . . . JUNCUS (pelocarpus)[4]
37. Plants without rhizomes; sheath not abruptly auricled; leaves less than 4 cm long, somewhat flattened dorsoventrally (especially toward base), with numerous small hollow areas of irregular size; inflorescence (often submersed) a few- (often only 2-) flowered raceme of 4-merous flowers . . . . SUBULARIA (aquatica)
36. Leaves ± terete, scarcely or no wider at base than at middle, of ± uniform width at least to middle (or even slightly thicker there before tapering to apex); plants with rhizomes or stolons at, near, or above surface of substrate
38. Plants with green stolons strongly arching above substrate; leaves filiform, ± uniform in diameter, about 0.5-1 mm thick, truncate at tip . . . . RANUNCULUS (flammula var. reptans)
38. Plants producing delicate horizontal white to green stolons at or near (above or below) surface of substrate (in addition to stouter rootstock); leaves about 0.7-3 mm thick at middle, whence tapered to apex . . . . LITTORELLA (uniflora)
19. Plants with leaves cauline, simple or compound (basal and dissected in one species)
39. Leaves compound, dissected, forked, or deeply lobed
40. Leaves apparently in a basal rosette, few . . . . SIUM (suave)
40. Leaves definitely cauline: opposite, whorled, or alternate
41. Leaves all or mostly opposite or whorled
42. Leaves (morphologically, whorled branches) rolled inward at tip when young (circinate), bearing tiny stalked bladders; flowers (rare) emersed, zygomorphic, rose or purple . . . . .UTRICULARIA (purpurea)
42. Leaves not inrolled at tip, without bladders[9]; flowers various but not as above
43. Petiole evident (5-15 mm long on well developed leaves), the blade fan-shaped and much dissected beyond; flowers emergent, white . . . . CABOMBA (caroliniana)
43. Petiole absent or nearly so, the blade pectinate or much dissected or soon forking once or twice[10]; flowers inconspicuous or yellow

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[9]Do not confuse small shells or other extraneous organisms with the bladders of *Utricularia*.

[10]Two genera of algae, *Nitella* and *Tolypella*, might be sought here if not recognized as non-vascular plants. Neither is often collected except by algologists. At least some of the smooth "leaves" or "branches" are forked beyond the middle (not near the base, as in the usually toothed ones of *Ceratophyllum*).

44. Leaves once or twice dichotomously forked, the segments usually sparsely toothed along one edge (fig. 9); flowers inconspicuous, axillary, submersed. . . . . CERATOPHYLLUM
44. Leaves not dichotomously forked, the segments entire; flowers emersed or (rarely) submersed
45. Leaves pectinate (with straight central axis following midrib, once-pinnatifid or comb-like on both sides, fig. 11); flowers inconspicuous, in common species emersed in terminal spike, in rare species submersed and axillary . . . . MYRIOPHYLLUM
45. Leaves with no definite central axis, much dissected (fig. 10); flowers emersed in a showy yellow head (usually with at least one pair of merely serrate opposite leaves below it) . . . . MEGALODONTA (beckii)
41. Leaves definitely alternate
46. Leaves with a definite central axis (following midvein); flowers various
47. Leaves pectinate (the lateral segments not again branched); flowers inconspicuous, axillary; fruit a nutlet . . . . PROSERPINACA (palustris)
47. Leaves with lateral segments further narrowly divided (fig. 12); flowers with white corollas, in emersed raceme; fruit a silique[11]. . . . . ARMORACIA (aquatica)
46. Leaves with no definite central axis; flowers emersed, with conspicuous corolla
48. Petiole present (sometimes very short), ± adnate to a stipular sheath (e. g., fig. 8); plants without bladders[9]; flowers regular, white or yellow, with numerous separate carpels forming achenes . . . . RANUNCULUS
48. Petioles and stipular sheaths absent; plants with small stalked bladders on leaves (e. g., fig. 13) or on separate branches; flowers zygomorphic, yellow or purplish, with a single pistil producing a capsule . . . . UTRICULARIA
39. Leaves simple, unlobed, usually entire (toothed in a few species)
49. Leaves ± scale-like, not over 7 mm long, never distinctly opposite or whorled
50. Leaves minute, yellowish, merely widely spaced bumps on stem . . . . MYRIOPHYLLUM (tenellum)
50. Leaves up to 7 mm long, green or brownish, loosely overlapping . . . . (aquatic mosses & liverworts, Bryophyta)
49. Leaves much longer or distinctly opposite or whorled (or both conditions)
51. Leaves alternate, with ligule-like stipules (these wholly adnate to leaves in *Ruppia*)
52. Leaf blades ± filiform, terete or at least half as thick as broad, *and* the stipule adnate to leaf base for 10-30 mm or more, forming a sheath around the stem

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[11]Some other Cruciferae may occasionally be found with wholly submersed foliage, consisting of once-pinnately lobed or compound leaves, the lobes or leaflets often quite rounded, but they cannot be identified satisfactorily in sterile condition. Their sharp taste (like horse radish or water cress) will help to place them in this family.

53. Sheath with no free stipular ligule at summit (the stipule wholly adnate to leaf blade, merely rounded at summit, fig. 15); leaf blade terete; fruit stalked in an umbel-like arrangement on a ± spiraled and elongating limp peduncle . . . . RUPPIA (maritima)

53. Sheath with a short ligule-like extension of free stipule at summit (the stipule only partly adnate, fig. 14); leaf blade often somewhat flattened; fruit sessile or subsessile in a spike with a straight ± stiff peduncle . . . . POTAMOGETON

52. Leaf blades definitely flattened and several times broader than thick (even if narrow), *or* stipule little if at all adnate to blade (the latter not included in sheath if any) (or both conditions)

54. Blades flattened, ribbon-like (up to 5 or even 7.5 mm wide), with no definite midrib (no central vein more prominent than others except rarely toward base); flowers solitary, rare, cleistogamous in axils of submersed leaves or (these almost never on submersed plants) with 6 bright yellow tepals . . . . HETERANTHERA (dubia)

54. Blades filiform or flattened with a definite midrib; flowers in globose or cylindrical spikes, neither cleistogamous nor with showy yellow perianth . . . . POTAMOGETON

51. Leaves opposite or whorled, without stipules

55. Leaves nearly filiform, not over 0.5 mm broad, very gradually tapered from base to apex but not abruptly expanded basally, perfectly smooth; plants perennial by slender rhizomes; flowers axillary, 1 staminate flower (a single stamen) and (1) 2-several carpels at a node; fruit slightly curved and ± minutely toothed on convex side . . . . ZANNICHELLIA (palustris)

55. Leaves broader; or if filiform then abruptly expanded basally and with spiculate or toothed margins, the plants annual, and the fruit solitary and ellipsoid

56. Leaves definitely whorled

57. Whorled structures ("branches") cylindrical, elongate, usually stiff with calcium deposits; plants with distinctive musky odor . . . . ("stonewort" algae, Characeae)

57. Whorled structures (true leaves) flattened, short (not over 20 mm long) or elongate and very limp; plants without odor

58. Leaves 6-12 (usually 9) in a whorl, not over 2.5 mm wide, about 12-25 times as long as wide; flowers perfect, apetalous, sessile in axils of emersed leaves or bracts . . . . HIPPURIS (vulgaris)

58. Leaves mostly 3-4 (rarely 6) in a whorl, 0.8-5 mm wide, at most 10-13 times as long; flowers perfect or unisexual, but with petals

59. Leaves mostly 3 (rarely 6) in a whorl, very thin (2 cell layers) and delicate; stem round (not angled), smooth; flowers unisexual, with 3 often pink petals, at least the pistillate long-stalked from entirely submersed stem . . . . ELODEA

59. Leaves mostly 4 in a whorl, stiff and firm; stem square (4-angled), often with minutely retrorse-scabrous angles; flowers perfect, with 3-4 white petals (usually not developed on wholly submersed plants). . . . . GALIUM (trifidum)[4]

56. Leaves opposite (in some species, with bushy axillary tufts of leaves which may give a falsely whorled appearance)
60. Larger leaves at least 1-4 cm long, including distinct petiole and expanded diamond-shaped entire blade; flowers 4-merous, inconspicuous, axillary, with inferior ovary . . . . LUDWIGIA (palustris)
60. Larger leaves smaller, or sessile, or toothed (or all of these); flowers various
61. Leaves large, 3-13 cm long, 5-20 mm wide
62. Leaves sessile and clasping, limp, at most obscurely and remotely toothed; flowers (rarely present on plants with all foliage submersed) in axillary racemes . . . . .VERONICA (catenata)
62. Leaves sessile, clasping, tapered, or petioled, stiff, often regularly crenate or toothed; flowers various . . . . (abnormally submersed individuals of various terrestrial or marsh species, chiefly Labiatae)
61. Leaves small (shorter or narrower than the above, or usually both)
63. Leaves linear and bidentate at apex when well submersed, often becoming obovate, ± weakly 3-nerved, and not necessarily bidentate toward summit of stem (or floating in rosettes); fruit solitary in axils, somewhat heart-shaped, of two 2-seeded segments . . . . . CALLITRICHE
63. Leaves filiform to orbicular but essentially uniform on a plant and if linear not bidentate at apex; fruit various
64. Leaves at least 6 times as long as wide, filiform to linear-lanceolate but ± expanded at very base, minutely spiculate to conspicuously toothed on margin; fruit solitary in axil, ± ellipsoid . . . . NAIAS
64. Leaves less than 3 times as long as wide, often nearly round, and smooth-margined; fruit if axillary nearly globose
65. Stems forming moss-like mats but the erect or ascending tips (above rooted nodes) less than 3 cm long; leaves with at most 1 weak nerve; flowers axillary, inconspicuous . . . . ELATINE (minima)
65. Stems greatly elongate (generally 10-30 cm); leaves more evidently veined; flowers terminal, yellow (but usually absent on plants with all leaves submersed)
66. Stems stiffly erect; leaves weakly pinnately-veined (with evident midvein); with reddish to blackish shiny dots or flecks (these often also on stem) . . . . LYSIMACHIA (terrestris)[4]
66. Stems ± lax; leaves 3-nerved, without dark dots or flecks (though emersed leaves have translucent dots) . . . . HYPERICUM (boreale)[4]

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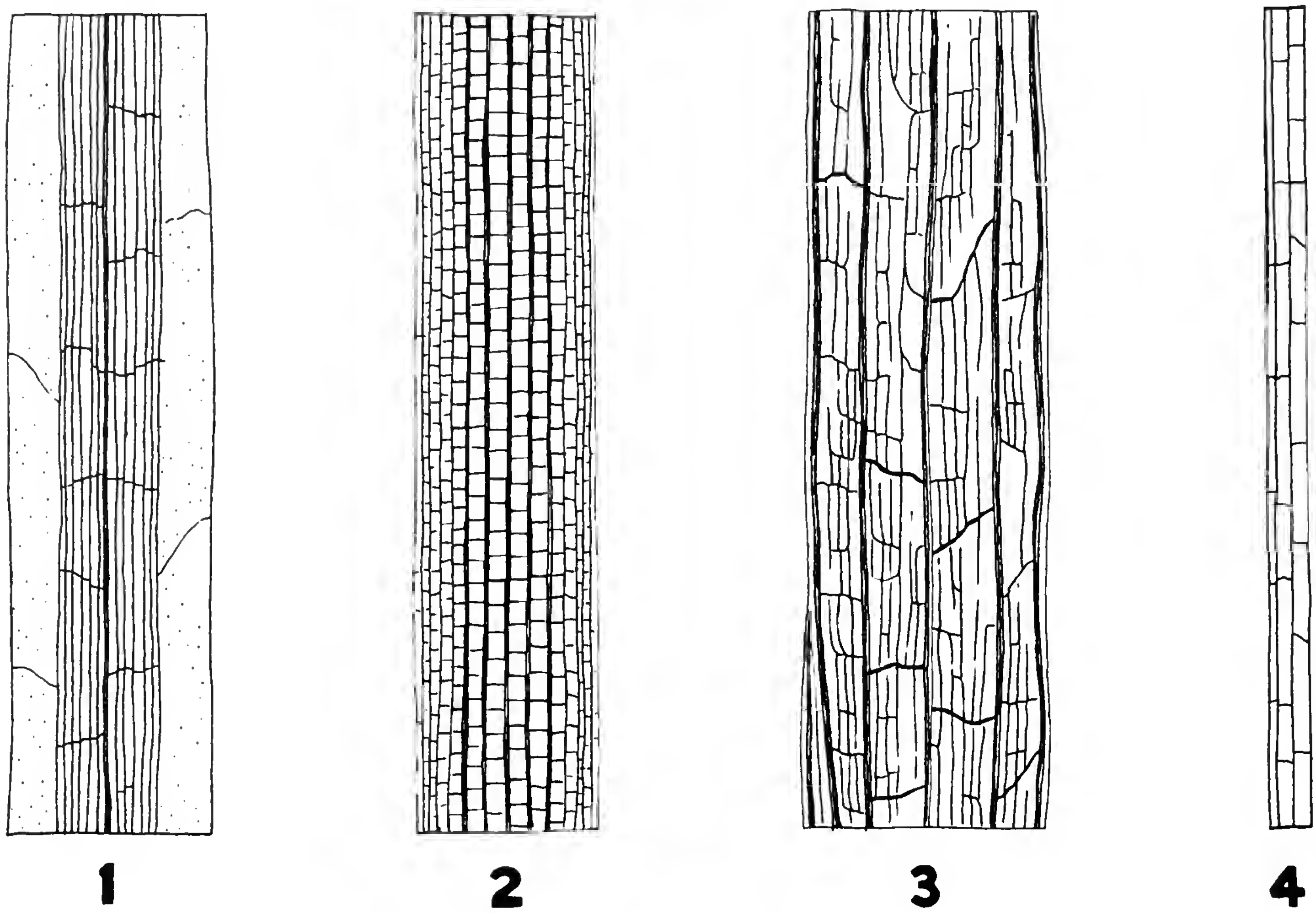
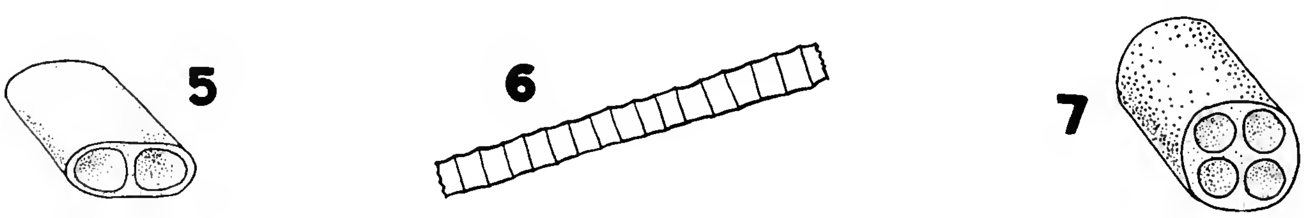
FIGURES

The figures which follow, all drawn from fresh or preserved (not dried) material by Edward M. Barrows, are intended to clarify the patterns of dissected leaves and certain other morphological features difficult to describe in words. In the legends, some additional terminology has been used and explained so that the figures become the basis for a partial (and non-alphabetical) glossary.



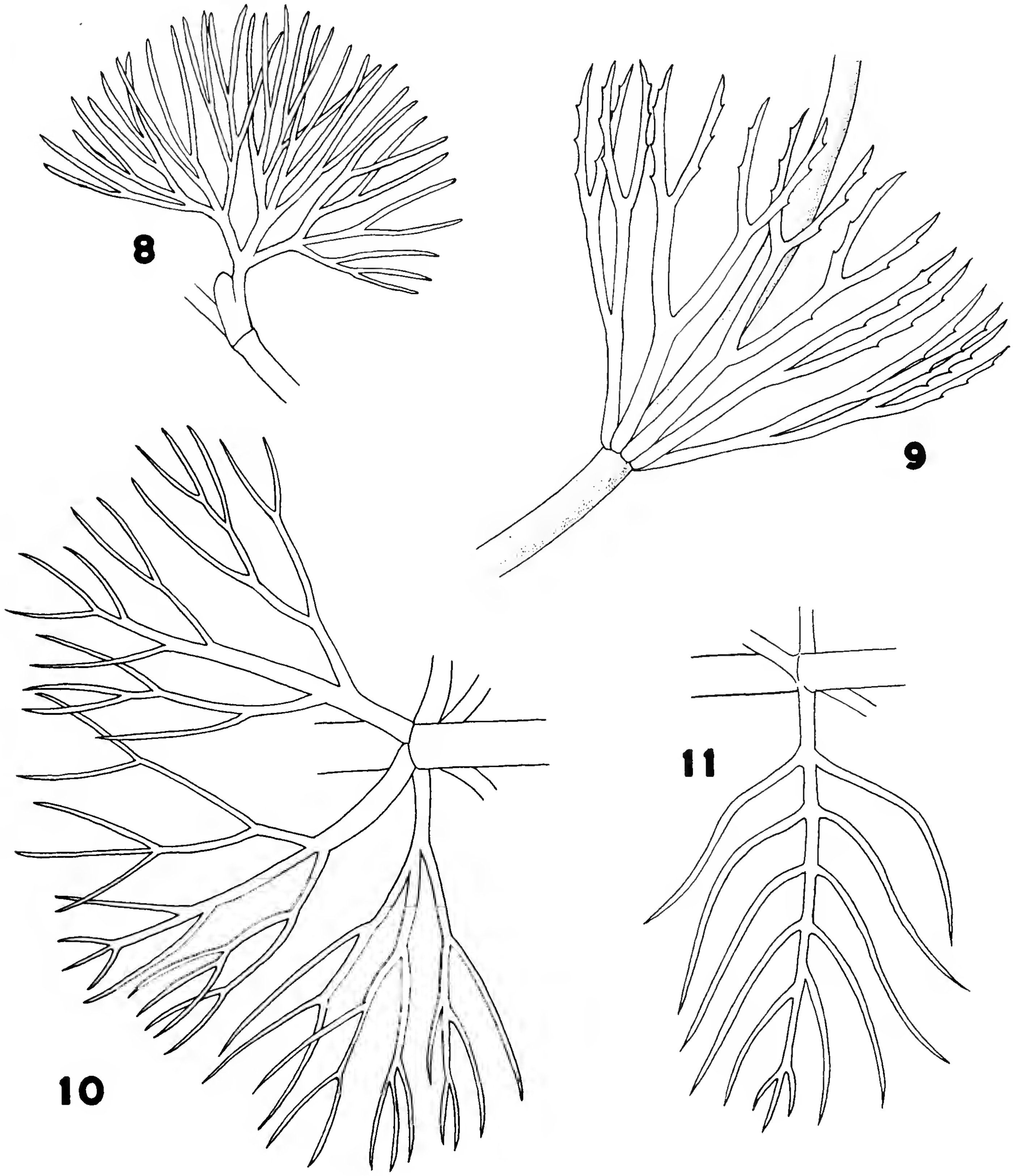
Figs. 1-4. Representative portions of limp elongate basal leaves, x 1-1/2:

1. Normal ribbon-like leaf of *Vallisneria americana,* showing characteristic 3-zoned appearance.
2. Ribbon-like leaf of a submersed rosette of *Sparganium,* showing distinctive fine checkered venation.
3. Ribbon-like leaf of a submersed rosette of *Sagittaria cuneata,* showing venation differences compared with Fig. 1 & Fig. 2.
4. Filiform leaf of *Scirpus subterminalis,* showing venation. [Filiform (threadlike, capillary) leaves are elongate, scarcely if at all broader than thick.]



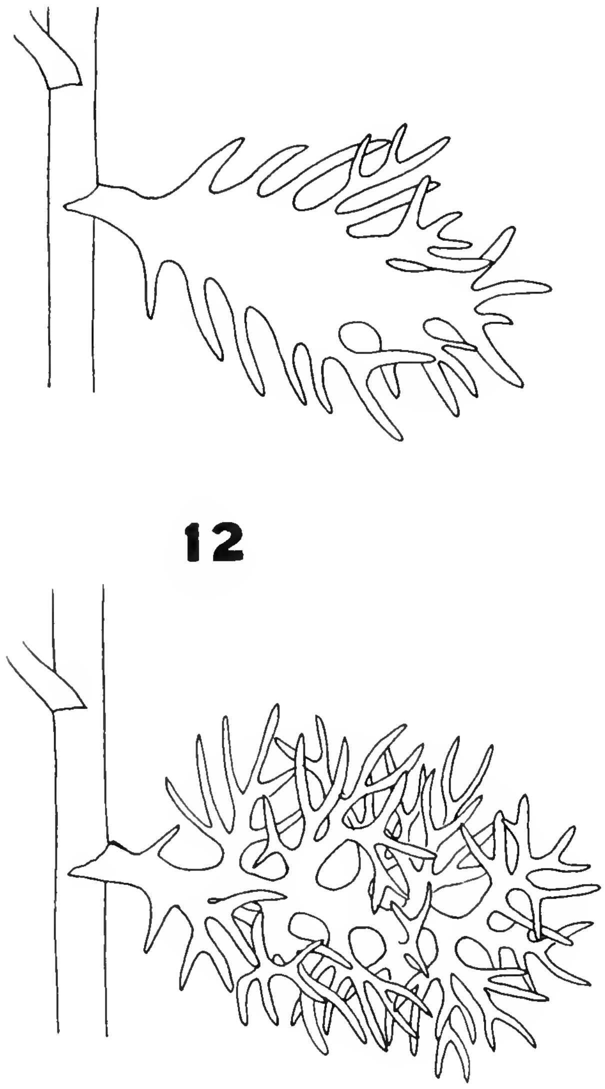
Figs. 5-7. Representative portions of plants with rosettes of quill-like (short and stiff) basal leaves, x 2:

5. Section of leaf of *Lobelia dortmanna,* showing the two hollow tubes of which it appears to consist. This leaf is flattened (perhaps a little more so in figure than in nature); cf. fig. 7.
6. Portion of root of *Eriocaulon septangulare,* showing characteristic cross-markings which at once distinguish this common species from all other submersed rosette-formers.
7. Section of leaf of *Isoëtes,* showing characteristic 4 hollow tubes. Note that this leaf is terete (circular in cross-section).



Figs. 8-11. Dissected leaves, × 2:

8. *Ranunculus longirostris*. Dissected leaves of some other aquatic species of this genus differ slightly in shape and outline, but all are alternate, lack a central axis, and are ± palmately dissected beyond the petiole or stipular sheath at base.
9. *Ceratophyllum demersum*. Note whorled leaves (more than 2 at the node), each equally forked (dichotomous) once or twice, toothed.
10. *Megalodonta beckii*. Leaves technically opposite and immediately forking, hence appearing whorled, but not dichotomous (as in fig. 9) nor with straight central axis (as in fig. 11).
11. *Myriophyllum* sp. Leaves in whorl of 4, each leaf pectinate (with definite straight central axis and unbranched lateral segments).



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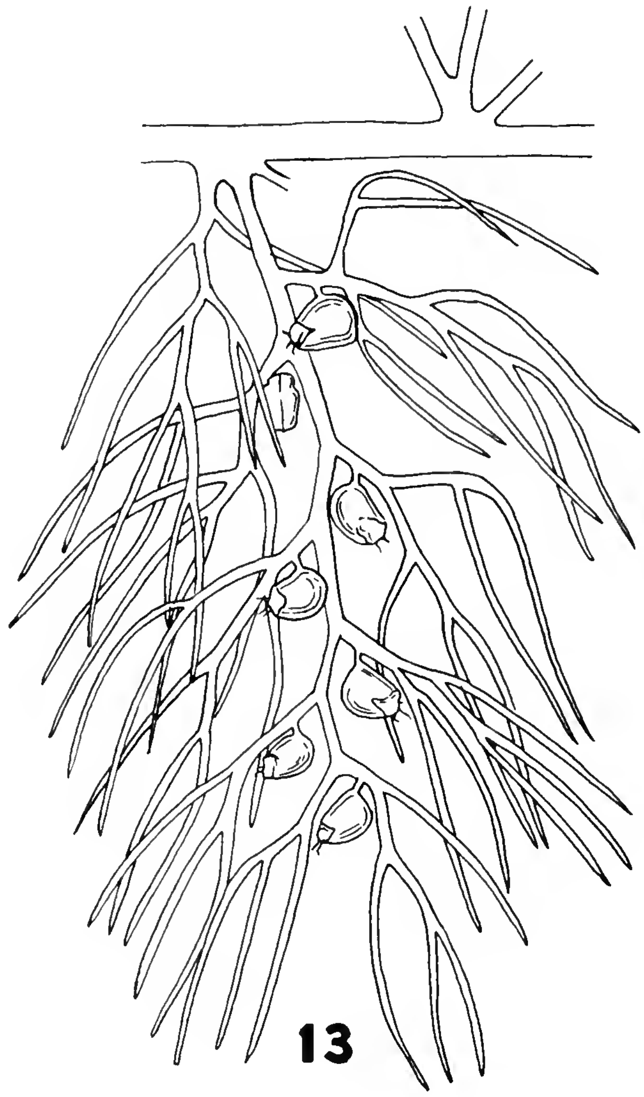

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Figs. 12-13. Dissected leaves, × 2:

12. Two leaves of *Armoracia aquatica*. Leaves alternate, with definite central axis, but the lateral segments again divided (cf. fig. 11); the submersed leaves of this species tend to fall off readily and to root at the base.
13. *Utricularia vulgaris*. A much-dissected alternate leaf, bearing bladders. Some other species of this genus have much smaller leaves (in *U. gibba,* only once-forked), and one (*U. intermedia*) has the bladders on separate branches from the leaves. In *U. purpurea* the arrangement is whorled rather than alternate.

Figs. 14-15 (next page). Leaf bases and sheaths, × 2:

14. *Potamogeton pectinatus*. Note that stipule is only partly adnate (fused) to leaf base, leaving a free ligule at summit. The sheath (formed by fusion of stipule and base of leaf blade) is split down the ventral side (the dorsal side corresponds to "under side" of leaf—which is toward the top of the figure, since the stem is drawn horizontal).
15. *Ruppia maritima* var. *occidentalis*. Note that stipule is wholly adnate to leaf base, leaving no free ligule. [In such species as these with the leaf blade partly fused to stipule, a distinctive aspect results from the appearance of the blade arising from *above* the node (which in both figures is to the left). In these figures, the sheath has been shown pulled slightly from its normal position surrounding the stem; in some other species of *Potamogeton,* a ligule-like stipule may surround the stem by itself, but is little or not at all adnate to leaf base; in some of these, the ventral margins of the stipule may be fused to each other (connate), forming a continuous tubular "sleeve" around the stem; in others, the distinct stipule margins may overlap closely without actually being fused.]

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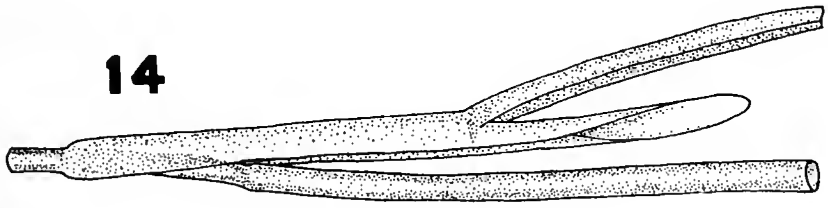

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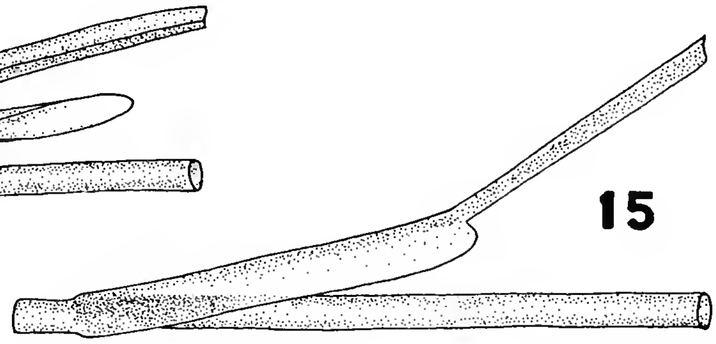

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1966 – THE YEAR OF THE BOLETES

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After one has collected mushrooms in an area for a period of years, he has a pretty good idea of when and where to seek them out. But the 1966 season in the Marquette, Michigan, area was different. The mushrooms were not "when and where" they should have been. Weather conditions, particularly the pattern of precipitation, appear to have been the significant factor.

Spring broke early in 1966 after a winter with very little snowfall. Most of the snow was gone by the end of March, a month early in this region. New growth on plants was evident early in April. By mid April reports came in of sizable fruitings of *Helvella esculenta* from the east end of the Upper Peninsula where they were being collected for food. An occasional specimen of *Morchella angusticeps* was to be found in late April on sunny south slopes of protected areas among the aspens. It looked like an early morel season with a heavy fruiting in prospect.

Then winter set in again. Snow, cold and freezing weather hit the last week of April and continued on beyond mid May. During the third week in May we had the first few days when the temperature was above, rather than below, normal. Plants began to show signs of life again, but the 11 days with below freezing temperatures had taken its toll. This, coupled with the fact that rainfall for the month was 1.86 inches below average, discouraged any heavy fruiting of morels. During the usual fruiting season for *M. angusticeps*, near Mother's Day weekend and the second week in May, the ground was still frozen.

There were a few *M. angusticeps* and a big black species of *Morchella* to be collected on May 26 in the southern part of Marquette County, but nothing like the fruitings in years when the weather was more nearly normal. By the last week in May forest fires became a real hazard. Lack of rainfall and lack of green growth kept fire-fighting crews busier than in many a year. It rained on the 3rd, 4th, and 5th of June, a total of almost two inches, which gave temporary relief from the drought and fire hazard. The remainder of the month of June was unusually hot, dry, and windy. Four days registered temperatures above 90^{o} with many days in the eighties. By the end of June, rainfall was three inches below normal.

The mill yards, which in normal or wet springs are literally covered with mushrooms growing in the wood debris, this year were barren, parched, crisp, and dry. Even the daisies and hawkweed gave up the effort to live.

The *Lyophyllums* failed to appear in the grass that grew up to mark the old barn sites at the log decking yards. The aspen were barren of *Pleurotus ostreatus*. A six-hour walk through the hardwoods, which ordinarily would have been brilliant with species of *Mycena*, *Hygrophorus*, and other early summer fruiting species, produced only one clump of *Mycena leiana*. Rather surprising during this hot, dry weather were fruitings of *Leccinums* of the *aurantiacum* group. Ordinarily we begin looking for *L. aurantiacum* in mid or late July in the aspen country. This year they began fruiting in mid June in spite of the heat and lack of moisture.

July brought no relief from one of the longest, hottest, driest periods in recorded history in the Marquette area.

Then came a cold, wet August. There were only four days in August without some precipitation. Rainfall for the month totaled 3.90 (above normal by .87 inches). It took a while (about two weeks of this weather) but by the third week in August there was a fruiting explosion with Boletes in heaviest profusion. *Suillus tomentosus* made a yellow carpet in the Jack Pine plains. *Boletus affinis*, not seen previously in this area by most local collectors, fruited heavily this year.

I had heard about Augusts when *B. edulis* buttons could be harvested by the bushels but this was the first time I had witnessed one. *B. edulis* was to be found anywhere and everywhere among the jack and red pines along Lake Superior shores. It became necessary to make several trips back to the car because you collected more than you could carry in one trip.

The ordinarily rare *B. projectellus* and related species were just as prolific. A variant lacking the projecting pileus margin was found and is being studied.

Although it was not the ordinary fruiting season for *Armillaria mellea*, the stumps in wooded areas, particularly along streams, blossomed out with masses of "stump" mushrooms. For the first time in my collecting experience I found the true, big, yellow, honey-colored variety of *A. mellea* fruiting this far north on yellow birch stumps. The white "hunter's heart" nodules of *Rhodophyllus abortivus* tried to crowd out the *Naematoloma sublateritium*.

Lepiota americana literally covered the base of the sawdust piles in the mill yard. Several species of *Agaricus* crowded up in the thistle patches and under the raspberry brush along the edges of the decking yards. *Amanitas* dominated the hemlock groves and the white birch and pine hillsides. The old tamarack stubs in the bogs bloomed forth with *Lentinus lepideus*.

And then it was over, just as suddenly as it all began. By the second week in September everything was crispy dry again. The rains that came the last week in September and in mid October failed to stimulate the mushrooms to fruit again. They had all had their big fling in late August and that was it for the year, even if their normal fruiting season was a month or two later.

As one reflects on bygone years, certain ones stand out in one's memory as the year of the heavy snow, or the big storm on the lake, or the "Florida" summer. The year of 1966 will stand out in my memory as the year of the Boletes.

Review

MICHIGAN WILDFLOWERS. By Helen V. Smith; illustrations by Ruth Powell Brede. Cranbrook Institute of Science (Bull. 42, revised), Bloomfield Hills, Mich., 1966. xii + 468 pp. (incl. 231 plates of line drawings) + 17 col. pl. $6.00.

The revised edition of this excellent guide includes a minimum of changes from the original printing, reviewed warmly in this journal five years ago (1: 60) by Mabel Jaques Cuthbert. The major improvement is in the index, which is now happily a single alphabetical list, including both common and scientific names, with the addition of all the species mentioned but not illustrated (unfortunately omitted from the original indexes).

The color plates are as beautiful as before, but the name of the artist has been mysteriously expunged from them. Some typographical errors have been corrected, but not the only one mentioned in a review (Am. Midl. Nat. 68: 509-510. 1962) of the original edition: the second lead in couplet 13 of the key on p. 14 should run to 35, not to 36. The only page which has been at all rewritten is the first one under the Monocots, where comments about *Typha* have been shortened and the plant is now said to have a rootstalk (whatever that is!) rather than a rootstock. There are no changes in species mentioned, names, descriptions, or keys.

Many alterations have been made in the sequence of species within a family, apparently in a commendable but partial attempt to have them described in the same order as they appear in the keys—but with unfortunate results from an editorial failure to read the text. Thus, *Streptopus amplexifolius* is said to be "quite similar to the preceding species"—which is now the entirely dissimilar *Maianthemum canadense*. Likewise, statements under *Pyrola elliptica* and *Liatris aspera* no longer refer to the same "preceding species," resulting in strange comparisons. In several other places, statements intended to appear after the last species described in a genus now appear earlier; e. g., under the first species of *Arabis* on p. 159 is the statement that "Several other species of *Arabis* are known from Michigan."—and indeed on page 163 two more of them are described.

The fact that a second edition is needed in only five years speaks for the general acceptance and usefulness of this book. Its coverage for our area is very good, compared to other wildflower guides, the drawings are copious and exceptionally lifelike, the keys apparently work, and the price is reasonable. Every school, summer camp, naturalist, and alert citizen in the state should own a copy.

—E. G. V.

BRYOPHYTES FROM THE UPPER FALLS OF THE TAHQUAMENON[1]

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With improved facilities for crossing the Straits of Mackinac, it has become increasingly common for students from the University of Michigan Biological Station to visit many parts of the Upper Peninsula in quest of habitats not represented south of the Straits. In July and August of 1966, in conjunction with class work, we made four brief and hurried visits to one of the loveliest and most popular of such areas, the Upper Falls of the Tahquamenon River in Luce County, Michigan. We collected only in the immediate vicinity of the falls, on dripping sandstone cliffs and in mature beech-maple woods, open fir and hemlock stands on the river bluffs, and white cedar swamp forest at the water's edge. Our collection from this beautiful spot, so greatly appreciated by casual tourists and naturalists alike, includes such a surprising number of interesting species that a brief record seems warranted.

Darlington's recent *Mosses of Michigan* (1964) gives only 24 records from Luce County, and 12 of those are inaccurate or of uncertain value. For example, Sharp's collection of *Hyophila tortula* actually came from the Lower Falls in Chippewa County, not Luce County, as Darlington said. The report of *Fontinalis missourica* can probably be disregarded, as it is not included in the recent, exhaustive monograph by Winona Welch (1960), nor can a specimen so-named be located. No specimens of the following have been found (although some or all of the species may well occur in the area or somewhere in the county): *Barbula convoluta, Calliergon giganteum, Dichodontium pellucidum, Dicranella schreberiana, Dicranodontium denudatum, Dicranum bergeri, Drepanocladus vernicosus, Rhabdoweisia denticulata,* and *Pogonatum alpinum*. (Darlington's record of *Drepanocladus exannulatus* is correct, but the specimen came from a different part of the county).

Fifteen liverworts were reported by Nichols and Steere (1936) from the Upper Falls. We have rediscovered all but *Nardia hyalina, Scapania subalpina,* and *S. undulata.*

Of the 46 species of liverworts and 106 species and two varieties of mosses listed below, all but one (*Trematodon ambiguus*) were represented in our own collections. *Pohlia annotina* var. *loeskei*, a record for the state, is being reported elsewhere in detail.

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[1]Contribution from the Biological Station of The University of Michigan.

HEPATICAE

Barbilophozia barbata (Schmid.) Loeske
hatcheri (Evans) Loeske

Bazzania trilobata (L.) S. F. Gray

Blasia pusilla L.

Blepharostoma trichophyllum (L.) Dum.

Calypogeia muelleriana (Schiffn.) K. Müll.

Cephalozia bicuspidata (L.) Dum.
media Lindb.

Chiloscyphus pallescens (Ehrh.) Dum.
polyanthus (L.) Corda

Conocephalum conicum (L.) Dum.

Frullania bolanderi Aust.
eboracensis Gottsche

Geocalyx graveolens (Schrad.) Nees

Harpanthus drummondii (Tayl.) Grolle

Isopaches hellerianus (Nees) Buch

Jamesoniella autumnalis (DC.) Steph.

Jungermannia lanceolata L.
pumila With.
sphaerocarpa Hook.

Leiocolea badensis (Gottsche) Joerg.
gillmanii (Aust.) Evans

Lejeunea cavifolia (Ehrh.) Lindb.

Lepidozia reptans (L.) Dum.

Lophocolea heterophylla (Schrad.) Dum.
minor Nees

Lophozia incisa (Schrad.) Dum.
longidens (Lindb.) Macoun
porphyroleuca (Nees) Schiffn.
ventricosa (Dicks.) Dum.

Marchantia polymorpha L.

Nowellia curvifolia (Dicks.) Mitt.

Pellia epiphylla (L.) Corda
neesiana (Gottsche) Limpr.

Plagiochila asplenioides (L.) Dum.

Porella pinnata L.
platyphylloidea (Schwein.) Lindb.

Preissia quadrata (Scop.) Nees

Ptilidium pulcherrimum (Web.) Hampe

Radula complanata (L.) Dum.

Riccardia palmata (Hedw.) Carruth.
pinguis (L.) S. F. Gray

Scapania mucronata Buch
nemorosa (L.) Dum.

Tritomaria exsecta (Schmid.) Schiffn.
exsectiformis (Breidl.) Schiffn.

MUSCI

Amblystegium juratzkanum Schimp.
varium (Hedw.) Lindb.

Anacamptodon splachnoides (Froel. ex Brid.) Brid.

Anomodon attenuatus (Hedw.) Hüb.

Atrichum angustatum (Brid.) BSG
undulatum (Hedw.) P.-B.

Aulacomium androgynum (Hedw.) Schwaegr.
palustre (Hedw.) Schwaegr.

Barbula unguiculata Hedw.

Bartramia pomiformis Hedw.

Brachythecium reflexum (Starke ex Web. & Mohr) BSG
rivulare BSG
rutabulum (Hedw.) BSG
salebrosum (Web. & Mohr) BSG
velutinum (Hedw.) BSG

Brotherella recurvans (Mx.) Fl.

Bryhnia novae-angliae (Sull. & Lesq. ex Sull.) Grout

Bryoerythrophyllum recurvirostrum (Hedw.) Chen

Bryum argenteum Hedw.
creberrimum Tayl.
pseudotriquetrum (Hedw.) Gaertn., Meyer & Scherb.

Buxbaumia aphylla Hedw.

Calliergon cordifolium (Hedw.) Kindb.

Campylium chrysophyllum (Brid.) Lange
hispidulum (Brid.) Mitt.

Ceratodon purpureus (Hedw.) Brid.

Climacium dendroides (Hedw.) Web. & Mohr

Cratoneuron filicinum (Hedw.) Spruce

Desmatodon obtusifolius (Schwaegr.) Schimp.

Dichelyma pallescens BSG

Dicranella heteromalla (Hedw.) Schimp.

Dicranum flagellare Hedw.
montanum Hedw.
polysetum Sw.
scoparium Hedw.
viride (Sull. & Lesq. ex Sull.) Lindb.

Didymodon rigidulus Hedw.

Diphyscium foliosum (Hedw.) Mohr

Distichium capillaceum (Hedw.) BSG

Drepanocladus uncinatus (Hedw.) Warnst.

Eurhynchium pulchellum (Hedw.) Jenn.

Fissidens cristatus Wils. ex Mitt.
minutulus Sull.
obtusifolius Wils.
osmundioides Hedw.
viridulus (Sw.) Wahl.

Fontinalis duriaei Schimp.

Gymnostomum recurvirostrum Hedw.

Heterocladium dimorphum (Brid.) BSG

Heterophyllium haldanianum (Grev.) Kindb.

Hygrohypnum luridum (Hedw.) Jenn.

Hylocomium pyrenaicum (Spruce) Lindb.
splendens (Hedw.) BSG

Hypnum lindbergii Mitt.
pratense Koch ex Spruce
reptile Mx.

Isopterygium striatellum (Brid.) Loeske
turfaceum (Lindb.) Lindb.

Leskeella nervosa (Brid.) Loeske

Leucobryum glaucum (Hedw.) Ångstr. ex Fr.

Leucodon sciuroides (Hedw.) Schwaegr.

Mnium affine Bland. ex Funck var. affine
var. ciliare (Grev.) C. M.
cuspidatum Hedw.
marginatum (With.) Brid. ex P.-Beauv.
medium BSG
orthorrhynchum Brid.
punctatum Hedw. var. punctatum
var. elatum Schimp.
spinulosum BSG
stellare Hedw.

Myurella sibirica (C. M.) Reim.

Neckera pennata Hedw.

Oncophorus wahlenbergii Brid.

Orthotrichum obtusifolium Brid.
sordidum Sull. & Lesq. ex Aust.

Paraleucobryum longifolium (Hedw.) Loeske

Philonotis fontana (Hedw.) Brid.

Plagiothecium denticulatum (Hedw.) BSG
laetum BSG
sylvaticum (Brid.) BSG

Platygyrium repens (Brid.) BSG

Pleurozium schreberi (Brid.) Mitt.

Pohlia annotina var. loeskei Crum, Steere, & Anders.
cruda (Hedw.) Lindb.
nutans (Hedw.) Lindb.
proligera (Kindb. ex Limpr.) Lindb. ex H. Arn.

Polytrichum commune Hedw.
formosum Hedw.
juniperinum Hedw.
piliferum Hedw.

Pterigynandrum filiforme Hedw.

Ptilium crista-castrensis (Hedw.) DeNot.

Pylaisiella selwynii (Kindb.) Crum, Steere, & Anders.

Rhodobryum roseum (Hedw.) Limpr.

Saelania glaucescens (Hedw.) Broth.

Sphagnum capillaceum (Weiss) Schrank
robustum (Russ.) Röll
squarrosum Sw. ex Crome

Tetraphis pellucida Hedw.

Thuidium delicatulum var. radicans (Kindb.) Crum, Steere, & Anders.
recognitum (Hedw.) Lindb.
scitum (P.-B.) Aust.

Tomenthypnum nitens (Hedw.) Loeske

Tortella tortuosa (Hedw.) Limpr.

Trematodon ambiguus (Hedw.) Hornsch.

Ulota crispa (Hedw.) Brid.

Weissia controversa Hedw.

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NEW AND INTERESTING BOLETES FROM MICHIGAN

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Although the fungal flora of Michigan has probably been studied more extensively than that of any other state, knowledge of the flora is still far from complete. During the summer of 1966, our attention was directed toward the higher fungi associated with the oak-hickory forests of southern lower Michigan. The areas studied consisted mostly of state-owned lands in Jackson, Livingston, and Washtenaw counties in southeastern lower Michigan and in Allegan, Barry, and Kalamazoo counties in the southwestern part of the state. Extensive collecting in these areas has brought to light a number of new state records as well as a few new species of higher fungi. This article deals with three of the more interesting boletes collected.

The first of these, *Tylopilus rubrobrunneus*, has been recognized in Michigan for some time; however, on July 14, 1966, a very interesting collection of this fungus was made in Jackson County. Here, in addition to a number of normal basidiocarps, several partially to completely sterile "carpophoroids," showing varying degrees of abnormality, were found (see figs. 14 and 15). The most extreme forms found were somewhat pillow-shaped in outline and up to 12 cm high and 15 cm thick, with a subglabrous, whitish surface, at times developing pale olivaceous or brownish stains where bruised. The context was moderately firm and slightly fibrous when broken open, watery white in color, with a bitter taste; the odor was slightly fungoid, but not distinctive. We do not wish to imply that these sterile forms are commonly associated with the normal basidiocarps as in the case with some fungi (e. g., *Rhodophyllus abortivus*). However, we know of no previous records of such sterile forms among the Boletaceae and for that reason they are included in this article.

Tylopilus rubrobrunneus sp. nov.[1]

Figs. 1-4, 13-15.

Pileus 8-20 (30) cm latus, convexus, siccus impolitus, interdum areolatus, umbrino-vinaceus vel vinaceobrunneus; caro sapore amaro. Tubuli 1-2 cm alti primo subalbidi, demum vinacei. Stipes 8-20 cm longus, 1-3(5) cm crassus, glaber vel ad apicem leviter reticulatus, pallide brunneus vel castaneus; sporae 10-14 × 3-4.5 μ. Specimen typicum legit in Jackson County, Mich., 20 Juli 1960. Smith 62570 (MICH).

Pileus 8-20 cm (up to 30 cm) broad, convex at first, becoming broadly convex to nearly plane at maturity; margin inrolled at first; surface dry and unpolished, at times becoming areolate in age; color when young dark vinaceous brown to chocolate color, slowly changing to deep vinaceous brown and finally dingy cinnamon in age, from near "dark livid brown"[2] or "dark vinaceous brown" through "natal brown" to near "army brown" or "sayal brown." Context firm, white except for the borders of larval tunnels, which may be stained olivaceous; taste very bitter; odor slight, not distinctive.

Tubes 1-2 cm deep, becoming depressed around the stipe, avellaneous at first and slowly becoming whitish before being colored vinaceous by the spores; mouths small and round at first, 1-2 per mm, expanding slightly to maturity, staining brownish where bruised.

Stipe 8-20 cm long, 1-5 cm thick at apex, up to 6-8 cm thick at the base in large specimens; usually swollen at first, becoming equal or enlarged downwards at maturity; surface glabrous or at times faintly reticulate above; vinaceous brown or dingy chestnut colored above, slightly paler and whitish near the ground; surface often staining olivaceous from handling and the base near the ground-line often dingy olive-brown in age. Context firm, white except larval tunnels which are sometimes stained olivaceous.

Spore deposit near "russet vinaceous" when fresh, near "vinaceous fawn" when dry. Spores 10-14 × 3-4.5 μ, smooth, thin-walled with a slight suprahilar depression, nearly hyaline in KOH sol., pale tan in Melzer's sol., or occasionally some spores becoming reddish brown in Melzer's sol.

Basidia 20-26 × 8-11 μ, short clavate, 4-spored, hyaline. Pleurocystidia 36-52 × 9-14 μ, scattered, but more abundant near the tube mouths, ventricose in the basal half with a narrow attenuate tip, hyaline, but containing an amorphous material which is pale yellow-brown in water or KOH sol. and becomes reddish-brown in Melzer's sol. Tube trama composed of hyaline subgelatinous hyphae, distinctly

[1] *Boletus felleus* f. *rubrobrunneus* Snell (Mycologia 28: 466. 1946) was one of three forms described without Latin diagnoses. We do not believe that our bolete is the same as Snell's form.

[2] Color terms in quotation marks are from Ridgway, Color Standards and Color Nomencalture (Washington, D. C., 1912).

bilateral with a medial layer of narrower hyphae. Pileus cuticle a trichodermium of loosely interwoven pale cinnamon hyphae, 4-6 μ thick. These hyphae contain an amorphous material which in KOH sol. or Melzer's sol. forms small refractive beadlike globules. These globules seem to be composed of a lipoid substance and readily take up iodine from Melzer's sol. to become reddish brown.

Gregarious to cespitose on sandy soil, mostly under rather open second-growth oak woods, not uncommon in the oak forests of southern Michigan after heavy rains in the summer and early fall.

This fungus is nearly identical microscopically to *Tylopilus plumbeoviolaceus*, but differs from that species in its strikingly different colors and in its slightly larger average size.

Although this is a common and conspicuous summer bolete in Michigan, it is, like *Tylopilus plumbeoviolaceus*, unfit for the table because of its persistent very bitter taste.

Tylopilus plumbeoviolaceus (Snell & Dick) Singer, Am. Midl. Nat. 37: 93. 1947.[3]

Figs. 5-8, 16-17.

Pileus 4-15 cm broad, convex at first, becoming broadly convex to nearly plane at maturity, margin slightly inrolled at first; surface dry and unpolished, occasionally becoming rimulose in age; color at first distinctly violaceous, becoming darker slate colored in the young pilei and then becoming browner at maturity from "dark heliotrope gray" through "dark vinaceous drab" to near "drab" at maturity. Context firm, white, only slightly if at all discoloring; taste very bitter; odor slight, not distinctive.

Tubes 1-2 cm deep, depressed around the stipe, cream colored at first, near "pale vinaceous tan" at maturity, mouths small and nearly round at first, 1-2 per mm, expanding and becoming slightly irregular at maturity.

Stipe 8-12 cm long, 10-17 mm thick at the apex, somewhat swollen centrally at first, becoming equal, or slightly larger downwards at maturity, surface glabrous and only rarely with faint reticulations at the apex; color at first a mottled dark violaceous with white base, becoming paler and browner in age, near "cinnamon drab" at maturity, occasionally developing olivaceous stains in the whitish base near the ground line; context firm, white, unchanging.

Spore deposit between "russet vinaceous" and "vinaceous fawn," spores 10-13 × 3-4 μ, smooth, thin-walled with a slight suprahilar depression, nearly hyaline in KOH sol., only slightly tan in Melzer's sol.

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[3]We feel that the transfer of *Boletus plumbeoviolaceus* Snell & Dick (Mycologia 33: 32. 1941) to the genus *Tylopilus* was first validly made by Singer (1947). "*Tylopilus plumbeoviolaceus*" Snell & Dick (Mycologia 33: 33. 1941) was merely given as the name that this species would have "in the newer European classifications" and was not a validly published combination (Art. 34, Note 2, International Code of Botanical Nomenclature).

Basidia 21-24 × 7.5-8.5 μ, 4-spored (rarely 2-spored), hyaline in KOH sol., short-clavate. Pleurocystidia 35-55 × 8-12 μ, abundant, especially near the tube mouths, ventricose below with a long attenuate tip, frequently covered by adhering spores, hyaline, but filled in the basal portion by a pale yellow-brown amorphous material which becomes reddish brown in Melzer's sol. Tube trama bilateral, from a distinct central strand, made up of loosely arranged hyaline hyphae.

Cutis of pileus made up of a tangled trichodermium of smooth-walled, narrow brownish hyphae containing an amorphous material which beads up in KOH sol. or in Melzer's sol., similar to the pigment balls in the cuticular hyphae of *Leccinum aurantiacum*. No clamp connections were found in any part of the basidiocarp.

Gregarious to cespitose on sandy soil in rather open oak-hickory-aspen woods, summer and early fall.

This is the only truly violet-colored bolete that we have seen. Its collection in Michigan represents a considerable extension of the known range of this species which as given by Singer (1947) was "Massachusetts south to Florida and west to Tennessee and Mississippi." Our collections of this species were made along the south side of Otis Lake, Barry County, Michigan.

It will be noted in the descriptions of the species of *Tylopilus* included here that the content of the pleurocystidia is given as reddish brown in Melzer's solution (dextrinoid). This feature has not been sufficiently emphasized in the taxonomy of *Tylopilus*, but in our estimation it is one of the characters which aid in defining the genus. The reaction varies in intensity with the species. Cystidia with such a characteristic content are generally classed as some category of gloeocystidia. That this classification may apply here is substantiated to some extent by the fact that in North American Species of *Pholiota* (Smith & Hesler, in press) it has been found that not infrequently the content of the chrysocystidia shows this same reaction.

Gastroboletus scabrosus sp. nov.

Figs. 9-12, 18.

Pileus 2.5-6.5 cm latus, primo convexus, deinde fere planus maturus; superficies sicca, subtomentosa, fere "snuff brown"; caro pallide bubalina, mitis sapore, indistincta odore; tubuli 1.5-2 cm longi, curvati et diversi, primo pallide lutei, demum obscure olivaceo-brunnei; stipes 7-10 cm longus, 9-14 mm crassus, leviter reticulatus supra, scaber aurantiaco-brunneis punctis alibi. Specimen typicum legit in Barry Co., Michigan, 1 Sept. 1966. Smith 73295 (MICH).

Pileus 2.5-6.5 cm broad; convex at first becoming broadly convex at maturity; surface dry and unpolished to subtomentose; dingy yellow brown with ochraceous undertones, near "snuff brown" or a little paler, near "clay color" at the margin. Context 1-1.4 cm thick, pale buff when first cut, but slowly staining dull pinkish buff mottled with pale olive gray in places; taste mild; odor slight, not distinctive.

Tubes 1.5-2 cm long, curved in a flaring arrangement so that the distal portions of the tubes are oriented away from the stipe in a position approximately horizontal to the ground; mouths small, 2-3 per mm, soon collapsing and becoming flattened as the cap expands, dull lemon yellow at first, becoming dingy olivaceous-yellow (near "old gold") and developing brownish to blackish stains on bruising.

Stipe 7-10 cm long, 9-14 mm thick at the apex, equal with a tapering base; surface faintly striate-subreticulate above, scurfy over-all; color yellow above, paler and duller below, scabrose from yellow-brown to orange-brown dots which are larger above and finer and more numerous below; base with a yellowish mycelium. Context pallid yellow, staining brownish around larval tunnels or where bruised.

Spores 15-18.5 × 4-5 μ, subfusiform, thin-walled, pale brown in KOH sol. Basidia 22-24 × 9.5-12 μ, 4-spored, hyaline. Pleurocystidia 35-55 × 7-11 μ, fusoid-ventricose, thin-walled, hyaline. Cheilocystida similar to the pleurocystidia.

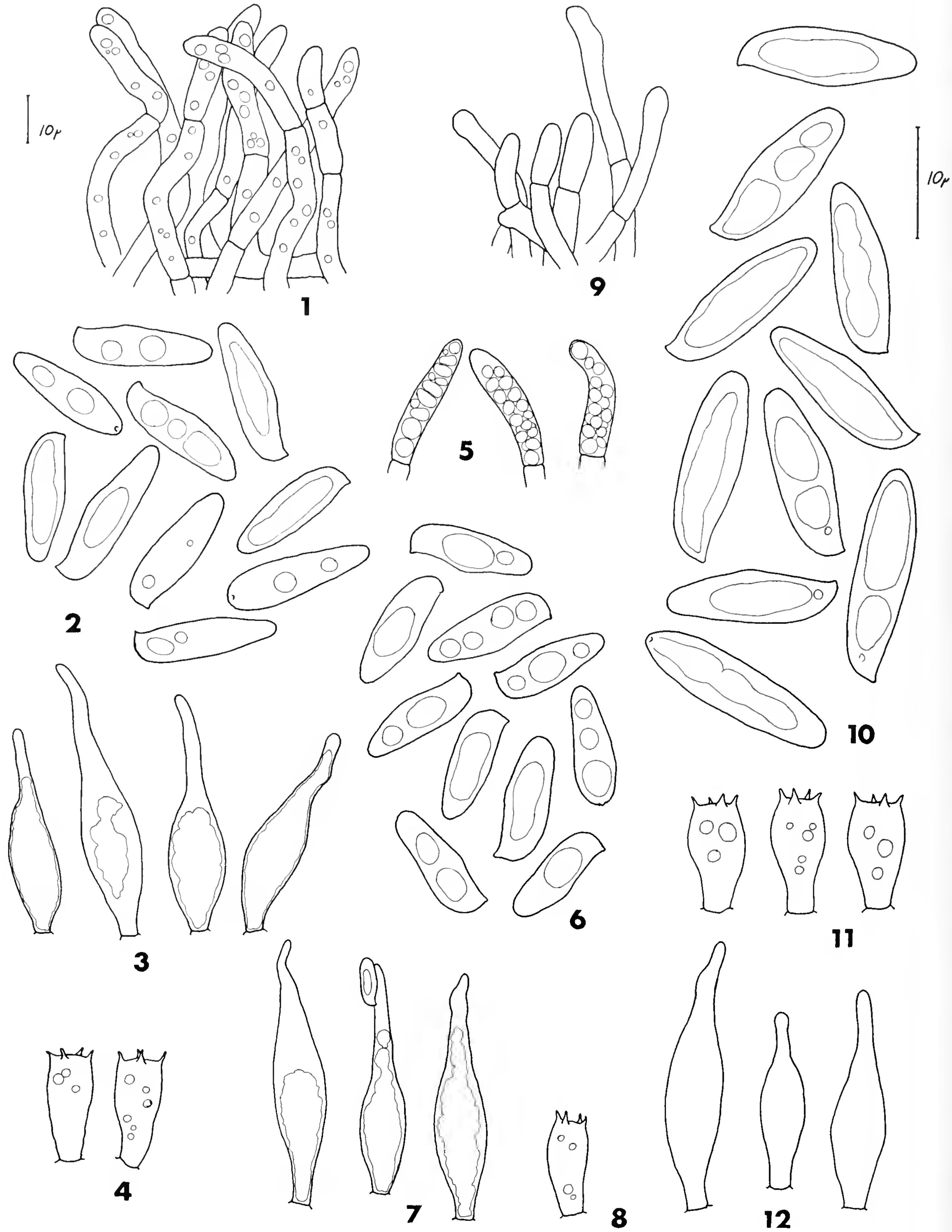
Hymenophoral trama bilateral, with a distinct medial layer, composed of hyaline, subgelatinous hyphae. Pileus cuticle a trichodermium of loosely interwoven, septate, pale brown hyphae 3-6 μ wide, some with slightly swollen tips. Clamp connections not observed in the hyphae of the basidiocarp.

Gregarious on sandy soil in a second-growth oak-hickory forest, south of Otis Lake, Barry County, Michigan, Sept. 1, 1966.

This fungus is obviously closely related to the genus *Leccinum;* however, because of the gastroid hymenophore, we feel it is best to describe it as a new species of *Gastroboletus*.

ACKNOWLEDGMENTS

We wish to acknowledge with gratitude the financial aid received in support of field work during the summer of 1966 from faculty research grant 1417 (A.H.S.) and NSF Grant GB-3366 (S.J.M.) (Systematic and Evolutionary Biology Program) without which this study would not have been possible.



Figs. 1-4. *Tylopilus rubrobrunneus:* 1, Trichodermial hyphae; 2, Spores; 3, Pleurocystidia; 4, Basidia. Figs. 5-8. *Tylopilus plumbeoviolaceus:* 5, Trichodermial hyphae; 6, Spores; 7, Pleurocystidia; 8, Basidium. Figs. 9-12. *Gastroboletus scabrosus:* 9, Trichodermial hyphae; 10, Spores; 11, Basidia; 12, Pleurocystidia.

The scale for the drawings of the basidia, cystidia, and hyphae is indicated by the small vertical bar at the upper left; that for the spores is indicated at the upper right.

Fig. 13. *Tylopilus rubrobrunneus* about × 1/2 Smith 62598

Fig. 14. *Tylopilus rubrobrunneus* parasitized, slightly reduced Mazzer 4060.

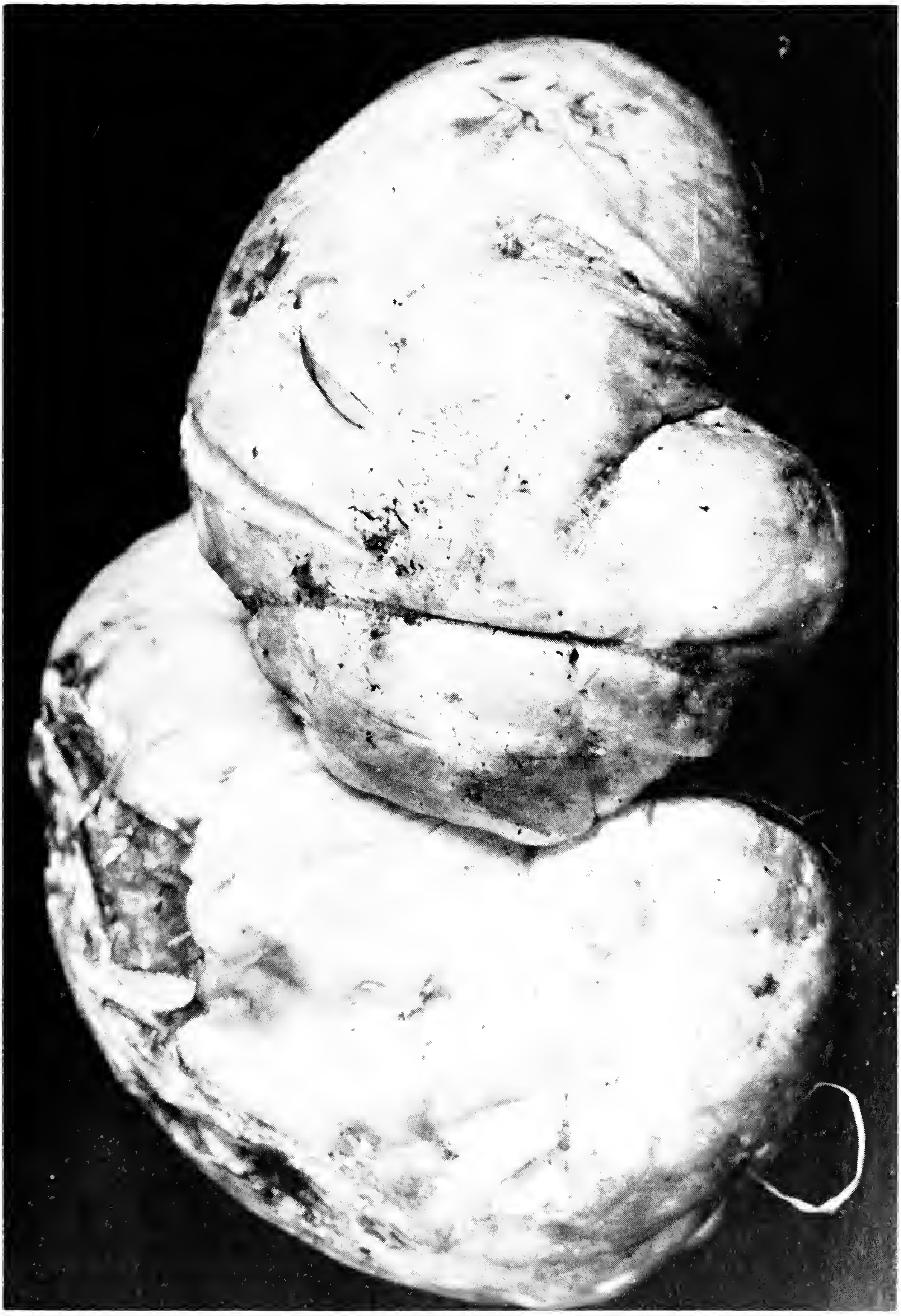


Fig. 15. *Tylopilus rubrobrunneus* completely aborted "carpophoroids" slightly reduced Mazzer 4060.

Fig. 16. *Tylopilus plumbeoviolaceus* slightly reduced Smith 73296.

Fig. 17. *Tylopilus plumbeoviolaceus* x1 Smith 73211.

Fig. 18. *Gastroboletus scabrosus* x1 Smith 73295 (Holotype).

MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

C. JOURNAL ARTICLES

Barnes, Burton V. 1966. The clonal growth habit of American aspens. Ecology 47: 439-447. [Studies made at University of Michigan Biological Station.]

Bates, David M. 1965. Notes on the cultivated Malvaceae l. Hibiscus. Baileya 13: 56-130. [These "notes" include a key to 40 species, with descriptions and comments for each; *M. moscheutos* ssp. *palustris* is said to range naturally into southern Michigan.]

Bowden, Wray M. 1965. Cytotaxonomy of the species and interspecific hybrids of the genus Agropyron in Canada and neighboring areas. Canad. Jour. Bot. 43: 1421-1448. [A companion processed leaflet, "Citations of voucher specimens of the species and interspecific hybrids of the genus Agropyron in Canada and neighboring areas," 31 pp., dated 1966, lists "representative specimens to verify the geographical ranges." However, the representative specimens are only from Canada and do not verify the stated range of *A. spicatum* "from Michigan"; cytological vouchers are cited from Michigan for *A. repens* and *A. trachycaulum*.]

Chrobak, Beverly, & A. J. Sharp. 1965. A preliminary comparative study of asexual reproduction in Dicranum flagellare and Dicranum montanum. Jour. Hattori Bot. Lab. 28: 122-128. [Material studied was mostly from northern Michigan.]

Cline, Morris G. 1966. Effects of temperature and light intensity on the growth of Scrophularia marilandica. Ecology 47: 782-795. [Includes studies in natural sites on property of University of Michigan Botanical Gardens, Washtenaw Co.]

Crum, Howard. 1966. A note on the taxonomy and distribution of Polytrichum ohioense. Advancing Frontiers of Plant Sciences (New Delhi) 17: 23-26. [Michigan included in stated range of this moss.]

Curtis, E. J. C., & J. E. Cantlon. 1965. Studies of the germination process in Melampyrum lineare. Am. Jour. Bot. 52: 552-555. [The seed came from Crawford Co.]

Gangwere, S. K. 1965. Food selection in the Oedipodine grasshopper Arphia sulphurea (Fabricius). Am. Midl. Nat. 74: 67-75. [Many plant species among the food of the sulphur-winged grasshopper on George Reserve, Livingston Co.; includes description of "Southwest field."]

Gilbert, Elizabeth F. 1966. Structure and development of sumac clones. Am. Midl. Nat. 75: 432-445. [10 of 13 clones studied were in Stinchfield Woods, Washtenaw Co., 2 in Cheboygan Co., & 1 in Ohio.]

Gysel, Leslie W. 1966. Ecology of a red pine (Pinus resinosa) plantation in Michigan. Ecology 47: 465-472. [Includes comparison of repopulation by vegetation with adjacent unplanted area in Iosco Co.]

Hagenah, Dale J. 1966. Notes on Michigan pteridophytes, II. Distribution of the Ophioglossaceae. Am. Fern Jour. 56: 150-163. [Includes distribution maps showing county records of all Michigan species.]

Heatwole, Harold. 1966. Moisture exchange between the atmosphere and some lichens of the genus Cladonia. Mycologia 58: 148-156. [Study made at University of Michigan Biological Station.]

Johns, Robert M. 1966. Morphological and ecological study of Physoderma dulichii. Am. Jour. Bot. 53: 34-45. [Studies of this parasitic fungus in northern Michigan; includes map and history of Smith's Bog, near University of Michigan Biological Station.]

Kilburn, Paul D. 1966. Analysis of the species-area relation. Ecology 47: 831-843. [Includes data from jack pine woodlands in Cheboygan and Baraga cos.]

Malcolm, William M. 1966. Root parasitism of Castilleja coccinea. Ecology 47: 179-186. [Host plants (and presumably the parasite) used in study came from Houghton Lake area.]

Mason, Charles T., Jr., & Hugh H. Iltis. "1965" [1966]. Preliminary reports on the flora of Wisconsin No. 53. Gentianaceae and Menyanthaceae—Gentian and Buckbean families. Trans. Wis. Acad. 54:295-329. [Repeats distribution maps of the two fringed gentians with Michigan localities, and speculates on history of the species in this region.]

McMillan, Calvin. 1965. Ecotypic differentiation within four North American prairie grasses. II. Behavioral variation within transplanted community fractions. Am. Jour. Bot. 52: 55-65. [Clones from Michigan were included for two species of *Andropogon* and *Panicum virgatum*.]

Moore, R. J., & C. Frankton. 1966. An evaluation of the status of Cirsium pumilum and Cirsium hillii. Canad. Jour. Bot. 44: 581-595. [*C. pumilum* ssp. *hillii* mapped in four Michigan locations, cited from Muskegon Co., and chromosome count of 2n = 30 given for Cheboygan Co. material.]

Mosquin, Theodore. 1966. A new taxonomy for Epilobium angustifolium L. (Onagraceae). Brittonia 18: 167-188. [The new ssp. *circumvagum* (tetraploid) is the one in our region, for which a very few localities in Michigan are given on distribution map.]

Santamour, Frank S., Jr. 1965. Cytological studies in red and silver maples and their hybrids. Bull. Torrey Bot. Club 92: 127-134. [Quotes a report of 2n = ca. 78 on red maple in Upper Peninsula.]

Seikel, Margaret K., et al. 1965. Chemotaxonomy as an aid in differentiating wood of eastern and western white pine. Am. Jour. Bot. 52: 1046-1049. [Some of the material studied was from Michigan.]

Singer, Rolf. 1962. Diagnoses fungorum novorum agaricalium II. Sydowia Ann. Mycol. 15: 45-83. [The types of three new species are from Michigan.]

Singer, Rudolf [sic]. 1962. Monographs of South American Basidiomycetes, especially those of the east slope of the Andes and Brazil. 4. Inocybe in the Amazone region, with a supplement to Part 1 (Pluteus in South America). Sydowia Ann. Mycol. 15: 112-132. [Includes observation on clamp connections in out-of-season *Pluteus* in Michigan.]

Singer, R. 1964. Die Gattung Gerronema. Nova Hedwigia 7: 53-92. [*G. alexandri* cited from Tahquamenon Falls.]

Singer, Rolf. 1965. Monographic studies on South American Basidiomycetes, especially those of the east slope of the Andes and Brazil. 2.) The genus Marasmius in South America. Sydowia Ann. Mycol. 18: 106-358. [Two Michigan collections of *M. siccus*, an extra-limital species, are cited.]

Sparrow, Frederick K. 1965. A preliminary note on a population of Monoblepharis. Trans. Brit. Mycol. Soc. 48: 55-58. [Includes description of a new species from Rifle River Area, Ogemaw Co.]

Sparrow, F. K., & R. M. Johns. 1965. Observations on chytridiaceous parasites of phanerogams XVI. Notes on Physoderma from Scirpeae. Arch. Mikrobiol. 51: 351-364. [Data mostly from Michigan.]

Sparrow, F. K. 1966. A new bog chytrid. Arch. Mikrobiol. 53: 178-180. [Type locality is in Emmet Co.]

Stuckey, Ronald L. 1966. The distribution of Rorippa sylvestris (Cruciferae) in North America. Sida 2: 361-376. [Includes citations of Michigan specimens.]

Thompson, Thomas W., & M. B. Backus. 1966. Further notes on Pycnidiophora dispersa and Pseudeurotium multisporum. Mycologia 58: 650-655. [Type culture of first-named species was from Michigan; subculture of original isolate among those studied.]

Wagner, W. H., Jr. 1966. Illustrations of transient fern forms. Am. Fern Jour. 56: 101-107. [Includes illustrations of peculiar *Botrychium dissectum* population from Pinckney Recreation Area.]

Wohlrab, Gisela, & R. W. Tuveson. 1965. Distribution of fungi in early stages of succession in Indiana dune sand. Am. Jour. Bot. 52: 1050-1058. [Studies at Warren Dunes, Berrien Co., as well as in Indiana.]

Wright, H. E., Jr. 1964. Aspects of the early postglacial forest succession in the Great Lakes region. Ecology 45: 439-448. [Includes pollen diagrams, redrawn from Potzger, for Third Sister Lake (Washtenaw Co.) and Douglas Lake (Cheboygan Co.—erroneously given as Emmet), and many implications for Michigan forest history.]

Zahner, Robert, & Norbert V. DeByle. 1965. Effect of pruning the parent root on growth of aspen suckers. [Ecology 46: 373-375. Work done in 5 stands of bigtooth aspen near the University of Michigan Biological Station.]

Zahner, Robert, & Ned A. Crawford. 1965. The clonal concept in aspen site relations. p. 229-243 (Chapter 18) in Forest-Soil Relationships in North America (Papers Presented at the 2nd North American Forest Soils Conference, 1963), ed. Chester T. Youngberg. [Much of the work surveyed was done in Michigan, although specific geographical data are not given.]

Publications of Interest

From time to time we briefly call attention under this heading to recent publications which may be of interest for one reason or another to members of the Michigan Botanical Club and to other readers, although their lack of specific reference to plants in Michigan does not qualify them for the regular listings of "Michigan Plants in Print."

HORTULUS. By Walahfrid Strabo. Translated by Raef Payne. Commentary by Wilfred Blunt. Hunt Botanical Library, Pittsburgh. 1966. 91 pp. + [10] folded leaves of facsimile. $12.00. Number 2 of The Hunt Facsimile Series presents the work of "Walahfrid the Squint-eyed," a young Benedictine monk who, about 840, wrote the first book (at least in the Western world) in praise of gardens. Altogether, 29 plants are mentioned by name in 27 poems considered of high literary merit—a selection of medicinal herbs and vegetables from the monastery garden. Walahfrid's "Hortulus" has been published in various forms since as early as 1510. The present edition includes, for the first time, a facsimile of the 9th century medieval Latin manuscript in the Vatican Library, plus a transcription in classical Latin form and an English translation in free verse. Accounts of the poet, the plants he wrote about, and the printed editions complete the work, which is beautifully printed and bound and illustrated with linoleum-block page decorations depicting the plants. In addition to its historical importance as a landmark of gardening literature, its literary qualities and handsome presentation in the present limited edition (1500 copies) would make it a welcome gift for a gardening friend.

> Wherever it is, your land cannot fail to produce
> Its native plants. If you do not let laziness clog
> Your labor, if you do not insult with misguided efforts
> The gardener's multifarious wealth, and if you do not
> Refuse to harden or dirty your hands in the open air
> Or to spread whole baskets of dung on the sun-parched soil—
> Then, you may rest assured, your soil will not fail you.

NATURAL VEGETATION OF OHIO at the Time of the Earliest Land Surveys. Prepared by Robert B. Gordon. The Ohio Biological Sruvey & The Ohio State University, Columbus. 1966. A large color map of the original vegetation of our neighboring state, with legend and abbreviated references; a full explanatory bulletin is mentioned but is not yet written. Available for $1.00 from Ohio Biological Survey, O. S. U., 124 W. 17th Ave., Columbus, Ohio 43210. Add $.40 per order for mailing if rolled rather than folded copies are desired.

PROGRAM NOTES

March 17-18: Michigan Academy of Science, Arts, & Letters, 71st Annual Meeting, University of Michigan, Ann Arbor. The Botany Section will meet at the Botanical Gardens, with lunch Friday at the North Campus Commons.

April 9: Michigan Botanical Club, at University of Michigan Botanical Gardens:
10:00 Board meeting
12:00 State meeting
2:30 Huron Valley Chapter annual meeting

May 27-28: Annual spring campout, Michigan Botanical Club, this year at the University of Michigan Biological Station on Douglas Lake.

Editorial Notes

COVER PHOTOS: Readers are encouraged to submit to the editor, for consideration as cover photos in future issues, good black and white prints (5 × 7 or 8 × 10) of botanical subjects.

The January number (Vol. 6, No. 1) was mailed January 23, 1967.

Publications of Interest

(Continued from page 70)

AQUATIC PLANTS OF ILLINOIS. By Glen S. Winterringer & Alvin C. Lopinot. Ill. St. Mus. Popular Sci. Ser. 6. 1966. 142 pp. An illustrated manual with keys and illustrations for the submersed and floating aquatic plants of Illinois, plus a few marsh species. $1.25 ($ .75 ea. for 10 or more) from Illinois State Museum Society, Springfield, Illinois 62706.

THE FLORA OF THE "DRIFTLESS AREA." By Thomas G. Hartley. Univ. Iowa Stud. Nat. Hist. 21(1). 1966. 174 pp. Consists chiefly of an annotated catalog of vascular plants from area of Wisconsin and adjacent Minnesota, Iowa, and Illinois not recently glaciated. $2.00 from Dept. of Publications, University of Iowa, Iowa City, Iowa 52240.

SELECTED GUIDES TO THE WILDFLOWERS OF NORTH AMERICA. Compiled by Elaine R. Shetler. Dep. Bot., Smiths. Inst. 1966. 9 pp. [processed]
FLORAS OF THE UNITED STATES, CANADA, AND GREENLAND. Compiled by Elaine R. Shetler. Dep. Bot., Smiths. Inst. 1966 (revised). 12 pp. [processed] These two annotated bibliographies of selected references are arranged geographically (including Hawaii and Alaska) and are available from the Department of Botany, Smithsonian Institution, Washington, D. C. 20560.

PROTECTING OUR FOOD. The Yearbook of Agriculture 1966. 386 pp. Topics range from plant diseases and weed control to supermarkets and food, drug, and meat inspection. In language reminiscent of medieval herbals, we are told that a "spoonful of 25 percent fenuron pellets, thrown from horseback, will kill a medium sized mesquite bush." Quite probably if one does not have a horse, throwing by the light of the full moon is equally effective. $2.50 from Superintendent of Documents, Washington, D. C. 20402, or without charge from one's congressmen.

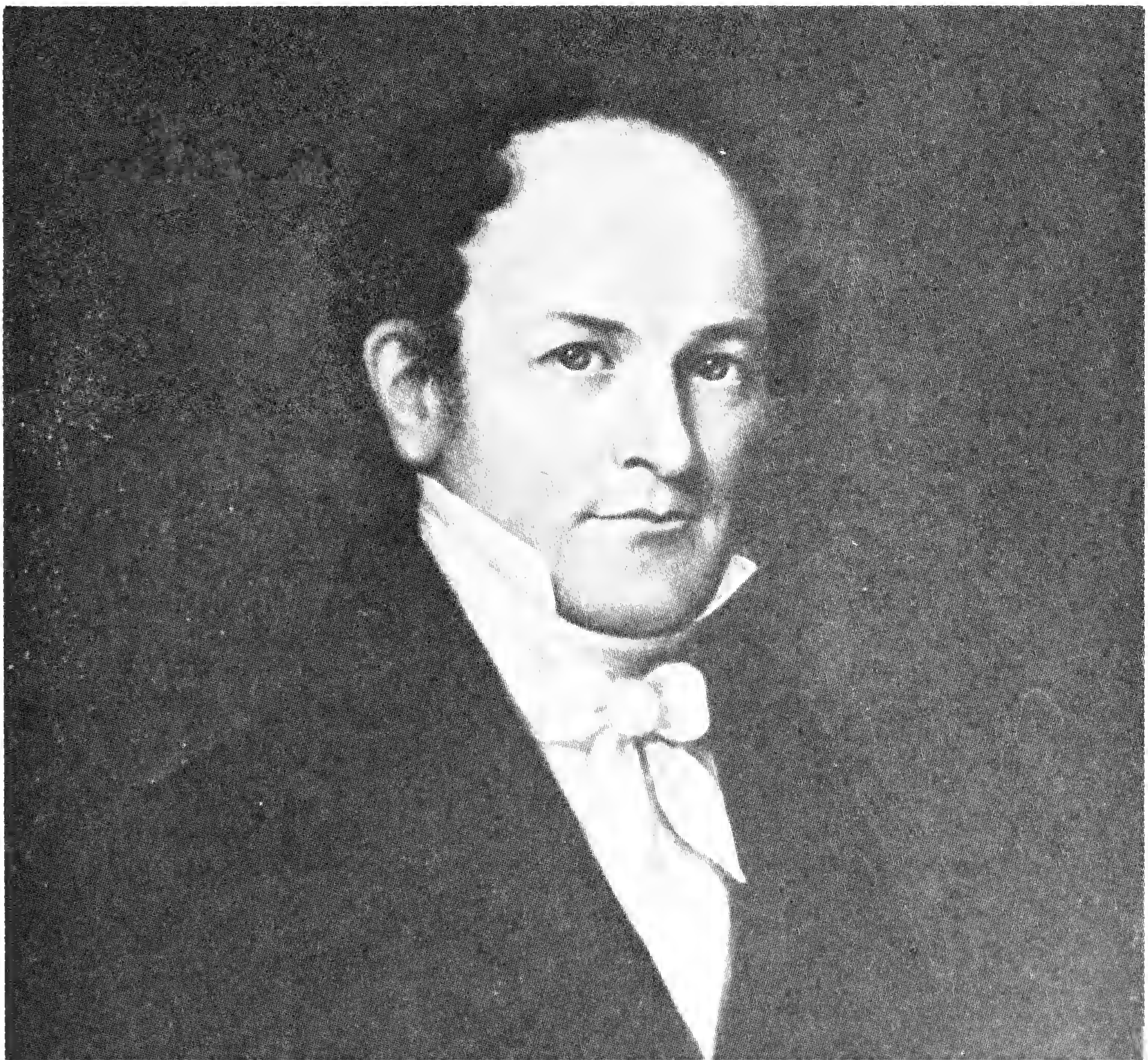
CONTENTS

(*On the cover: Mosses, chiefly* Ptilium crista-castrensis *and* Hylocomium splendens, *photographed by Carl B. Obrecht southwest of Watersmeet, Gogebic Co., Michigan, summer, 1949.*)

Vol. 6, No. 3

THE MICHIGAN BOTANIST

May, 1967



THE MICHIGAN BOTANIST—Published by the Michigan Botanical Club four times per year: January, March, May, and October. Second-class postage paid at Ann Arbor, Michigan.

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Articles and notes dealing with any phase of botany in the Upper Great Lakes Region may be sent to the editor in chief. The attention of authors preparing manuscripts is called to "Information for Authors" (Vol. 4, p. 38; reprints available from the editor).

THE MICHIGAN BOTANICAL CLUB

Membership in the Michigan Botanical Club is open to anyone interested in its aims: conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on the plant life of the State; sponsorship of legislation to promote the preservation of Michigan native flora and to establish suitable sanctuaries and natural areas; and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

Dues are modest, but vary slightly among the chapters. In all cases, they include subscription to THE MICHIGAN BOTANIST.

SOME OBSERVATIONS ON SPREADING OF AQUATIC FLOWERING PLANTS IN DEEP WATER OF DOUGLAS LAKE, MICHIGAN[1]

Dennis D. Bromley
Department of Wildlife Management,
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The methods by which shallow fresh-water plants spread can be easily determined by anyone who has access to a pond or lake shore where he can observe them. However, a man equipped with only hip boots cannot observe rooting structures of plants in water from five to seven meters deep. Very little information is available in the literature on the growth and spreading of deep-water plants. This paper reports observations on spreading of deep-water plants made in Douglas Lake, Cheboygan County, Michigan.

MATERIALS AND METHODS

The research was conducted during late July and early August, 1966, at The University of Michigan Biological Station as a project for the course in Aquatic Flowering Plants taught by Dr. Edward G. Voss. Ten stations were established in the lake (see Fig. 1) and one to six dives made at each station employing S.C.U.B.A. (Self Contained Underwater Breathing Apparatus) gear. The stations varied from protected coves to exposed sand shoals to provide as wide an ecological diversity as possible.

Depths were determined by holding the end of a light-weight nylon line on the bottom where the plant specimen was taken and allowing a buoyant aluminum fishing float, to which the line was attached, to reel out to the surface. The assistant then marked the line at the surface level after pulling it taut, reeled it up, and measured it. Frequently it was necessary for my assistant to swim to the float I released owing to the lack of maneuverability of the heavy boat in choppy water. The type of structure from which each plant originated was determined by grasping the plant with one hand and fanning the substrate in which it was growing with the other. This exposed the base of the plant and revealed its means of spreading.

After returning to the surface I dictated my observations on species of plant, substrate, means of spreading and other pertinent data to my assistant, who recorded them.

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[1]Contribution from the Biological Station of The University of Michigan.

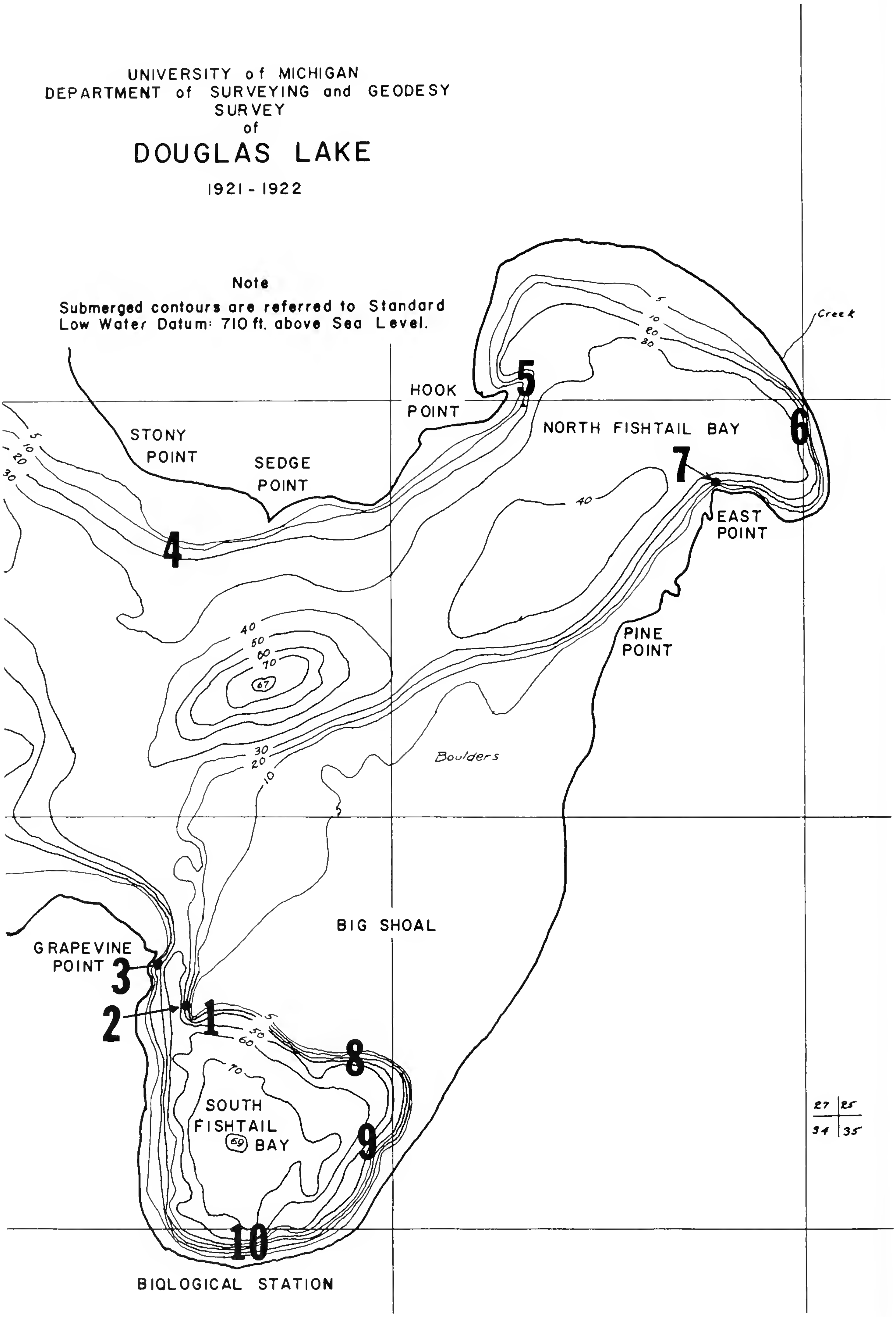


Fig. 1. Location of study areas. (Horizontal and vertical lines represent 4000-foot intervals.)

OBSERVATIONS

All investigations were made at depths of 5-7 m (16-23 ft.), where a total of seven species of vascular plants were observed among the 10 stations. (See Fig. 2 for species and depths.) In general, the densest growth of aquatic vascular plants was at depths of 4.5 to 6 m.

Winter-buds: Numerous plants of *Potamogeton zosteriformis*, at 5 of the 10 stations and depths of 2.6 to 7 m, were obviously arising from old winter-buds. This observation is similar to that of Fernald (1932, p. 21) who states that in such heavily fruiting species as *Potamogeton zosteriformis* (and others), "one would expect, naturally, to find that many, if not most, of the plants spring from seeds; but so generally is the old winter-bud found at the base of the ascending stem that we are forced to the conclusion that, in the species which regularly produce winter-buds these hardened and abbreviated branch-tips are the usual, if not the only, means of reproduction."

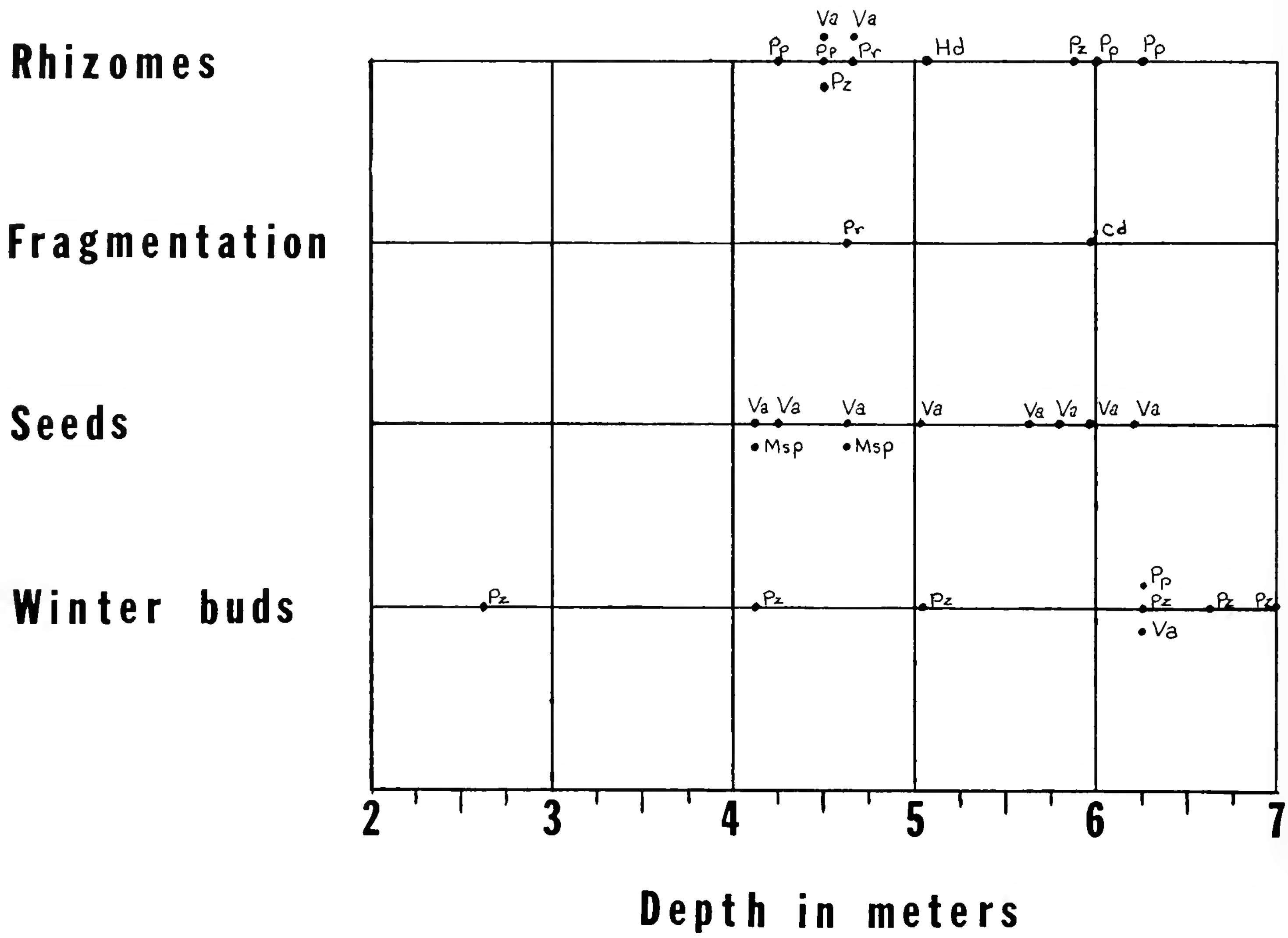
Fragmentation: One plant of *Potamogeton richardsonii* (station 3 at 4.7 m) evidently started by fragmentation for the erect portion of the stem was arising from a node of a prostrate basal fragment of plant.

Only a single plant of *Ceratophyllum demersum* was observed (station 6 at 6 m), but it, too, appeared to have grown from fragmentation. The buried segment was similar to the erect shoot arising from it except that the color was black rather than green. *Ceratophyllum* produces no roots (Arber 1920, p. 85; Subramanyam 1962, p. 53) and the buried fragment observed was not a "rhizoid-branch" as described by Arber (p. 88). It is curious that no other plants were seen spreading by fragmentation, for in almost every sampling area fragments of aquatic plants or entire plants were noticed lying on the bottom. Three obvious reasons may explain this: (1) the species of plants which I saw do not spread by fragmentation; (2) the water in which the plant or fragment settled was too deep for it to produce a shoot; or (3) the plant material had not been there long enough to take root.

Seeds: The deep-water specimens of *Vallisneria americana* (7 stations, at depths of 4.2 to 6.2 m) had invariably arisen by seeds, for the seed coating could still be seen attached to the rooting structures. In nearly every case, two or more stems of this plant were connected by rhizomes, but there was no connection with plants of shallower water.

Two plants of *Myriophyllum* sp. (station 3 at 4.7 m and station 10 at 4.1 m) appeared to start from seeds. There was no evidence to indicate the plants were arising from rhizomes, winter-buds, or fragments.

Rhizomes: Apparently the species of aquatic plants which I observed do not usually reach the area of the deepest water by rhizomes. Only one instance, a stem of *P. zosteriformis* which was not spreading by winter-buds, provided any evidence that this might have happened. This stem was located at a depth of 5.8 m at station 1 and was attached to an old, partly decomposed segment of rhizome about 30 cm long. Although there was no direct attachment to plants growing more densely in shallow water (4.8 m, about 1.5 m away), the rhizome segment was more or less perpendicular to the shore. It is



Legend

Ceratophyllum demersum	**Cd**
Heteranthera dubia	**Hd**
Myriophyllum sp.	**Msp**
Potamogeton praelongus	**Pp**
Potamogeton richardsonii	**Pr**
Potamogeton zosteriformis	**Pz**
Vallisneria americana	**Va**

Fig. 2. Methods and depths of spreading of deep-water vascular plants.

probable that this plant grew from a rhizome which might have gotten to that depth in a previous season. In many instances stems of *Vallisneria americana* were rising from rhizomes which had no connection with plants of shallower water. These rhizomes appeared to remain at the same depth except in one case where there were four stems connected by a rhizome which was oriented toward shallow water. This terminated in an immature shoot about 50 cm from the nearest plant of the same species.

At the deep edge of the dense vegetation (4.5 to 6 m), *Potamogeton praelongus* was arising from rhizomes 7 mm in diameter. Prostrate stems of this species of plant were extending deeper for another one to two meters, but were neither taking root nor producing new shoots at these depths. *P. zosteriformis* and *V. americana* were both spreading by rhizomes in the dense vegetation area, but as mentioned above, they were not spreading to deeper water by this method.

DISCUSSION

Apparently there are several accidental agents which, singly or in combination, are often responsible for the spreading of fresh-water plants into deep areas:

1. Fish moving through the vegetation zone often tear plants from their anchorage or break off pieces of plant and set them adrift, allowing them to be carried by water movements to other areas where they may take root and grow. In two instances while I was diving a smallmouth bass (*Micropterus dolomieui*), about 18 inches long, darted away breaking off small fragments of *Myriophyllum* sp., *Potamogeton praelongus*, and *Ceratophyllum demersum* from the main stems. These settled to the bottom. I also observed two carp (*Cyprinus carpio*) and one northern pike (*Esox lucius*) darting through the vegetation, violently disrupting it, dislodging fragments of plant material. However, I had no opportunity to observe whether they had just been broken off by the fish at that moment, or were fragments which had been broken off at some previous time and settled to the bottom to be churned up as the fish passed.
2. Waves, currents, and underwater turbulence caused by storms may break off and move already broken plant fragments, winter-buds, seeds, or whole plants to deeper water where they may take root.
3. Animals other than fish (and of course, man), may well play an important role in the spreading of plants to deeper water. It is well known that muskrats and many species of ducks utilize the tender portions of submerged aquatic plants for food. Bits and pieces of their intended meal probably are dropped and lost, allowing them to drift away and settle in new locations and possibly take

root. Water sport activities of man obviously disrupt aquatic vascular plants, dislodge them from the bottom, and set them adrift. 4. Underwater mud or sand slides may carry many plants to deeper water where they could become established. Where the drop-off was steep in areas 7 and 9 (see map Fig. 1), mud slides were evident as mud paths leading toward deeper water. In area 10 similar evidence of a sand slide was present.

CONCLUSION

Apparently the species of aquatic plants observed do not usually reach the area of the deepest water (5 to 7 m) by rhizomes from shallow water. Winter-buds, seeds, and fragmentation, singly or in combination with various accidental agents such as fish or other animals, wind, currents, water turbulence or underwater land slides generally enable these plants to spread into deeper water.

LITERATURE CITED

Arber, Agnes. 1920. Water Plants. Univ. Press, Cambridge. 436 pp.

Fernald, M. L. 1932. The linear-leaved North American species of Potamogeton, Section Axillares. Mem. Am. Acad. 17: 1-183. (Also Contr. Gray Herb. 3)

Subramanyam, K. 1962. Aquatic Angiosperms. Council of Scientific & Industrial Research, New Delhi (Bot. Monogr. 3). 190 pp.

Publications of Interest

A DICTIONARY OF THE FLOWERING PLANTS AND FERNS. By J. C. Willis, 7th ed. revised by H. K. Airy Shaw. Cambridge Univ. Press, 1966. xii + 1214 + liii pp. £5 [= $14.00], or $18.50 from U. S. office of the publisher. The long-awaited new edition of "Willis," indispensable in every herbarium and on every taxonomist's reference shelf, contains about 40,000 entries including, with authors, all generic names since 1753 and family names since 1789, together with those of some other taxa. Families are concisely described, with indication of numbers of genera and species, general distribution, chief genera, etc. Genera are referred to family, with number of species, general range, and major economic plants stated. Synonyms and variant names are referred to accepted names—with suitable caution where taxonomic judgments are involved. Botanical terms, common names, and names of economic products, so useful in previous editions, have had to be omitted to conserve space. Appended are synoptic keys to the families of flowering plants, based on the Engler-Prantl and Bentham-Hooker systems.

INTERNATIONAL CODE OF BOTANICAL NOMENCLATURE. Prepared and edited by J. Lanjouw, et al. Internatl. Assoc. for Plant Taxonomy (Reg. Veg. Vol. 46), Utrecht, 1966. 402 pp. $6.00 The Code, as revised at Edinburgh in 1964, with French and German translations, appendices (including lists of conserved names), and index.

THE "LOST" PLANTS OF THOMAS NUTTALL'S 1810 EXPEDITION INTO THE OLD NORTHWEST[1]

Ronald L. Stuckey
Department of Botany and Plant Pathology,
The Ohio State University, Columbus

Thomas Nuttall, one of North America's greatest and best known pioneer naturalists, was one of the earliest, if not the first botanist to study plants in the "Old Northwest" (the Great Lakes region). The plants he observed and collected were described in his now classic book, *The Genera of North American Plants, and a Catalogue of the Species, to the Year 1817,* published by its author in 1818. This was the first comprehensive work on plants of the western hemisphere published in the United States. Until thirty years ago the details of Nuttall's botanical activity and travel in the Great Lakes region were virtually unknown, except for the fragmentary locality references for certain plants described in the *Genera,* and a brief outline of his journey through the Great Lakes published in his *Observations on the Geological Structure of the Valley of the Mississippi* (Nuttall, 1821). In that work Nuttall wrote:

> In the summer of 1809 [actually 1810], my attachment to the study of Botany, induced me to make a pedestrian tour round the greatest part of the southern shore of Lake Erie, to Detroit, from whence I proceeded in a canoe along the same coast of the Huron lake to the island of Michilimakinak, situated near its commencement. I then took a southwest direction along the coast of Michigan, to Green Bay; thence to the banks of the Mississippi, by ascending Fox River, near to its source, and embarking on the Ouisconsin, which disembogues itself two miles below the village called Prairie du Chien. I then descended to the town of St. Louis.

In 1936 Francis W. Pennell prepared an account of Nuttall's travels and scientific collections. The portion dealing with the Great Lakes region was based almost entirely on the above notice and fragmentary data in the *Genera,* from which Pennell was able to map Nuttall's route of travel. Fifteen years later Jeannette E. Graustein (1951) published Nuttall's diary prepared on the 1810 trip. This diary gives many details clarifying portions of the 1810 journey. In a history of floristics in the Douglas Lake region of Michigan, Voss (1956) related Nuttall's contribution to the botany of the Straits of Mackinac area, based on the information in the *Genera* and on the work of both Pennell and Graustein. These studies give us as reasonably clear a picture as is now possible of Nuttall's botanical

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work in the Great Lakes region.[2] However, in these papers no mention is made of any botanical specimens supporting Nuttall's records in the *Genera*.

NUTTALL'S PLANT SPECIMENS

Nuttall collected many plants while engaged in his several botanical expeditions in North America. Most of these plants are today in the herbarium of the Academy of Natural Sciences of Philadelphia and in the British Museum, London. According to Pennell (1936), previous to the publication of the *Genera*, Nuttall apparently kept few or no specimens for himself, but presented a nearly complete series of his plants to the Academy, his American headquarters. Here repose most of the specimens (the types) on which the descriptions of the newly proposed species in the *Genera* are based. In an attempt to determine the extent of Nuttall's specimens at the Academy, I searched for those plants which were obtained on his trip into the Ohio valley in 1816 (Stuckey, 1966). This study revealed that specimens were extant representing all the species from the Ohio valley which Nuttall described as new to science in the *Genera*, although the published locality data for three of these new species do not agree with information on the labels. Species previously known to science were not necessarily represented by specimens. The conclusion reached was that Nuttall collected and preserved those plants he thought represented new species, and usually did not take specimens of those already known to science. Studies of his plants from earlier and later expeditions would be desirable to determine if this conclusion is valid for other phases of Nuttall's botanical work.

Nuttall's diary (Graustein, 1951) gives names and descriptions of plants he observed and apparently collected during the early portion of the 1810 trip. These descriptions are numbered from 1 to 47, but as pointed out by Ewan (1952) the whereabouts of the corresponding plants is not known. In his *Genera* Nuttall noted 58 species from the Great Lakes region (localities between western Pennsylvania and St. Louis). Of this number, Nuttall probably would have considered 20 of them as new to science.[3] This paper discusses only the latter group. A search of the Academy herbarium reveals supporting specimens for only some of these new species. Therefore, a different picture is presented for Nuttall's Great Lakes

[2]A distorted and grossly inaccurate account of Nuttall's botanical activity in the Great Lakes region is given by Eifert (1965).

[3]Included in this total are three species Nuttall credited to Fraser's Catalogue (Anonymous, 1813). *Dentaria heterophylla*, listed for both western Pennsylvania and near Philadelphia, is not included. Supporting specimens at the Academy and the British Museum are labeled "Dentaria heterophylla N^{r} Philadelphia" and "Den heterophylla Phil.," respectively.

plants than for his Ohio valley plants. A study of Nuttall's *Genera*, his diary, his other publications, and the data from those specimens that are preserved at the Academy provides us with a possible explanation for the fate of Nuttall's plants from the 1810 trip.

EVIDENCE FROM NUTTALL'S WRITINGS AND PLANTS

Nuttall's own paper in which he described the genus *Collinsia* gives certain clues toward a plausible explanation. In this paper Nuttall (1817) wrote:

> In the spring of 1810, during the course of an extensive journey into the north-western interior of the territories of the United States, I first became acquainted with the very singular and interesting plant which forms the subject of the present memoir. The specimens which I then obtained on the alluvial soils of the Alleghany and on the borders of lake Erie were finally lost. On arriving at St. Louis, near the confluence of the Missouri and Mississippi rivers, I found that Mr. John Bradbury, a botanist, had also detected this plant about the same time, on the banks of the Missouri and Mississippi, but I saw no specimen. In the spring of last year (1816), having undertaken a tour to the western states, I determined, if possible, again to collect this neglected plant, but after a journey of more than a hundred miles, for scarcely any other purpose, I arrived at Pittsburgh disappointed of my object. On descending the Ohio, however, nearly to Galiopolis, I at last recognised it on the more open alluvions of the river, withered and nearly past affording seed, . . .

There are two important points in this notice: (1) Nuttall lost his specimens of this species on the 1810 trip, and (2) on a later expedition Nuttall replaced the lost material. With regard to the first point, were these the only specimens lost? Apparently not, because with his specimen of *Rubus parviflorus* at the Academy is a note, ". . . lost all but this fragment," evidently meaning that all other specimens of the *Rubus parviflorus* were lost. In two instances, therefore, we have Nuttall's own record that certain specimens were actually lost. The idea that Nuttall may have replaced inadequate or even lost specimens with others is not new. Pennell (1935, p. 406) had suggested this procedure with regard to Nuttall's collections of *Seymeria macrophylla*. In the case of the *Collinsia verna*, we know Nuttall was successful in making the replacement, since he again found mature plants and seeds of that species on a later trip. The specimen in the Academy herbarium is a young plant in flower and is therefore believed to have been grown from the seeds he found in 1816 (Pennell, 1935, p. 293, and Stuckey, 1966). Could Nuttall have lost other specimens of the 1810 trip and replaced them when possible by other collections at a later time?

Nuttall's *Erythronium albidum* may have had a fate similar to that of the *Collinsia verna*. Nuttall wrote a short description of the former in his diary (Graustein, 1951) and noted its location as along the Monongahela River opposite the city of Pittsburgh, but the description and locality data in the *Genera* are not in complete agreement with the information in the diary. This discrepancy suggests that Nuttall may not have had a specimen from the Pittsburgh locality when he wrote the description for the *Genera*. Nuttall's specimen of *E. albidum* is one he apparently obtained from Dr. Daniel Drake (Stuckey, 1966). Perhaps his specimen from Drake represents a replacement for the 1810 material.

EVIDENCE FROM THE *GENERA*

A study of the locality data for the 20 species from the Great Lakes region described in the *Genera* shows that for 11 of them, the localities include one location east of the Mississippi River (such as Lake Erie, Lake Huron, Michilimakinak, Lake Michigan, and Prairie du Chien) where Nuttall visited in 1810, and one location on or west of the Mississippi River (such as Missouri, St. Louis, and Louisiana) where Nuttall visited in 1811. For the other nine species there is only one location or local region given, which is always east of the Mississippi River. When these locality data from the *Genera* are correlated with the data on the specimens that survive at the Academy or with the absence of certain specimens, an interesting pattern appears:

A. EASTERN AND WESTERN LOCALITIES. In the case of those species cited with both eastern and western locations, all of the plants that have been found are labeled as having come only from the western localities. Such a phenomenon suggests that Nuttall, having lost his specimens taken from the eastern localities in 1810, replaced them by specimens he found later in the west during 1811. Slightly over half of Nuttall's new species from the Great Lakes region belong in this category. These species can further be divided into two groups:

(1) Species which Nuttall credited as having been previously listed in Fraser's Catalogue (Anonymous, 1813). These species are *Phalangium esculentum*, *Pènstemon grandiflorus*, and *Amorpha canescens*. According to Graustein (1956), at the conclusion of the 1810-1811 trip when Nuttall arrived in New Orleans, Louisiana, he shipped seeds and dried plants to the sponsor of his expedition, the eminent Benjamin Smith Barton, of the University of Pennsylvania. The remainder of the plants Nuttall took with him to England. While there Nuttall supplied seeds, bulbs, and plants to John Fraser, a nurseryman of London; a list of many of these plants was prepared, but without indication of author (Anonymous, 1813). Shinners (1955, 1956) has argued that Thomas Nuttall was not the author of the catalogue, but Cronquist, Keck, and Maguire (1956) and Graustein (1956) have contended that Nuttall was its author. Furthermore, many of the names in Fraser's Catalogue are not accompanied by

any description; other names have very brief diagnoses. Nuttall's *Genera* was not published until 1818, and many of the species in Fraser's Catalogue were published with diagnoses before that date, either in Curtis's *Botanical Magazine* or in Pursh's *Flora* (1814 [1813]). Thus, determining the correct names of these species today depends on how one interprets Fraser's Catalogue, from the viewpoints both of its authorship and the validity of its publication.

Supporting specimens for the three species considered here were not found at the Academy. (See "Evidence from Barton's Herbarium," below.) We could infer that Nuttall lost the specimens from the eastern localities, recollected plants of the same species in 1811, and then turned these materials over to Barton or took them to England where they were contributed to Fraser, with Nuttall retaining none of the specimens for himself.

(2) Species which were not listed in Fraser's Catalogue. In this group are *Batschia longiflora*, *Melanthium glaucum*, *Euchroma grandiflora*, *Carduus undulatus*, *Artemisia serrata*, *A. gnaphalodes*, *Coreopsis palmata*, and *Juniperus repens*. Nuttall's specimens have been found at the Academy for all of these species except *Juniperus repens*.

B. EASTERN LOCALITIES ONLY. In various ways, Nuttall appears to have replaced specimens representing the species described only from locations east of the Mississippi River. These specimens can be placed into the following groups:

(1) Specimens possibly replaced by plants obtained on another trip. His *Carex aurea* probably belongs to this category. Although not originally described in the *Genera*, his *Collinsia verna* does belong to this category as pointed out above.

(2) Specimens possibly replaced by plants from another botanist, such as his *Tanacetum huronense* and possibly his *Primula farinosa*. The suggestion that his *Erythronium albidum* may belong to this category was also mentioned above.

(3) Specimens evidently not replaced: *Iris lacustris*, *Cakile americana*, *Thlaspi tuberosum*, and *Orchis huronensis*. We can understand why Nuttall did not collect *Iris lacustris* and *Cakile americana* later on the 1810-1811 trip or even on future expeditions, because of these species, confined to the shores of the Great Lakes (Guire and Voss, 1963), would not have been seen again by him. The *Thlaspi tuberosum* and *Orchis huronensis* were probably also not seen again in the field by Nuttall.

(4) Specimens apparently not entirely lost, such as *Rubus parviflorus* and *Lysimachia revoluta*.

(5) Nuttall's specimen of *Euonymus obovatus* evidently was obtained on the 1816 trip. It has been misinterpreted as an 1810 collection.

EVIDENCE FROM PURSH'S *FLORA*

In 1812 Nuttall became acquainted with Frederick Pursh in London. Pursh had examined American plants in Nuttall's herbarium sometime between Nuttall's arrival in England in 1812 and the publication (in London) of the former's *Flora Americae Septentrionalis* in December of 1813. According to Pennell (1936, p. 18) Pursh's *Flora* "contains only 15 species cited to Nuttall's herbarium, ("V.s. in Herb. Nuttall"), all of which are from the Missouri River. Only a part of these were new to science, . . ." Why, we might ask at this point, did Pursh list from Nuttall's herbarium only species from the Missouri River and not also some species from localities east of the Mississippi River? Had Pursh seen material of such distinctive Great Lakes region plants later to be described as *Iris lacustris*, *Tanacetum huronense*, *Cirsium pitcheri*, *Cakile americana*, and *Rubus parviflorus*, he certainly would have included them in his *Flora*!

It might be thought that Nuttall kept plants of these species from Pursh's examination. This idea could even find support in Nuttall's own statement given under his description of *Bartonia* (*Genera* 1: 298): "This unfortunate want of fidelity, prevented me from communicating to Mr. F. Pursh, many of the plants which now appear in this work." This "unfortunate want of fidelity" refers to Pursh's publication (Bot. Mag. *t.* 1487. 1812) of *Bartonia decapetala* [now = *Mentzelia*], a species actually based on a collection of Nuttall's, but one for which Pursh did not give Nuttall proper credit. Apparently Pursh's examination of Nuttall's herbarium was limited to the period between their meeting early in 1812 and the publication of *B. decapetala* in August of that year, while the two were still on friendly terms. When Nuttall returned to England in 1812, he probably had no intention of writing a flora of North America or publishing the genera or species he found, except for the *Bartonia* (Graustein, 1956). Because of a written agreement (Pennell, 1936, p. 45) with Barton, Nuttall was still under obligation to the professor for both his actions and the plants, although Nuttall had already broken portions of that agreement on several previous occasions. Making his herbarium available to Pursh was probably considered in Nuttall's mind to be no offense against Barton and the terms of the agreement. Thus on meeting Pursh, Nuttall probably communicated freely his plants—including even his prize, the newly proposed *Bartonia*. Why then didn't Pursh see some of Nuttall's plants collected in the Great Lakes region and record them in the *Flora*? I suggest that Nuttall's collections from the Great Lakes region had been lost.

EVIDENCE FROM BARTON'S HERBARIUM

Benjamin Smith Barton, the sponsor of Nuttall's 1810-1811 expedition, was to receive plants, as well as other items of information, from Nuttall. Barton wrote in a memorandum three days before his death (Pennell, 1936, p. 50) that Nuttall had transmitted a number of dried specimens and seeds which he had collected on the 1810-1811 trip. According to Tatnall (1940), "the fate of all the specimens sent to Barton by Nuttall is a matter of conjecture." Tatnall's report covered only those plants obtained by Nuttall in 1807 in southern Delaware. Pennell (1942) mentions many of the contributors to Barton's herbarium, but there is no information concerning Nuttall's plants from 1810-1811. I did not find any of Nuttall's plants from this expedition in Barton's herbarium at the Academy of Natural Sciences.

EVIDENCE FROM BRITISH HERBARIA

As pointed out above, many of Nuttall's plants are in the British Museum, but they are mostly those collected after the publication of his *Genera* (Pennell, 1936). In a brief search at the British Museum, Dr. Alfred E. Schuyler did not find any of Nuttall's specimens of *Cakile americana*, *Carex aurea*, *Iris lacustris*, *Tanacetum huronense*, or *Thlaspi tuberosum*.

Dr. E. F. Greenwood, who has recently surveyed the herbarium of the City of Liverpool Museums, informs me that he found 53 of Nuttall's specimens that had come directly from the former Liverpool Botanic Garden. However, none of these specimens represent Nuttall's species from the Great Lakes localities.

The herbarium of the Royal Botanical Gardens, Kew, also contains some of Nuttall's plants, but the extent of his 1810-1811 collections that may be there is not known to me. There apparently is no specimen of Nuttall's *Thlaspi tuberosum* in the Kew herbarium (Stuckey, in press).

DOCUMENTATION

As previously discussed in some detail (Stuckey, 1966), the data on Nuttall's specimens are extremely cryptic. The name of the plant and a general locality are usually the only data provided on the labels. Often when Nuttall considered a species as new to science, he placed an asterisk beside its name on the label and in the *Genera*. Study of his 1816 Ohio valley plants showed that Nuttall was inconsistent in his use of the asterisk, both on the labels and in the *Genera*. Similar inconsistencies occur with the plants of the 1810-1811 expedition; thus the selection of new taxa based on the presence of an asterisk has little meaning. Charles Pickering, who helped organize many of the Academy's early collections, added

Nuttall's name, abbreviated "Nutt." and enclosed in parenthesis, to the labels of these 1810-1811 plants.

With reference to the categories outlined earlier in this paper, a list and explanatory notes are given below for the species from the Great Lakes region described as new to science in Nuttall's *Genera*. Data from the *Genera*, the specimen (if extant at the Academy), and the diary (when possible) are recorded here to show the relationship of the data. Current equivalent names are given for those Nuttall species whose names are no longer in use because of taxonomic and/or nomenclatural reasons.

A. Species from both eastern and western localities.

1. Species listed in Fraser's Catalogue. (Specimens not extant at the Academy.)

Phalangium esculentum Nutt. Wild Hyacinth

Genera 1: 219. "In the spring of the year 1810, I discovered this plant near the confluence of Huron river and Lake Erie, I have since found it abundantly in alluvial situations a few miles from St. Louis, Louisiana, and more recently very plentiful on the lowest banks of the Ohio."

Diary p. 51. 13 June Found ". . . in a low alluvial situation . . ." in the evening after having crossed the "Kiaoga" and "rocky river" earlier in the day. Nuttall did not arrive at Huron on the Huron River until the evening of 15 June (p. 52). There is no indication in the diary that Nuttall found plants of this species at a later time near Huron. Disagreement between the data in the *Genera* and the diary, as shown here, makes me suspect that Nuttall did not consult his diary[4] when writing the *Genera*.

As pointed out by Gould (Am. Midl. Nat. 28: 715, 716, 725. 1942) the currently accepted name of this species is *Camassia scilloides* (Raf.) Cory.

*Penstemon *grandiflorum* Nutt. Large-flowered Penstemon

Genera 2: 53. "On the plains of the Missouri, common, from the confluence of the river Platte to the Mountains; also near the Prairie du Chien, Mississippi."

Pennell (1935, p. 261) accepted the name *P. grandiflorum*, but no specimen so named by Nuttall was found by Pennell in the British Museum. If one follows Shinners (1955), then the correct name is *P. bradburii* Pursh.

*Amorpha *canescens* Nutt. Leadplant

Genera 2: 92. "From the banks of Fox river and the Ouisconsin to the Mississippi; around St. Louis, Louisiana, and on the banks of the Missouri probably to the Mountains."

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[4] The question of whether or not Nuttall consulted his diary when he wrote his *Genera* is not known to me to have been considered in any published information about Nuttall. A detailed study and comparison of the information in the two works is beyond the scope of this paper, but such a study might prove desirable for further clarification of Nuttall's work. I have noticed several other inconsistencies between the two works suggesting that Nuttall may not have consulted his diary when preparing the *Genera*.

Diary p. 70. Described under the name *A. pumila* with the probable locality as "F[ox] Riv[er] 50 l[ea]gues from Le Bay cedar & hills Wt. from L. Winnebago."

Wilbur (Jour. Elisha Mitchell Sci. Soc. 80: 61. 1964), Shinners (1955), and Palmer (Jour. Arnold Arb. 12: 164. 1931) accept *A. canescens* Pursh as the correct name of this species.

2. Species not listed in Fraser's Catalogue. (Specimens only from the localities west of the Mississippi, visited in 1811, are extant at the Academy.)

*Batschia *longiflora* Nutt. Long-flowered Puccoon

Genera 1: 114. "In open plains; around the Prairie de Chien, Mississippi, and on the banks of the Missouri to its sources."

Specimen. "B. longiflora Missouri"

Johnston (Contr. Gray Herb. 70: 24. 1924) placed this species in synonymy under *Lithospermum angustifolium* Michx., later recognized as a homonym and supplanted by *L. incisum* Lehm.

*Melanthium *glaucum* Nutt. White Camass

Genera 1: 232. "On the gravelly banks of the St. Lawrence in calcareous soil; around the cataract of Niagara, on the borders of Lakes Erie, Huron and Michigan and up the Missouri to Fort Mandan... Flowering in July and August."

Specimen. "Melanthium glaucum Nutt. Gen. Sources of Missouri" Nuttall's later annotation is "Zigadenus glaucus." Pickering has added a note that this specimen came to Nuttall from "[Nathaniel] Wyeth," a pioneer plant collector of the Upper Missouri valley.

Fernald's interpretation (Rhodora 37: 256-258. 1935) of this species as *Zigadenus glaucus* (Nutt.) Nutt. has been followed in recent manuals.

**Euchroma *grandiflora* Nutt. Downy Painted-cup

Genera 2: 55. "On the plains of the Missouri from the confluence of the river Platte to the Mountains, common; also near the Prairie du Chien, Mississippi. Flowering from April to May."

Specimen. "Euchroma *grandiflora Missouri." Det. as *Castilleja sessiliflora* Pursh by F. W. Pennell, 1924.

*Carduus *undulatus* Nutt. Undulate Thistle

Genera 2: 130. "On the calcareous islands of lake Huron, and on the plains of Upper Louisiana."

Specimen. "Carduus *undulatus Missouri"

Nuttall's collection at the Academy is a single basal leaf. According to Ownbey (1952) this specimen represents the taxon *Cirsium undulatum* (Nutt.) Spreng., a species of the plains which is not known to occur on the islands of Lake Huron. Voss (1956, p. 23) suspected that Nuttall may have had in mind the Great Lakes shore endemic, *Cirsium pitcheri* (Torrey ex Eaton) Torrey & Gray, not described until 1829. Voss suggested that Nuttall may have associated vegetative material of the cream-flowered *C. pitcheri* with the later encountered reddish purple flowered plant which Nuttall described as *Carduus undulatus.* I shall further suggest that Nuttall lost a specimen of *C. pitcheri* from the Lake Huron islands, from memory thought it was the same as the plant he found in Missouri, and therefore gave the localities of both under *Carduus undulatus.*

*Artemisia *serrata* Nutt. Saw-toothed Wormwood

Genera 2: 142. "Near the Prairie du Chien, on the banks of the Mississippi, also on the banks of the Missouri, in open alluvial soils."

Specimen. "A. serrata upper Louisiana"

*Artemisia *gnaphalodes* Nutt. White Sage

Genera 2: 143. "On dry savannahs about Green Bay, Lake Michigan, and on the banks of Fox river, and the Missouri. Flowering in September."

Specimen. "Artemisia *gnaphalodes (St. Louis"

This name is treated as a synonym of *A. ludoviciana* Nutt. by Keck (Proc. Calif. Acad. 25: 440. 1946).

*Coreopsis *palmata* Nutt. Palmate Tickseed

Genera 2: 180. "On the open plains of the Michigan Territory, Illinois and Lower Louisiana."

Specimen. "Coreopsis *palmata (St. Louis) Louisiana."

*Juniperus *repens* Nutt. Prostrate Juniper

Genera 2: 245. "On the sandy shores of lake Huron, and also on the high hills of the Missouri, near Fort Mandan."

Specimen. No specimen from either locality has been located at the Academy.

This name is considered a synonym of *J. horizontalis* L.

B. Species from eastern localities only.

1. Specimens possibly replaced by plants obtained on another trip at a later date.

*Carex *aurea* Nutt. Golden Carex

Genera 2: 205. "On the shores of Lake Michigan."

Specimen. "C. aurea Nutt. Gen. Am. Cambridge"

According to Pennell (1936, p. 5) there are no plants mentioned from New England in the *Genera.* However, the name of the town on this label evidently refers to Cambridge, Massachusetts, where Nuttall spent much of his time between 1825 and 1833. It would appear that Nuttall designated this later specimen to serve as a replacement for the original material.

2. Specimens possibly replaced by plants from another botanist.

*Tanacetum *huronense* Nutt. Lake Huron Tansy

Genera 2: 141. "With *Artemisia canadensis* on the sandy shores of Lake Huron, near Michilimakinak; abundant."

Diary p. 71. Described under the name *Tansey.*

Specimen. "Tanacetum * Nutt. Herb Sch^{W} as 'Omolanthus camphoratus Lessing Arctic Am Hook'"

From the data on this specimen it appears that Nuttall obtained it from the herbarium of Rev. Lewis David von Schweinitz.

Nuttall's specimen labeled as "Artemisia canadensis Mak [inac]" has been found at the Academy.

*Primula *farinosa* Nutt. Bird's-eye Primrose

Genera 1: 119. "On the calcareous gravelly shores of the islands of Lake Huron; around Michilimakinak, Bois Blanc, and St. Helena, in the outlet of Lake Michigan: abundant, *v.v. sine fl.*"

Specimen. "Primula farinosa Michigan Canada" A line has been drawn through the word "Michigan." The line appears to have been made with the same pen and ink as was used for the other writing on the label. The specimen consists of one small plant with five flowers. Since Nuttall had not seen flowers on the plants of this species previous to the publication of its description in 1818, it could be inferred that he did not obtain this specimen in 1809 when he was in Canada. Furthermore, that trip was taken in the summer and fall, at a time when the Bird's-eye Primrose would not be in flower. It seems doubtful that this specimen represents a later addition collected by Nuttall, since there is no evidence that he was in Canada after 1818. Nuttall may have obtained the specimen from another botanist, but did not note its source.

The asterisk with *P. farinosa* suggests that Nuttall was proposing the species as new, but in fact the description is essentially an English translation of the description of Smith (Flora Brit. 1: 224. 1804), whom Nuttall cites. Smith's *P. farinosa* is based on the diagnosis of Linnaeus (cited as Sp. Pl. [ed. 2], p. 205, but first published ed. 1, p. 143. 173). Here is another example of Nuttall's inconsistency in the use of the asterisk; his *P. farinosa* was not really intended to be different from *P. farinosa* L.

On a taxonomic basis, Fernald (Rhodora 30: 86. 1928) decided that the *P. farinosa* of Nuttall's *Genera* was not the *P. farinosa* of Linnaeus, and he renamed the former as *P. intercedens*. There is no evidence that Fernald saw Nuttall's specimen at the Academy. Vogelmann (Rhodora 62: 33. 1960) was not able to separate *P. intercedens* from the older *P. mistassinica* Michx.

3. Specimens evidently not replaced.

*Iris *lacustris* Nutt. Dwarf Lake Iris

Genera 1: 23. "On the gravelly shores of the calcareous islands of lake Huron, near Michilimakinak. (I have seen no perfect specimens, and therefore recommend the examination of this plant to future botanists.)"

*Cakile *americana* Nutt. Sea-rocket

Genera 2: 62. "Common on the strand of the sea-coast, and also on the shores of the great North Western Lakes of the St. Lawrence."

Diary p. 42. 2 June "*Bunias Cakile*" seen growing on the beach of Lake Erie after leaving "Presque-isl" or "Erie." p. 64 "on the margin of Detroit River . . . grows *Cakile Aegyptiaca*!"

C. americana is a synonym of *C. edentula* (Bigel.) Hook.

*Thlaspi *tuberosum* Nutt. Spring Cress

Genera 2: 65. "In Western Pennsylvania. Flowering in April and May."

Diary p. 29. 26 April On route to Lake Erie, about 27 miles from Pittsburgh and 8 miles west of Butler.

This name is a synonym of *Cardamine douglassii* Britt. (Stuckey, in press).

*Orchis *huronensis* Nutt. Northern Green Orchis

Genera 2: 189. "In wet places on the islands of Lakes Huron and Michigan. Flowering in August and September."

Diary p. 71. Nuttall's description of a new orchid on this page is very similar to his description of *O. huronensis* in the *Genera*, and therefore both descriptions probably refer to the same species. Graustein (1951) believed the diary description pertained to *Habenaria* *dilatata* (Pursh) Hook., a decision based primarily on two outline drawings of the lip.

In various manuals, Nuttall's *O. huronensis* is now usually treated as a variety or synonym of *Habenaria hyperborea* (L.) R. Br.

4. Specimens apparently not entirely lost.

*Rubus *parviflorus* Nutt. Thimbleberry

Genera 1: 308-309. "On the island of Michilimackinak, lake Huron."

Diary p. 71. With respect to the vegetative parts of the plant, Nuttall's description of a "R. hispida" appears to pertain to *R. parviflorus*, but his statement of the berries being black would refer to *R. hispidus* L. Graustein (1951) interpreted this description to represent *R. parviflorus*.

Specimen. "Rubus parviflorus Michilimackinak lost all but this fragment."

*Lysimachia *revoluta* Nutt. Four-flowered Loosestrife

Genera 1: 122. "On the banks of the St. Lawrence, Lake Erie, and in the state of Ohio, always in calcareous soil."

Diary p. 63. at Detroit "a new linear leav'd Lysimachia."

Specimen. "Lysimachia *revoluta. N[orthern?] Ohio."

If the "N" is an abbreviation for northern, then this specimen probably came from northern Ohio and was one that was not lost. The data in the diary and the *Genera* do not agree, however. There is the possibility that Nuttall may have obtained specimens of this species in the "state of Ohio" on his journey down the Ohio River in 1816. Of the counties bordering on the Ohio River, this species is known from Belmont and Adams (data from specimens in The Ohio State University Herbarium).

L. revoluta Nutt. is a synonym of *L. quadriflora* Sims; see Ray (Ill. Biol. Monogr. 14: 49. 1956).

5. Specimen obtained in 1816, previously misinterpreted as an 1810 collection.

*Euonymus *obovatus* Nutt. Running Strawberry-bush

Genera 1: 155. "In shady fir swamps betwixt Franklin and Waterford, Pennsylvania. Flowering in June."

Specimen. "Euonyus [*sic*] obovatus Penns^{ia}"

Pennell (1936, p. 9) thought that Nuttall had passed through western Pennsylvania in May of 1810, and therefore he had difficulty in explaining Nuttall's comment that the flowering season for this species was June. Pennell's explanation was that Nuttall had "found the bush just coming into bloom, or perhaps by 1818 he had forgotten the month of his visit." From the diary we now know that Nuttall actually passed through western Pennsylvania in April of 1810, a month earlier than Pennell had suggested, making the chances of Nuttall's obtaining this plant in flower at that time still more remote. Furthermore, Nuttall does not mention this species in his diary. It should also be recalled that in 1816 Nuttall returned to the Allegheny River of western Pennsylvania to search for the lost and later described *Collinsia verna* (Nuttall, 1817). In a letter (Rutherfordton, North Carolina, 2 Oct. 1816) to Zaccheus Collins, well-known Quaker philanthropist and botanist of Philadelphia, Nuttall mentions his unsuccessful search for *Collinsia verna* "(nearly to Waterford)," the northern town. This journey evidently was taken later in the spring than the one in 1810, and after having retraced his route through Franklin, Nuttall reached Pittsburgh in early June (Pennell, 1936, p. 22). This evidence suggests that Nuttall obtained his specimen of *Euonymus obovatus* between Franklin and Waterford in the spring of 1816 (probably late May or early June) and not from this locality in April of 1810, as has been believed previously.

ACKNOWLEDGMENTS

My thanks are extended to Dr. E. F. Greenwood (City of Liverpool Museums) and Dr. Alfred E. Schuyler (The Academy of Natural Sciences, Philadelphia) for the information they contributed, and to The Academy of Natural Sciences for the use of their facilities where a portion of this study was conducted.

I am grateful to Dr. Edward G. Voss (The University of Michigan), Dr. Alfred E. Schuyler, and Dr. James Pringle (Royal Botanical Gardens, Hamilton, Ontario, Canada), all of whom have made suggestions after reading the manuscript; and to the Hunt Botanical Library (Pittsburgh) for supplying a photograph of the portrait of Nuttall reproduced on the cover.

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THE GENUS *POLYMNIA* (COMPOSITAE) IN MICHIGAN[1]

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Of the three species of *Polymnia* ("leafcup") known to occur in the United States, namely *P. canadensis* L., *P. uvedalia* (L.) L., and *P. laevigata* Beadle, two are recorded from Michigan. The northern limits of known distribution of *P. canadensis* and *P. uvedalia* include the southern portion of Michigan's Lower Peninsula.

Both *P. canadensis* and *P. uvedalia* occur in shaded sites and are frequently encountered along stream banks. Alkaline soils are often found where *P. canadensis* grows, while *P. uvedalia* occurs in more acid situations where the ranges in pH, at least in the southeastern United States, include 5.3 to 6.7.[2] These species may be distinguished as follows:

At least the middle or lower leaves pinnately lobed, the sinuses extending at least halfway to midvein; ray corollas white or very pale yellow, to 1.5 cm long; fruit 3-sided, about 2 mm wide, 4 mm long . . . . *P. canadensis*

[1]I gratefully acknowledge the assistance of Mr. Dale J. Hagenah for helpful suggestions and criticisms in the preparation of this report, and of the curators of the several herbaria for loans of specimens.

[2]Determinations of pH were made by the Ohio State University Soil Testing Laboratory, which also loaned a Hoffer Soil Sampler used in obtaining samples.

Leaves palmately lobed or entire, sinuses sometimes broad and shallow; ray corollas distinctly yellow, to 3 cm long; fruits ovoid or obovoid, about 5 mm long, 4 mm wide . . . . *P. uvedalia*

Recently, collections were examined from the herbaria at The University of Michigan, Michigan State University, Wayne State University, Aquinas College, Cranbrook Institute of Science, Eastern Michigan University, and the University of Notre Dame. When these records were combined with those obtained four years ago from 13 other herbaria,[3] there appeared the distribution patterns recorded in Figure 1.

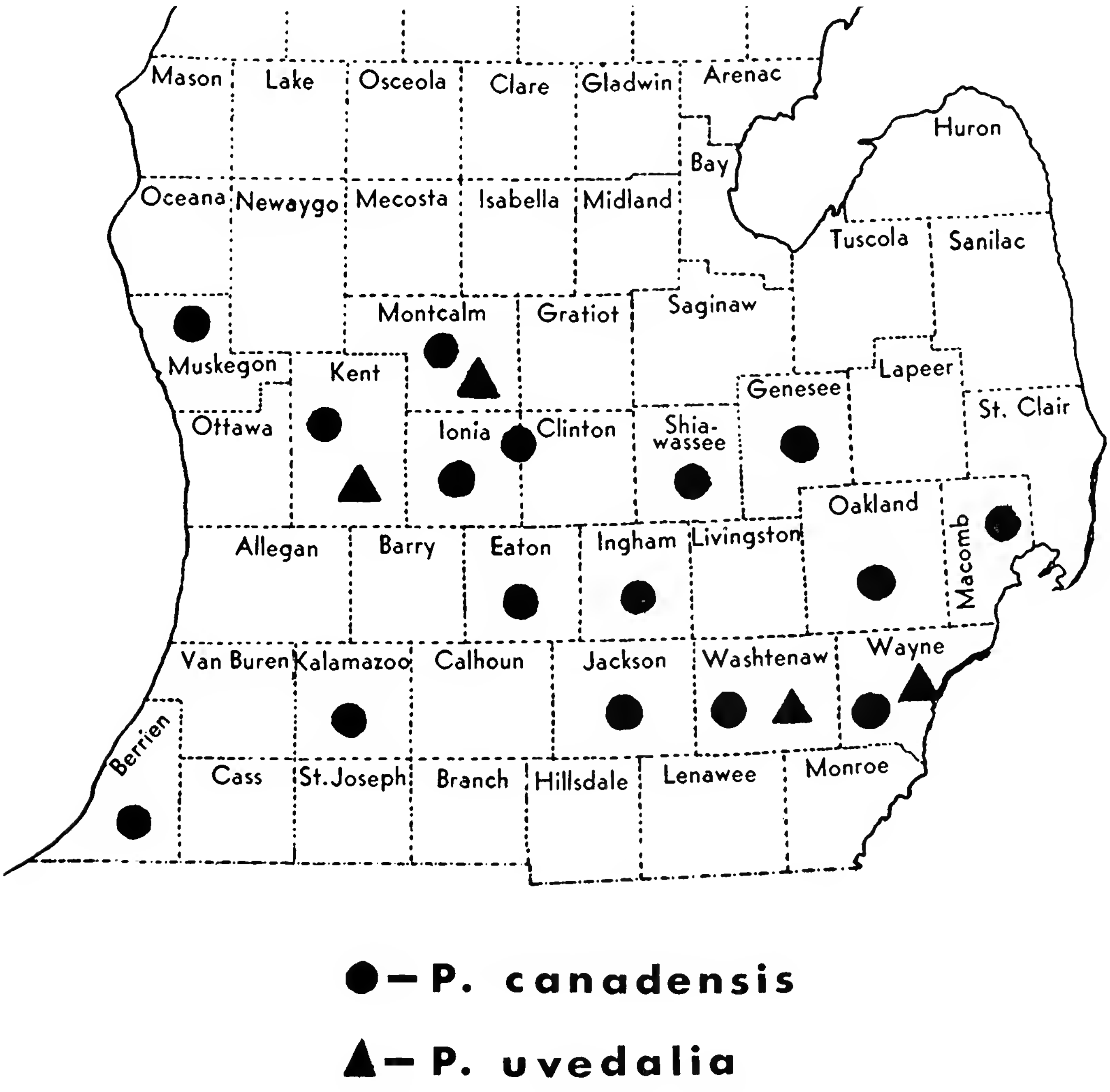

Fig. 1. County distribution of *Polymnia canadensis* and *P. uvedalia* in Michigan, based on herbarium specimens examined.

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[3]F, GH, IND, LSU, MO, NY, NCU, OS, OU, PH, TENN, TEX, US (not all of these included Michigan specimens).

No collection of *P. uvedalia* from Michigan was seen among herbarium material from any institution outside of Michigan. The earliest records of *Polymnia* in Michigan are those of *P. uvedalia* and *P. canadensis*, both of which were collected by John Wright and George H. Bull in 1838 during the First Geological Survey of Michigan. No further location is given for *P. uvedalia*, but *P. canadensis* was collected August 3 in Kalamazoo County. The four county records of *P. uvedalia* mapped in Fig. 1 probably do not represent the totality of its distribution in Michigan. The counties comprising the southernmost row in the state are among those least known floristically; we would expect more thorough collecting to produce records for one or both species in this region.

If varieties of *P. uvedalia* (Blake, 1917) are recognized, vars. *uvedalia* and *floridana* are found in Michigan. Plants of the former have peduncles that are stipitate-glandular while the peduncle vestiture of the latter includes glands and some hairs. A third variety, var. *densipilis*, occurs principally in the southern U. S. and is characterized by densely pilose hairs on the peduncles. The future treatment of these varieties will depend upon results obtained from current experimental investigations directed toward elucidating the mode of inheritance of varietal characters.

Apparently, *P. canadensis* is more widely spread in Michigan than is *P. uvedalia*. The former may be found among our wintergreen vegetation. Dodge (1900) makes note of *P. canadensis* in St. Clair County: "in rich woods near North St. Rare." Judging from the 15 to 16 county records indicated, one might expect it in all of our southernmost counties.

It is not likely that *P. laevigata* will be found in Michigan. Its known range includes only seven counties among the states of Missouri, Alabama, Georgia, Tennessee, and Florida.

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THE HYPOGEOUS SEEDLING IN *DESMODIUM* (LEGUMINOSAE)

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When there are questions of plant classification it is often necessary to take into consideration new characters that have previously been ignored. Sometimes these new characters are technical ones, difficult to use in routine identifications, such as chromosome numbers, anatomical details, and chemistry. In this paper a striking new difference is reported for certain species of tick trefoil, *Desmodium,* which makes them stand apart from the others. It involves the form and development of their young seedlings.

Historically, the limitations of the genus *Desmodium* Desv. have been questioned to a considerable extent. After the name *Desmodium* was conserved over *Meibomia* Adans. by the International Botanical Congress at Vienna (1905), Schindler (1924) proposed that the genus (as now delimited, for example, by Schubert, 1950b) be divided and both names applied. Of the plants in our northeastern United States range, *Desmodium* in Schindler's sense would contain only the species of the series *Americana* Schub. (*D. glutinosum* (Muhl. ex Willd.) Wood, *D. nudiflorum* (L.) DC., and *D. pauciflorum* (Nutt.) DC.), whereas *Meibomia* would contain the remaining species. He contended that the genus *Desmodium* could not be maintained within its present limits because of the excess of heterogenous elements. I have also found the series *Americana* to be considerably different from the remaining series of this range. There appears to be little more than the form of the fruit uniting them, and even this is only superficially similar. Recent observations on the seedling development by the present author led to the finding of a striking new criterion for further differentiating this series from the remaining series, viz., hypogeous in contrast to epigeous cotyledons. (Table 1.)

In the family Leguminosae, the seed characteristically has large cotyledons and little or no endosperm (Lawrence, 1951). Upon

TABLE I. Characters separating Series *Americana* from the other series of *Desmodium* in the northeastern United States.

Character	Series Americana	Other Series
Stamens	Monodelphous	Diadelphous
Seed Coat	Chartaceous	Horny
Habitat	Rich woods	Dry open fields, dry woods to moist open areas
Cotyledons	Hypogeous	Epigeous

germination, the cotyledons remain underground (hypogeous) and non-photosynthetic, or emerge (epigeous) and become photosynthetic (there are a few exceptions in which the epigeous cotyledons never become photosynthetic). From a study made by Kummer (1951), out of 16 genera (23 species) of weedy members of the Leguminosae in the north central United States, the epigeous condition is predominant, with only two genera (three species studied) being hypogeous (*Vicia* and *Lathyrus*).

In the case of the genus *Desmodium* the species which I have grown in series *Americana* were hypogeous (*D. glutinosum*, *D. nudiflorum*), whereas seven species of the remaining four series had epigeous and photosynthetic cotyledons. This conclusion is based on 69 lots of seedlings including the following species:

Ser. *Stipulata* Schub.	*D. rotundifolium* DC.
	D. illinoense Gray
Ser. *Pauciarticulata* Schub.	*D. marilandicum* (L.) DC.
Ser. *Longibracteata* Schub.	*D. canadense* (L.) DC.
	D. cuspidatum (Muhl. ex Willd.) Loud.
Ser. *Stipitata* Schub.	*D. paniculatum* (L.) DC.
	D. dillenii Darl.

The finding of this major difference in cotyledon position and function is further evidence that this genus is an admixture of heterogeneous elements. At this point one would tend to think that one of the major characters uniting the genus—the loment fruit type—may well be a case of convergent evolution in the Leguminosae. This certainly could not be considered an unlikely occurrence, since there are examples in each of the subfamilies in which the legume has become partially constricted between the seeds, and oftentimes even disarticulates at these constrictions, as in *Desmodium*. Examples are *Desmanthus leptolobus* (Mimosoideae), *Cassia marilandica* (Caesalpinioideae), and *Ornithopus sativus* (Papilionoideae).

Since series *Americana* has close relatives in Mexico and Asia (Schubert, 1950a), it may be necessary to make a careful study of these members of *Desmodium*, as well as other related genera, to determine more soundly where the affinities of series *Americana* really lie.

I wish to express my appreciation to Mr. Louis K. Ludwig, who helped me grow the seedlings shown in the photograph (Fig. 1), and to Mr. W. Howard Bond who photographed them.

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Fig. 1. Seedlings of tick-trefoils: Left, *Desmodium nudiflorum*, Ambrose no. (1540)-2. Center, *D. marilandicum*, (1575). Right, *D. glutinosum*, (1540)-3. The line represents approximate soil level. Note that in *D. marilandicum* the cotyledons do not remain in the seed, but are brought above the soil and become photosynthetic. Approx. half natural size.

Nature education feature --

A TRIP AFIELD

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With the coming of another spring both children and adults will be eager to savor anew the delights and satisfactions of exploring the out-of-doors.

Herewith are some suggestions for a trip afield with children whose ages might range from ten to thirteen years. No special props are necessary but a knapsack or basket for collectable materials which can be arranged at some available place for later observation is very desirable. Since a hand lens can open a new world, it is well worth carrying.

Children are naturally in tune with the rebirth of life in the spring and the leader might keep this in mind as a focal point for observations and questions.

A general look around "to see what you can see" is a good starting point. Trees are easily the most conspicuous feature in our landscape. As early as late March buds will be swelling and species like willow and aspen will already be in bloom.

A variety of twigs can be examined and even with the naked eye last year's leaf scars will be visible under the new buds. With the aid of a lens some curious patterns can here be observed. These are made by vascular bundles which carried nutrients and food materials between last year's leaves and the rest of the plant. What is a bud and how does it live over the winter?

The presence of flowers on trees may be a new idea to pursue. Find several trees in bloom and note the difference between a catkin of aspen and a red maple flower.

What are the essential parts of a flower? This might lead to discovering that some flowers bear only stamens, while others bear only pistils. On aspen these two kinds appear on separate trees while the red maple may have both male and female flowers on the same tree. See if you can find a perfect flower bearing both pistils and stamens on the same red maple. Can you find a tree flower with petals?

There may be an opportunity to suggest the importance and methods of pollination. Are they related to the presence or absence of petals? How is a willow or aspen flower pollinated? A showy bloom like the locust or catalpa? Why do trees with petals generally bloom later than those without petals?

The function of every flower is to bear a seed. Find several kinds of seeds. All hold a folded "baby plant" plus a "lunch" packed within a protective shell.

If there are both evergreen and deciduous trees present this would be a good time to suggest their differences and similarities. Compare a pine needle and an oak leaf from the previous summer. Both have the same function, to make food for the tree. Only a green leaf trapping the sun's energy can make sugars from the non-living substances which it draws from the soil and the air. All animals including man must get their food second-hand.

Pick up a pine cone. Can you find a hidden seed? Which of the above two groups of trees appeared first in the earth's history?

On such a walk you will also see evidence of the presence of animals. The male red-winged blackbird is already singing on fence post, wire and cattail. Why does he sing? Why the red epaulet on his wings?

Look for a last year's bird nest in a tree. Compare it with one you may have seen on the ground. Have you noticed (on previous years) a difference between baby birds like the red-wing newly hatched above ground and those like the duck or the sandpiper which nest on the ground? Would you call a bird's nest a home or a cradle?

Look for other animal homes: a mouse's nest in an old cattail, a muskrat house, a vespid wasp's paper house, a dry cocoon on leaf or fence.

If your walk takes you into a woodlot, overturn a few stones. A red-bellied salamander may be hiding there. Break up a well rotted log. You might surprise some beetles or sowbugs.

Almost any ditch will hold the eggs of frogs and toads. You might here define some animal families. Is a salamander a reptile or an amphibian? How can you distinguish between a frog and a toad?

Carry home a small vial of stagnant water from the ditch. Perhaps you have access to a microscope at school or at the office of an interested parent. Put a drop of this water between two glass slides and you will see it is alive with wriggling forms. These are tiny plants and animals which resemble the first life in the ancient seas which once covered the earth. Perhaps a trip could be arranged to the Cranbrook Institute of Science where you could see a drop of stagnant water magnified 250 times and where some of the primitive plants and animals which it holds are named.

Among the above plants and animals are some like the amoeba whose entire body is composed of a single cell. This observation might well lead to the fundamental truth that all that is alive, be it tree or man, is made up of cells. These variously shaped and sized units are filled with protoplasm, a clear jelly-like substance. This is the stuff of life, for protoplasm is the only living substance. When it ceases to act, the result is death. Cells have diverse functions and occur in many combinations to make plants and animals of varied complexity. A good conclusion here: "If you are alive, you are either a plant or an animal."

It has been my experience that children respond to the idea that plants are generally characterized by the presence of green chlorophyll and vertebrate animals by the presence of red blood. The chemical formulae for these two life-giving substances are similar: the hub of every molecule of chlorophyll is an atom of magnesium while in hemoglobin (the essence of blood) it is an atom of iron.

As you conclude your trip you might ask the children to arrange and label the objects they have collected on two large blotters, one red and one green, thus defining our two living worlds. They enjoy this type of participation and I have found it productive of interest and learning.

* * *

Successive field trips might lead to a more selective habitat, such as a pond, a meadow, or a woodlot, where you could emphasize how plants and animals live together in mutually beneficial communities and where their names could be linked to their individual habits and manners.

Take the time to listen to a child's "talk" even if it may seem irrelevant. Children have much to contribute to each other and to their leader. An interested and enthusiastic leader will capture the interest and enthusiasm of the child and without these there can be little of enjoyment or learning.

Publication of Interest

THE EVOLUTION OF CANADA'S FLORA. Edited by Roy L. Taylor and R. A. Ludwig. Univ. of Toronto Press, 1966. 137 pp. $5.50. A collection of articles commemorating the founding of the Canadian Botanical Association in 1965, and dealing basically with postglacial history of Canadian vegetation, on land very "young" geologically speaking (like Michigan!). Included are biographical notes on Frère Marie-Victorin (by Raymond) and articles on phytogeographic zonation (Rowe), patterns in Canadian moss flora (Crum), reproductive specialization (Mosquin), late-Pleistocene history of Canadian flora (Ritchie), man's influence on migration (Rousseau), marine algal communities (Lee), and vegetative propagation in relation to aggressiveness of species (Steeves). (Although price on dust-jacket is $5.50, copy was billed at $6.50, an unexplained discrepancy.)

PROGRAM NOTES

May 27-28: Annual spring campout, Michigan Botanical Club. Headquarters at University of Michigan Biological Station on Douglas Lake; field trips to Wilderness State Park, bogs, shores, etc. Be sure your reservations have been returned to Edmund S. Mueller, 427 Bauman Ave., Clawson, Michigan 48017.

Sept. 24: Fall meeting, Michigan Botanical Club. Tentative plans include picnic at Park Lyndon (Washtenaw Co.) and trip to the newly purchased Waterloo Black Spruce Bog including its official dedication.

Persons interested in becoming charter members of a southwestern chapter of the Michigan Botanical Club should notify Dr. Harriette V. Bartoo, Department of Biology, Western Michigan University, Kalamazoo, Michigan 49001.

Editorial Notes

The October issue will include a 3-year index to volumes 4-6 of THE MICHIGAN BOTANIST.

The March number (Vol. 6, No. 2) was mailed March 1, 1967.

Flora North America

Flora North America, as the project will be called, was officially launched on January 30, 1967, when the newly formed Editorial Committee held its first meeting at the Smithsonian Institution in Washington, D.C. This three-day meeting, convened by William L. Stern (Smithsonian), Chairman *pro tem.* of the Steering Committee, was attended by all members of the Editorial Committee:

Peter H. Raven, Chairman, Stanford University
Stanwyn G. Shetler, Secretary, Smithsonian Institution
John H. Beaman, Michigan State University
Kenton L. Chambers, Oregon State University
Robert Kral, Vanderbilt University
Walter H. Lewis, Missouri Botanical Garden
John T. Mickel, Iowa State University
Roy L. Taylor, Canada Department of Agriculture, Ottawa
John H. Thomas, Stanford University

Also attending were Robert F. Thorne (Rancho Santa Ana Botanic Garden), Chairman of the Advisory Council, and Vernon H. Heywood (University of Liverpool), Secretary of *Flora Europaea,* who served as a consultant in the discussions. The purpose of the project is to prepare a concise diagnostic manual to the vascular plants of the continental United States, Canada, and Greenland. It is expected that the first 12 to 18 months will be occupied getting the project fully organized and the working procedures implemented. This will be followed by the second phase of intensive writing and editing for the first volume. Tentatively, four volumes, followed by a fifth comprising a theoretical symposium on the North American flora, are anticipated. The whole effort is expected to last 12-15 years.

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(*On the cover: Thomas Nuttall, probably the first botanist to collect in Michigan.* *See pp. 81-94.* *From a lithograph in the Hunt Botanical Library, Pittsburgh, Pennsylvania.*)

Vol. 6, No. 3A

THE MICHIGAN BOTANIST

May, 1967

A PRELIMINARY ACCOUNT OF THE NORTH AMERICAN SPECIES OF *LECCINUM*, SECTIONS *LUTEOSCABRA* AND *SCABRA*

Alexander H. Smith, Harry D. Thiers, and Roy Watling

THE MICHIGAN BOTANIST—Published by the Michigan Botanical Club four times per year: January, March, May, and October. Second-class postage paid at Ann Arbor, Michigan.

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Vol. 1 (2 numbers, at $1.00 each): $2.00
Vol. 2-5 (4 numbers, at $.50 each): $2.00
Vol. 6- (4 numbers, at $.75 each): $3.00

Subscriptions (from those not members of the Michigan Botanical Club) and all orders for back issues should be addressed to the business and circulation manager, who will assume that subscriptions received prior to the last number of a volume are intended to begin with the first number of that volume unless specified to the contrary.

Articles and notes dealing with any phase of botany in the Upper Great Lakes Region may be sent to the editor in chief. The attention of authors preparing manuscripts is called to "Information for Authors" (Vol. 4, p. 38; reprints available from the editor).

THE MICHIGAN BOTANICAL CLUB

Membership in the Michigan Botanical Club is open to anyone interested in its aims: conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on the plant life of the State; sponsorship of legislation to promote the preservation of Michigan native flora and to establish suitable sanctuaries and natural areas; and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

Dues are modest, but vary slightly among the chapters. In all cases, they include subscription to THE MICHIGAN BOTANIST.

A PRELIMINARY ACCOUNT OF THE NORTH AMERICAN SPECIES OF *LECCINUM*, SECTIONS *LUTEOSCABRA* AND *SCABRA*

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San Francisco, California; and
Royal Botanic Garden, Edinburgh, Scotland

The present paper, in which sections *Luteoscabra* and *Scabra* are treated, is a continuation of our studies on *Leccinum* directed toward an eventual monograph. The problems encountered are generally similar to those discussed previously for section *Leccinum*. We encountered certain variations in the color of the spore deposit which we regard as significant, and have had the same difficulties in the interpretation of the blue staining of the flesh when injured and hence have avoided emphasizing this feature at the species level. In some species pleurocystidia apparently are lacking but we have not emphasized this feature in delimiting taxa as we believe many more observations are necessary before the absence of such cystidia can be established as a constant character. In *Leccinum* leptocystidia are typically present though at times difficult to demonstrate. As we found when studying section *Leccinum* the structure of the pileus cuticle is of the utmost importance in the taxonomy of the group.

As pointed out previously, since a monograph is planned, the present treatment does not include citation of all the material studied, or drawings of the microscopical structures. It is a provisional treatment, in a sense, to enable our species concepts to be widely tested. We have reserved comment on many variants of uncertain taxonomic validity which we hope to collect in greater quantity in the future. In other words we believe that much more field work must be done in North America before a *Leccinum* monograph based on an adequate sampling of our flora can be written.

From the studies completed to date it is evident to us that species concepts in *Leccinum* should parallel those in other groups of boletes such as *Xerocomus* and *Suillus*. We find, for instance, that the species Singer originally described as *Krombholzia rotundifoliae* falls readily into place as a valid species in our system. As a subspecies of *L. scabrum*, however, it makes the definition of the latter more ambiguous. Because of the discovery of "new" characters for the genus, such as pseudocystidia in the hymenium, it is imperative that in the future any specimen saved as a herbarium specimen be accompanied by notes on the characters observable on the fresh basidiocarps. The lack of these data makes the accurate identification of most herbarium specimens impossible. Corner (1966) commented on the failure of the "Herbarium Method." As long as materials inadequate for their purpose are preserved, this condition will continue. Thus it is the scientists who have failed in the past, not the "Herbarium Method."

The feature that has impressed us so far is the number of characters that are actually available in *Leccinum* and the obvious gene flow in the genus to produce so many variants showing various combinations of the features in the gene pool. On the basis of the circumstantial evidence that we have encountered we find ourselves inclined to wonder whether or not hybridization between taxa is commonplace in the genus.

Our field work to date on this project has been incidental to other projects financed by the Faculty Research Fund of the University of Michigan, and in recent years by the National Science Foundation. However, in the summer of 1966, with financial aid from the Faculty Research Fund of the University of Michigan, project 1417, we collected in southern Michigan. Dr. Thiers collected in the Gulf Coastal Plain of the southern United States on Grant G-5845 from the National Science Foundation, for a study of the boletes of that area. He also collected in California, N.S.F. Grant GB-2760, in connection with his study of the boletes of that state. Dr. Watling was financed in part by N.S.F. Grant G-13282 to the University of Michigan Herbarium for work in Michigan in 1965, and by a travel grant from the Institute of Science and Technology of the University of Michigan for passage from Edinburgh, Scotland, to Idaho in 1966. The cost of excess pagination was defrayed in part from N.S.F. grant 2760 to Dr. Thiers.

Subgenus LECCINUM

Stipe ornamentation typically darkening more or less appreciably, or dark colored from the beginning; if the pileus, tubes, or stipe are yellow wholly or in part then the pileus trichoderm often contains sphaerocyst-like units at least in part, or consists of a cellular epithelium.

Type species: *Boletus aurantiacus* Bull. (= *Leccinum aurantiacum* (Bull.) S. F. Gray)

KEY TO SECTIONS

1. Pileus trichoderm with elements containing short, ellipsoid to rounded or almost globose cells, or the layer appearing as if cellular . . . . Section *Luteoscabra*
1. Trichodermal elements of elongate, cylindrical (long or short) but scarcely inflated cells 2

2. Pileus margin appendiculate with segments of a broad sterile margin . . . . Section *Leccinum* (see Smith, Thiers, & Watling, 1966)
2. Pileus margin regular or wavy, sometimes slightly involute, rarely ever splitting to become appendiculate or if so then never broad and prominent . . . . Section *Scabra*

Section LUTEOSCABRA Singer

Type species: *Leccinum crocipodium* (Let.) Watling

Pileus trichoderm with at least some short, inflated (ellipsoid, subglobose, to globose) cells in the component hyphae, or the layer appearing cellular; hymenophore pallid to yellow when young; stipe ornamentation unchanging or darkening—often blackish at maturity; pileus margin never appendiculate.

KEY TO SUBSECTIONS

1. Context and/or hymenophore yellow in some degree when young or on drying; stipe ornamentation unchanging or darkening . . . . Subsection *Luteoscabra*
1. Young hymenophore pallid to whitish or if yellowish at some stage then stipe ornamentation darkening and context never wholly yellow 2
   2. Pileus trichoderm forming a more or less distinct cellular epithelium, pileus often glabrous and viscid . . . . . Subsection *Albella*
   2. Pileus trichoderm with constituent cells, particularly towards the end, inflated sometimes to sphaerocyst proportions but the enlarged cells not numerous enough to form an epithelium . . . . Subsection *Pseudoscabra*

Subsection LUTEOSCABRA

Type species: *Leccinum crocipodium* (Let.) Watling

KEY TO SPECIES

1. Spores 6-8 μ wide. . . . . *L. crocipodium*
1. Spores 3.5-6.5 μ wide 2
   2. Pileus typically uneven to pitted; stipe reticulate and furfuraceous-punctate as well as resinous to the touch . . . .*L. rugosiceps*
   2. Pileus smooth to slightly rugulose or if pitted then stipe ornamentation dry to the touch and never in the form of a reticulum 3
3. Stipe ornamentation pallid becoming blackish in age; young hymenophore pallid and pileus subviscid . . . . *L. luteum*
3. Stipe ornamentation very fine and yellow to brown, unchanging. 4
   4. Pileus cuticle of inflated cells 2-4 deep . . . . *L. subglabripes*
   4. Pileus cuticle a disarranged hymeniform layer . . . *L. brunneo-olivaceum*

Leccinum brunneo-olivaceum Snell, Dick, & Hesler

Pileus 5-9 cm broad, convex, viscid or subviscid at least in part, glabrous in the center, minutely subtomentose toward the margin, perhaps subtomentose all over at first and becoming glabrous, light brownish olive. Context thick, yellowish, with reddish stains when cut; odor and taste mild.

Tubes nearly free, yellow, unchanging; pores concolorous, subrotund to subangular (small, 2-3 per mm when dried).

Stipe 4-8 cm long, 7-12 mm thick, tapering upwards, furfuraceous-scabrous throughout, subconcolorous or paler, with scurfiness amber to rusty, within yellowish, stained red.

Spores 10-14 × 3.5-4.5 (5) μ, smooth, pale golden yellow when revived in KOH, dingy ochraceous in Melzer's, in face view many slightly ventricose but basic shape subfusoid to oblong, in profile ventricose-inequilateral to obscurely inequilateral with the suprahilar depression most pronounced in the ventricose spores, often "sway-backed" as in some species of *Suillus*.

Basidia 4-spored, 20-28 × 7-10 μ, clavate, very thin-walled and delicate, yellow at first but content soon dissolving in KOH. No pleurocystidia found. Cheilocystidia mostly resembling basidioles. Caulocystidia in patches, 36-62 (70) × 8-18 μ, clavate, subventricose to oval, thin-walled and delicate, soon hyaline from the dissolving of the yellow content in KOH. Pileus cutis a poorly organized layer of cystidiate end-cells 40-70 × 8-15 μ, walls thin and delicate, outline of cell soon becoming obscure even in H_2O mounts. Context and subcuticular hyphae 4-15 μ diam., yellow in KOH but fading, content not distinctive in Melzer's, large oleiferous hyphae present. Clamp connections absent.

In the type the stipes are ochraceous yellow beneath the ornamentation. The soft punky texture of dried specimens is a prominent feature. The species appears related to *L. subglabripes*.

The above microscopic data were taken from the type, kindly loaned us by Dr. Snell.

Leccinum subglabripes (Peck) Singer Fig. 5

Pileus 4.5-10 cm broad, convex becoming broadly convex to plano-convex or broadly umbonate, glabrous, dry to moist, dull, often pitted or somewhat rugose, yellow to ochraceous to clay-color or more rarely dull cinnamon ("warm buff" to "yellow-ocher," "clay-color," "tawny-olive," "ochraceous orange," "buckthorn-brown," or rarely "sayal-brown"); margin flaring at times, entire, often decurved. Context thick (up to 2 cm), firm, whitish to pale yellow, occasionally irregular areas changing to olive-buff or "citron-yellow" in old specimens where damaged, typically unchanging when injured (rarely slightly bluish); odor not distinctive; taste mild to slightly acid, sometimes sweetish.

Tubes deeply and broadly depressed around the stipe, 10-15 mm deep, yellow ("barium-yellow") in sectioned pilei; pores yellow ("citron-yellow" to "sulphur-yellow"), in age wax-yellow to amber-yellow, unchanging when injured, not stuffed when young, small, round, about 2 per mm, many depressed areas present.

Stipe 5-10.5 cm long, 10-20 mm thick, equal to ventricose, tapering slightly toward the base or apex, solid, surface dry, furfuraceous to scabrous or fibrillose, never reticulate, whitish within at the base but pale bright yellow in the remainder, cortex sometimes staining reddish in old basidiocarps, surface pale to bright yellow, occasionally with reddish stains at the base.

Spore deposit olive to olive-ochraceous brown. Spores (10) 11-14 × 3-5 μ, smooth, in face view narrowly fusoid, in profile somewhat narrowly inequilateral, pale greenish-yellow when revived in KOH, merely yellowish in Melzer's, wall less than 0.25 μ thick and showing no evidence of a pore at apex.

Basidia 4-spored, 18-26 × 8-10 μ, clavate, hyaline to yellowish when revived in KOH, yellowish in Melzer's. Pleurocystidia rare to scattered, 32-54 × 8-15 μ, fusoid-ventricose, thin-walled and smooth, apex acute, content hyaline to yellowish when revived in KOH. Cheilocystidia numerous, 20-32 × 8-12 μ, fusoid to fusoid-ventricose, hyaline to yellowish in KOH. Caulohymenium present in patches; caulocystidia clavate to subglobose, 35-60 × 10-30 μ, thin-walled, smooth, soon hyaline.

Hymenophoral trama more or less divergent from a distinct central strand of non-gelatinous hyphae, the diverging hyphae gelatinous, central strand hyaline to brownish in KOH; subhymenium subcellular to indistinct, of hyaline thin-walled cells. Pileus with a compact trichoderm the elements of which have the distal 2-5 cells inflated to sphaerocyst proportions and some so closely packed together as to produce a cellular layer, the cells (6) 10-25 μ diam., more or less isodiametric and with yellow walls as revived in KOH or in Melzer's. Hyphae of the context loosely interwoven, thin-walled, smooth, and yellowish to brownish in Melzer's but content not distinctly colored. Clamp connections absent.

Scattered to gregarious under hardwoods in a mixed forest or in pure stands of hardwoods, late summer and early fall throughout the Great Lakes region, often abundant. Thiers has collected it from Florida, Alabama, Louisiana, Mississippi, and Texas, and, like Singer, noticed that the specimens from the South were not exactly like those from the Great Lakes region.

We debated at some length whether or not to include this species in *Leccinum* since the ornamentation of the stipe is not typical. However, the patches of caulohymenium combined with the anatomy of the trichoderm of the pileus is the important combination of characters. In the dried specimens there is some resemblance to *L. rugosiceps*.

Leccinum rugosiceps (Peck) Singer

Pileus 5-15 cm broad, convex, unpolished, dry to moist but not viscid, uneven to rugulose or pitted, becoming areolate-rimulose in age and then showing the white context in the cracks, orange-yellow to yellow-ocher (duller) and finally some shade of crust brown. Context thick but thinner than the depth of the tubes, pallid yellowish but slowly changing to dull reddish when cut or when bruised in at least some specimens.

Tubes pale bright yellow at first, dingy ochraceous in age, 10 mm or more deep at maturity, depressed around the stipe to free, not changing color when bruised; pores small and round, less than 1 mm diam.

Stipe 8-10 cm long, 2-3 cm thick, fleshy-fibrous, solid, surface reticulate over all and furfuraceous-punctate from a resinous (to the touch) covering, apex pale yellow, pallid orange-yellow over the remainder from the punctae which in age become blackish on the yellow ground color, yellow within, not staining blue anywhere.

Spore deposit not obtained. Spores (14) 16-21 × 5-5.5 μ, smooth, in face view fusoid, in profile elongate-inequilateral, ochraceous when revived in KOH, in Melzer's pale tawny but some finally dark reddish brown over all or over the basal half, the wall slightly thickened.

Basidia 4-spored, 24-30 × 10-12 μ, clavate, yellowish in both KOH and Melzer's, mostly with a homogeneous content. Pleurocystidia 36-48 × 9-13 μ, fusoid-ventricose with more or less obtuse apices, thin-walled, hyaline, smooth, content yellow at first but the pigment diffusing into the mount, not distinctive in either KOH or Melzer's. Cheilocystidia similar to pleurocystidia or with apex more acute, many yellowish in KOH. Caulocystidia 35-70 × 7-15 μ, fusoid-ventricose to mucronate, thin-walled, smooth, content hyaline to yellow-brown as revived in KOH; brachybasidioles also present and intergrading with the caulocystidia.

Hymenophoral trama of the bilateral *Boletus* type, hyphae with yellow content when revived in KOH but pigment diffusing into the mounting medium; subhymenium cellular to filamentous. Pileus trichoderm more or less cellular and consisting of enlarged hyphal cells with the upper 3-6 cells of the element subglobose and the largest 10-25 (30) μ diam., the ultimate and penultimate cells often greatly reduced in size and cystidioid (10-30 × 7-14 μ) or at times almost reduced to a papilla on the end of the trichodermal element, the 3rd and 4th cells back usually the largest, thin-walled, smooth, yellow in KOH but soon fading and in Melzer's with reddish orange to orange-brown content. Context of inflated thin-walled hyphae "empty" as revived in KOH and Melzer's or a few of the hyphae with ochraceous to orange content in Melzer's; oleiferous hyphae occasional, (4) 6-12 (15) μ diam. Clamp connections absent.

Solitary to gregarious in thin grassy oak woods during wet weather in July, August and early September, rare in Michigan but more common southward.

The resinous feel of the stipe immediately separates this species from *L. subglabripes*, and the latter shows no reticulum over the stipe surface. Actually *L. rugosiceps* is most closely related to *L. crocipodium* but differs in its stronger yellow coloration throughout. Singer reported *L. rugosiceps* as common in northern Florida where it is collected for the table. He reported the KOH reaction on the fresh context and tubes as intensely deep golden yellow to golden ferruginous.

Leccinum crocipodium (Letellier) Watling

Pileus 4-7.5 cm broad, obtuse, expanding to convex or the margin finally flaring, the margin obtuse when young, not viscid but with a resinous feel, soon becoming irregularly rimose, very rugulose to pitted, the prominences soon blackish brown, the valleys mottled with pallid where the context shows, on drying the surface blackish with an undertone of yellow. Context pallid to yellowish pallid, soon stained vinaceous gray where cut, finally distinctly vinaceous near apex of stipe, green with $FeSO_4$ and distinctly orange-ochraceous with KOH; odor and taste not distinctive.

Tubes about 10 mm deep, depressed around the stipe, grayish brown in sections ("wood-brown"); pores about 2 per mm, pale olive-ochraceous and staining brown where injured, yellow when dried.

Stipe 5-7 cm long, 10-17 mm at apex, equal to narrowed at base at maturity, solid, olive-buff . and brownish resinous-furfuraceous from discolored glandular papillae, more or less squamulose below and at base scarlet to dull red in at least some American specimens, interior pallid to olive-buff, brown around the larval tunnels, staining vinaceous when cut, cortex yellowish.

Spore deposit honey-yellow. Spores 14-20 × 6-8 (9) μ, smooth, in face view broadly ventricose-fusoid to fusoid, in profile broadly inequilateral, dingy yellow-brown in KOH, more rusty tan in Melzer's but not dextrinoid, wall about 0.5 μ thick when measured in Melzer's but appearing thicker in KOH, apex with a minute pore in some spores but not all.

Basidia 4-spored or some 1-spored (?), (18) 20-28 × 9-13 μ, short-clavate with a broad base or more elongate-clavate with a narrow (3-4 μ) base, hyaline in KOH, yellowish in Melzer's but with no distinctive content in either medium. Pleurocystidia rare, 38-62 × 9-15 μ, thin-walled or wall slightly thickened and distinctly refractive, smooth, hyaline to yellowish in both KOH and Melzer's. Cheilocystidia 18-36 × 6-12 μ, fusoid-ventricose to clavate-mucronate, content dingy yellow-brown in KOH, walls thin to slightly thickened (0.3 μ) and slightly refractive as in the pleurocystidia. Caulocystidia

30-66 × 7-15 (20) μ, narrowly fusoid-ventricose with flexuous neck and often a short narrow subacute to rounded apical extension, or broadly fusoid-ventricose to clavate-mucronate, content hyaline to yellowish and walls slightly thickened and refractive or not as revived in KOH.

Hymenophoral trama with a thin central scarcely gelatinous strand of thin-walled hyphae and from it on either side a slight divergence in the hyphae giving an obscure bilateral effect; subhymenium cellular to filamentose near the tube mouths. Pileus trichoderm of tangled hyphae 8-15 μ diam., the cells of various lengths but some inflated to 20-30 × 14-20 μ, but not forming a chain of subglobose cells near apex as in *L. rugosiceps* although the end-cell is often reduced in size as in that species, content ochraceous brown in KOH and dark dingy orange-brown in Melzer's reagent. Context hyphae beneath the trichoderm with dark brownish orange content as revived in Melzer's. Clamp connections absent.

This species is apparently very rare in North America. Our description was taken from material found at the Ypsilanti Golf Course, Washtenaw County, Mich., Sept. 15, 1961, Smith 64289.

It is readily distinguished from *L. rugosiceps*, the most closely related species, by the width of the spores. The giant spores mentioned by Kallenbach (1926) for *Boletus rimosus* (the name he used for *L. crocipodium*) were also present in the American collection. The width of the spores immediately distinguishes *L. crocipodium* from *L. luteum*. The trichoderm in *L. crocipodium* is not a truly "cellular" layer; in fact in many sections it is difficult to find any globose cells. Dried specimens of the collection cited blackened considerably over the pileus whereas this is not at all true for *L. rugosiceps*. Our material differs slightly from descriptions of European collections in having a more permanent scarlet to dull red stipe-base, the surface of the stipe being more olive-buff than yellow when fresh, and in the lack of yellow in the fresh tubes. The latter is the more significant difference but on drying the tubes of the American specimens became yellow so the apparent differences are not given taxonomic emphasis at this time.

Leccinum luteum sp. nov. Fig. 1

Pileus 3-6.5 cm latus, convexus, demum late obtusus, subviscidus, alveolatus, levis, demum areolate rimosus, pallide luteus demum olivaceo-brunneus; contextus mollis, pallidus tactu vinaceo-griseus. Tubuli pallidi demum ligno-brunnei; pori subolivacei. Stipes 6-13 cm longus, 8-10 mm crassus, deorsum 10-15 mm crassus, pallidus, deorsum demum luteus, atroscabrosus. Sporae 17-20 × 5-6.5 μ, leves. Typus: Smith 73252 (MICH).

Pileus 3-6.5 cm broad, convex to obtuse when young, remaining merely obtuse in age, glabrous, subviscid, alveolate or smooth and even, becoming areolate-rimose, pale yellow, becoming olive-brown in age, on drying becoming nearly date brown, with KOH orange-cinnamon to pale red. Context thin, soft, pallid or flushed yellow near the trichoderm, staining vinaceous gray to avellaneous when sectioned; slowly olive with $FeSO_4$; odor none; taste acidulous or mild.

Tubes ventricose, up to 15 mm deep, deeply depressed around the stipe to nearly free, pallid to pale gray to fuscous; pores pallid when young, on old pilei about 2-3 per mm (small), slowly becoming olive-buff and when injured avellaneous to wood-brown.

Stipe 6-13 cm long, 8-10 mm thick at apex, 10-15 (17) mm at base, nearly equal, pallid and solid, when sectioned the cut surface in the lower portion greenish in places and slowly staining fuscous overall, dark blue with guaiac; surface pallid above, yellow below, ornamentation present as sparse fine blackish points and squamules.

Spore deposit olive-brown. Spores 17-20 × 5-6.5 μ, smooth, no apical differentiation visible or merely a thin spot but no distinct pore, in face view subfusoid, in profile elongate-inequilateral, dull yellow-brown to dingy clay color in KOH, nearer ochraceous tawny in Melzer's but not dextrinoid, wall about 0.5 μ thick as measured in Melzer's, slightly thicker when revived in KOH.

Basidia 18-20 × 10-14 μ near tube mouths, 25-30 × 10-15 μ near pileus context, clavate, content homogeneous in KOH or with a large hyaline globule, merely yellowish in Melzer's but a few with dark yellow-brown granules. Pleurocystidia scattered, 37-52 (75) × 6-10 (12) μ, fusoid to subfusoid with acute to subacute apex, smooth, thin-walled, not encrusted, content when revived in KOH homogeneous and hyaline to pale ochraceous to ochraceous brown, dark yellow-brown (bister) in many when revived in Melzer's. Cheilocystidia like the pleurocystidia but varying to subcylindric or narrowly clavate and mostly with colored content. Caulocystidia mostly fusoid-ventricose with proliferated neck, 50-120 × 10-20 μ, flexuous and many branching once but lacking a cross wall at base of neck, many appear to be flexuous hyphal end-cells with only a slight inflation near the base, both types intergrading, smooth, thin-walled, hyaline to bister when revived in KOH and globules tending to form in some. Caulobasidioles rare and intergrading with caulocystidia. Caulobasidia mostly 2-spored, mostly with yellow-brown content when revived in KOH.

Hymenophoral trama of hyaline, thin-walled, smooth hyphae with a subfloccose central strand and a diverging subgelatinous lateral band of hyphae extending into the subhymenium which is cellular near the tube mouths but hyphal near the pileus trama. Pileus trichoderm very compact, composed of elements in which the 2-4 distal cells in each are inflated to sphaerocyst proportions (10-30 μ) and the walls of which are thin and smooth, the content yellow in

KOH and pale bister in Melzer's but no pigment balls forming. Context of thin-walled hyphae dingy yellowish when revived in KOH or in Melzer's, cells inflated to 10-20 μ. Clamp connections absent.

Scattered under *Carpinus caroliniana* near Highlands, Livingston County, Mich., Aug. 27, 1966, Smith 73252, type.

This species has been found rarely in Michigan since the 1930 decade, but the collection cited above was the best one made to date. It contained all stages of development and enough material was seen to assure the constancy of the characters. The material observed obviously came from several different mycelia. The yellow pileus, the "cellular" cuticle, the KOH reaction of the cells of the trichoderm when fresh, the yellow tint over most of the stipe in age, the color changes in the stipe apex when cut, and the proliferating caulocystidia combined in single bolete are unique.

Boletus crocipodius sensu Heinemann (1961) is close to *L. luteum* but according to Heinemann's account it does not belong in this section and it has yellow, not pallid tubes at first.

Subsection ALBELLA Subsect. nov.

Cuticula pilei cum cellulis subglobosis; tubuli pallidi demum ligno-brunnei.

Type species: *Leccinum albellum* (Peck) Singer

Pileus trichoderm of elements more or less fused into an epithelium by the 2-6 distal cells becoming so closely packed as to obscure the nature of the trichoderm; the young tubes never truly yellow.

KEY TO SPECIES

1. Pileus yellow at first . . . . see *L. luteum*
1. Pileus yellow-brown to fuscous or whitish 2
   2. Context in stipe apex not staining when cut . . . . *L. albellum* & variants
   2. Context staining staining gray and finally blackish . . . . . . *L. griseum*

Leccinum albellum (Peck) Singer f. albellum

Pileus 3-6 cm broad at maturity, convex to acutely convex when young, becoming broadly convex to plano-convex to pulvinate with age, moist to dry, apparently not becoming viscid or subviscid when wet or old, smooth, occasionally appearing pitted with age, glabrous to subvelutinous to somewhat pruinose at times when young, appearing glabrous with age, sometimes remaining subvelutinous, frequently becoming rimose-areolate with age, whitish to pale pinkish-buff to pale olive-buff to pallid, sometimes yellowish during all stages of development, margin incurved but not appendiculate, decurved or finally spreading, entire. Context 1-1.5 cm thick, white, unchanging when injured; odor and taste not distinctive.

Tubes shallowly and typically deeply depressed when young, becoming broadly depressed with age, white when young becoming more or less olive-buff with age, up to 10 mm deep; pores angular, less than 1 mm broad, pallid, unchanging or darkening only slightly with age.

Stipe 5-8 cm long, 0.7-1.1 cm broad at apex, subequal to tapering toward the apex, dry, white to pale olive-buff during all stages of development, when young appearing subtomentose to appressed fibrillose, typically becoming scabrous but often not strongly or conspicuously so with age, scales white when young, typically becoming darker with age or when handled, solid, white within, unchanging.

Spores (10) 15-19.5 (24) × 3.9-6 μ, smooth, in face view cylindric to subfusoid, in profile somewhat elongate-inequilateral, pale yellow when revived in KOH, with a moderately thick wall (-0.5 μ).

Basidia 4-spored, 21-26 × 9-12 μ, clavate, hyaline in KOH. Pleurocystidia scattered to numerous, more abundant near the pores, often difficult to locate in old basidiocarps, hyaline, 30-48 × 7-12 μ, thin-walled, versiform—aciculate, clavate with elongated tapered distal portion, subcylindric or fusoid-ventricose. Hymenophoral trama obscurely divergent to subparallel, hyaline in KOH and Melzer's. Pileus with trichoderm of more or less upright hyphae composed of globose to pyriform cells, these disarticulating with age resulting in a loosely attached layer of thin hyaline vesiculose cells on the surface or these becoming worn away and finally at times in old caps often difficult to locate. Cuticle of stipe differentiated as a layer of loosely interwoven hyphae, the filaments with occasionally upright tips with inflated cells similar to those of the pileus trichoderm, hyaline in KOH and Melzer's. Clamp connections absent.

This is a common species in the Gulf region. We have collections from Alabama, Mississippi, Louisiana, and Texas, and Singer found it in Florida. Peck's type was collected at Sandlake, New York, in August.

Leccinum albellum f. epiphaeum Singer

The following is from Singer's original account in Am. Midl. Nat. 37:120.1947.

"*Pileus* 'buffy olive' or 'citrine drab,' or brownish gray to sordid gray, or areolate-punctate in these colors on white ground because of early disruption of the cuticle under normal weather conditions, rimose-tessellate in old specimens, otherwise as the type form, 40-70 mm broad.—*Hymenophore* grayish cream or gray, otherwise as the type form.—*Stipe* with umbrinous scabrosities all over on white to palest grayish ground, or fuliginous-scabrous only below, and the scales of the apex white, up to 15 mm broad, otherwise as the type.—*Context* white, in the base of the stipe often faintly yellowish, otherwise as the type."

It is known from north Florida from Singer's collections and Alabama from a collection by Thiers.

Leccinum albellum f. reticulatum Murrill in Singer

Pileus 3-6 cm broad, obtuse to convex, broadly convex in age, surface glabrous but deeply alveolate-reticulate, color whitish to very pale avellaneous, the ridges darker avellaneous to wood-brown, subviscid to the touch; margin even. Context white, inky fuscous with $FeSO_4$, with NH_3 no reaction on pileus; odor none; taste slightly sour.

Tubes pale grayish brown, about 10 mm deep, deeply depressed to nearly free; pores whitish, round, 1-2 per mm, not readily staining when bruised, on standing slowly becoming grayish brown.

Stipe 5-8 cm long, 8-10 mm at apex, 10-12 mm at base, equal or evenly enlarged downward, white, solid, white within and not staining when cut, punctate above, ornamentation whitish above, downward avellaneous to gray, the base whitish.

Spores 12-16 (18.5) × 4.5-6 (7) μ, smooth, in face view subfusoid, in profile somewhat inequilateral-elongate, suprahilar depression usually shallow, yellowish to brownish-ochraceous when revived in KOH and yellowish in Melzer's but about one percent showing some degree of dextrinoid reaction, wall slightly thickened but showing no apical differentiation.

Basidia 20-25 × 9-12 μ, 4-spored (some 2-spored), hyaline in KOH, merely yellowish in Melzer's. Pleurocystidia scattered, 25-36 × 9-14 μ, with a narrow neck and subacute apex, content hyaline, thin-walled and smooth. Caulohymenium of cells 20-32 × 8-13 μ, some of which have a hyphal-like short proliferation about 3-4 μ diam. and originating at apex of cell, thin-walled, clavate to fusoid-ventricose, hyaline, no colored or giant cells observed. Hymenophoral trama of very gelatinous hyaline hyphae divergent from a central strand. Pileus with a trichoderm containing elements with cells in chains of 3-6, the cells 12-30 × 8-15 μ and ellipsoid to subglobose but gelatinizing very soon, hyaline in KOH, merely yellowish in Melzer's. Clamp connections absent.

Scattered to solitary in hardwood stands, late summer and fall, in Alabama, Florida, and Massachusetts.

We do not regard our studies of this group as complete since the specimens we have studied fresh were collected before we had worked out the details of speciation for the genus as a whole. Accurate comparisons of the color of the spore deposit in all variants are needed.

Leccinum griseum (Quélet) Singer Fig. 2

Pileus 3-9 cm broad, obtuse to convex becoming broadly convex or with a low broad umbo, at times nearly plane, margin not extending beyond the tubes, glabrous at first and often conspicuously rugulose-pitted, eventually areolate (particularly when dried) as in

Boletus chrysenteron and then the areolae appearing subtomentose, pallid context showing in the cracks, dingy yellow-brown, ("snuff-brown" to "tawny-olive"), in age often olivaceous or pea-green at least in patches. Context very thick and soft, pallid but gradually avellaneous when cut.

Tubes 10-20 mm deep, free or nearly so at maturity, pallid, slowly becoming wood-brown but when bruised staining purplish brown; pores pallid avellaneous but staining greenish when bruised, the stains often slowly becoming dingy yellowish.

Stipe 4-12 cm long, 8-15 mm thick, pallid to avellaneous and densely furfuraceous to scabrous, the ornamentation avellaneous to wood-brown, base of stipe with white appressed mycelium which frequently is stained greenish, solid, pallid within but slowly staining gray when sectioned, drying whitish over the cut surface.

Spore deposit near cinnamon-brown. Spores 11-15 × 4.5-6 μ, smooth, fusoid to subfusoid in face view, in profile inequilateral, the suprahilar depression broad and distinct, ochraceous to dingy ochraceous in KOH, mostly ochraceous but many very dark rusty brown in Melzer's, wall slightly thickened.

Basidia 4-spored, 26-32 × 9-12 μ, hyaline in KOH, yellowish in Melzer's. Pleurocystidia 30-42 × 9-14 μ, fusoid to fusoid-ventricose, with obtuse apex, thin-walled, smooth, content hyaline in KOH and Melzer's. Pileus trichoderm with elements having the upper 2-4 cells inflated to nearly isodiametric and enlarged to 15-35 μ, in older stages the layer appearing pseudoparenchymatous, with a dull brown content when fresh in water mounts, nearly hyaline as revived in KOH or in Melzer's. Clamp connections absent.

Gregarious to scattered in old-growth stands of hardwoods, southeastern Michigan during late summer and early fall after heavy rains. Under the right conditions it is not infrequent.

This is basically a glabrous species tending to become rugose-reticulate, but it becomes very conspicuously areolate in age and on drying, a feature not present in anything like the same degree in other species of this group. No pseudocystidia were found. It differs from *L. carpini* in the flesh not distinctly turning vinaceous when sectioned and in the tubes showing no yellow flush when young. Our use of Quélet's name is tentative, but his description covers the essential features of our bolete. Our concept is not that of Singer (1967).

Subsection PSEUDOSCABRA Subsect. nov.

Hyphae cuticularum cum cellulis saepe ellipsoidiis, subglobosis vel globosis; tubuli pallidi.

Type species: *Leccinum snellii* Smith, Thiers, & Watling, 1967.

The pileus in the species placed in this subsection has a trichoderm in which the hyphal elements maintain their identity as filaments because few of the cells in an individual element inflate markedly. A "scalp" of the pileus does not present a "cellular" appearance under the microscope.

KEY TO SPECIES

1. Stipe apex when cut staining vinaceous and finally gray . . . . *L. subleucophaeum*
1. Color change not progressing to gray or none present 2
   2. Pileus white to pallid or slightly tinged crust brownish on the disc . . . . *L. oxydabile*
   2. Pileus gray to blackish; caulocystidia often with an apical proliferation and a cross wall often present at upper end of ventricose part . . . . *L. snellii*

Leccinum snellii sp. nov. Figs. 3, 4

Pileus 3-9 cm latus, convexus, siccus demum subviscidus, ad centrum fusco-fibrillosus. Tubuli ventricosi, albidi, demum ligno-brunnei; pori tactu sordide ochracei. Stipes 4-11 cm longus, 1-2 cm crassus, deorsum incrassatus, griseo-scabrosus. Sporae (15) 16-22 × 5.5-7.5 μ. Caulocystidia saepe supra parte ventricosa septata. Typus: Smith 72119 (MICH).

Pileus 3-9 cm broad, obtuse to convex, margin sterile at times but not lobed, expanding to plane or with a low umbo, dry but becoming subviscid in age, minutely fibrillose with fuscous brown fibrils, pallid ground showing near margin or rarely almost overall, in age at times with minute spotlike squamules, toward the margin staining yellowish brown where injured. Context thick, firm but very soon soft, blue with $FeSO_4$ and yellow on cutis with KOH but no reaction with NH_4OH; odor slight; taste slightly acid.

Tubes depressed, 10-15 mm deep, becoming ventricose, white becoming wood-brown by maturity; pores small, white becoming grayish by maturity and staining dingy ochraceous as bruised.

Stipe 4-11 cm long, 1-2 cm thick near apex, evenly enlarged downward or equal, ornamented with drab-gray to blackish punctae and squamules to the pallid apex, white ground color showing but obscured over midportion, greenish to yellow to yellowish in some degree over basal area as dried, solid, pallid within, when cut staining pink to dull red, in the lower half caerulean blue in some places, rarely yellowish near the blue stains except where treated with alkali.

Spore deposit between cinnamon-brown and bister when moist, dull cinnamon on drying. Spores (15) 16-22 × 5.5-7.5 μ, smooth, in face view definitely fusoid, in profile inequilateral but the suprahilar depression often shallow, clay-color and tawny singly and in groups respectively as revived in KOH, in Melzer's tan or slowly becoming reddish tawny, wall slightly thickened, apex with a minute hyaline spot but not truncate.

Basidia 22-30 × 10-13 μ, 4-spored, clavate, hyaline in KOH, with 1-2 large oil globules, merely yellowish in Melzer's. Pleurocystidia observed neither in young or old specimens. Cheilocystidia 28-42 × 7-12 μ, fusoid-ventricose, hyaline to dingy brownish ochraceous within. Caulocystidia distinctive (60) 75-150 (250) × 10-20 μ, mostly ventricose but with a long filamentose often flexuous neck 4-6 μ diam. ending in a subacute apex, often septate at the base of the neck, and if septate the filamentous part hyaline, ventricose part with bister content in KOH, these cells occurring in large fascicles with few caulobasidia or caulobasidioles present.

Pileus cutis of appressed fibrils, the constituting cells of the hyphae varying from as long as wide to greatly elongated, the inflated cells 9-25 μ diam., the end-cell clavate to cystidioid and often almost globose, with homogeneous smoky brown content in KOH, near bister and remaining homogeneous or in some cells becoming slightly stringy mounted in Melzer's, hyphal cells appreciably disarticulating by maturity. Subcutis of interwoven subgelatinous hyphae 4-8 μ diam. and merely yellowish in Melzer's, numerous laticiferous hyphae present which are dark brown to blackish brown in Melzer's. Clamp connection absent.

Scattered to gregarious along roads in a slashing through beech, maple, and yellow birch, with much yellow birch reproduction along the roads, Emerson, Michigan, Aug. 17, 1965, Smith 72119, type.

The distinguishing features of this *Leccinum* are the caulocystidia as described, the yellow stains which develop over the pileus margin and the bruised pores, the broad spores, and the almost moniliform appearance of many of the epicuticular hyphae on young caps. The inflated cells of the cuticular hyphae, broader spores, and change to red when bruised or sectioned distinguish the species from *L. flavostipitatum*. *L. oxydabile* Singer is a paler species with different caulocystidia. However, *L. snellii* was one of the species Singer confused with *L. oxydabile* when he was at the University of Michigan Biological Station in 1953. We dedicate this very unusual *Leccinum* to Dr. Walter H. Snell of Brown University in recognition of his years of study of the bolete flora of our northeastern states.

We found no pleurocystidia in our mounts but find it difficult to believe that they are characteristically absent.

Leccinum oxydabile Singer Fig. 8

Pileus 2.5-3 cm broad, convex, the margin fertile and even, white when fresh and young but soon becoming somewhat yellowish to buff to pinkish-buff or pale crust-brown from handling or on aging, appressed fibrillose becoming glabrous but dry to the touch. Context white, when sectioned staining pinkish buff under the subcutis and pale vinaceous in the region of the stipe apex, pea-green to bluish green with $FeSO_4$; odor and taste mild.

Tubes ventricose, about 10 mm deep, depressed to practically free around the stipe, snow-white when young, staining cream-buff after cutting; pores white, minute, staining ochraceous when bruised.

Stipe 6-7 cm long, 8-10 mm at apex, 12-13 mm at base, with very fine ornamentation which is white at first, darkening over the lower two-thirds to avellaneous and on drying yellowish over the basal third, base blue where handled, solid, watery streaked on the cut surface, pallid but slowly staining vinaceous (not becoming gray, however).

Spores 15-21 × 5-6.5 μ, smooth, in face view bluntly fusoid, in profile elongate-inequilateral, suprahilar depression shallow and indistinct, dingy ochraceous and pale tawny singly or in groups respectively as revived in KOH, not changing significantly in Melzer's, wall somewhat thickened and apex with a pallid minute spot but not a true pore.

Basidia 4-spored, 26-32 × 10-13 μ, hyaline in KOH, with globules of various sizes, hyaline in Melzer's. Pleurocystidia scattered, 48-75 × 9-16 μ, fusoid-ventricose with prolonged narrow neck and subacute apex. Cheilocystidia 18-32 × 6-10 μ, subfusoid to subcylindric, smooth, thin-walled, hyaline in KOH. Caulocystidia in fascicles 40-75 × 7-15 μ and narrowly fusoid-ventricose, neck up to 20-30 μ long, also some large clavate to mucronate cells present which measure up to 20 μ wide, content ochraceous brown in KOH. Pileus trichoderm of hyphae 7-15 μ diam., the cells more or less inflated, the end-cells clavate to subglobose, with hyaline to brownish content in KOH and Melzer's. Subcutis of hyaline interwoven subgelatinous (revived in KOH) hyphae and also hyaline in Melzer's. Context hyphae 9-16 μ diam. and hyaline to yellowish as revived in Melzer's. Clamp connections absent.

Two basidiocarps were found under birch near the edge of a road, Emerson, Mich., Aug. 17, 1965, Smith 72257.

This collection is worth recording because in essential details it appears to represent *L. oxydabile* as originally described by Singer. It is pallid becoming somewhat discolored, has the white stipe with grayish ornamentation, the context slowly slightly rubescent, and spores in the 15-17 × 5-6.5 μ range. Singer made no mention of "sphaerocysts" in the pileus trichoderm in his original description, but the cells were given as more than 10 μ broad, and in all his accounts Singer has adhered to the idea that some of the elements of the trichoderm contained greatly inflated cells. The basidiocarps in the cited collection were smaller than average, and Singer did not describe any fusoid caulocystidia. However, these appear to be present to some degree in all members of this group.

Leccinum subleucophaeum Dick & Snell Fig. 6

Pileus 3-10 (15) cm broad, convex or pulvinate, expanding to broadly convex or nearly plane, rarely with a low obtuse umbo, dry and typically obscurely matted-fibrillose with dark appressed hairs or fibrils, becoming almost glabrous in age, margin even, often blackish over disc and grayish toward margin, in age becoming dingy yellow-brown at times. Context thick, white, changing slowly to gray when cut, slowly bluish gray with $FeSO_4$; odor and taste mild.

Tubes adnate becoming deeply depressed, white when young becoming avellaneous to wood-brown, 10-20 mm deep when mature; pores small (about 2 per mm), round, pallid, staining yellowish and then brownish slowly after injury, orange-brown with KOH, blue with $FeSO_4$.

Stipe 5-10 (15) cm long, 10-20 mm thick at apex, clavate becoming equal, white beneath a coating of blackish scabrous points, staining blue to greenish below where handled, solid, white within and typically staining pinkish and then avellaneous to wood-brown when cut, often with a blue line in a longitudinal section of the base.

Spore deposit near cinnamon-brown when moist, near dingy cinnamon when dried. Spores 13-16 (19) × 4.5-6.5 (7) μ, smooth, in face view subfusoid to fusoid, in profile view inequilateral, pale dingy ochraceous-cinnamon in KOH, some becoming dark red-brown in Melzer's, thick-walled.

Basidia 4-spored, 24-30 × 9-11 μ, clavate, hyaline to yellowish in KOH. Pleurocystidia scattered, 34-46 × 9-14 μ, fusoid-ventricose with an elongated often flexuous neck and subacute apex, thin-walled, smooth, reviving poorly, content not distinctive in either KOH or Melzer's; pseudocystidia not observed. Caulocystidia ventricose-subcapitate, 36-60 × 9-16 μ, or clavate and very variable in size. Context hyphae of stipe dull cinnamon in KOH. Pileus with a trichoderm of broad hyphae 6-12 μ diam., with some cells short and inflated to 15-20 μ, with smoky brown content in KOH but paler in Melzer's and lacking amyloid granules or particles. Clamp connections absent.

Solitary to gregarious in the sandy aspen-birch forests of Michigan, common and widely distributed, summer and fall. Apparently it is associated with various species of *Betula*.

Dick and Snell indicated that the cells of the elements of the trichoderm occasionally reached 18 μ broad. There may be two species involved here, as we have material from Priest Lake, Idaho, in which the stipe did not change to reddish first and then gray. The outstanding features of the species as we recognize it at present are the wide spores, the staining of the flesh to gray or finally fuscous, and the tubes staining yellow on the pores when slightly bruised. It is very close to *L. oxydabile* but the latter does not stain gray following the color change to red on cut flesh.

Section SCABRA Sect. nov.

Cuticula pilei cum cellulis tubulosis.

Type species: *Leccinum scabrum* (Fr.) S. F. Gray

In this section are placed those species in which the trichodermal elements of the pileus do not contain markedly inflated cells, the majority being tubular. In some species some of the cells may be constricted slightly at the septum or the cells may actually disarticulate. In the majority of species the trichoderm consists of hyphae with elongated cells 4 times as long as broad or more. In addition to the character of the trichoderm, the pileus margin does not develop a broad sterile band that becomes lobed (crenate) by maturity, though in some species a very narrow inconspicuous sterile band about 1 mm wide may be present. The stipe ornamentation is usually brown to fuscous at maturity.

KEY TO SUBSECTIONS

1. Pileus white, pallid, or tinged pale crust-brown on disc . . . . Subsect. *Pallida*
1. Pileus yellow-brown, gray-brown, to blackish 2
   2. Context in apex of stipe eventually staining gray to fuscous when cut . . . . Subsect. *Fumosa*
   2. Context unchanging or becoming yellow to reddish. . . . Subsect. *Scabra*

Subsection PALLIDA Subsect. nov.

Pileus pallidus vel dilute fulvus.

Type species: *Leccinum holopus* (Rostk.) Watling

The species with white, pallid, or pale crust-brown pilei are placed here but the color should be observed on young or freshly matured basidiocarps as in age some become flushed bluish green or greenish gray. Rarely a few brownish squamules occur over the disc but these do not obscure the ground color.

KEY TO SPECIES

1. Pseudocystidia present in hymenium . . . .*L. olivaceo-pallidum*
1. Pseudocystidia not present in hymenium but leptocystidia present or absent 2
   2. Tubes staining rusty cinnamon when injured; odor strong of radish . . . . see *L. parvulum*
   2. Tubes staining avellaneous to ochraceous or olivaceous; odor when present not raphanoid 3
3. Spores 14-20 × 4-5 μ . . . . *L. angustisporum*
3. Spores 14-19 (26) × 5-6.5 (8) μ 4
   4. Spores 16-26 × 6-7.5 (8) μ (see also *L. variabile*) 5
   4. Spores 14-19 × 5-6.5 μ 6
5. Stipe staining grayish directly when sectioned; under *Populus grandidentata* . . . . *L. proliferum*

5. Stipe unchanging or slightly crust-brown in sectioned apex; in bogs under dwarf birch . . . . *L. rotundifoliae*
   6. Context staining reddish violet-gray or purplish lilac when cut 7
   6. Context slowly staining slightly pinkish to tan when cut 8
7. Tubes staining yellow when bruised lightly; spores 12-19.5 × 4.5-6 (23-40 × 5.5-8 μ) . . . . *L. variabile*
7. Tubes dingy olive-gray when handled; spores 16.3-17.7 × 5.5-6.2 μ . . . . *L. chalybaeum*
   8. Pileus slimy-viscid; sectioned context very slowly changing to pale pinkish tan . . . . *L. glutinopallens*
   8. Pileus dry becoming subviscid; sectioned context staining vinaceous or not staining at all . . . . *L. holopus*

Leccinum olivaceo-pallidum sp. nov. Fig. 7

Pileus 6-9 cm latus, convexus, demum late convexus, pallidus, demum pallide griseo-brunneus; contextus tactu vinaceo-griseus. Tubuli pallidi, subolivacei, tactu vinaceobrunnei; pori subolivacei, tactu vinaceo-brunnei. Stipes 11-14 cm longus, 10-13 mm crassus, solidus, brunneo-scabrosus. Sporae 11-15 × 4-5 μ. Pseudocystidia 3-6 μ diam., subfilamentosa, intus brunneo-granulosa. Typus: Smith 64177 (MICH).

Pileus 6-9 cm broad, convex, the margin at first with narrow sterile flaps of tissue which are inconspicuous and soon obliterated, expanding to broadly convex, dry and unpolished, whitish to "pale olive-buff" when young, becoming grayer in age and slowly dark brown in spots where injured. Context pallid, soon vinaceous gray when cut, pale blue with $FeSO_4$ and giving no reaction with KOH; odor and taste none.

Tubes about 10 mm deep, adnate becoming depressed around the stipe, pallid to olive-buff, staining dingy vinaceous brown when injured; pores small, 2-3 per mm, olive-buff staining vinaceous brown where injured.

Stipe 11-14 cm long, 10-13 mm thick, equal, coarsely scabrous but tips of scales mostly merely discolored dingy brownish (when dried blackish brown), base dingy olive to pallid, remainder dingy pallid beneath the ornamentation, solid, pallid within and staining less than in pileus context, olive in the base and with greenish areas in the cortex but mostly remaining pallid.

Spore deposit near sepia (as taken naturally on a pileus). Spores 11-15 × 4-5 μ, smooth, narrowly fusoid in face view, somewhat inequilateral in profile, the suprahilar depression shallow, dingy ochraceous to ochraceous tan in KOH, dingy tan to ochraceous in Melzer's, only a few becoming dark reddish brown.

Basidia 4-spored, 20-25 × 7-9 μ, clavate, yellowish to hyaline in KOH and Melzer's. Pleurocystidia numerous as filamentous pseudocystidia projecting into the hymenium and with bister amorphous content as seen in both KOH and in Melzer's. Pileus trichoderm matted down, consisting of hyphae 4-7 (10) μ diam., with the end-cells mostly tubular and obtuse. Clamp connections absent.

Under *Populus grandidentata* on sandy soil, in a cluster, Waterloo Recreation Area, Michigan, Sept. 10, 1961, Smith 64177, type.

The tube mouths did not stain yellow as happens in so many of the species in this section, and the spores are narrower than in *L. subleucophaeum*. The distinguishing combination of features is the whitish to olivaceous pileus, general tendency to stain vinaceous brown, the numerous pseudocystidia in the hymenium best demonstrated with KOH or Melzer's, and the lack of inflated elements in the trichoderm of the pileus. The slightly appendiculate margin of the pileus indicates a possible connection to section *Leccinum* but in view of its being poorly developed the species is placed here.

Leccinum angustisporum sp. nov.

Pileus 3-5 cm latus, siccus, convexus, pallidus demum subvinaceus. Tubuli pallidi; pori tactu subochracei vel tarde ligno-brunnei. Stipes circa 7 cm longus, 1 cm crassus, pallidus, minute brunneo-squamulosus. Sporae 14-20 × 4-5 μ. Typus: Smith 71902 (MICH).

Pileus 3-5 cm broad, convex, dry and plush-like to nearly unpolished, vinaceous buff over disc, whitish over margin, when young dull whitish over all, margin irregular but no sterile zone showing. Context white, scarcely changing when sectioned, slowly bluish with $FeSO_4$; odor none; taste mild.

Tubes pallid with whitish pores, depressed around the stipe, staining avellaneous where bruised; pores small, whitish, staining yellowish to brownish and when severely bruised staining wood-brown.

Stipe about 7 cm long and 1 cm thick near apex, whitish and with very fine dark brown punctation, lower part faintly yellowish in places but no blue to blue-green stains present, solid, when sectioned the cortex pinkish tan, fuscous-brown around worm holes, pallid in the base.

Spores 14-20 × 4-4.5 (5) μ, smooth, elongate subfusoid in face view, in profile elongate-subfusoid, the suprahilar depression very shallow and broad (almost absent in some), pale clay-color and tawny singly and in masses respectively when revived in KOH, scarcely changing color in Melzer's, wall very slightly thickened and no apical differentiation discernible.

Basidia 4-spored, 18-26 (35) × 10-14 μ, clavate, hyaline to ochraceous in KOH, with some refractive granular material, yellowish in Melzer's. Pleurocystidia scattered, 38-56 × 9-14 μ, fusoid-ventricose, apex subacute, content hyaline to smoky ochraceous from dissolved pigment. Cheilocystidia mostly resembling basidioles but many more with ochraceous content. Caulocystidia fusoid-ventricose and of two subtypes, 40-70 × 15-25 μ and with relatively short neck, and 45-70 × 8-14 μ with a long tapered neck, both types with smoky ochraceous content and smooth walls. Pileus trichoderm of tangled smooth, thin-walled filaments 5-12 μ diam. with end-cells somewhat cystidioid and hyaline to ochraceous content in KOH and Melzer's, content homogeneous. Subcutis of interwoven hyaline (in both KOH and Melzer's) subgelatinous hyphae 4-7 μ diam. Context hyphae 8-15 μ diam. and strongly orange to orange-red in Melzer's toward the subcutis and paler away from it. Clamp connections absent.

Under birch, St. Ignace, Mich., July 29, 1965, Smith 71902, type.

This species is distinct by reason of the long narrow spores and the unchanging context which slowly becomes fuscous-brown around worm holes. It is most closely related to *L. flavostipitatum* but the spores are longer and the pileus is much paler in color.

Leccinum proliferum sp. nov.

Pileus 4-6 cm latus, convexus, siccus, demum subviscidus, albidus, brunneo-squamulosus; contextus tactu tarde griseus. Tubuli pallidi demum ligno-brunnei. Stipes 4-6 cm longus, 8-11 mm crassus, solidus, albus, tactu tarde griseus, brunneoscabrosus. Spores 18-26 × 6-7.5 μ. Caulocystidia demum circa 200 μ longa, 4-6 μ crassa. Typus: Smith 71726 (MICH).

Pileus 4-6 cm broad, convex becoming broadly convex, surface dry to subviscid, white, spotted with minute brownish appressed squamules, margin even and sterile for about 0.25 mm. Context white, when cut slowly grayish near stipe apex.

Tubes depressed around the stipe, pallid becoming wood-brown and when dried dark yellowish brown.

Stipe 4-6 cm long, 8-11 mm at apex, 12-18 mm at base, pallid overlaid with dull brown ornamentation which blackens on drying, solid, white within, slowly grayish when cut but with no intermediate reddish stage, no yellow stains or tints inside or out as dried.

Spores 18-26 × 6-7.5 μ, smooth, fusoid in face view, inequilateral in profile view, pale cinnamon and dark cinnamon singly and in groups respectively in KOH, becoming reddish cinnamon in Melzer's, wall thickened slightly, apical spot distinct but not a true pore.

Basidia 4-spored, 18-28 × 10-14 μ, yellow in Melzer's, readily gelatinizing in KOH, lacking a large globule when revived in KOH. Pleurocystidia rare, mostly near tube mouths, 33-45 × 8-11 μ, hyaline in KOH. Cheilocystidia 18-50 × 4-11 μ (long and narrow), fusoid-ventricose with acute apex, yellow to hyaline in KOH. Caulocystidia dull ochraceous in KOH, clavate-mucronate to fusoid-ventricose but neck hyphal-like (some branched once or twice), ventricose part 25-40 × 8-15 μ, neck finally up to 200 μ long and 4-6 μ diam., some filamentous elements present in fascicles over lower half of stipe in addition. Pileus trichoderm with elements soon appressed, tubular, 4-10 μ diam., the cells moderately long, walls smooth to inconspicuously roughened, with ochraceous content in KOH and hardly changing in Melzer's, end-cells tubular to slightly enlarged. Subcutis of hyphae 3-5 μ diam., gelatinous, orange to bright ochraceous in Melzer's. Context hyphae not as bright as subcuticular hyphae in Melzer's. Clamp connections absent.

In a swamp under large-toothed aspen (*P. grandidentata*), St. Ignace, Mich., July 7, 1965, Smith 71726, type.

This species is similar in some respects to *L. snellii* but the caulocystidia and the elements of the trichoderm of the pileus separate the two readily.

Leccinum rotundifoliae (Singer) comb. nov. Fig. 9

Krombholzia rotundifoliae Singer, Schw. Zeitschr. Pilzk. 16: 148. 1938.

Pileus 2-6 cm broad, obtuse to convex becoming broadly convex, margin not appendiculate, dry at first and unpolished, becoming somewhat viscid by maturity, white to dull white overall at first, slowly becoming pale buff to pinkish-buff, then cinnamon-buff to dingy clay-color, rimulose in age at times or on drying. Context white, showing no appreciable color change when sectioned and pallid when properly dried, with $FeSO_4$ blue both in pileus and stipe; odor and taste not distinctive.

Tubes 10-15 mm deep, white to olive-buff, slowly becoming pale wood-brown by maturity, unchanging when cut or bruised; pores small, 2-3 per mm, whitish becoming avellaneous.

Stipe 4-10 cm long, 5-12 mm at apex, equal or nearly so, white and roughened from a white scabrosity which slowly becomes brown like the pileus but was never seen to become blackish, solid, white within when cut, soon greenish blue in the base and brownish in the apex, as dried with a faint yellow tone over basal half in some.

Spores 16-20 (25) × 5.5-7.5 (8) μ, smooth, narrowly subfusoid to elongate-subovate in face view, very obscurely inequilateral in profile, the suprahilar depression often very indistinct, pale ochraceous to brownish ochraceous in KOH, many soon becoming dextrinoid in Melzer's, wall thickened slightly, no distinct pore present.

Basidia 4-spored, hyaline to yellow in KOH, 23-28 × 9-13 μ. Pleurocystidia 28-36 × 8-14 μ, more or less fusoid-ventricose, hyaline or nearly so. Caulocystidia versiform but mostly fusoid-ventricose, 32-60 × 8-12 μ, the neck tapered and flexuous or irregular in outline, ending in an acute to subacute apex, with lemon-yellow content in KOH. Pileus trichoderm consisting of tangled mostly thin-walled flexuous narrow hyphae with hyphal ends 3-5 μ diam., subgelatinous in KOH, with yellow-brown content and often flexuous, the tips of the cells obtuse to subcapitate, merely dull yellowish to orange-buff in Melzer's. Context hyphae 8-15 μ diam., with "colloidal" content in KOH causing them to be very boldly defined as seen under the microscope, hyaline in KOH but in Melzer's reddish to brownish red and color located in the content which remains homogeneous. Clamp connections absent.

Scattered in a cold sphagnum bog near dwarf birch, Warren, Idaho, 30 August, 1962, Smith 66296. It is apparently common in Canada.

This is one of the truly distinctive species of *Leccinum*, as Groves (1955) has indicated. The narrow elements of the trichoderm contrast strongly both in KOH and in Melzer's with the context hyphae. It is distinct from *L. scabrum* in the consistently paler pileus, the paler stipe ornamentation, the context hyphae which are red in Melzer's, and the caulocystidia which are lemon-yellow in KOH.

Leccinum chalybaeum Singer

Pileus 4.2-8.4 cm broad, pulvinate becoming more or less applanate, more or less distinctly viscid in wet weather, slightly shining when dry, glabrous or subtomentose, pale buff when young ("pinkish-buff" to "cinnamon") becoming dingy yellow-brown, margin often tinged caesius or this showing in the surface cracks and frequently in part greenish blue. Context white becoming reddish-violet-gray or purplish-lilac ("dark vinaceous-gray") when bruised, eventually becoming blackish, at first firm, then soft and watery, fibrous and hard in lower part of stipe; green with $FeSO_4$ and red with formalin; odor none; taste mild.

Tubes whitish becoming weakly yellowish, deeply depressed around stipe, convex beneath, up to 14 mm deep; pores concolorous but becoming dingy olive-gray when handled, small to very small, deep reddish brown with alkali.

Stipe 4-6.5 cm long, 1.3-2.1 mm thick, solid, subequal, with a very slightly attenuate apex, or ventricose or tapered upward from the base, white becoming sordid, beset with white scabrosities at apex, squamules pale brown to darker brown below, dry.

Spore deposit olive-brown. Spores 16.3-17.7 × 5.5-6.2 μ, melleous brown, fusoid, with thin or slightly thickened walls.

Basidia 28-34 × 9-14 μ, 4-spored. Pleurocystidia 31-51 × 6-11 μ, hyaline, fusoid, thin-walled, rather numerous near pores. Hymenophoral trama bilateral. Pileus trichoderm consisting of intricately interwoven smooth, filamentous brownish to hyaline hyphae 4-10 μ diam., not arranged in erect chains. Caulocystidia 38-82 × 6.2-16.2 μ, fusoid to fusoid-ampullaceous, thin-walled or wall up to 0.7 μ thick; basidioles small, hyaline to faintly pigmented.

In gardens, open woods, and flatwoods with *Quercus* on sandy ground or on humus, solitary or in small groups mostly in July.

Our data are taken from Singer's original account. The species, with its colors as described, its color change when sectioned, and southern distribution, is readily distinct.

Leccinum variabile sp. nov. Fig. 10

Pileus 3-5 cm latus, convexus, siccus, impolitus, pallidus, demum pallide avellaneus. Contextus pallidus tactu vinaceo-griseus. Tubuli 10 mm altis, pallidis demum luteolis. Stipes 8-12 cm longus, 10-15 mm crassus, albidus, subscabrosus, intus tactu vinaceo-brunneus vel violaceus. Sporae 12-19.5 × 4.5-6 (23-40 × 5.5-8 μ). Typus: Smith 66784 (MICH).

Pileus 3-5 cm broad, convex with an incurved margin, dry and unpolished, no fibrils or squamules visible to naked eye, whitish ("tilleul-buff") varying to pale avellaneous (grayish). Context pallid, thick, firm when young, when sectioned staining reddish then avellaneous and finally violaceous, slightly bluish with $FeSO_4$; taste slightly acrid to mild.

Tubes about 10 mm deep, pallid to yellowish, depressed around stipe; pores pallid at first, staining yellow when bruised.

Stipe 8-12 cm long, about 10-15 mm thick, equal or nearly so, white and furfuraceous when young, ornamentation merely brownish at maturity, solid, white within, staining reddish then avellaneous to violaceous when sectioned.

Spores 12-19.5 × 4.5-6 (23-40 × 5.5-8 μ), smooth, in face view typically obscurely fusoid, somewhat inequilateral-elongate in profile, pale tawny when revived in KOH, slightly more cinnamon in Melzer's or occasionally dextrinoid, with moderately thickened wall, lacking a germ pore.

Basidia typically 4-spored but some 1-spored, 26-30 × 9-12 μ, clavate, hyaline to yellow-brown in KOH, yellowish in Melzer's. Pleurocystidia 38-50 × 7-14 μ, fusoid-ventricose with elongated neck and obtuse apex, scattered, hyaline or with yellowish content when revived in KOH; oleiferous hyphae present and often with brown pigment. Caulocystidia 40-65 × 13-15 μ, fusoid-ventricose with a short or elongate neck and subacute to obtuse apex, yellow-brown in KOH. Hymenophoral trama bilateral from a central strand. Pileus trichoderm poorly developed, consisting of appressed readily disarticulating interwoven hyphae with hyaline to pale yellow content in KOH, cells often constricted at the septa, 7-12 μ diam., the end-cells equal in width throughout and rounded at apex, smooth and thin-walled, content when colored merely dingy orange-buff and homogeneous to granular in Melzer's. Clamp connections absent.

Gregarious under *Fraxinus* in a bog, west of Rose City, Mich., July 16, 1963, coll. C. Bas (Smith 66784), type.

This species is closest to *L. chalybaeum* but has a paler less intensely colored pileus, yellow staining pores and a bluish $FeSO_4$

reaction. A similar degree of variability in spore size was encountered in *L. solheimii*. In the weak yellowish tint developed by the tubes as they mature it resembles *L. chalybaeum*. It is readily distinguished from *L. holopus* by the flesh changing to violaceous.

Leccinum glutinopallens sp. nov.

Pileus 6-7 cm latus, convexus, glaber, glutinosus, pallidus; contextus tactu tarde incarnato-cinnamomeus. Tubuli griseo-pallidi, demum ligno-brunnei tactu avellanei. Stipes 6-8 cm longus, 10-15 mm crassus, subclavatus, pallidus, pallide subscabrosus. Sporae 15-19 × 5-6.5 μ. Typus: Smith 71905 (MICH).

Pileus 6-7 cm broad, broadly convex, margin even, glabrous, slimy-viscid, pallid along the margin, dingy vinaceous-buff over disc, margin even and fertile. Context very soft, white, when cut slowly staining pinkish tan, with a bluish green line developing above the tubes by maturity, pale bluish with $FeSO_4$ and orange-tan in Melzer's.

Tubes about 15 mm deep, ventricose and nearly free, wood-brown or darker at maturity, pores small and round, grayish pallid, when bruised staining avellaneous or finally dingy brown.

Stipe 6-8 cm long, 10-15 mm thick, equal to clavate at base, pallid becoming variously stained pinkish tan from handling, very minutely ornamented by fine points and streaks, the ornamentation pallid at first becoming pinkish-tan or slightly darker, solid, pallid within and when sectioned soon stained vinaceous-tan and here and there greenish blue.

Spores 15-19 × 5-6.5 μ, smooth, in face view broadly fusoid, in profile inequilateral with a distinct suprahilar depression, pale ochraceous tawny individually in KOH, pale tan in Melzer's but some becoming reddish tawny, wall about 0.5 μ thick, no apical pore observed.

Basidia 4-spored, 20-25 × 10-14 μ, clavate, hyaline in KOH. Pleurocystidia 38-56 × 11-16 μ, fusoid-ventricose, apices subacute, content hyaline to pale smoky ochraceous. Cheilocystidia basidiole-like to somewhat fusoid. Caulocystidia the usual mixture of large and small fusoid-ventricose cells with smooth walls or with some adhering debris, the content pale ochraceous as revived in KOH, in Melzer's dingy yellowish. Pileus trichoderm a tangled layer of gelatinous smooth-walled hyphae 4-8 μ diam., the cells mostly 30-300 μ long, hyaline to yellowish in KOH, the cells disarticulating and the end-cells tubular to somewhat cystidioid with hyaline to weakly ochraceous content in Melzer's or in some hyphae with darker granular material. Subcutis and context hyphae adjacent to it lacking distinctively colored contents revived in Melzer's. Clamp connections absent.

Along an old logging road in a mixed woods of birch, aspen, balsam, and spruce. Sugar Island, Mich., July 31, 1965, Smith 71905, type.

This is a slimy-viscid pallid bolete with very fine inconspicuous stipe ornamentation. It is close to *L. holopus* but differs in a more prominently slimy-viscid pileus, avellaneous staining pores, and a stipe that discolors pinkish-tan from handling.

Leccinum holopus (Rostk.) Watling Fig. 11

Pileus 3-10 cm broad, pulvinate to convex, becoming broadly convex or nearly flat, margin often exceeding the tubes by 0.5 mm; surface soft and tacky to the touch (subviscid) in age or when wet, typically glabrous and unpolished but some areolate over the disc or with streaks of fibrils, dull white when young, becoming vinaceous-buff to avellaneous and in age often with a pea-green flush overall or only along the margin. Context thick, white, soft, when sectioned staining pink to vinaceous or not staining, finally often vinaceous-brown around larval tunnels; odor none; taste acid.

Tubes 1-2.5 cm deep, adnate but soon deeply depressed around the stipe, pallid to pale olive-buff, in age wood-brown; pores whitish becoming brownish as spores mature, when bruised staining yellow and then brown.

Stipe 8-14 cm long, 1-2 cm thick, equal or nearly so, staining pink in apex when cut; surface pallid, ornamented with squamules which become brownish (rarely blackish), apex merely scurfy and remaining pallid a long time, greenish to bluish in the base of the stipe when mature.

Spore deposit about cinnamon-brown. Spores 14-20 × 5-6.5 μ, smooth, subfusoid in face view, narrowly inequilateral in profile, pale dingy cinnamon to ochraceous cinnamon when revived in KOH, yellowish in Melzer's when immature and dark reddish brown when mature, wall slightly thickened, no apical pore evident.

Basidia 4-spored, 26-32 × 8-11 μ, clavate with hyaline to pale cinnamon content in KOH, yellowish in Melzer's. Pleurocystidia scattered to rare, fusoid-ventricose, 28-36 × 9-12 μ, almost imbedded in hymenium, content not distinctive in either KOH or Melzer's, no pseudocystidia present. Caulocystidia mostly the fusoid-ventricose type with elongate somewhat flexuous necks and subacute apex; clavate cells also present. Pileus trichoderm appearing as an interwoven layer of subgelatinous hyphae 4-7 μ diam., thin-walled, content hyaline or in a few smoky yellowish as revived in KOH, content reddish in Melzer's in some; end-cells tubular to somewhat cystidioid with obtuse apex. Clamp connections absent.

Scattered to solitary in cold bogs, cedar swamps, and the like, common from Bay City north in Michigan and in northern and eastern North America generally and Canada.

There are apparently two variants in this species, one which turns pinkish slightly when sectioned and one which is unchanging. These need further study. As usually happens, one does not take careful notes on the common species, and when a critical study is attempted, one finds himself lacking data he should have had. There is no question but that in Europe the unchanging form is the typical one. In the Michigan form the older pilei show disarticulation of the cells of the trichodermal hyphae, and the hyphal walls finally become minutely roughened.

Subsection SCABRA

In this subsection are grouped the species with yellow-brown to fuscous brown or blackish pilei in which the sectioned context does not stain gray readily. However, nearly all species show a change to blue or greenish in some part of the stipe and some show a change to pink or red in addition, and some a change to yellow.

Type species: *Leccinum scabrum* (Fr.) S. F. Gray

KEY TO SPECIES

1. Spores 10-15 × 3.5-4.8 μ; stipe usually becoming yellowish over a considerable area . . . . *L. flavostipitatum*
1. Spores wider or stipe not yellow as in above choice 2
   2. Odor strongly raphanoid; pores staining rusty cinnamon . . . . *L. parvulum*
   2. Odor not distinctive; pores merely staining yellow or unchanging when bruised . . . . *L. scabrum* & variants

Leccinum flavostipitatum Dick & Snell

Pileus 6-10 cm broad, very minutely reticulately fibrillose, the disc later subglabrous or glabrous, gray, dark gray, brownish, or blackish gray, occasionally with tinges of greenish. Context dingy white changing very slowly to pale salmon-pink or to bright blue-green quickly when wet.

Tubes depressed to free, very dingy white or dirty yellowish-white, quite long; pores concolorous.

Stipe up to 11 cm long, 1-2 cm thick, enlarged at apex and base, faintly black, subscabrous or faintly concolorous-reticulate here and there, but mostly reticulately torn or brown- to black fibrillose-subreticulate-scabrous, usually pale yellow, occasionally more grayish or dingy whitish, drying bright yellow, often with spots or areas of blue-green at the base, dingy whitish to dingy tan within, the cortex variously coloring with some pinkish, pale yellow or blue-green, the base a deeper dingy tan with greenish-blue areas especially when wet.

Spore deposit dark olive-buff. Spores 9.6-14 (16.5) × 3.5-4.8 μ (mostly 9.6-14 × 3.8-4.2 μ). Mycelium white, slowly turning to very pale salmony pink.

In stands of *Picea glauca*, Nova Scotia.

The above data are from the original description. The following are our notes on a Michigan collection:

Pileus 6 cm broad, convex, subgranulose but tacky (after a rain), dull gray brown, in drying becoming dingy dark yellow-brown, with a slight sterile margin less than 1 mm broad but remaining even. Context white, when cut slowly pinkish in apex of stipe but yellowish to pale tan in the base, drying yellowish, becoming dingy olive with $FeSO_4$.

Tubes pallid becoming wood-brown and drying near "tawny olive" (a dark yellow-brown), about 15 mm deep, depressed around the stipe; pores minute, pallid, staining yellow when bruised.

Stipe 7 cm long, 13 mm at apex, solid, enlarged below, pallid to yellowish beneath the blackish ornamentation which is coarser downward but the paler ground color readily visible; context changing as in the pileus when sectioned.

Spores 12-16 × 4-5 μ, smooth, ochraceous in KOH, becoming reddish tawny in Melzer's, narrowly subfusoid in face view, obscurely inequilateral in profile, wall scarcely thickened but an apical spot evident.

Basidia 4-spored, 26-32 (40) × 9-12 μ, pedicellate-clavate, hyaline in KOH, seldom with a large internal refractive globule. Pleurocystidia scattered, 36-52 × 7-12 μ, ventricose part elongated, tapered to narrow neck, apex subacute to acute, pedicel often 2-2.5 μ diam. and with hyaline content. Cheilocystidia abundant, 18-32 × 4-9 μ, narrowly clavate to subfusoid, or more rarely resembling pleurocystidia and usually with ochraceous content. Caulocystidia versiform, clavate and up to 18 μ diam., clavate-mucronate or fusoid-ventricose, with a short often flexuous neck and smoky ochraceous content, both small (26-35 × 8-11 μ) and large (40-65 × 12-18 μ) types present. Pileus trichoderm of smooth hyphae 5-12 (15) μ diam., the cells of which readily disarticulate and some of which are more or less inflated, end-cells subfusoid to bullet-shaped (if short) and with dingy yellow-brown content in KOH, dull brownish and granular in Melzer's. Subcutis of interwoven hyphae 4-8 μ diam., subgelatinous, orange-red when revived in Melzer's. Context hyphae 9-15 μ diam., orange-red when revived in Melzer's in the area next to the subcutis, paler away from it. Clamp connections absent.

Under *Betula lutea*, Huron Mountain Club, Big Bay, Mich., June 17, 1963, Smith 66637.

Through the courtesy of Dr. Walter H. Snell the type has been examined. The following are our notes:

The pilei have dried pale gray for the most part, and the stipe nearly lemon yellow with blackish streaks from the matted down ornamentation.

Spores 13-17 × 3.8-5 μ, smooth, weakly yellow in KOH, dingy ochraceous in Melzer's, in face view narrowly fusoid to subfusoid, in profile narrowly inequilateral, wall thin (-0.25 μ), apical differentiation none. Basidia 20-26 (32) × 7-11 μ, clavate, hyaline, 4-spored. Pleurocystidia not found. Cheilocystidia like small basidioles and discolored brownish. Caulocystidia in fascicles, 40-80 × 12-20 μ, thin-walled, smooth, empty, clavate to fusoid-ventricose, many smaller cystidia and basidioles also present; cortex hyphae of stipe lemon-yellow in KOH. Pileus cuticle a layer of interwoven hyphae 4-10 μ diam., with thin smooth walls and bister content in KOH and Melzer's, becoming granular in the latter medium but not forming pigment balls, very few short scarcely inflated cells present, terminal cell cylindric to narrowly cystidioid. Subcutis of hyaline subgelatinous hyphae 4-12 μ broad, these and context hyphae hyaline in KOH also, both scarcely yellow in Melzer's. Clamp connections absent.

Smith 66637 apparently represents a distinct taxon since the cells of the pileus trichoderm disarticulated and in it the subcutis hyphae and those of the context were orange-red in Melzer's. In the dried condition the stipes are scarcely yellow. There is also a difference in the associated tree species, but with only one fruit body available of Smith's collection a comparison there is hardly justified.

Leccinum parvulum sp. nov.

Pileus 2.5-3.5 cm latus, late umbonatus, viscidus, pallidus; odor raphanaceus. Tubuli sordide cinnamomei; pori tactu fulvo-cinnamomei. Stipes 6-8 cm longus, 7-9 mm crassus, tactu ligno-brunneus, cinnamomeo-scabrosus. Sporae 14-17 × 4.5-5.5 (6) μ, in cumulo sordide cinnamomeae. Typus: Smith 71534 (MICH).

Pileus 2.5-3.5 cm broad, obtuse, expanding to broadly umbonate, viscid, pallid when very young, soon becoming pale tan (dull "pinkish-cinnamon" to "pinkish-buff"), in some specimens pallid beneath minute pinkish-buff areolae and hence giving a somewhat mottled appearance but some remaining perfectly even. Context firm but soon soft, white, unchanging when cut in young material, in old ones slowly changing to near wood-brown, slowly and weakly olive with $FeSO_4$, slowly brownish with KOH; odor strong of radish but taste mild.

Tubes 1 cm deep, dull cinnamon when mature ("sayal-brown"), adnate at first, becoming nearly free from stipe; pores minute, dull cinnamon staining rusty cinnamon where injured.

Stipe 6-8 cm long, 7-9 mm at apex, up to 12 mm at base, with a napiform bulb (pointed below), ornamented with dingy cinnamon scabrosities which do not darken in age, solid, white within but slowly becoming dingy wood-brown when cut.

Spore deposit dull cinnamon ("sayal-brown"). Spores 14-17 × 4.5-5.5 (6) μ, smooth, pale tawny in KOH, duller in Melzer's, narrowly suboblong to obscurely fusoid in face view, in profile obscurely inequilateral from a shallow broad suprahilar depression, wall only slightly thickened and no apical differentiation evident.

Basidia 4-spored, 18-23 × 8-9 μ, clavate, very soon gelatinizing. Pleurocystidia scattered to rare, 36-45 × 9-15 μ, fusoid-ventricose, apex subacute, hyaline in KOH and in Melzer's. Caulocystidia smooth, clavate and up to 40 × 18 μ, broadly fusoid-ventricose and 40-60 × 15-22 μ or elongate and up to 70 × 15 μ, content mostly hyaline in KOH but in some pale ochraceous. Pileus trichoderm of appressed tangled smooth hyphae 5-11 μ diam., with homogeneous yellow-brown content in KOH (near "argus brown"), often only the terminal cell colored, some terminal cells bullet-shaped and with granular to somewhat stringy content in Melzer's but not with globules. Subcutis of hyphae which are hyaline in KOH, interwoven, subgelatinous, and orange-ochraceous in Melzer's. Hyphae of context with homogeneous reddish orange content when revived in Melzer's. Clamp connections absent.

Scattered under oak and pine, Douglas Lake, Cheboygan County, Mich., June 23, 1965, Smith 71534, type.

This species is outstanding because of its dull cinnamon spores, tubes dull cinnamon, the rusty cinnamon stains on the pores, and the dull cinnamon stipe ornamentation along with the strong raphanoid odor. This taxon appears to be isolated in its combination of characters and is placed here tentatively. The wood-brown stains are slow to develop.

Leccinum scabrum (Fr.) S. F. Gray f. scabrum Fig. 12

Pileus 4-10 cm broad, pulvinate to broadly convex, margin even and scarcely projecting beyond the tubes, moist to dry or when wet fairly viscid, glabrous and often with depressions in age, grayish brown to dull yellow-brown and often flushed olivaceous in age. Context white, when cut not staining or slowly slightly brownish (near "pinkish buff"); odor and taste mild.

Tubes 8-15 mm deep, pallid, slowly becoming wood-brown as spores mature, depressed deeply around the stipe; pores small, pallid then concolorous with the sides and either not staining when bruised or staining yellow.

Stipe 7-12 (15) cm long, 7-12 (16) mm thick above, evenly enlarged downward, with dark brown to blackish punctae or nearly reticulate to squamulose, the pallid ground color visible, solid, white within, slowly staining pinkish to brownish in cortex when sectioned, and also developing both blue and red stains in restricted areas especially if wet.

Spores 15-19 × 5-7 μ, smooth, subfusoid in face view, in profile ventricose-inequilateral to elongate-inequilateral, often with a pronounced suprahilar depression, pale tawny singly and darker in groups when revived in KOH, pale tawny in Melzer's, wall thickened to about 0.5 μ as measured in KOH mounts.

Basidia 4-spored, 11-13 μ broad, hyaline in KOH and yellowish in Melzer's. Pleurocystidia not observed. Caulocystidia mostly clavate, 32-46 × 9-16 μ, with smoky ochraceous content in KOH, some with an apical protrusion causing cell to be clavate-mucronate and a few varying to fusoid-ventricose. Pileus trichoderm a tangled layer of floccose hyphae 6-12 (15) μ diam. above a subgelatinous subcutis, their content smoky-ochraceous in KOH and with a grayer shadow in Melzer's but content remaining granular to homogeneous, wall at first seen to be enveloped in an outer gelatinous matrix as observed in both KOH and in Melzer's, the layer or matrix of irregular extent and thickness but at times enveloping two adjacent hyphae, this material slowly dissolving in KOH, at times a few short slightly inflated cells observed. Clamp connections absent.

The description is of a collection by Victor Potter, Brough's woods, Edgewood, Mich., Oct. 16, 1959, Potter 12595.

We apparently have a series of variants grouped here but whether they deserve taxonomic recognition is a problem still to be solved. Characters of possible value are the staining of the pores to yellow, as contrasted to pores not staining, the shape of the terminal cell of the trichodermal elements, which seems to be rather variable, and the degree to which the context of pileus and stipe change color when basidiocarps are sectioned.

Leccinum scabrum f. coloratipes (Singer) Singer

Pileus about 6 cm broad, convex, slimy viscid, olive-gray, margin even. Context pallid, when sectioned unchanging. Pores gray, staining yellow when bruised. Stipe flushed red beneath fine brown ornamentation in lower part and with very fine ornamentation above, becoming distinctly ochraceous on drying; context pallid becoming yellow in midportion when sectioned and cinnabar-red near base.

Spores 14-18 × 5-6 (6.5) μ. Caulocystidia both fusoid-ventricose and clavate-mucronate to clavate, extremely variable in size. Pileus trichoderm of narrow hyphae 3-8 μ diam., the end-cells not appreciably enlarged though generally narrowly clavate to fusoid. Subcutis of narrow highly gelatinous hyphae, yellowish hyaline in Melzer's. Context hyphae yellow in Melzer's. Clamp connections absent.

Under white birch and aspen, Douglas Lake, Mich., Oct. 1, 1965, Smith 72749.

The above are notes from a single basidiocarp. The degree of variation in the color changes of the context of pileus and stipe when sectioned in various basidiocarps assigned here indicates that Singer's (1967) proposed disposition of the taxon is entirely correct. The specimen described above does not check with his account perfectly since in it the stipe base was red instead of yellow, but it did turn yellow in drying. The Michigan collection agrees with European collections assigned to this form by the third author.

Subsect. FUMOSA Subsect. nov.

Contextus tactu griseus vel fuscus.

Type species: *Leccinum olivaceo-glutinosum* Smith, Thiers, & Watling

Species of this section have the pileus well colored brown to gray or blackish and the context staining gray to fuscous on sectioned basidiocarps.

KEY TO SPECIES

1. Odor strongly raphanoid . . . . see *L. parvulum*
1. Odor mild and not distinctive 2
   2. Stipe entirely gray (including ground color); spores 13-16.5 × 4-5 μ . . . . *L. murinaceo-stipitatum*
   2. Stipe showing pallid ground color beneath ornamentation 3
3. Pileus slimy-viscid; caulocystidia often with proliferated corkscrew-like neck . . . . *L. olivaceo-glutinosum*
3. Not as above 4
   4. Spores 4-5.5 μ wide . . . . *L. griseonigrum*
   4. Spores (5) 5.5-6.5 (7) μ wide . . . . see *L. subleucophaeum*

Leccinum murinaceo-stipitatum sp. nov.

Pileus 8-12 cm latus, convexus, glaber, viscidus, cinnamomeo-brunneus vel subfuscus. Contextus albidus, tactu vinaceus demum fuscus. Tubuli albidi, demum olivaceo-pallidi. Stipes 5-10 cm longus, ad apicem 1-2 cm crassus, deorsum 2.5-3 cm crassus, intus tactu vinaceus demum fuscus, extus murinus sed ad basin albidus, scabrosus. Sporae 13-16.5 × 4-5 μ. Typus: Smith 71909 (MICH).

Pileus 8-12 cm broad, obtuse to convex, margin even, glabrous, viscid, in appearance subgranulose when perfectly young and fresh, dark cinnamon-brown with a grayish overcast, appearing blackish brown to the naked eye when fresh and fuscous as dried, extreme margin at times dull yellow-brown. Context when young and fresh hard, becoming soft by maturity or on aging, white, staining slowly to pinkish then avellaneous and finally fuscous when cut, slowly olive-gray to bluish with $FeSO_4$; odor and taste mild.

Tubes 1-1.5 cm deep, depressed around the stipe, whitish becoming olive-pallid and then finally dark wood-brown; pores small, round, olivaceous-pallid staining dull olivaceous if bruised lightly and vinaceous-buff when severely bruised.

Stipe 5-10 cm long, 2.5-3 cm thick in basal part, 1-2 cm at apex, drab to cinereous over all except the buried base which is whitish, the color caused by the combined effect of colored ground hyphae as well as colored ornamentation, the apex with gray ridges, not staining when handled but in drying a few yellowish areas show on the pallid ground color at or near the base, solid, white within, at the apex staining vinaceous to fuscous on cutting.

Spores 13-16.5 × 4-5 μ, smooth, pale clay-color singly and pale tawny in groups respectively as revived in KOH, pale tawny revived in Melzer's, narrowly subfusoid in face view, obscurely elongate-inequilateral in profile, the suprahilar depression obscure, wall only slightly thickened and with no apical differentiation.

Basidia 4-spored, 20-26 × 10-12 μ, clavate, hyaline and usually with a large oil drop when revived in KOH. Pleurocystidia variable, essentially fusoid-ventricose, 50-70 × 9-13 μ, near the pores 30-45 × 7-11 μ and here also may be found scattered filaments resembling pseudocystidia but which lack granular content, content of all types hyaline to ochraceous. Cheilocystidia clavate to fusoid-ventricose, 20-34 × 6-10 μ, brighter ochraceous than pleurocystidia when revived in KOH. Caulocystidia 40-90 × 9-22 μ, fusoid-ventricose to ventricose-mucronate, with pale smoky brown content in KOH, typically with a proliferated neck. Caulobasidia mostly 7-9 μ broad, narrower than hymenial basidia and with colored to hyaline content. Hyphae of the trichoderm of the pileus of tubular thin-walled often disarticulating cells 5-12 μ diam. or some cells near or including the terminal cell somewhat inflated, walls mostly smooth but some with incrusting pigment and on standing in KOH there is a tendency for blisters to develop on the outer wall, with smoky brown content in KOH and near bister in Melzer's and in this medium also showing a tendency to form globules or become stringy, terminal cells cystidioid and those on the broadest hyphae somewhat bullet-shaped. Context hyphae below the subcutis yellow or orange-red in Melzer's from the colored homogeneous content. Clamp connections absent.

In mixed woods, birch present, Sugar Island, Mich., July 31, 1965, Smith 71909, type.

This species differs from *L. subleucophaeum* in narrower spores even if the color of the stipe is disregarded. The colored pigment incrusting some of the epicuticular hyphae is possibly significant at the species level; it is certainly unusual in the genus. In *L. griseonigrum* the pores stained yellowish instead of olive, the pallid ground color of the stipe was readily visible, and no red stage was observed in the change of the flesh to gray or fuscous.

Leccinum griseonigrum sp. nov. Fig. 13

Pileus 4-9 cm latus, pulvinatus, obscure fibrillosus demum subareolatus, fuscus; contextus tactu violaceo-griseus. Tubuli albidi demum ligno-brunnei; pori tactu ochracei. Stipes 5-11 cm longus, 1-1.7 cm crassus, griseo-scabrosus, intus albus tactu fuscus. Sporae 13-16 (17) × 4-5.5 μ. Typus: Smith 72469 (MICH).

Pileus 4-9 cm broad, pulvinate becoming convex, margin even and fertile, but at first slightly incurved, obscurely fibrillose when young becoming subgranular, nearly glabrous before becoming areolate, bluish black to bluish umber, slowly becoming paler to avellaneous or a dingy cinnamon-buff. Context white, slowly changing to blue in places when cut and in age changing to violaceous gray, with $FeSO_4$ bluish pallid, yellow on blue or green areas with KOH; odor and taste not distinctive.

Tubes 10-20 mm deep, sharply depressed around the stipe, white when young, wood-brown in age, slightly pinkish when cut; pores minute and pallid, staining wood-brown when severely bruised but if lightly bruised staining yellowish.

Stipe 5-11 cm long, 1-1.7 cm at apex, more or less equal, crooked at base, finely ornamented with brown to dark gray squamules and points, solid, pallid within but wood-brown around the worm tunnels.

Spore deposit dark yellow-brown ("bister"). Spores 13-16 × 4-5.5 μ, smooth, more or less fusoid in face view, elongate-inequilateral in profile, the suprahilar depression distinct, ochraceous in KOH, pale tan to ochraceous in Melzer's, wall thickened somewhat (0.5 μ).

Basidia 4-spored, 20-24 × 9-12 μ, often with large hyaline oil drops. Pleurocystidia not observed. Cheilocystidia fusoid-ventricose, 28-42 × 8-12 μ, neck long and often crooked, apex subacute, with hyaline to yellowish content. Caulocystidia with a filamentous apical projection, ventricose part with bister content when revived in KOH. Pileus trichoderm of hyphae 4-8 μ diam., with smoky ochraceous to brown content in KOH, the walls smooth to roughened and the cells readily disarticulating at maturity, the end-cells more or less tubular; wider hyphae 8-16 μ diam. also present and with some of the cells short (2-4 times as long as wide) and the end-cells bullet-shaped. Context hyphae hyaline to yellowish in Melzer's. Clamp connections absent.

Gregarious under a clone of aspen, Waterloo, Mich., Sept. 2, 1965, Smith 72469, type. The clone is *Populus tremuloides* with the largest trees about twenty years old.

The context stains gray to fuscous finally and this shows on dried material. The base of the stipe dries olive-yellow. In this species more than in any other the outline of the subcuticular hyphae as revived in KOH appears blistered to eroded from irregular gelatinization of the outer wall. In the trichodermal hyphae this may also show but more often one observes the roughness in bands.

Leccinum olivaceo-glutinosum sp. nov. Fig. 14

Pileus 5-10 latus, convexus, glutinosus, olivaceo-brunneus, demum olivaceus. Tubuli pallidi demum ligno-brunnei; pori tactu luteo-brunnei. Stipes 9-15 cm longus, 9-15 mm crassus, solidus, pallidus, deorsum tactu luteus, sursum tactu ligno-brunneus, atrosquamulosus. Sporae in cumulo "argus brown" (laete luteo-brunneae), 16-19 × 5-6.5 (7) μ. Typus: Smith 72408 (MICH).

Pileus 5-10 cm broad, obtuse to convex, the margin flaring in age but lacking a sterile extension, surface glabrous and viscid to slimy, dull olive to olive-brown when young, becoming olive-green over marginal area, disc developing a cinnamon under-tone in age. Context pallid, firm, slowly changing to brownish (near avellaneous) when cut, instantly blue with $FeSO_4$; odor and taste mild.

Tubes 1-2 cm deep, depressed, pallid becoming wood-brown when mature, cinnamon-stained in age; pores pallid staining dingy yellowish brown when injured.

Stipe 9-15 cm long, 9-15 mm thick at apex, evenly enlarged downward to equal, pallid tinged vinaceous and occasionally olive at apex, lower part cottony-reticulate to striate, with brown or finally blackish dots or squamules at apex, rarely with reddish stains at the base, solid, pallid but staining yellow in base at times when cut, slowly changing to olivaceous near tube line and finally at times flushed olive green in apex of stipe and below this slowly becoming brownish gray ("wood-brown").

Spore deposit rich yellow-brown (near "argus brown"). Spores 16-19 × 5-6.5 (7) μ, smooth, rich yellow-brown singly and more so in groups when revived in KOH, duller brown in Melzer's, only a small number dextrinoid, fusoid to subfusoid in face view, inequilateral-elongate with a distinct suprahilar depression in profile, wall slightly thickened and apex with a thin spot but no distinct pore.

Basidia 4-spored, 26-33 × 10-13 μ, clavate, with large hyaline droplets, yellowish in Melzer's. Pleurocystidia not observed. Cheilocystidia 18-26 × 6-9 μ, clavate to subfusoid and ochraceous in KOH. Cheilocystidia 18-26 × 6-9 μ, clavate to subfusoid and ochraceous in KOH. Caulocystidia basically fusoid-ventricose, 40-75 × 9-18 μ, in addition usually developing a hyphal-like apical flexuous to cork-screw-like proliferation up to 50 μ or more long and 4-5 μ thick, with pale brown content. Caulobasidia scattered, hyaline or a few dark bister (at times including the sterigmata) from a colored wall. Pileus trichoderm of appressed, thin-walled, smooth, readily dis-articulating hyphae 4-9 (12) μ wide, the cells tubular and with dingy ochraceous content when revived in KOH (when fresh some were seen to have green granules), content granular and pale ochraceous to brownish revived in Melzer's, terminal cells mostly elongate-fusoid, not or only slightly inflated but tapered to apex, with no tendency to produce short cells. Clamp connections absent.

Scattered in mixed woods, birch present, Little Lake, Luce Co., Mich., Aug. 7, 1965, Thiers and Smith; near Goetzville, Mackinac Co., Aug. 27, 1965, Watling and Smith 72408, type.

The pale caulocystidia with the often corkscrew-like neck, the slimy-viscid olive-colored pileus, the pattern of color changes—particularly the change to olive in the stipe apex—in addition to the wood-brown stains, all distinguish this species from others in the section. The color of the spore deposit is about like that of *Boletus affinis* Peck. In view of the generally dull yellow-brown spore deposit of species of section *Scabra* it is not at all surprising to find one species in which this color is accentuated. We certainly would not think of erecting a genus parallel to *Xanthoconium* for *L. olivaceo-glutinosum*.

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Fig. 1. *Leccinum luteum*, type ×1

Fig. 2. *Leccinum griseum* x1

Fig. 3. *Leccinum snellii*, type ×1

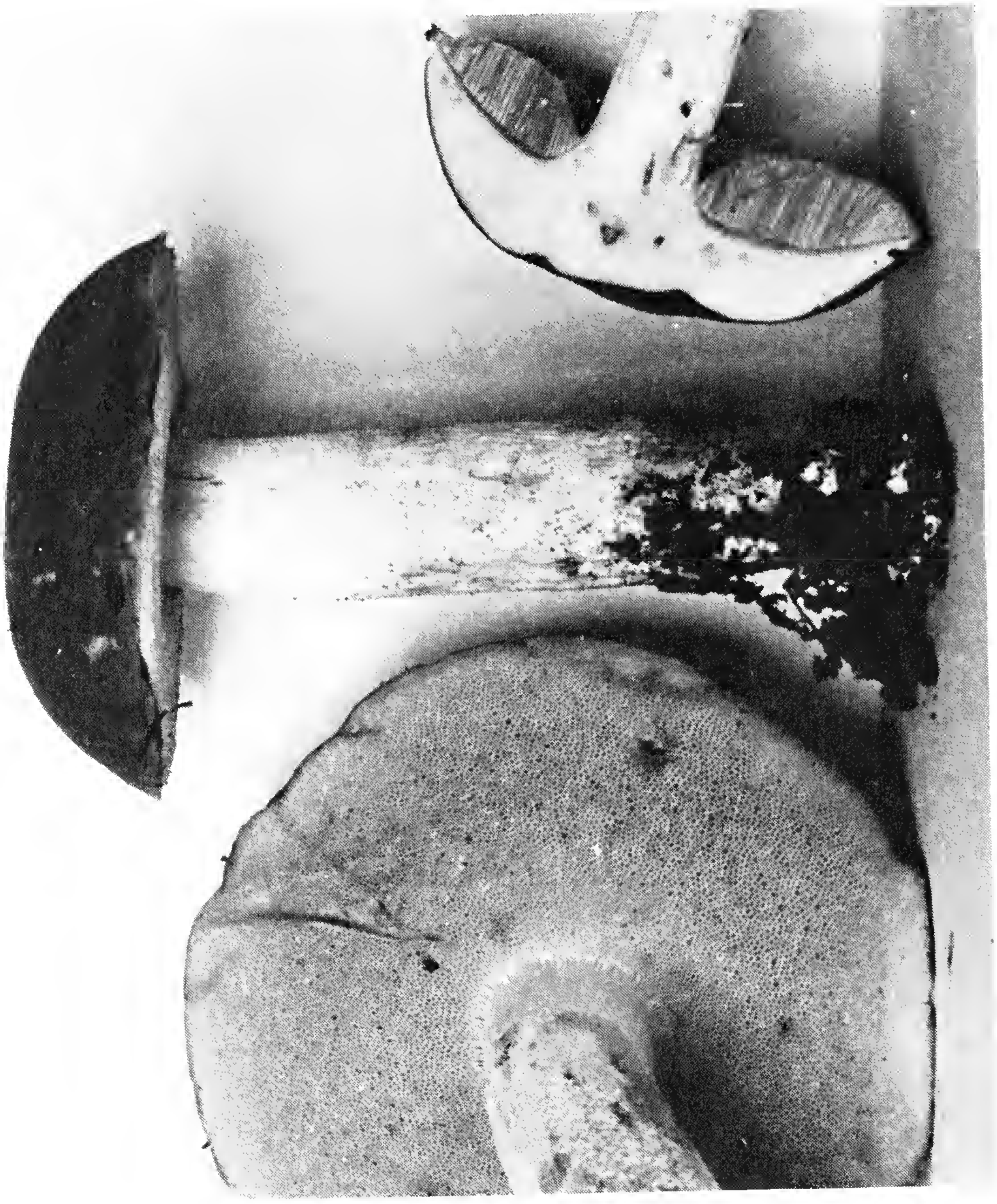

Fig. 5. *Leccinum subglabripes* ×1

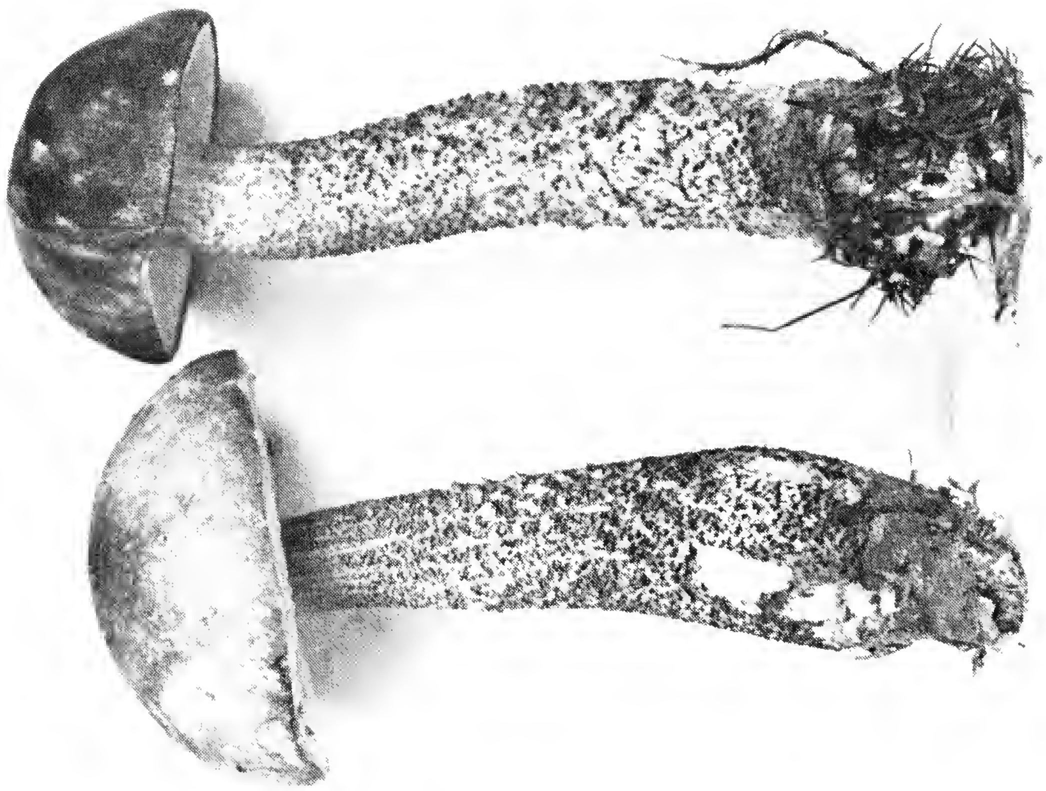

Fig. 4. *Leccinum snellii* ×1

Fig. 6. *Leccinum subleucophaeum* ×1

Fig. 7. *Leccinum olivaceo-pallidum*, type ×1

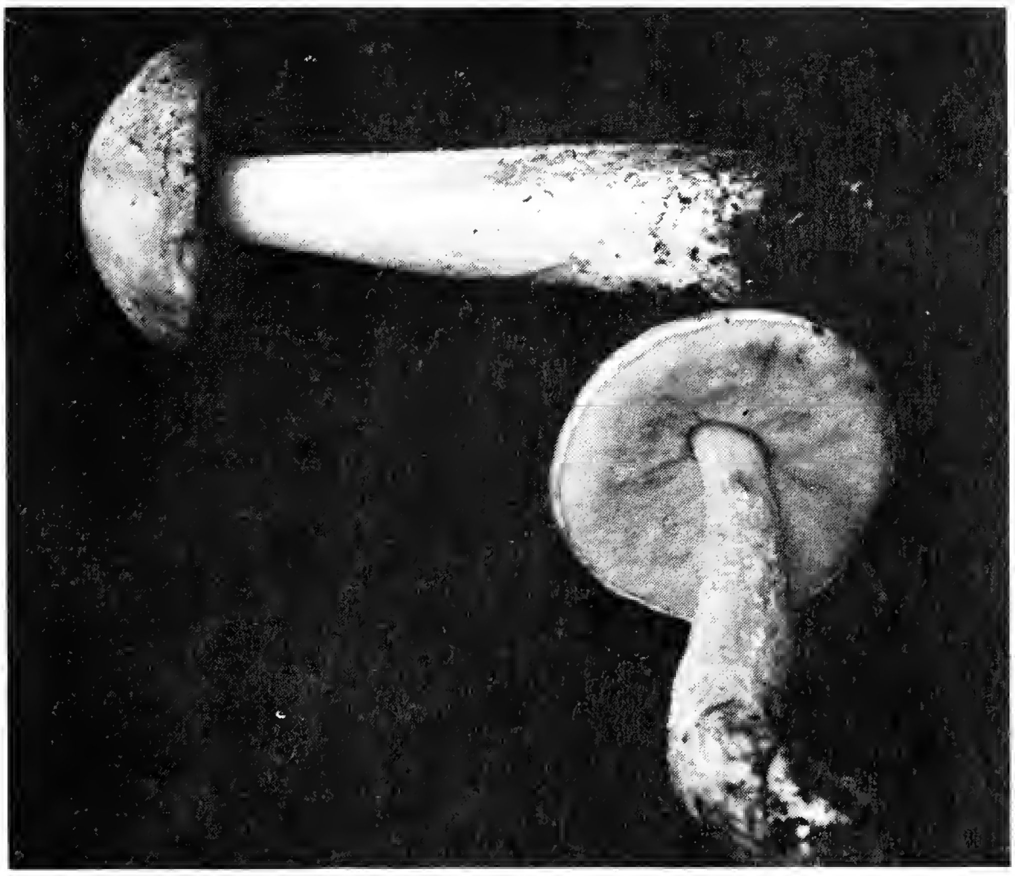

Fig. 8. *Leccinum oxydabile* ×1

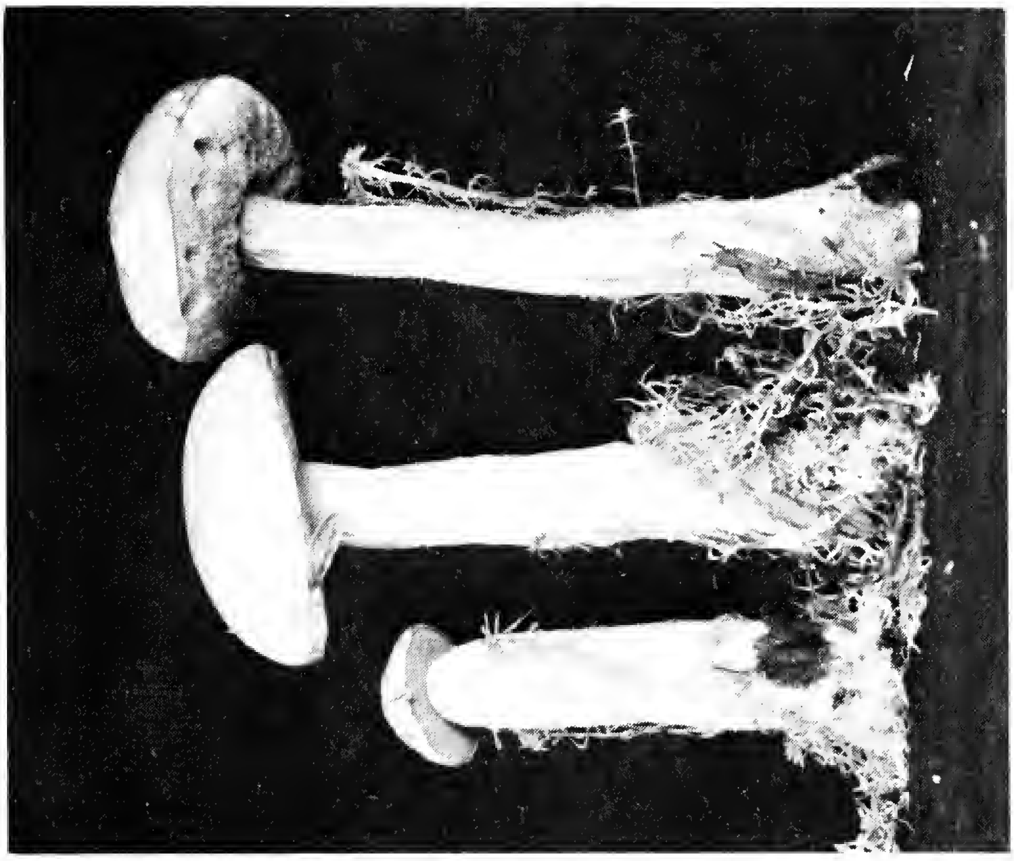

Fig. 9. *Leccinum rotundifoliae* ×1

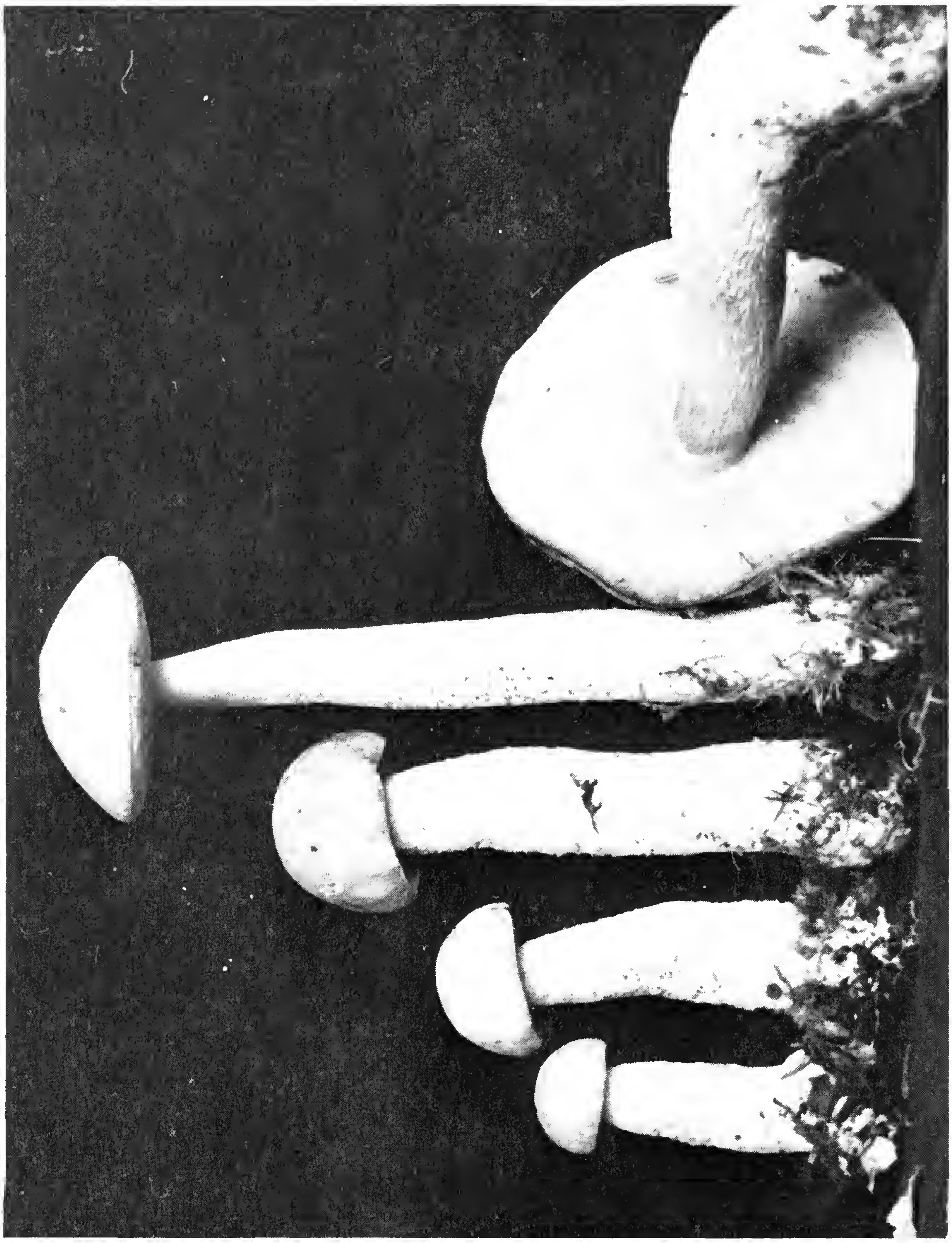

Fig. 10. *Leccinum variabile*, type ×1

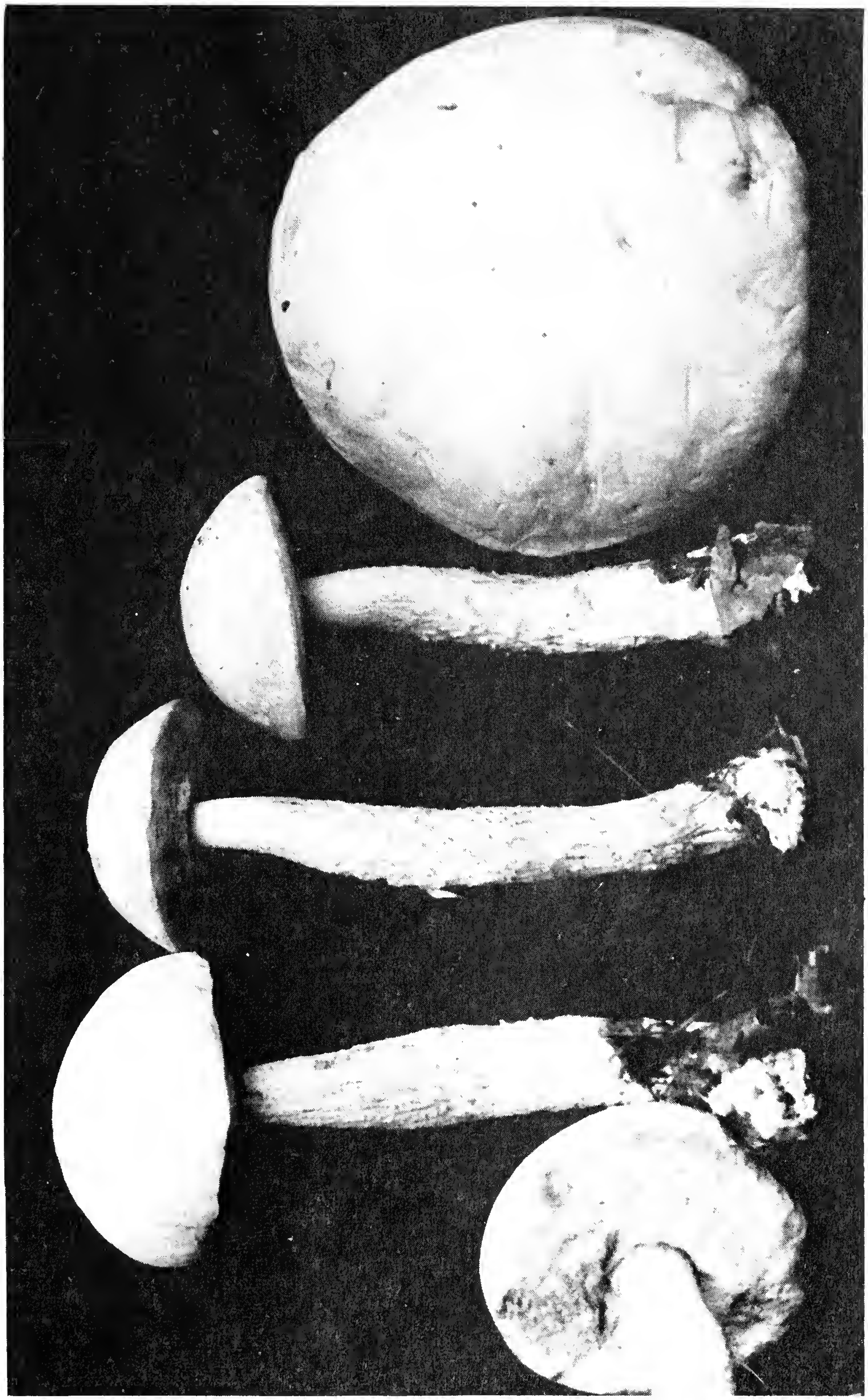

Fig. 11. *Leccinum holopus* ×1

Fig. 12. *Leccinum scabrum* f. *scabrum* ×1

Fig. 13. *Leccinum griseonigrum*, type ×1

Fig. 14. *Leccinum olivaceo-glutinosum*, type ×1

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FLOWER BIOLOGY OF THE LADY'S-SLIPPERS

(Orchidaceae: *Cypripedium*)[1]

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THE GENUS *CYPRIPEDIUM*

The northern hemisphere Cypripediums are familiar subjects for wild flower books, for wild gardening advice columns, and for conservation-oriented publications. The plants are attention-getters, and deservedly so, but not enough attention has been paid to some aspects of their biology. Flower biology, including both the functional aspects of the flower which attract pollinators and the reactions of the visitors, especially needs study. One of our American species, *Cypripedium calceolus,* is in a state of taxonomic confusion, due partly, I think, to a lack of knowledge of the flower-pollinator relationship. What follows is a review of present knowledge of pollination in this and other *Cypripedium* species.

Cypripedium species are deciduous, terrestrial orchids with subterranean rhizomes, plicate leaves, and often large, brightly colored flowers. The unilocular ovary produces seeds with thin integuments. The species number from about 28 (Rosso) to 40 (Sadovský) depending on the degree to which geographic races are given specific names. Species range through much of eastern North America with a few in the Rocky Mountain and Pacific states. One, *C. irapeanum,* is isolated in the highlands of southern Mexico and Guatemala. If all of the yellow-flowered eastern taxa are considered to be one species, there are eleven species in the western hemisphere. More than half of the species of the genus occur in eastern Asia and Siberia, and one occurs in western Europe.

Three tropical genera related to *Cypripedium* are *Selenipedium* and *Phragmipedium* in the western hemisphere and *Paphiopedilum* in the eastern. Together these four genera make up the subfamily Cypripedioideae of the Orchidaceae, characterized by the presence of 2 functional stamens. The few species of *Selenipedium* are tall, reed-like plants with plicate leaves, trilocular ovaries, and hard seed coats, while members of *Phragmipedium* differ by having thin seed coats and conduplicate leaves borne on short stems. *Paphiopedilum* differs in only minor details from *Phragmipedium.* Almost all of the "*Cypripedium*" plants grown by tropical orchid fanciers are in fact *Paphiopedilum* species and hybrids.

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[1] Research supported by NSF grant GB5784X.

The genus *Cypripedium* appears to be cytologically uniform. The 7 species which have had chromosome number determinations have diploid numbers of 20 or 22. *Paphiopedilum* species and hybrids have reported diploid complements of 26, 28, 30, 32, 36, 38, 40, 42, approx. 48, 58, and 70 (Cave, 1956-64; Darlington & Wylie, 1955). I have seen no published chromosome counts for the tropical western *Phragmipedium* or *Selenipedium* species.

FLOWER MORPHOLOGY

The most prominent part of the *Cypripedium* flower is the pouch-like lip or labellum, varying in color from white through shades of cream, yellow, pink, mauve-purple, and brown. Flat or twisted petals spread from either side of the labellum, above which projects an erect sepal. Two free or variously united sepals are partially hidden behind and below the labellum. The column, partially closing the labellum, is a compound organ made up of fused portions of the pistil and stamens. Two functional anthers are present, one on each side of the style and stigma, while a reproductively functionless staminode forms a flat appendage on the front of the column. The anthers produce sticky pollen masses which adhere to anything touching them. *Cypripedium* species are obligate outbreeders because of the spatial separation of anther and stigma and because of the one-way mechanism which usually prevents pollen from being carried backward toward the stigma.

The flowers function as traps. Insect visitors entering the opening in front of the labellum are prevented from exiting by the same route because of the downward projecting rim of the entrance. The escape route through the narrow base of the labellum forces the insect to crawl under and touch the stigma. After passing this organ, the visitor can leave through the openings on either side of the column, but in leaving it must force its way under one of the anthers and thus usually carries away the pollen mass. The dimensions of the labellum entrance, of the escape route under the stigma, and of the final opening under the anther are selective as to visitor size. For example, the large-flowered *C. acaule* accommodates a much larger pollinator than the often minuscule *C. arietinum*.

MECHANISM OF ATTRACTION

Flowers have been grouped into functional classes, depending on the animal group which is most attracted to the flower and most likely to effect pollination. These functional groups have been discussed by Vogel, van der Pijl and Dodson, Faegri, and others. A flower which attracts a particular group of visitors tends to exhibit a concurrence of characters which is common to other species attracting the same visitors. Flowers adapted to bees, butterflies, moths, different groups of flies, bats, or birds tend to exhibit different character associations. The floral characters developed in most species of *Cypripedium* are those most attractive to bees, although flies and other insects also visit the flowers but do not function as effective pollinators. The bee-oriented flower is often brightly colored, has a sweet diurnal odor, often has a landing platform, and may exhibit lines or spots of contrasting color called nectar guides. The nectar, if present, is not hidden in a deep nectary. Bee-oriented *Cypripedium* flowers contrast with some tropical *Paphiopedilum* and *Phragmipedium* species which are attractive to and pollinated by flies and bees (van der Pijl and Dodson, 1966). Flower characters which attract carrion-visiting flies include dull colors, strong and often unpleasant odors, and, occasionally, trapping devices.

We do not know the sequence of stimuli which induce insects to approach and enter *Cypripedium* flowers, although this information is available for some other flowers. It has been demonstrated that color and form of a flower are most important initially in attracting some bees (Butler, 1951; Jorgensen, 1939; Manning, 1956), with odor becoming more significant after the visitor has made an approach. The local species of Lady's-slipper all produce odors which may orient approaching visitors. The site of odor production can be determined by dissecting the flower, placing each part in a closed bottle for several minutes, and then sniffing. In all the species observed in this study the main sources of odor are the lateral petals and sepals. The labellum produces a weaker odor than that produced by the peripheral organs and the central column has little or no flower odor. Faegri and van der Pijl (1966) suggest that the lateral sepals and petals of *Cypripedium calceolus* are of little importance in attracting or orienting visitors, a statement which may be true as far as visual stimuli are concerned. However, these lateral organs may be very important in orienting an approaching visitor because of their strong odor-producing function. Vogel (1962) found that the strong odor of urine produced by the lateral petals of a *Phragmipedium* was associated with the trichomes lining these petals. Similar trichomes are well developed in *Cypripedium* species, being especially prominent near the base of the lateral petals (fig. 2, 5, 6). These may be the source of the generally more pleasant odors in this genus.

Upon entering the labellum an insect investigates the interior, paying particular attention to the long trichomes lining the bottom and exit route. These hairs are often chewed, although nectar and other food substances have not been convincingly demonstrated on or in them. Chewing may be a reaction to confinement or the hairs may provide some stimulus other than food. *Cypripedium* flowers have been described as attracting by deceit, since there is no obvious food material for the visitor which has entered the labellum.

THE VISITORS

I have watched and collected *Cypripedium* visitors during the past two seasons in order to determine the local pollinators and to learn more about their activity in the flowers. Visitors to *Cypripedium* flowers observed by myself and others are listed in Table 1. Some of these visitors may enter the labellum in search of a hiding or resting place, and would not be efficient pollinators. Guignard (1886) reported that visitors to New England *Cypripedium* species were killed by crab spiders. These arachnids are also active in flowers in Ontario and Michigan (fig. 2, 3) and are helpful in collecting flower visitors, since they leave prey in the labellum after feeding. Spider kills may be misleading since the predator may select only what it can handle. Legitimate pollinators may be avoided in some cases and would have to be collected in other ways. In any event, spiders play a role in immobilizing the medium-sized and smaller visitors to *Cypripedium* flowers whether they function as pollinators or not and such kills are listed along with other visitors. A discussion of visitors to selected *Cypripedium* species follows.

Cypripedium acaule Ait. (Fig. 1). The Stemless Lady's-slipper with its 2 basal leaves and large pink-mauve labellum is widespread in eastern North America. The odor is, like that of most flowers, difficult to describe in anything more than vague terms. The adjectives sugary and sweet best fit it.

Several students and I watched a large population of *Cypripedium acaule* growing in a black spruce-blueberry bog in Ingham County, Michigan, in early June, 1966. We made repeated visits to the bog during the 2 weeks of bloom but we at first observed no pollinators at the flowers. Pollination was taking place as witnessed by the pollen smeared on the stigmas of many flowers and by the anthers which had been pushed out of their normal position. In this species the fresh anthers face inward toward the exit canal and a large-bodied insect must force its way under the lower edge of the anther. The anther is pushed outward as the insect crawls under and this permanent change in the anther position can be easily observed. A pollen mass weighing 20 mg was found in the labellum of one flower, this obviously having been detached from the leg of a large bee. The material consisted of *Vaccinium* pollen tetrads and individual grains of a rosaceous plant, probably *Aronia melanocarpa* which was blooming in the bog along with *Vaccinium corymbosum*.

We attempted to capture the visitors by placing aluminum mesh traps over the exits of 50 flowers, but this was a failure as far as the suspected pollinator was concerned. Numerous flies, several small bees, and one crab spider were captured in these traps but none carried pollen and none were effective pollinators. Several labellums had large holes chewed in their sides after traps were installed, indicating that visitors had entered the labellum but refused to enter the trap. One specimen of *Bombus vagans* was finally captured in a labellum (fig. 4) and the insect carried *Cypripedium* pollen on its thorax from previous visits to other flowers in the same colony. It had not entered the trap waiting above, and, like visitors to other trapped flowers, it had avoided doing so. This species of bumble bee was common in the bog and was observed flying near ground level where individuals were investigating and entering openings in the bases of *Vaccinium* shrubs. This nesting activity was accompanied by frequent visits to *Vaccinium* and *Aronia* flowers.

I made a search of the *Bombus* specimens in the entomological collection of Michigan State University and 2 specimens of *Bombus borealis* collected in Charlevoix (May 31, 1960) and Iron (June 13, 1960) counties, Michigan, by R. and K. Dreisbach, carried translucent smears of what appeared to be *Cypripedium* pollen.[2]

Cypripedium reginae Walt. (Fig. 3). The Showy Lady's-slipper was reported to be visited by Lepidoptera, Coleoptera, and Hymenoptera by Guignard and others. The flowers are large, brightly colored, and have a sweet odor. I have observed only one pollinator of this species—a medium sized black bee which flew directly to the flower, alighted on the edge of the opening, and without hesitation dropped to the base of the labellum. It explored the long trichomes for a few seconds, crawled up the base of the labellum, and forced its way out under the anther. Pollen was removed by the bee, which was not captured. The large opening to the labellum allows large bees to enter but the exit is smaller than that of *C. acaule*, and *Bombus* species would have a more difficult time forcing their way out. Guignard (1886, 1887) observed *Megachile centuncularis* and *M. melanophaea* bees pollinating the orchid, the former flying directly to the labellum and entering quickly, an observation paralleling mine.

Cypripedium irapeanum Lhave & Lex. (Fig. 8), restricted to the highlands of southern Mexico and Guatemala, is similar to *C. reginae* in growth habit but the flowers of the former are yellow and the lateral petals are acute, rather than obtuse. Mr. Stirling Dickinson informs me that *C. irapeanum* flowers have a strong, sweet odor "too sweet to be used in Chanel #5." As yet, nothing is known of its insect visitors.

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[2] *Cypripedium* pollen grains are relatively large (25-43μ diam.), spherical when expanded in water, thin walled and non-ornamented. Pollen samples from *C. acaule, calceolus, reginae, arietinum, irapeanum, macranthum, debile,* and *montanum* were examined and none have distinctive form or ornamentation. Pollen of *C. reginae* and *acaule* tended to have larger grains (31μ+) than the other species but my samples are too limited to draw any conclusions as to consistent size differences. The pollen from the *Bombus* specimens was examined and in form and size could represent either of the 2 latter Lady's-slippers, both of which occur in northern Michigan. The large size of the bees (thorax width 8-9 mm, body length 17 mm) and the larger dimensions of the *C. acaule* exit canal suggest that this *Bombus* is better fitted to pollinate *C. acaule* than *C. reginae*.

Cypripedium arietinum R. Br. (Fig. 5). The Ram's Head Lady's-slipper occurs sporadically in cooler parts of eastern North America and western China. The flower differs from most other North American species in that the two lower sepals are free for their whole length and the small labellum has a deep pouch which is not developed in other local species. The pubescent white top of the labellum contrasts strongly in color with the rest of the labellum and this signal patch is the most striking part of the flower. The small opening into the interior, 1-2 mm wide, is further constricted by long trichomes. The exit, with a clearance of 1 mm between the labellum and the anther, also restricts visitors to small insects. A light, sweet odor is produced by both the labellum and the lateral sepals and petals. The labellum plays a greater role in odor production than in other local species.

I watched a colony of *C. arietinum* in Lambton County, Ontario, in June, 1966, the colony having 88 flowering plants in an area of about 2 square meters. The plants were surprisingly inconspicuous in spite of their abundance. The most plentiful insects here were mosquitoes, which rested for prolonged periods of time on the flowers when not engaged in other pursuits. Mosquitoes have been reported as pollinators of *Habenaria obtusata* in Michigan (Dexter, 1913) but they showed no interest in the contents of these flowers.

On June 3 the sky was overcast most of the day, the temperature was 75° F, and no visitors appeared until 5 PM, when the sky cleared. A small black bee made a slow, hesitant approach to a flower from the front, landed at the edge of the white signal patch of the labellum, crawled to the center, and slowly entered the labellum. It remained inside for approximately 2 minutes and then forced its way out an anther opening, carrying a pollen mass on the thorax (Fig. 5). June 5 was warm with a shade temperature of 86°F, and plants were in full sun. Between 9 and 11 AM several small, swift bees repeatedly approached the signal patch of different flowers, occasionally alighted, then swiftly flew away without entering the opening. At 11:30 a bee alighted, crawled quickly across the labellum, entered the opening, and remained within the flower for 1-2 minutes. It emerged, and again carried a pollen mass on its thorax. Both bees were identified as species of *Dialictus* and in size they closely conform to the physical restrictions of the flower. Dodson (1966) published a photograph of another small bee escaping from *C. arietinum* and it appears to be of the same size as the *Dialictus* observed here.

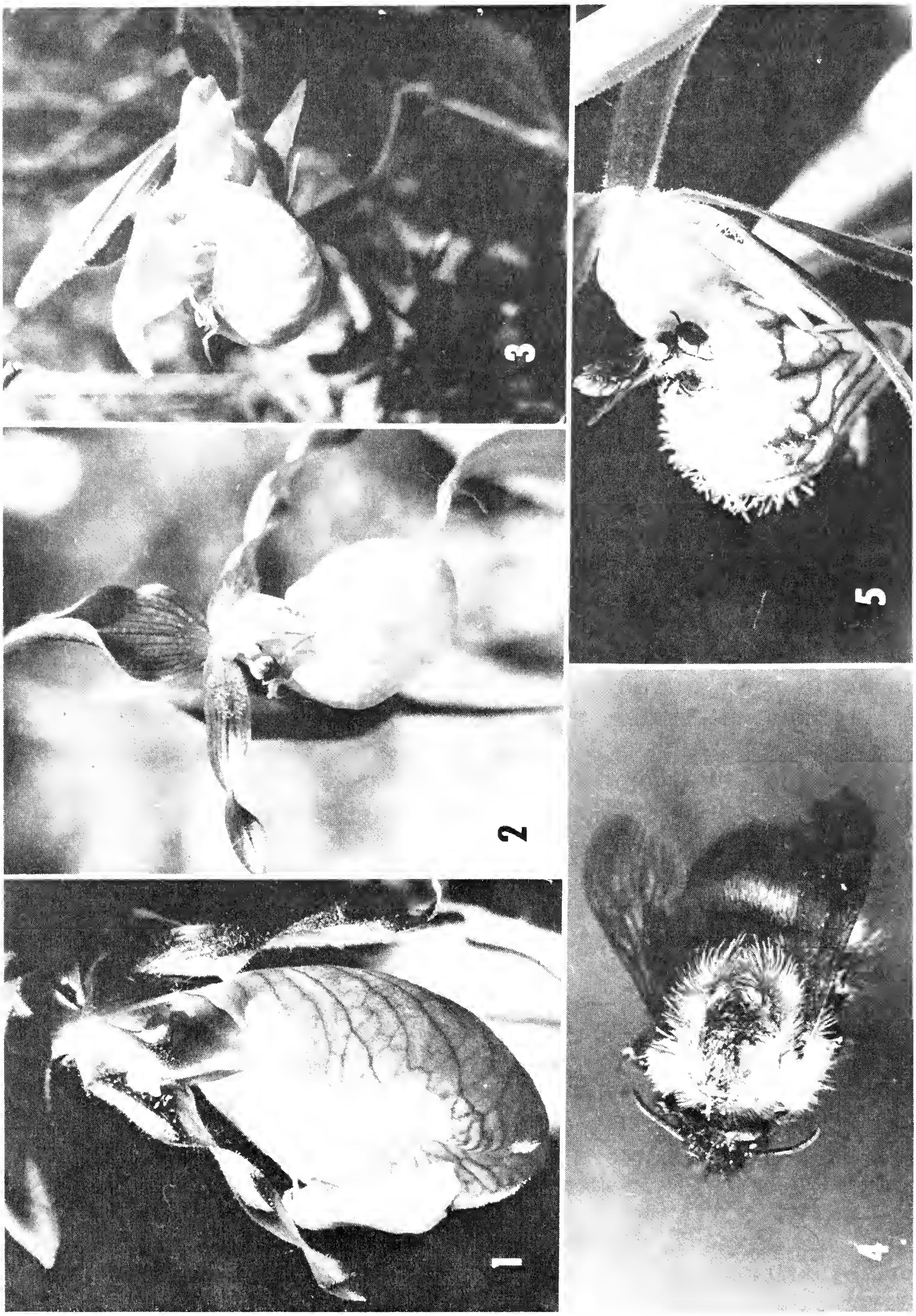
Cypripedium calceolus L. (Fig. 2, 6). The Yellow Lady's-slipper is the most widespread species of the genus. Its distribution includes much of eastern North America and the range extends westward to Alaska and Oregon. It is the only species native to England and Europe, and it also extends eastward through Siberia. In Europe, where it is restricted to limestone-derived soils, the species is relatively constant in its morphological characters, but in North America it is variable both in habitat and in morphology. The American taxa have been given several names by different workers, but until more is known of the biology of these plants they are most conveniently treated as a single variable species. Flowers of the two best known taxa, *pubescens* and *parviflorum*, have a strong, spicy odor, most of which originates in the lateral petals and sepals. The labellum, stigma, anthers, and staminode produce less intense sweet odors. I have not made direct comparisons of odor as produced by the two taxa except in one population in Ingham County, Michigan, where both and numerous intermediates occur together. There was no clear odor difference between the plants in this mixed population but this may be due to considerable gene interchange. Scent should be compared between non-hybridizing populations of the two taxa.

The European populations were reported to be visited by females of 5 species of *Andrena* bees and 3 species of flies by Müller (1883) and Darwin (1877) while Robertson (1928) in North America reported visits by two other bees now included in the genus *Ceratina*. The coleopteran *Anthaxia* reported by Guignard (1886) probably is not an effective pollinator. I have collected *Ceratina* species as well as *Evylaeus, Lasioglossum, Agapostemon, Apis, Osmia, Halictus*, and *Dialictus* bees in the flowers. Flowers are visited frequently enough by insects to make it worthwhile for yellow crab spiders to exploit the situation.

My only observation of a complete pollination event in this species involved a population of the taxon *pubescens* in Oakland County, Michigan. A male *Ceratina calcarata* approached the flower, quickly entered, explored the labellum floor for approximately 1 minute, and then forced its way out of the exit, carrying a pollen smear on its thorax (Fig. 6). The 2 mm opening under the anther closely corresponds to the size of the small bee.

The races of *C. calceolus* in northeastern North America grow in well drained sandy soils, highly organic wet soils, calcium-rich and calcium-deficient soils. The plants may grow in almost full sunlight or in deep shade. They grow in well drained coniferous forest, coniferous bog, in deciduous forest, and in grassy fields and along roadsides. Since the insect visitors may be ecologically limited in their foraging and nesting habits, some of these populations of *C. calceolus* may be preferentially visited by different species of Hymenoptera. The small flowered *parviflorum* seems to be associated with wetter habitats, which may furnish a different spectrum of pollinating agents than the larger flowered *pubescens*, often found in better drained soils. Flower dimensions, varying from population to population, will also determine the effectiveness of various hymenopterans as pollinators.

If this species is adapting to available pollinators, the semi-isolated populations, already adjusted to slightly different habitats, may be diverging further on the basis of the available visitors. Ecologically



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restricted pollinators will tend to keep the populations reproductively isolated except where some habitat disturbance allows both taxa to occupy the foraging territory of a single pollinator. Ecological isolation on the part of the orchid is not necessarily the first step in this type of divergence. Any species which is capable of occupying two different habitats with different pollinating agents would in time exhibit morphological divergence, due to selection on the part of the pollinator. Habitat requirements can be stabilized before, during, or after morphological divergence, so long as the populations remain reproductively separate. Heslop-Harrison (1958) discussed this micro-ecological isolation mechanism as he saw it occurring in European *Dactylorhiza* species, a mechanism in which pollinator behavior provides a shield against introgression between two adjacent but ecologically distinct populations of plants. Once the flower form and ecological requirements become stabilized, the divergent taxa can migrate more or less independently of each other. No strict genetic barrier needs to be present in order for the populations to remain largely distinct. Iltis (1965) has suggested that the divergence of the two *Cypripedium* taxa discussed here may be correlated with the Pleistocene glaciations, the small flowered taxon being isolated to the west of one or more of the ice lobes while the larger flowered was probably eastern in distribution. This early geographic isolation may also have involved two different groups of pollinators with concurrent flower and edaphic specialization. The retreat of the ice and subsequent migration of the taxa could have made possible limited introgression, resulting in the present-day variation pattern.

Cypripedium candidum Muhl. The White Lady's-slipper grows in grassy or shrubby wet meadows where the soil and ground water contain large amounts of calcium carbonate. It is intolerant of heavy shade and disappears when woody plants replace the herbaceous vegetation (Curtis, 1946). The lateral sepals and petals are yellow-green while the white labellum is flecked with purple around the opening and in the interior. The odor is sweet and pungent or spicy, similar to that of *C. calceolus* but not as strong as in that species. It is easily distinguished from the sugary odors of other species. Most of the odor is produced in the lateral sepals and petals, with the labellum playing a minor role.

I have observed pollination in this species only once in spite of numerous visits to colonies in flower. A specimen of *Andrena placida*,

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Fig. 1. *Tetracis lorata* (Geometridae) resting on labellum of *Cypripedium acaule*. x 1
Fig. 2. Crab spider on *C. calceolus* var. *pubescens*. x .75
Fig. 3. Crab spider on *C. reginae*. x .60
Fig. 4. *Bombus vagans* (Apidae), thorax smeared with pollen of *C. acaule*. x 2.6
Fig. 5. *Lasioglossum coeruleum* (Halictidae) after emerging from *C. arietinum*. Note pollen mass on thorax. Posed. x 3

collected from a cultivated plant, carried pollen from other flowers cultivated nearby. LaBerge (written communication) states that the bee is a relatively common vernal species with a variety of food sources. Since the cultivated plant was not in the normal species habitat, we cannot be sure that this *Andrena* is a common visitor in wild populations. It is of the appropriate size, however, and was functioning efficiently as a pollinator in this case.

Cypripedium candidum and *C. calceolus* occasionally occupy the same or adjacent habitats and hybrids have been reported several times. A study of the attracting mechanisms of the two species in relation to the common pollinators would be a worthwhile project.

Cypripedium macranthum Sw. (Fig. 7). I have cultivated Japanese plants of this species for 3 years. The species occupies a large area from the southern Ukraine eastward through Siberia to the Kurile Islands and south to China, Japan, and Formosa. Several geographic races differing from the type have been given specific names. The complex of forms is partially responsible for the uncertainty of the number of species in the genus. *Cypripedium macranthum* reportedly hybridizes with *C. calceolus* (Mandl, 1924), resulting in intermediate types. Flowers of *C. macranthum* are large and generally pink with darker purple veining. The flower odor is a very sugary one, similar to that of *C. arietinum*, *reginae*, and *acaule*, and very different from that of *C. candidum* and *calceolus*. Because of the labellum size, color, and sweet odor the plant is probably visited by small to medium sized bees in its native habitats.

Cypripedium debile Reichenb. f. (Fig. 9). I have cultivated this native of coniferous forests of Szetschuan (China) and Hokkaido, Honshu, and Shikoku (Japan) for 3 years. The small plant is 10-15 cm tall, bears two cordate glossy leaves at the top of the stem, and the single flower, pendent beneath the leaves, almost rests on the ground. The color of the sepals and lateral petals is pale green, fading to white as the flower ages. The small labellum is white with dark purple bosses and lines on the inner edge of the labellum opening and in the interior. The odor is very distinctive: it is the odor of super-market mushrooms, a strong fungus-like odor. The syndrome of characters here suggests pollination by fungus-seeking insects, perhaps small Diptera. The Rocky Mountain *C. fasciculatum* resembles *C. debile* in its possession of sub-opposite cauline leaves, nodding dull colored small flowers, and adaptation to

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Fig. 6. *Ceratina calcarata* (Apidae) emerging from *Cypripedium calceolus* var. *pubescens*. The bee removed pollen during the exit. × 1.2
Fig. 7. *Cypripedium macranthum*, cultivated. × .5
Fig. 8. *C. irapeanum*, photo by Stirling Dickinson. × .5
Fig. 9. *C. debile*, cultivated. × 2


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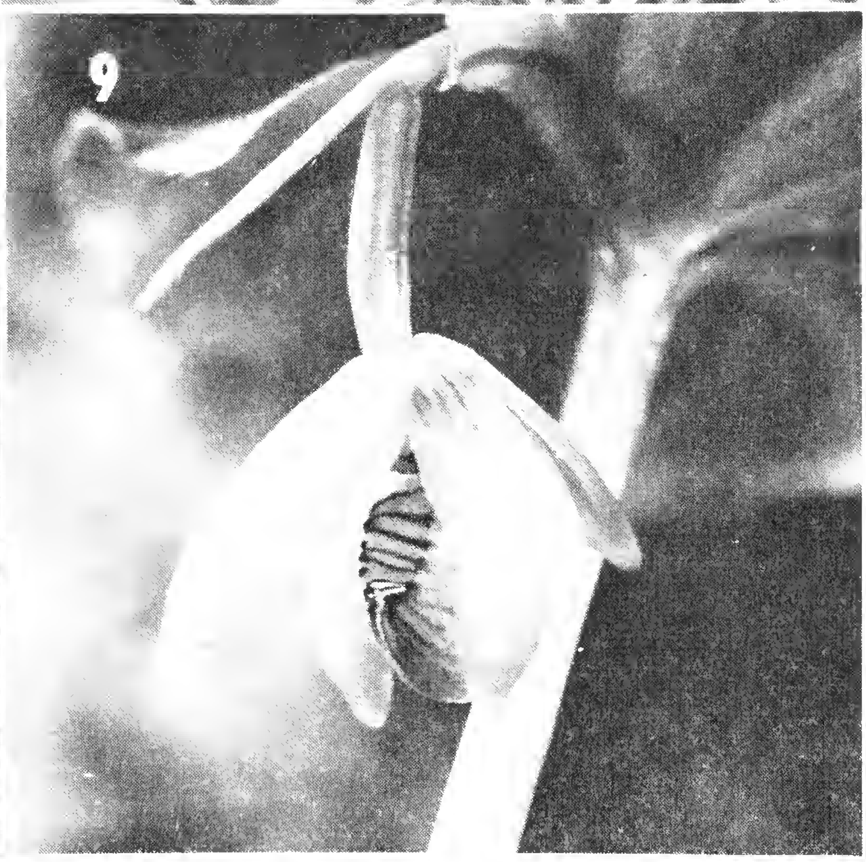
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cool coniferous forest habitats. There are no reports of the pollination biology of the North American species, however.

These observations will serve to review what is presently known of the floral biology of *Cypripedium* species. There is obviously much which needs to be done in observing and identifying pollinators, and in the cases where interspecific or interracial hybridization is occurring, the habits of the pollinators should be observed. Discussions of evolutionary mechanisms in species of *Cypripedium* must remain largely conjectural until the critical stage of pollination, involving another organism, is better understood.

ACKNOWLEDGMENTS

I would like to thank the following individuals for their assistance in identifying insects: Robert W. Husband, George C. Eickwort, W. W. Wirth, John Newman, Roland L. Fischer, R. B. Roberts, George Steyskal, and Wallace E. LaBerge. Dr. Aureal Cross and son Timothy assisted in pollen studies and Mrs. J. T. Woolfenden was helpful in many ways in making possible the observations of *Cypripedium* populations in Ontario.

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TABLE I. Insect Visitors to Flowers of *Cypripedium* species. Names of American Hymenoptera follow Muesebeck, et al. (1951), and those of butterflies (Lepidoptera) follow Klots (1951); names as originally reported are in parentheses if different.

	Visitor	Determined by	Collected or Observed by	Remarks
C. ACAULE:				
Hymenoptera	*Bombus vagans* F. Smith ♀	R. W. Husband	W. P. Stoutamire	Found in labellum, thorax smeared with pollen. Ingham Co., Mich.
	Bombus borealis Kirby ♀	R. W. Husband	R. & K. Dreisbach	Thorax smeared with pollen. Charlevoix Co., Mich. Pollen is suggestive of *C. acaule*, but not proof.
	Bombus borealis Kirby ♀	R. W. Husband	R. & K. Dreisbach	Same comments as above, but specimen from Iron Co., Mich.
	Augochlorella striata Provancher ♀	G. C. Eickwort	W. P. S.	No pollen, dead in mesh trap. Ingham Co., Mich.
	Anthophora furcata terminalis Cresson ♂	G. C. Eickwort	W. P. S.	No pollen, dead in mesh trap. Ingham Co., Mich.
Diptera	*Rhingia nasica* Say	W. Wirth	W. P. S.	13 specimens in mesh traps, no pollen. Ingham Co., Mich.
Lepidoptera	*Tetracis lorata* Grote	J. Newman	W. P. S.	3 specimens resting on labellum, not pollinators. Ingham Co., Mich.
C. REGINAE:				
Hymenoptera	*Bombus* sp. ?	---	Raffill, 1913	Visited cultivated plant at Kew. Thorax smeared with pollen in exit which insect attempted to remove.

TABLE I (Cont'd.)

	Visitor	Determined by	Collected or Observed by	Remarks
	Megachile centuncularis L.	---	Guignard, 1886	Entered labellum without alighting, emerged with pollen smear.
	Megachile melanophaea Smith	---	Guignard, 1886, 1887	Removed pollen, but chewed way out.
Lepidoptera	*Adopaea lineola* Ochs. (*Thymelicus lineola*)	---	Arthur, 1962	European skipper inside labellum.
	Epargyreus clarus Cramer (*Eudamus tityrus*)	---	Guignard, 1886	Entered labellum.
	Polites mystic Scudder (*Pamphila mystic*)	---	Guignard, 1886	Entered labellum.
	Polites themistocles Lat. (*Pamphila cernes*)	---	Guignard, 1886	Entered labellum.
Coleoptera	*Trichius affinis* Gory	---	Guignard, 1886	Sucking exudate of labellar trichomes.
	Anthobium convexum Fauvel	---	Smith & Fletcher, *in* Guignard, 1886	Crawled across anther and then stigma.
C. CALCEOLUS:				
Hymenoptera	*Ceratina* sp. ♀	---	Robertson, 1928	
	Ceratina sp. ♂ (*Zaodontomerus*)	---	Robertson, 1928	
	Ceratina calcarata Robertson ♂	R. L. Fischer	W. P. S.	Captured in labellum, pollen on thorax. Oakland Co., Mich.
	C. dupla Say ♂	R. L. Fischer	W. P. S.	Killed by crab spider. Oakland Co., Mich.

Andrena nigroaenea K. ♀	---	H. Müller, 1883	Visitor at European locality.
A. fulvicrus K. ♀	---	H. Müller, 1883	Visitor at European locality.
A. albicans K. ♀	---	H. Müller, 1883	Visitor at European locality.
A. atriceps K. ♀	---	H. Müller, 1883	Visitor at European locality.
A. pratensis Nyl. ♀	---	H. Müller, 1883	Visitor at European locality.
A. parvula K. ♀	---	H. Müller, 1883, Darwin, 1877	Visitor at European locality.
A. nivalis Sm.	---	Guignard, 1886	Dead in labellum, no pollen on thorax.
Evylaeus pectoralis Smith ♀	R. L. Fischer	W. P. S.	Captured in *pubescens*, no pollen on thorax. Oakland Co., Mich.
Lasioglossum coriaceum Smith ♀	R. L. Fischer	W. P. S.	Dead in *pubescens*, heavy pollen smear. Oakland Co., Mich.
L. forbesii Robertson ♀	R. L. Fischer	W. P. S.	Dead in labellum, mixed colony of *pubescens-parviflorum*. Ingham Co., Mich.
Agapostemon splendens Lepeletier ♀	R. L. Fischer, R. B. Roberts	W. P. S.	3 specimens, living, 2 with thoracic pollen smears. Oakland Co., Mich., & Lambton Co., Ont.
Apis mellifera L., worker.	R. L. Fischer	W. P. S.	Living, in *pubescens*, pollen smear. Oakland Co., Mich.
Osmia sp. ♀	G. C. Eickwort	W. P. S.	Dead, in *pubescens*, pollen smear. Ingham Co., Mich.
Osmia pumila Cress. (*O. vicina*)	---	Guignard, 1886	Thorax with pollen smear.
Halictus rubicundus Christ ♀	G. C. Eickwort	W. P. S.	Dead in *pubescens*, no pollen. Lambton Co., Ont.

TABLE I (Cont'd.)

	Visitor	Determined by	Collected or Observed by	Remarks
	Lasioglossum pilosum Sm. ♀ (*Dialictus pilosus*)	G. C. Eickwort	W. P. S.	Living in *pubescens*, no pollen. Lambton Co., Ont.
Diptera	*Empis punctata* F.	---	H. Müller, 1883	---
	Cheilosia sp.	---	H. Müller, 1883	---
	Anthomyia sp.	---	H. Müller, 1883	---
	Spilogaster semicinera Wied.	---	H. Müller, 1883	---
	Eristalis dimidiatus Wied.	W. Wirth	W. P. S.	Dead under stigma of *pubescens*, pollen on head and thorax. Saginaw Co., Mich.
	Odontomyia interrupta Oliv.	W. Wirth	W. P. S.	Living in *pubescens*, Oakland Co., Mich.
	Zodion fulvifrons Say	G. Steyskal	W. P. S.	Dead in *pubescens*, no pollen. Oakland Co., Mich.
Coleoptera	*Anthaxia inornata* Rand.	---	Guignard, 1886	Spider killed.
C. CANDIDUM				
Hymenoptera	*Andrena placida* Smith ♀	LaBerge	W. P. S.	Visiting cultivated plants, pollen smear on thorax. Oakland Co., Mich.
C. ARIETINUM:				
Hymenoptera	*Lasioglossum coeruleum* Robt. ♀ (*Dialictus coeruleus*)	G. C. Eickwort	W. P. S.	Thorax with old smear, new pollen removed from flower. Lambton Co., Ont.
	Lasioglossum sp. ♀ (*Dialictus* sp.)	G. C. Eickwort	W. P. S.	Pollen removed from flower upon exit. Lambton Co., Ont.

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Review

VEGETATION AND COMMON PLANTS OF SLEEPING BEAR. By Paul W. Thompson. Cranbrook Institute of Science (Bulletin 52), Bloomfield Hills, Michigan. 1967. 47 pp. $1.50.

Members of the Michigan Botanical Club and others who know of Paul Thompson's long devotion to the plant life of Leelanau County will need no urging to obtain a copy of this handsome bulletin. It consists chiefly of brief descriptions of the major habitats of the region, with lists of vascular plants (both common and scientific names) found in each. A helpful appendix states where to find representative plant communities, and champion big trees of the region are listed. There are 20 superb photographs. A generalized map includes "park site boundaries"—which will seem premature to those citizens who have long (and thus far successfully) fought establishment of a National Lakeshore ("Park") at Sleeping Bear dunes. Reading that "the Wisconsin glacier" pushed into the Lake Michigan basin approximately 100,000 years ago and that "later, when the glacier retreated northward" there was Lake Algonquin, one should remember that "later" covers over 90,000 of those 100,000 years! *Cirsium pitcheri* (p. 12) is not an example of an "Atlantic coastal plain endemic species," being entirely restricted to the shores of the western Great Lakes.

—E. G. V.

LACTIC-ACETIC-ORCEIN AS A CHROMOSOME STAIN

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The use of lactic-acetic-orcein for the staining of chromosomes in animal tissues has recently been reported by Welshons, Gibson and Scandlyn (1962), and Micklem and Loutit (1966, p. 205). We investigated its value as a routine stain for chromosome studies in plant tissues as well as in animal, and found it to yield excellent results in both. The stain would seem to have great potential value in systematic surveys of chromosome numbers and morphology. It also has distinct advantages for use in classwork.

Lactic-acetic-orcein was found to be more satisfactory than the widely used acetic-orcein in several ways. The stain can be prepared at room temperature and does not require filtration at concentrations of 1% or less. Staining of chromosomes is rapid and uniform with little evidence of dye uptake in the cytoplasm. Because of the almost complete absence of background staining, counting of chromosomes and study of their morphology are greatly facilitated. Temporary mounts of plant squash preparations do not have to be sealed and remain in good condition for a week or longer.

The stain was used at concentrations of 0.5%, 1%, and 2%. It was prepared by dissolving the required amount of synthetic orcein in a solution of equal parts of 65% lactic acid and glacial acetic acid. The chromosome preparations in Figures 1-4 were made according to the following procedures.

A. Mitotic chromosomes in onion root tips.

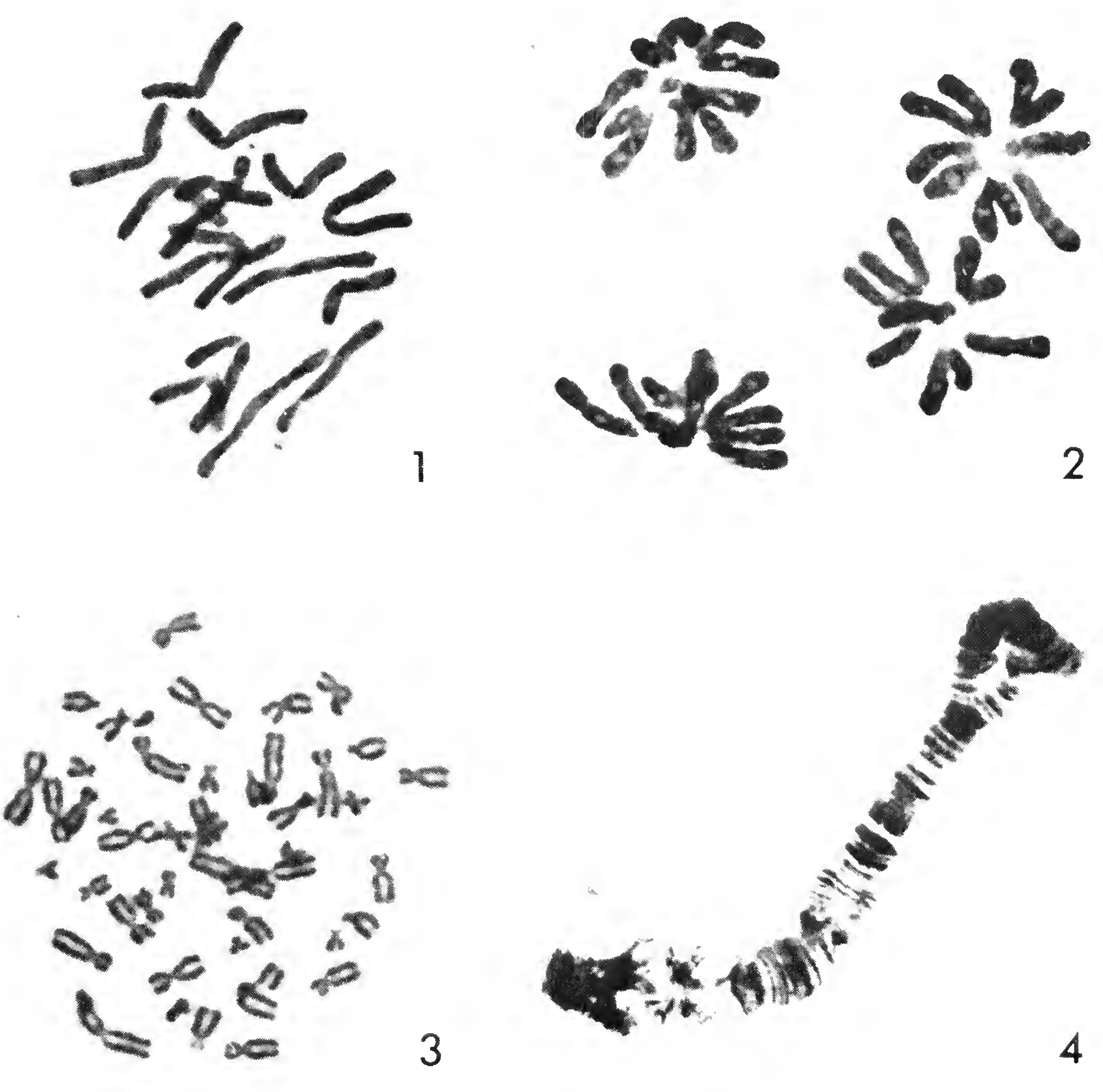
1. Roots were pretreated in saturated solution of paradichlorobenzene for 2 hours, then transferred to a mixture of 6 parts absolute methanol : 3 parts chloroform : 2 parts propionic acid and stored under refrigeration.
2. Roots were placed in N HCl in a water bath at 55°C for 18 minutes.
3. Root tips were cut into a drop of 1% stain on a slide and tapped with a glass rod. A coverslip was then added, and the material squashed between sheets of bibulous paper.

B. Meiotic chromosomes in May-apple anthers.

1. May-apple buds with perianth parts removed were fixed in a mixture of 6 parts absolute methanol : 3 parts chloroform : 2 parts propionic acid and stored under refrigeration.
2. Anthers were placed in a drop of 2% stain, cut in half, tapped with a glass rod, and squashed as above.

C. Mitotic chromosomes from cultured human leukocytes.

1. Culture, preparation, and fixation of human chromosomes were made from peripheral blood in accordance with directions supplied with "Chromosome Medium 1A" (Grand Island Biological Company, Grand Island, N. Y.).
2. A drop of 2% stain was added to the air-dried chromosome preparations; after a few minutes a coverslip was added.
3. Permanent slides were made by dehydrating preparations overnight in tertiary butyl alcohol, then mounting in Diaphane.



Figs. 1-4. Chromosomes stained with lactic-acetic-orcein.

1. *Allium cepa* (onion), metaphase in root tip cell. x 1125.
2. *Podophyllum peltatum* (May-apple), Anaphase II in microsporocyte. x 690.
3. Chromosomes of human leukocyte at mitotic metaphase. x 1020.
4. *Chironomus* sp. larva (bloodworm), giant polytene chromosome from salivary gland showing cross bands and puffs. x 620.

D. Polytene chromosomes from salivary glands of *Chironomus* larvae (bloodworms).
   1. A larva was placed on a slide and surrounded with a 0.7% NaCl solution.
   2. With forceps, the anterior end of the body was pinched off at the first segment behind the head. The salivary glands were freed by applying pressure gently with forceps at a position between the second and third segments of the body.
   3. The glands were placed in a drop of N HCl at room temperature for 5 minutes.
   4. Glands were then transferred to a drop of 0.5% stain, a coverslip added, and the material squashed between sheets of bibulous paper.

ACKNOWLEDGMENTS

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Welshons, W. J., B. H. Gibson, & B. J. Scandlyn. 1962. Slide processing for the examination of male mammalian meiotic chromosomes. Stain Tech. 37: 1-5.

Review

THE NUT JAR A Cookbook. Edited by Mrs. J. Lee Taylor and Mrs. Robert Turner. Michigan Nut Growers Association (Box 297, Charlotte, Michigan 48813). 1967. xiv + 132 pp. $2.50

Cookbooks, like botanical keys, have to be tried before their worth can be safely evaluated. But we suspect that quite a number of people will be grateful to the "wives of the Michigan Nut Growers Association and their friends" for this thorough compilation. An introduction covers the handling of nuts. Recipes range from tender nut-fed squirrels through appetizers, sandwiches, salads, main dishes, breads, desserts, candies, jams, soups, pancakes, and pickles—all using cultivated and native wild Michigan nuts and fruits. There are concluding chapters on the use of nuts in crafts and the history of nut culture in Michigan. A couple of botanical quibbles: The fruit of "*Sambucus* spp." is said to ripen "in August and September," but this applies only to *S. canadensis*, the desirable one for jam; our other species, the red-berried elder, *S. pubens*, ripens in early summer and is considered inedible. *Gaylussacia* (we have only *G. baccata* native) is indeed the true huckleberry, but it would make a very seedy substitute for blueberries (*Vaccinium*) in muffins.

—E. G. V.

THE RELATIONSHIP OF RHIZOBIA IN THE NODULE FORMATION OF NORTHWEST GRIMM ALFALFA (*MEDICAGO SATIVA*)[1]

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INTRODUCTION

Cytological studies on the nodules of red clover (*Trifolium pratense*) have shown that the cells of the nodules infected with bacteria, *Rhizobium*, contain a double number of chromosomes (4n=28) compared to the diploid number of the uninfected cells (2n=14) (Wipf & Cooper, 1938). This was also found to be true in *Medicago sativa;* the cells in the infected area of the nodule contained twice the number of chromosomes as the uninfected cells. In the case of *Medicago sativa*, however, tetraploidy occurs naturally. Uninfected root tip cells have 32 chromosomes while the infected cells have 64. These early findings suggested that a doubling of the chromosomes in the nodules may be associated directly with the invasion of the cells by the bacteria. However, a later investigation (Wipf & Cooper, 1940) has shown that occasionally in species of pea and vetch, cells with the 4n number of chromosomes were among the 2n cells. This led to the idea that the invading *Rhizobia* entered only these natural tetraploid cells.

Investigations have found that materials such as coconut milk (Virtanen & Miettinen, 1963) and colchicine (Eigisti & Dustin, 1955; Kihlman, 1966) can induce polyploidy. If these substances could induce polyploidy, is it not possible that *Rhizobia* bacteria could do the same?

Therefore, the purpose of this study was to investigate the question: Are naturally occurring polyploid cells responsible for the initiation of nodule formation, or are the enlarged polyploid cells the result of some outside influence such as bacterial infection?

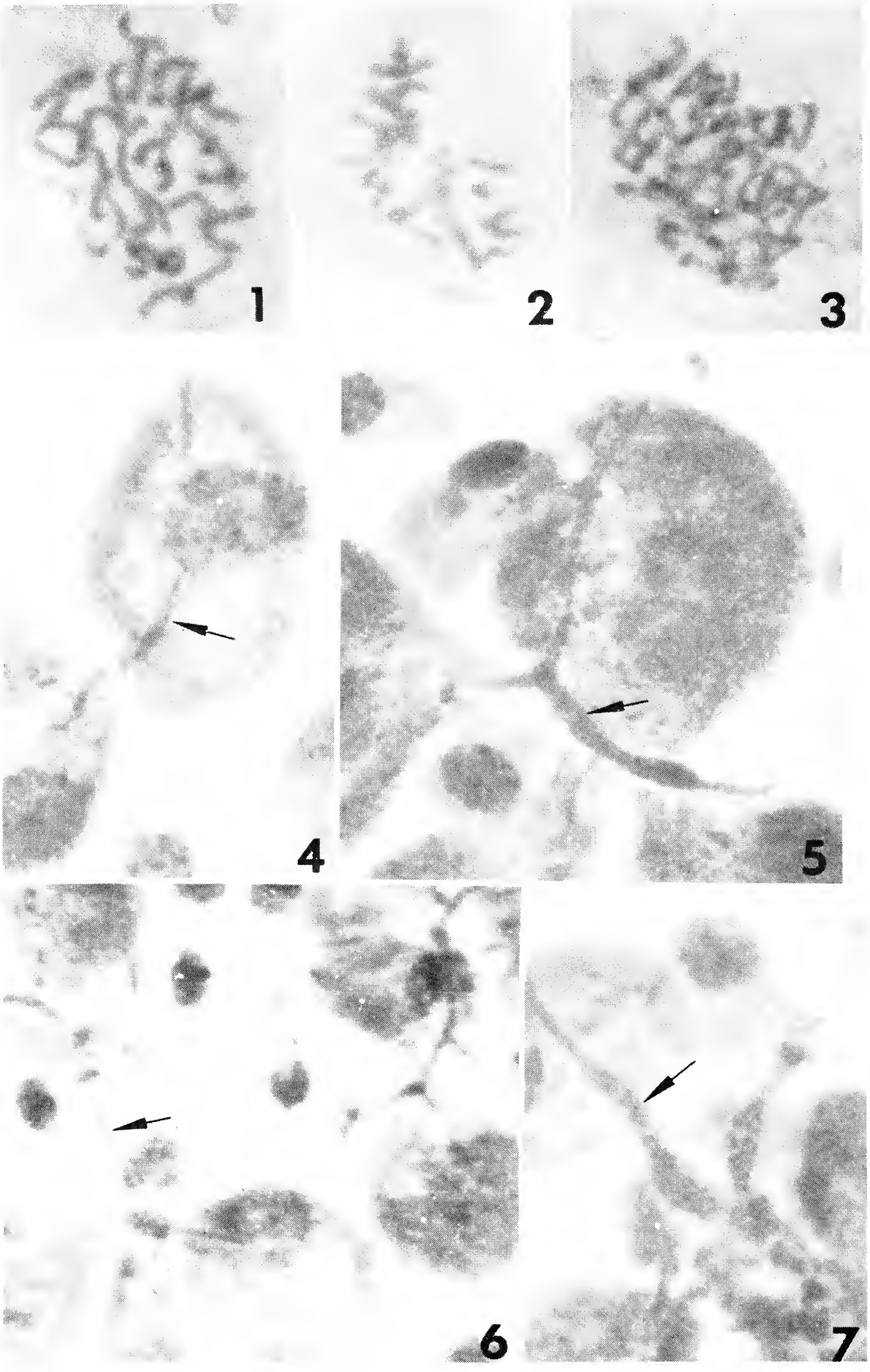
MATERIALS AND METHODS

The plant material studied was *Medicago sativa*, Northwest Grimm variety. The seeds were grown on water-soaked filter paper in sterile petri dishes. Root tips were harvested at 11:00 AM to obtain the greatest number of mitotic divisions in metaphase (approximately 60% of the dividing cells were in metaphase at this time compared to 30% or less for other times). Immediately after harvesting, the tips were put in a saturated solution of paradichlorobenzene for one-half hour to shorten the chromosomes, and fixed in a solution of glacial acetic acid—absolute ethyl alcohol (1:3) for a 24-hour period, then transferred to 75% alcohol.

Plants were grown in growth chambers for a three- to five-week period and then uprooted for examination of nodules. The nodules were harvested at 4:00 PM and treated as above.

Two percent aceto-orcein (2 gm orcein, 45 cc glacial acetic acid,

1 This study was partially supported by NSF URP grant G.E. 6575.



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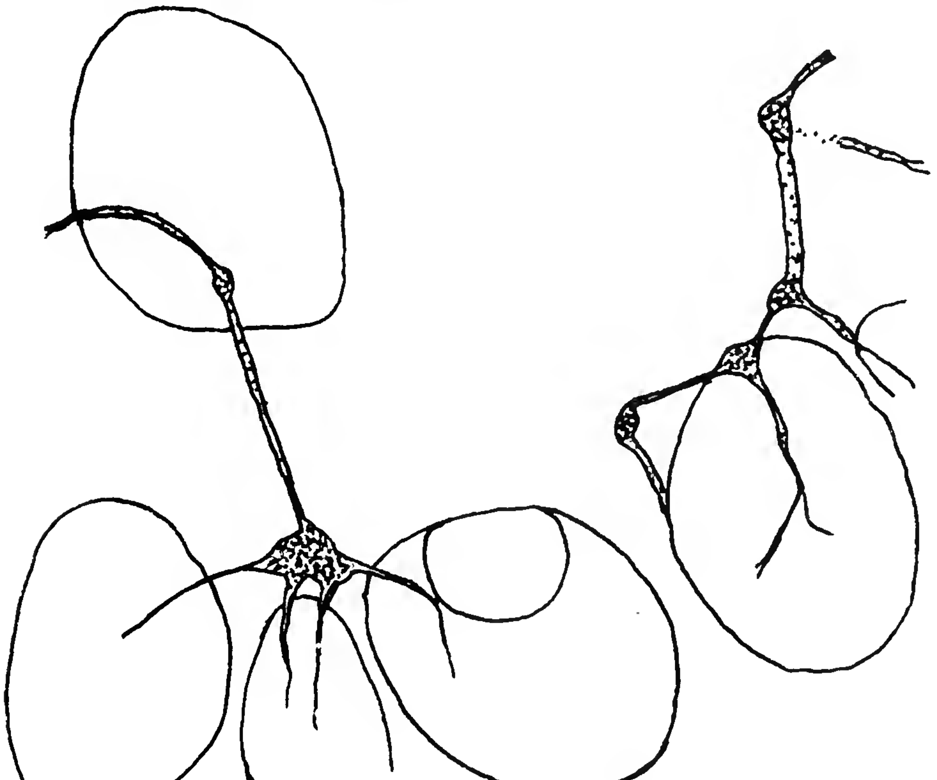

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Figs. 1-7 (facing page) and 8-10 (above). Chromosomes and bacterial infections (*Rhizobium*) in root tip and nodule cells of alfalfa (*Medicago sativa*).

Fig. 1. Untreated, uninfected root tip cell with 32 chromosomes (2000x).
Fig. 2. Untreated, uninfected root tip cell with 32 chromosomes (1700x).
Fig. 3. Untreated, uninfected root tip cell with more than 32 chromosomes (2000x).
Fig. 4. Bacterial infection thread (arrow) in a nodule preparation (1600x).
Fig. 5. Bacterial infection thread (arrow) in a nodule preparation (1600x).
Fig. 6. Bacterial infection thread (arrow) in a nodule preparation (1600x). (Also see Fig. 10.)
Fig. 7. Bacterial infection thread (arrow) in a nodule preparation (1600x).
Fig. 8. Chromosome number of 32 of an untreated and uninfected root tip cell. (Also see Fig. 1.)
Fig. 9. Chromosome number of 24 of an untreated and uninfected root tip cell.
Fig. 10. Bacterial infection threads. (Also see Fig. 6.)

55 cc distilled water) was used for chromosome staining. For best results, the uninfected root tips were stained for a 24-hour period. The thicker nodules were stained for a 48-hour period.

Squashes proved to be more effective than sectioning in observing the cells and chromosomes.

Plants were also grown for a 24-hour period on filter paper soaked with 0.02% colchicine, transferred to a carton of "Perlite," grown for a four-week period, uprooted for examination of nodules, and compared to a control group.

Plants were inoculated with *Rhizobia* bacteria. (Nitrogin for alfalfa and clover, Nitrogin Co., Inc., Milwaukee, Wisconsin.) The bacteria and filler material were sprinkled on and mixed with the "Perlite" and seeds or young plants.

OBSERVATIONS AND RESULTS

1. Root-tip Cells: The prevalent number of chromosomes in the root tip cells was found to be 32. (Fig. 1, 2). As mentioned previously, *Medicago sativa* is a natural tetraploid (4n=32). Several counts of 24 chromosomes per cell were also found. (Fig. 9). Out of about 150 slides made of root tips, four cells were found which appeared to have more than 32 chromosomes (Fig. 3) and in two, 48 chromosomes were counted. The cells varied in size, depending on the stage of development; the average size of those in which chromosomes were visible was 16 × 18μ.

2. Nodule Cells: The nodules were at varying stages of maturity, ranging from three to five weeks when they were collected and fixed. Two types of cells were found in the region of a bacteria-infected nodule: (a) enlarged cells (avg. 27 × 34μ) with large nuclei, which were prevalent, and (b) scattered throughout these large cells were smaller cells (avg. 19 × 24μ) approximately the same size as those found in the meristematic region of a root tip. These smaller cells appeared to occur in groups. Their cytoplasm was "clear" with no evidence of bacterial infection. The majority of the larger cells had bacterial infection threads leading into them (Fig. 4, 5, 6, 7, 10). The cytoplasm in the infected cells stained darker than in the uninfected cells, and the nuclear area appeared granular. As the infected cells of a young module mature, they become filled with *Rhizobia*. The nuclei of these host cells appear to be in various stages of disintgeration. Some binucleate cells were also observed among these enlarged cells.

3. Colchicine-treated Cells: The root tips which grew for 24 hours on colchicine-soaked filter paper were swollen and bulbous. Colchicine, which is an effective mitotic inhibitor, induces polyploidy (Eigisti & Dustin, 1955; Kihlman, 1966). The colchicine-affected cells (avg. 26 × 35μ) were very similar to the size and appearance of the enlarged nodule cells except for one major difference—there were no bacterial infection threads in the large colchicine-affected cells.

Binucleate cells were observed in the colchicine-treated material. About one cell in fifty appeared to be binucleate whereas about one in twenty in the nodule cells appeared to be binucleate.

4. Colchicine Plants Versus the Control Plants: The colchicine-treated plants and the control plants grown for four weeks in "Perlite" were uprooted for examination. The general appearance of both sets of plants was similar, and the average number of nodules per plant was one for each group.

The greatest number of nodules found on any plant was four. This was found on a control plant. There were no nodules found on plants that did not have at least one true leaf. The average size of nodules on the control and treated plants was 0.5 mm. The greater the number and vigor of the true leaves, the greater was the number of nodules.

DISCUSSION

If polyploid cells found in the root tips were responsible for the initiation of nodules as suggested by Wipf and Cooper (1940), it was reasoned that the colchicine-treated plants, which contained many polyploid cells, should have a greater number of nodules than the plants which had not been affected by colchicine.

However, since the nodules in the colchicine-affected plants did not have either a greater number of nodules or larger nodules, it seems plausible to conclude that nodule initiation is linked with a factor or factors other than the relatively few naturally occurring polyploid cells found in the roots. One factor might very well be associated with the effect of the initial bacterial infection of diploid cells. Another possibility to consider is the effect that the appearance of the first true leaves may have upon nodule initiation, for no nodules were found prior to the appearance of the first true leaves, and the number of nodules appears to increase as the number of true leaves increases.

SUMMARY

The examination of colchicine-treated and untreated alfalfa plants (*Medicago sativa*) has indicated that factor(s) other than naturally occurring polyploid cells may be instrumental in nodule formation. Chromosome numbers of 24, 32, and 48 were obtained from non-bacterially infected and untreated cells of the root. Included in this report are the first known published photographs of bacterial threads in the nodule.

LITERATURE CITED

Eigisti, O. J., & P. Dustin, 1955. Colchicine- in Agriculture, Medicine, Biology, and Chemistry. Iowa State College Press, Ames. 470 pp.

Kihlman, B. A., 1966. Actions of Chemicals on Dividing Cells. Prentice-Hall, New Jersey. 260 pp.

Virtanen, A. I., & J. K. Miettinen, 1963. Biological Nitrogen Fixation *in* Plant Physiology 3: Inorganic Nutrition of Plants (Edited by F. C. Steward). Academic Press, New York. 811 pp.

Wipf, L., & D. C. Cooper, 1938. Chromosome numbers in nodules and roots of red clover, common vetch and garden peas. Proc. Natl. Acad. U.S. 24:87-91.

Wipf, L., & D. C. Cooper, 1940. Somatic doubling of chromosomes and nodular infection in certain Leguminosae. Am. Jour. Bot. 27: 821-824.

Review

THE MONOCOTYLEDONEAE CAT-TAILS TO ORCHIDS. By E. Lucy Braun. With Gramineae by Clara G. Weishaupt. Original drawings by Elizabeth Dalvé and Elizabeth King. Ohio State University Press, Columbus. 1967. 464 pp. $10.00.

This work is identified as Volume One of "The Vascular Flora of Ohio" on a leaf two pages before the title page, which, like the dust jacket and binding, fails to restrict the title to Ohio. Almost all native species of Ohio are excellently figured, and maps indicate their known distribution in that state by counties. The maps are based on specimens (in certain cases, examined by a specialist rather than the author), chiefly from 11 institutional herbaria in Ohio and the author's large personal herbarium. The aid of many specialists was enlisted in checking identifications. The keys, although not always dichotomous, look original and workable, in line with the professed aim of the book to be usable "not alone by the student or botanist, but also by the amateur and the fieldworker in any of the natural sciences."

The whole book sparkles with a freshness which could not come from merely copying the work of others. As one might expect from its distinguished author, who in her 79th year continues to be one of Ohio's most ardent field botanists, this flora speaks with particular authority in its ecological notes; e.g.: "Said to grow in 'damp woods and bogs;' all that I have seen were in dryish oak woods." Although geographic distribution is usually (except for the grasses) not given for each species as a whole, there are numerous phytogeographic comments where they are appropriate. Instances of taxonomic ambiguity are frankly acknowledged and discussed from experience, not swept under the rug nor forced to conform to any existing manual. A brief "General Index" preceding the one to plant names is a useful guide to discussions of cytotaxonomic studies in various genera; economic, edible, poisonous, and saprophytic plants; geographic distribution, and such topics. The interesting digressions in the Lemnaceae are not indexed.

Nomenclature is usually that of Gray's Manual; the Lõves' adoption of *Acorus americanus* for our plant is followed, for example, but numerous other recent taxonomic and nomenclatural proposals are neither mentioned nor adopted. Since 1950 the International Code of Botanical Nomenclature has outlawed such names of typical subgenera as "Eucarex," and has specified that the hybrid sign in a binomial be placed immediately before the specific epithet (*Carex* ×*subimpressa*), not before the genus. But this is not the only work in which these refinements have been slow of adoption. *Lemna perpusilla* is said to be represented by "a single Ohio record from Mercer County," but is mapped, in addition, from Knox Co. *Vallisneria* is said (p. 60) to be distinguished "from all other of our aquatic plants by the long, thin, wholly submersed ribbon-like leaves," but the characteristic three-zoned nature of those leaves is not mentioned, leaving it unclear how one would distinguish them from those of the aquatic form of *Sagittaria cuneata* which is described (p. 53) as having "ribbon-like phyllodia."

Some species, admittedly not part of the Ohio flora, are nevertheless keyed and numbered despite their exclusion (e.g., *Juncus scirpoides, Iris lacustris, Carex paupercula, C. disperma*). Surely there are dozens of other species equally erroneously reported from Ohio in the past, which are, rightfully, not mentioned at all.

If "The Vascular Flora of Ohio" can be completed by the excellent standards of the Monocot volume, it will stand beside the monumental floras of Deam and Steyermark as among the best state floras produced. It will be most useful in southern Michigan, somewhat less so northward, of course. Those interested in statistics can note that Ohio has 140 species of *Carex* and Michigan, 170; Ohio has "over 650" species of Monocots, while Michigan has about 720.

—E. G. V.

MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

A. MAPS, SOILS, GEOGRAPHY, GEOLOGY

Eichmeier, A. H., et al. 1965. Michigan Freeze Bulletin. Mich. Agr. Exp. Sta. Res. Rep. 26. 40 pp. [Includes maps, data on near and subfreezing temperatures for various stations about the state, and a list of 94 weather stations in Michigan with elevations and remarks.]

Winkler, Erhard M. 1966. Moisture measurements in glacial soils from air-photos. Ecology 47: 156-158. [Four of 5 soils studied were in southwestern Lower Peninsula.]

B. BOOKS, BULLETINS, SPECIAL REPORTS, AND MISCELLANEOUS

Critchfield, William R., & Elbert L. Little, Jr. 1966. Geographic Distribution of the Pines of the World. U. S. Dep. Agr. Misc. Publ. 991. 97 pp. $ .75 (U. S. Gov. Printing Off.). [Range maps include boundaries of the three native species in Michigan, with fair detail though small scale precludes showing counties.]

Rudolf, Paul O. 1966. Botanical and Commercial Range of Balsam Fir in the Lake States. North Central For. Exp. Sta., U. S. For. Serv. Res. Note NC-16. 4 pp. [Includes detailed distribution map based on herbarium specimens and plot data.]

Rudolf, Paul O. 1966. Botanical and Commercial Range of Tamarack in the Lake States. North Central For. Exp. Sta., U. S. For. Serv. Res. Note NC-17. 4 pp. [Includes detailed distribution map based on herbarium specimens and plot data.]

Schneider, G. 1966. A Twenty-year Ecological Investigation in a Relatively Undisturbed Sugar Maple-Beech Stand in Southern Michigan. Mich. Agr. Exp. Sta. Res. Bull. 15. 61 pp. [Study in Tuomey Woodlot, Ingham Co.]

Schuyler, Alfred E. 1967. Scirpus hattorianus in North America. Not. Nat. 398. 5 pp. [Species cited from Isle Royale and an apparent hybrid with the similar *S. atrovirens* from Washtenaw Co.]

Skog, Roy E., & M. W. Day. 1966. Cutting Practices for Conifer Swamps and Upland Spruce-Balsam Fir in Northern Michigan. Mich. State Univ. Extension Serv. Bull. E-526. 14 pp. [Includes some general ecological information for "northern third of the Lower Peninsula and the Upper Peninsula."]

Smith, Helen V. 1966. Michigan Wildflowers. Cranbrook Inst. Sci. Bull 42, revised. 468 pp. + 17 col. pl. $6.00. [See review, Mich. Bot. 6: 53. 1967.]

C. JOURNAL ARTICLES

Bigelow, Howard E., & Margaret E. Barr. 1966. Contribution to the fungus flora of northeastern North America. IV. Rhodora 68: 175-191. [Includes mention of *Clitocybe asterospora* in Michigan and designates type of new species, *Pleurotus elongatipes*, from Detroit.]

Clewell, Andre F. 1966. Native North American species of Lespedeza (Leguminosae). Rhodora 68: 359-405. [Distribution maps include numerous Michigan dots for 5 species and 4 hybrids.]

Davis, Ray J. 1966. The North American perennial species of Claytonia. Brittonia 18: 285-303. [Cites just one "representative" specimen of *C. caroliniana* from Michigan (Ontonagon Co.); no maps.]

Erdman, Kimball Stewart. 1965. Taxonomy of the genus Sphenopholis (Gramineae). Iowa St. Jour. Sci. 39: 289-336. [Distribution maps include dots in Michigan for *S. obtusata* var. *obtusata*, var. *major* (= *S. intermedia*), and *S. nitida*.]

Gates, David M. 1966. Transpiration and energy exchange. Quart. Rev. Biol. 41: 353-364. [Includes data on several species of various habitats "in northern Michigan."]

Graffius, J. Herbert. 1966. Additions to our knowledge of Michigan Pyrrhophyta and Chloromonadophyta. Trans. Am. Micr. Soc. 85: 260-270. [Records from Barry Co.]

Mitchell, William W., & Richard W. Pohl. 1966. Variation and aneuploidy in Muhlenbergia glomerata. Am. Midl. Nat. 76: 211-221. [Distribution map includes dots in Michigan; collection sites for aneuploids include stations at Clare and Grayling.]

Ouellette, G. B., & L. P. Magasi. 1966. Lophomerum, a new genus of Hypodermataceae. Mycologia 58: 275-280. [*L. autumnale* distribution includes occurrence on *Abies* host from Michigan.]

Ray, Peter M., & William E. Alexander. 1966. Photoperiodic adaptation to latitude in Xanthium strumarium. Am. Jour. Bot. 53: 806-816. [Strains studied included ones from Wayne, Washtenaw, Crawford, and Emmet counties.]

Robinson, Thane S. 1966. Effects of canopy density and slope exposure on the subcanopy microenvironment of a northern hardwood forest. Am. Midl. Nat. 75: 339-346. [Study made in Cooper's Glen, Kalamazoo Co.]

Roussine, N. "1961" [1962]. Note sur les espèces du genre Thymus aux Etats-Unis d'Amérique. Naturalia Monspeliensia 13: 59-61. [Refers to herbarium specimen (GH or NY) of *T. pulegioides* from Michigan, according to label established only in 1941.]

Seymour, Frank C. 1966. Bromus mollis and allies in New England. Rhodora 68: 168-174. [Includes citation of representative specimens from Michigan of *B. mollis* and *B. thominii*.]

Smith, Alexander H. 1966. Notes on Dendrogaster, Gymnoglossum, Protoglossum, and species of Hymenogaster. Mycologia 58: 100. [Type locality of *H. farinaceus* sp. nov. is Cross Village, Emmet Co.]

Southern, William E. 1961. A botanical analysis of Kirtland's warbler nests. Wilson Bull. 73: 148-154. [Includes data on mosses, lichens, and vascular plants in jack pine region of Michigan.]

Taboada, Oscar, & Julius R. Hoffman. 1965. Distribution of leafhopper vectors of plant diseases in Michigan. Trans. Am. Micr. Soc. 84: 201-210. [Includes mention of the virus diseases carried.]

Voss, Edward G. 1966. Nomenclatural notes on Monocots. Rhodora 68: 435-463. [Includes mention of *Puccinellia fernaldii*, *Spartina pectinata* var. *suttiei* (type locality), and *Sisyrinchium farwellii* in Michigan.]

Wagner, Warren H., Jr. 1966. New data on North American oak ferns, Gymnocarpium. Rhodora 68: 121-138. [Includes description of *G. heterosporum* as an apomictic species (hybrid) with citation of material from Marquette Co.]

Whitney, Marion Isabelle. "1966" [1967]. Chestnut blossoms in Michigan. Jack-Pine Warbler 44: 172-175. Semi-popular article which mentions a few of the many chestnut trees which survive where once planted in Michigan.

Wujek, Daniel E. 1967. Some plankton diatoms from the Detroit River and the western end of Lake Erie adjacent to the Detroit River. Ohio Jour. Sci. 67: 32-35. [List of species gives names only, not exact localities.]

INDEX TO VOLUMES 4–6

With the exceptions here noted, this index is intended to be complete for the three volumes, including all scientific names of genera and species, titles (by important words), authors, and subjects. NOT indexed, in general, are the following: News items, program notes, announcements, etc.; items in literature lists, bibliographies, and summaries; common names except when there is a major discussion or use of them; names of taxa higher than genus or lower than species. Reviews are ordinarily listed only (by title) under "Reviews"—not under the author or title of the works reviewed, nor under the reviewer's name; "Publications of Interest" are not indexed in any way, although the heading is. If an article has three or more joint authors, the others are cross-referenced to the senior author without repetition of title; if there are only two authors, both are fully indexed with title. Most references to persons are not indexed unless of special importance to the subject matter of the article itself. Names of persons not followed by a title (or cross-reference) refer to information about the person.

Some inconsistencies are inevitable as to whether or not species mentioned in passing, or in habitat descriptions, are indexed; generally, if they seem to provide good records in themselves, they are indexed. Exceptions in the past three volumes are the long list of mushroom field identifications in Vol. 4, pp. 54-60; the names of vascular plants in sample relevés in Vol. 5, p. 111; and the mushroom names given in the questionnaires reported upon in Vol. 5, pp. 120-124. Pictures are indexed under their explanations (whether on the same page, a facing page, or in the case of cover pictures, the rear cover).

The attention of phytogeographers is called to the special entry, "Distribution Maps," where all species are listed for which partial or complete maps have been published.

Information for Authors — The Michigan Botanist

THE MICHIGAN BOTANIST is distributed not only to a considerable number of individual and institutional subscribers domestically and abroad, but also to all members of the Michigan Botanical Club, an organization composed in large part of non-professionals with concerns for conservation and nature study as well as the local flora. (Total paid circulation is over 800 copies.)

Articles and notes may relate to any phase of botany in the Upper Great Lakes region. Considering the range of interests among members and subscribers, we seek to include (in each year if not each issue) the widest possible range of subject matter in regard both to the entire plant kingdom and to branches of the field of botany. Notes on techniques useful to the teacher and hobbyist are welcomed.

To promote clarity to non-technical readers (without sacrifice of accuracy and precision), such means are encouraged as illustrations, inclusion of a generally accepted "common name" (when such exists) at least once in the title or text of any article devoted to consideration of one or a few species, and introductory material placing the author's studies in perspective and briefly indicating their significance.

Manuscripts should (unless in the nature of a "review" article) include some new botanical information, and should pertain to the Upper Great Lakes region. Not acceptable are manuscripts of primarily literary nature (including all poetry and articles of an "editorial" orientation).

Manuscripts are considered on their botanical merit and clarity of presentation, and their acceptability is judged without special regard for repetition of authors, length, or prospect of subsidies (see below). All manuscripts are subject to review by botanists prepared to evaluate not only their content but also their suitability for this journal.

Manuscripts are ordinarily published in the order of acceptance, with allowance as necessary for maintenance of diversity within our space limitations. In the interests of diversity, acceptable articles occupying more than 10 printed pages can be published only if divided into two or more issues or if the necessary additional pages can be subsidized at cost. (Present cost is approximately $12.50 per page.) Subsidy of the entire cost of an acceptable article will permit its publication as extra pages without delay, and authors with access to funds for this purpose are encouraged to allow complete subsidy, regardless of length of article, in order to avoid contributing toward a large backlog of manuscripts.

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An order blank for reprints will be supplied when a manuscript is accepted. Reprints (with extraneous matter removed), folded and saddle-stitched as required, are supplied at standard prices established by the printer (rate schedule available from the editor).

—The Editorial Board

INDEX NOTICE

TO LIBRARIANS, SUBSCRIBERS, AND BINDERS

In this issue is a single cumulative index to Volumes 4, 5, & 6 of THE MICHIGAN BOTANIST—our second triennial index. It is expected that these three volumes will make a more convenient unit for binding and future consultation than would single volumes. Note that all covers are included in the consecutive pagination. There are no special title pages.

The editor would appreciate receiving opinions concerning the index. Would readers rather have one every year? Every 5 years? Is it too detailed, by listing *all* mention of species names? Would an index of authors and titles suffice?

Editorial Notes

For the labor of alphabetizing the 3-year index, we are again indebted to Miss Dorothy Blanchard, who was aided by Mrs. F. N. Blanchard and Miss Mary Cooley.

The May number (in two sections, Vol. 6, No. 3, and No. 3A) was mailed May 17, 1967.

WATERLOO SPRUCE BOG

On September 24, 1967, less than two and a half years after dedication of Horner Woods (Mich. Bot. 4: 103), the Michigan Botanical Club participated in the dedication of a second natural area, the Waterloo Spruce Bog. Within a year of learning of the availability of this 40-acre tract in northeastern Jackson Co., which includes a southern outlier of black spruce (*Picea mariana*), the Club raised the funds for its purchase. Warren H. Wagner, Jr., president of the Club, presided at the dedication ceremonies. Ronald O. Kapp, president of the Michigan Natural Areas Council, spoke for that cooperating organization. Charles Barclay, past president of the Botanical Club, made the formal presentatian of the property to the State of Michigan, Department of Conservation, which will administer the tract as a Nature Study Area. William Laycock, regional manager of the Department, accepted the land for the State. A large crowd attended, and there were field trips to the bog.

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(*On the cover: A mosquito,* Aedes fitchii,
visiting the flower of a Ram's Head Lady's-Slipper,
Cypripedium arietinum. *Photo by W. P. Stoutamire*
at Ipperwash Beach, Ontario, June 3, 1966.
See page 164.)