

4. *Etheostoma caeruleum*: Montgomery County: Budds Creek, Barren Fork Creek, McAdoo Creek, Hurricane Creek, Yellow Creek; Houston County: \*White Oak Creek.
5. *Etheostoma spectabile spectabile*: Montgomery County: Budds Creek, McAdoo Creek.
6. *Etheostoma squamiceps*: Montgomery County: Spring Creek; Robertson County: Sulphur Fork Creek.
7. *Etheostoma blennioides*: Houston County: White Oak Creek.
8. *Etheostoma zonale zonale*: Sevier County: East Fork of Little Pigeon River.
9. *Etheostoma atripinne*: Montgomery County: Spring Creek.
10. *Etheostoma maculatum*: Robertson County: Sulphur Fork Creek; Houston County: White Oak Creek; Sevier County: East Fork of Little Pigeon River.
11. *Etheostoma simotera* (Probably most common darter in region studied): Montgomery County: Spring Creek, Big West Fork Creek, McAdoo Creek, Hurricane Creek, Yellow Creek, East Fork of Yellow Creek; Robertson County: Sulphur Fork Creek; Houston County: White Oak Creek; Stewart County: Saline Creek; Jefferson County: Dumplin Creek, Beaver Creek, Sartain Creek, Long Creek; Sevier County: East Fork of Little Pigeon River.
12. *Percina caprodes caprodes*: Montgomery County: Hurricane Creek; Robertson County: Sulphur Fork Creek; Jefferson County: Mossy Creek, Muddy Creek.
13. *Cogaster copelandi* (Possibly incorrectly identified): Montgomery County: Spring Creek.
14. *Hadropterus evides*: Sevier County: East Fork of Little Pigeon River.
15. *Hadropterus macrocephalus*: Sevier County: East Fork of Little Pigeon River.
16. *Hadropterus maculatus*: Montgomery County: Spring Creek; Robertson County: Sulphur Fork Creek.
17. *Stizostedion vitreum vitreum*: Jefferson County: Mossy Creek at mouth (A dead fish observed but not collected).
18. *Stizostedion canadense canadense*: Jefferson County: \*Holston River below Cherokee Dam (not collected.) \*French Broad River below Douglas Dam (not collected).

## THE GRAPEFERNS IN TENNESSEE

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### CUTLEAF GRAPEFERN

*Botrychium dissectum* Spreng. var. *typicum* Clausen

(Continued from the July number)

The rootstock is about 1/8 to 1 3/8 inches long and about 1/10 to 1/6 inch

thick at the upper end. It becomes gradually and slightly smaller downward and gives off fleshy roots on all sides. These roots may be as large as  $3/32$  inch in diameter. They are more or less spindle-shaped, especially distally where they rapidly become much smaller. Proximally, they are frequently but not always slightly constricted at the point of attachment to the rootstock. Branch roots are attached here and there to the other roots either at the fleshy portion or at the reduced part. The secondary roots may be fleshy or they may be small in diameter. The larger roots and the rootstock are a grayish slate in color and are free of scales and hairs. The smaller roots seem stramineous, yellowish, or flesh-colored. At the apical end of the rootstock is a white, small, and pointed bud covered by long, appressed white hairs, and completely surrounded by the base of the common stalk. Rarely, there is a very thin, white, and more or less complete sheath around the base of the petiole. In the few plants having this sheath, it usually seems very inconspicuous but in no. 10921 from Hawkins County, Tennessee, the sheath is large, being about  $2\frac{3}{8}$  inches long and about  $5/16$  inch wide. In this plant, the sheath encircles the petiole for a short distance only; most of the sheath appearing as a lanceolate and acuminate blade without a midrib. Outside of and below this sheath are sometimes the remains of the petiole of last year's leaf and, in a few cases (for example, no. 10921), the remains of the petiole from year before last's leaf. The vein seems to be the most persistent part of the petiole.

The common stalk or petiole is short varying from about  $1/2$  inch to 3 inches in my material. It is entirely or almost entirely subterranean. In color, it varies from white to yellowish below and from yellowish to yellowish-brown above. The common stalks of my plants have all been flattened in pressing but they look as though they were circular in life, as Small (1938, p. 368) indicates. They appear to have had some small ridges in life as Ogden mentioned for Maine plants (1948, p. 21). The common stalk branches into a sterile stalk which ends in a leaf blade and a fertile stalk which bears a panicle of sporangia (Fig. 224, B). Some plants have only a sterile stalk and a leaf blade. The sterile leaf stalk seems very similar to the petiole in shape. It is sparsely hairy with white hairs which are about  $1/16$  inch long. When part of a fertile plant, the sterile leaf stalk was found to be from  $1\frac{3}{4}$  inches to  $4\frac{1}{2}$  inches long, or, when only a sterile blade was present, from  $1\frac{3}{4}$  inches to  $5\frac{1}{2}$  inches. These differences, however, are probably not very significant because of the fewness of specimens for study. Most sterile leaf stalks seem to be from 3 to 4 inches long and are usually yellowish-brown in color at the base this color being quickly replaced above by dark green. When only the sterile stalk is present, the basal half usually varies from yellowish-brown below to brownish-green above with the distal half varying to dark green. Fertile stalks resemble very much sterile stalks in color being yellowish-brown near the petiole, then brownish-green midway, and dark-green distally. Sometimes they are dark-green or brownish throughout. White hairs similar to those on the sterile stalk occur here sparsely. Fertile stalks are mostly from 6 inches to 10 inches long—thus being very much longer than the sterile ones.

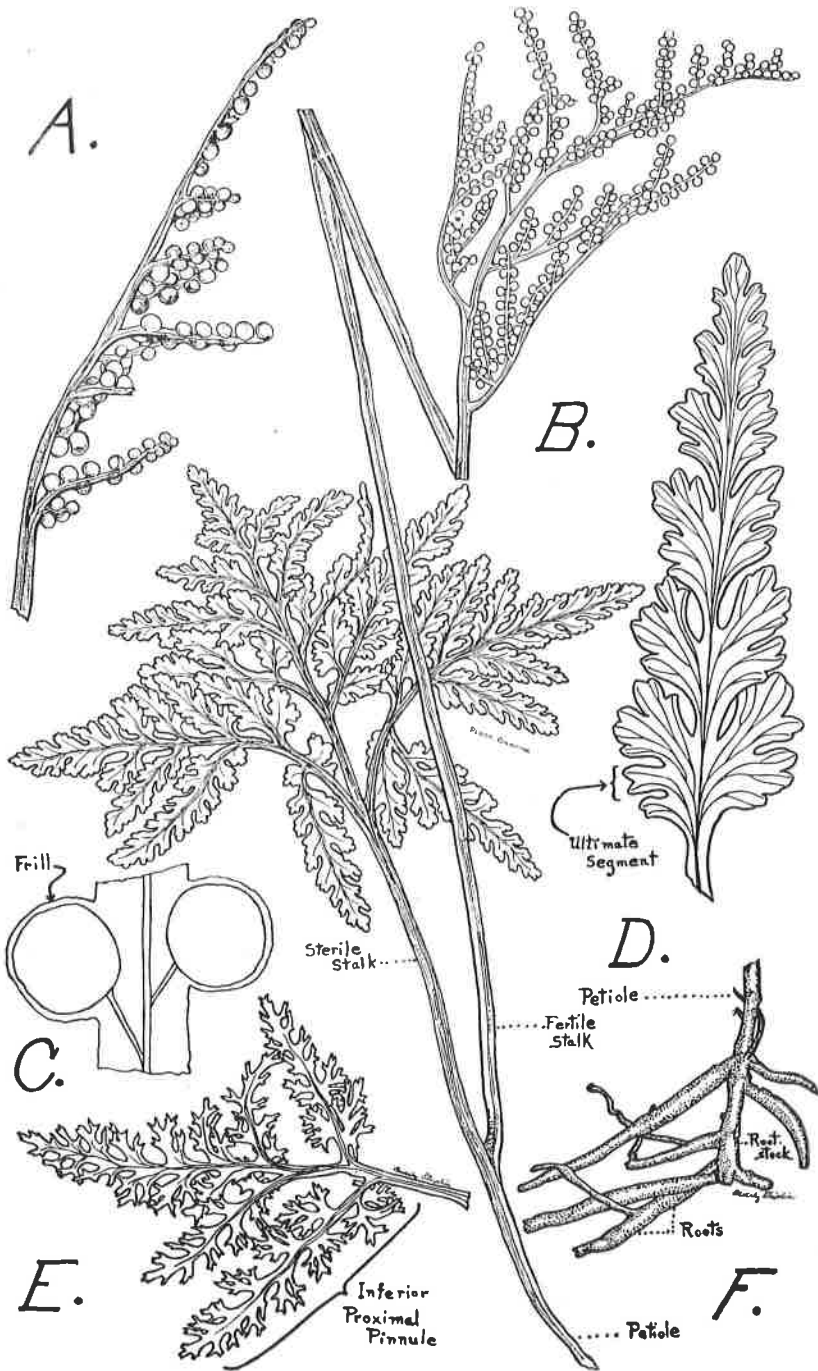
The venation of the petiole, of both the fertile and the sterile stalks, and of the rachis and main divisions in both the sterile and fertile blades, are considered together in this paragraph. The petiole seems to have a single vein which appears to fork distally to send a single branch into the sterile stalk and a single branch into the fertile stalk instead of two branches to each as St. John (1952) reported. The single vein in the sterile stalk usually forks into two veins somewhere between one-half and three-fourths the distance from the petiole to the base of the leaf blade. These two veins are continued into the rachis where each gives off one branch vein to each leaflet on its side, and then they fuse to form a single vein just before reaching the second pair of leaflets, or at, or slightly beyond this point (Fig. 223, B). In one case (no. 10924), the point of fusion is even nearer to the apex being close to the base of the terminal leaflet. This usual relation of veins in the sterile stalk and sterile blade from a fertile plant is essentially the same in the sterile leaf from a sterile plant and is approximately the same arrangement as shown by St. John (1952, p. 3) in his figure 4, plate 1, for the sterile leaf. Nevertheless, there are a few plants in my collection where each of the two veins gives off a branch to each

of the pair of basal leaflets; thus supplying each basal leaflet with a pair of veins. This condition is similar to the venation pictured by St. John (1952, p. 11) for a sterile blade of a fertile plant except that he has two veins throughout the sterile stalk and I have never been able to see more than one vein. There are some specimens where the single vein in the sterile stalk does not fork but gives off a single branch vein to each segment. The fertile stalk seems to have only one vein for a short distance before it forks into two veins. These two veins are continued into the rachis of the fertile panicle and each seems to give off a single vein to each fertile branch on its side. The two veins fuse into a single vein about two-thirds the length of the fertile panicle. Thus most fertile branches have a single vein but the basal pair sometimes appears to have two veins each, thus agreeing with St. John's figure (1952, pl. II). His figure also shows two veins throughout the fertile stalk but I have only been able to see one vein for the basal part of the stalk. However, my observations were on herbarium specimens which prevent venation studies from being as accurate as would be the case had either St. John's (1952) cleared plant method or Chrysler's (1910) serial section method been used.

The blade is thin, dark green and glabrous above, and a lighter green below with a greenish, minute meal which is scarce or absent on the upper side of the leaf but often rather common on the under leaf surface. Leaf blades are supposed to take on a bronzed or coppery color in winter but I have been unable to observe these plants in the field at that time. In shape the leaf is broadly ovate to almost orbicular. It is wider than long, my Tennessee material averaging about 4 inches in width and about 2¾ inches in length. The broadest leaf, 6¾ inches (no. 2286), is also the longest, 4¾ inches, and the narrowest leaf, 2 inches (no. 2167A), is also the shortest, 1¼ inches. The blade is acute and ternately compound into three main divisions (Fig. 224, B). Each one of the basal pair of leaflets is arranged opposite or almost opposite the other and has a stalk about ½ inch to ¾ inch long. These leaflets are about 1¾-3 inches long by 1¾-2½ inches wide. In general they are triangular to lanceolate in shape with acuminate, acute, or even obtuse apices. The basal leaflets are usually compound into stalked pinnules (Fig. 223, A). Occasionally, the inferior and superior proximal pinnules on the basal leaflets are about equal in size (no. 2165) but usually the inferior proximal pinnules are much longer (as may be seen in no. 2167B). The inferior pinnules are usually nearer the rachis than the superior pinnules and have a stalk about ⅓ inch long. The median portion of the ternate blade is much like the basal pair of leaflets in shape, in cutting, and in the shape of its apex. Its leaflets are much like the pinnules of the basal pair of leaflets of the blade, but differ in that the leaflets on one side match rather closely in size and shape the leaflets on the other side of the median portion; thus being symmetrical.

Pinnules are lanceolate or lanceolate-oblong and acute or sometimes obtuse. They are deeply pinnatifid into ovate, oblong, or lanceolate segments which are themselves deeply dissected into ultimate segments which are usually linear or rectangular in shape and have two to four acute or sometimes obtuse teeth; both the segments and their teeth being strongly divergent (Fig. 222). Some plants (for example, no. 2167B) have their pinnules pinnatifid into segments and these segments deeply cut into other segments which are dissected into the ultimate toothed segments (Fig. 223, A). While the rectangular or linear shape is most characteristic of the ultimate segments, occasional plants have most of their ultimate segments of this type and a few slightly wedge-shaped (see no. 2171). The teeth vary in length from short to fairly long, and in shape from lanceolate to oblong and rarely to linear (Fig. 224, E). Portions

Fig. 224. (Opposite page.) Some details of the Cutleaf Grapefern. A, Branch from the fertile panicle to show arrangement of sporangia, no. 2163, X 2.50. B, The above-ground parts of a plant that is not as much cut up as usual, no. 2163, X 1.00. C, Sporangia embedded in the side of the flat branch, with veins and a narrow fringe to each, no. 2162, X 12.00. D, A pinnule-like segment from the leaf, no. 2163, x 2.50. In most plants the ultimate segments are more rectangular than shown here. E, Basal leaflet with teeth more acute than usual, no. 2162, X 1.00. F, Roots, rootstock, and petiole, no. 10916, X 1.00.



of leaf blades intermediate in cutting between *Botrychium dissectum* var. *typicum* and *Botrychium dissectum* forma *obliquum* are illustrated in figures 223, C, E, F, G, and 224 B. Typically, the ultimate segments vary somewhat in size due to the incisions varying in depth, about every fourth incision being a deep one. The margin especially of the teeth sometimes has an extremely narrow, hyaline or greenish-white border, as mentioned by Tryon (1940), but it is very difficult to see. Indeed, in many cases, I have been unable to recognize this border even under a binocular microscope. Veins branch in the segments with the branches ending free in the teeth usually before quite reaching the margin (Fig. 224, D), or sometimes short veins will branch off and end where no teeth are present, and some few teeth seem not to have veins at all. On the upper side, and, with more difficulty, on the lower side, the straight sides of the epidermal cells may be seen under a binocular microscope. The relatively long hairs previously described from the sterile leaf stalk occur in very small numbers on the underside of the rachis, of the costa, and of the costule.

The fertile panicle is about two to three inches long. It is difficult to determine its width because the fertile branches pass off mainly on one side. These branches are linear and ribbon-like and give off mostly on one side similar ribbon-like branches. All branches bear on each side a row of globular sporangia, are ascending, and in some plants strongly so. There are two rows of sporangia for each branch (Fig. 224, A). Two veins have already been mentioned as passing into the rachis with each vein giving off a single branch vein to each fertile branch on its side. This single vein in each primary branch gives off a single branch vein to each secondary branch and this a single branch vein to each tertiary branch, if present. A single small vein passes from this vein to each sporangium (Fig. 224, C). The sporangia are variable in size—from about  $1/64$  inch to about  $1/24$  inch in diameter. It seems sometimes that most of the smaller sporangia are near the ends of the branches. Usually each branch extends beyond the sporangia as a small tongue of tissue. The sporangia are sessile in two rows on one side of the flattened segment, one row near one margin and the other row near the other margin. Generally, the sporangia in one row appear to alternate with those in the other row but occasionally they are oppositely arranged. Sporangia are glabrous, have no indusia, and become yellowish or stramineous when mature. Dehiscence is by a median, transverse slit into two approximately equal valves, exposing many white to yellowish spores. Usually there are no frills around the sporangia but in one plant (no. 2162) each sporangium has a very narrow frill of leaf-like material passing around it in a longitudinal direction (Figs. 223, D; 224, C).

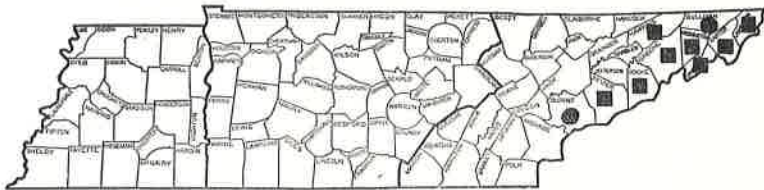


Fig. 225. The distribution of *Botrychium dissectum* var. *typicum* in Tennessee as known to the author. Solid squares equal the collections of the author; solid circular areas, the collections of others as follows. Blount and Sullivan Counties (Univ. of Tenn. herbarium).

The distribution of *Botrychium dissectum* var. *typicum* in Tennessee, as known to the author, is given in figures 225. Broun (1938, p. 33) gives its general distribution as “. . . southern Nova Scotia, New Brunswick, Quebec to southern Minnesota, south to Florida and eastern Missouri.”

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## COMMON GRAPEFERN

**Botrychium dissectum** Spreng. forma **obliquum** (Muhl.) Fern.

This fern belongs to a group of plants with ternately decomposed sterile blades and sporangia borne in a compound spike at the end of the fertile stalk. It seems that all of the ferns of this group might best be separated by an artificial key. In the key is included *Botrychium multifidum* (Gmel.) Rupr. var. *intermedium* (D. C. Eaton) Farwell, although it has not as yet been found in Tennessee, because of the possibility of it showing up in some of the eastern Tennessee mountains. According to Wagner (1946), it should be looked for in brushy fields where the moss, *Polytrichum*, is common. For completeness sake, *B. dissectum* var. *typicum* is included in the key although its characteristics have already been given. *B. dissectum* var. *oneidense* is also given in the key for undoubtedly it will be found in the mountains of eastern Tennessee.

Key to the Tennessee species, varieties, and forms of *Botrychium* with ternately decomposed sterile blades

- A. Sterile blade with a stalk, not sessile; bud for next year's leaf completely enclosed by the base of the stalk; sporangia maturing in late summer or in autumn \_\_\_\_\_ a
- a. Segments of the twice pinnate sterile blade deeply and laciniately cut into one- to two-toothed ultimate segments which often have parallel sides \_\_\_\_\_ *B. dissectum* var. *typicum*
- a. Segments of the twice pinnate sterile blade not laciniately dissected, with ultimate segments not as above \_\_\_\_\_ b
- b. Terminal segments of blade and basal leaflets usually elongated and not much divided, segments of the blade not usually of the same size and shape \_\_\_\_\_ c
- c. Terminal segments of blade and basal leaflets usually not very broad, mostly with acute, acutish, or rarely obtuse (but not rounded) apices \_\_\_\_\_ d
- d. Pinnules and pinnule-like segments usually coriaceous, often somewhat divided below and with truncate or adnate bases, margins more or less serrulate, crenulate, or almost entire \_\_\_\_\_ *B. dissectum* forma *obliquum*
- d. Pinnules and pinnule-like segments thin, little or undivided, and often with a cuneate base; typically with segments mostly long, narrow, and conspicuously serrated; stalks slender; often with a rather small and open spike \_\_\_\_\_ *B. dissectum* var. *tenuifolium*
- e. Terminal segments of blade and basal leaflets broad and rounded apically as are most of the other segments (in Tennessee?) \_\_\_\_\_ *B. dissectum* var. *oneidense*
- b. Terminal segments of blade and basal leaflets not elongated, all segments usually of about the same size and shape \_\_\_\_\_ e
- e. Ultimate divisions of sterile blade not usually flabellate, ultimate segments with acute or obtuse apices, crenate to entire margins, ultimate segments usually remote and not imbricated (not yet reported from Tennessee) \_\_\_\_\_ *B. multifidum* var. *intermedium* (D. C. Eaton) Farwell
- e. Ultimate divisions of sterile blade flabellate, broad and rounded at the apex, but contracted to an abruptly cuneate base; apices of main terminal segments rounded \_\_\_\_\_ *B. alabamense*

- A. Sterile blade without a stalk, sessile or almost so, broadly deltoid; bud for next year's leaf exposed by the split sheathing base of the stalk, sporangia maturing in the spring ..... *B. virginianum*

*Botrychium dissectum* forma *elongatum* (Gilbert & Haberer) Weatherby is given by Fernald (1950, p. 21) but the present author follows Clausen (1938, p. 51) in regarding this as a trivial variation not at all comparable to *B. dissectum* forma *obliquum*. It is more of the nature of the ferns once known as *Botrychium obliquum* var. *oblongifolium* Graves, in *Amer. Fern Jour.*, 22:50, pl. 4, 1932, and *Botrychium obliquum* var. *pennsylvanicum* Graves, in *Amer. Fern Jour.*, 25:118, 1935. In the present key, all of these would be given as *Botrychium dissectum* forma *obliquum*. This treatment seems sensible in view of the experimental results secured by Mrs. Hall (1943) in apparently transforming what was once called *Botrychium Coulteri* Underwood into *Botrychium silaifolium* Presl by changing the environment under which the plants grew.

Plants with characteristics intermediate between species, varieties, or forms, may be difficult to place properly. These intermediates may even be placed in different categories by different botanists depending on the relative weight given by each one to the different characteristics present. Ferns of the groups of *Botrychium* given in the key above are especially troublesome. Intermediates between *Botrychium dissectum* forma *obliquum* and *B. dissectum* var. *typicum* have already been considered under the latter variety.

In Tennessee, plants intermediate between *B. dissectum* forma *obliquum* and *B. dissectum* var. *tenuifolium* are very numerous. Most of these plants have these characteristics of var. *tenuifolium*: a very slender or lax petiole, sterile stalk, and fertile stalk; and a thin blade; together with long segments, some of which may be oblong and unlobed. Such plants often have many pinnules and pinnule-like segments that are often much lobed and with truncated bases and an almost entire or very shallowly toothed margin. These latter are characteristics of forma *obliquum*.

In view of the fact that the cutting of the sterile blade in each of these entities varies much, these plants could be regarded as either forma *obliquum* or var. *tenuifolium*. There seems to the author to be a tendency among the students of ferns to regard the slender stalks and the thin sterile blades as very important characters, and these plants as var. *tenuifolium*. If the leaf margins are prominently serrated and some of the segments narrowly oblong, this placement seems much strengthened. In this paper, intermediates like those mentioned above are usually regarded as belonging to var. *tenuifolium*.

In general, *Botrychium dissectum* forma *obliquum* has much the same appearance as *B. dissectum* var. *typicum* with the exception of the sterile leaf blade. Both ferns usually have a single ternately divided sterile blade at the end of a rather long sterile stalk which is nevertheless much shorter than the single fertile stalk with its terminal compound spike of sporangia, and in both cases the sterile stalk and the fertile stalk unite near the ground to form a short



common stalk. There is a short vertical rootstock which bears apically a hairy conical bud entirely surrounded by the base of the petiole, and bears laterally fleshy roots. All of the parts of these two ferns, with the exception already noted, have essentially the same external char-

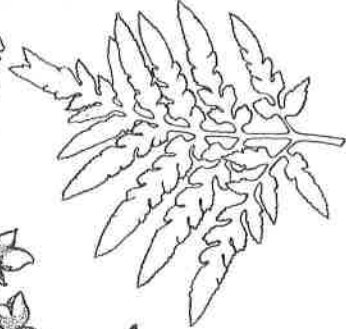


Fig. 226. *Botrychium dissectum* Spreng. forma *obliquum* (Muhl.) Fern. growing in woodland, Tull Bottom, Chester County, Tennessee, Sept. 2, 1934.

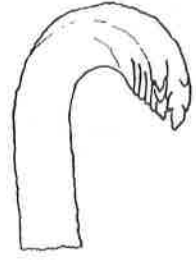
Fig. 227. (Opposite page.) Some details of *B. dissectum* forma *obliquum*. *A, C, D, F, G*. Some forms of basal leaflets X 0.5, the inferior side of the leaflets being towards the bottom of the page. *A*, no. 9820, *C*, no. 8148, *D*, no. 2206, *F*, no. 10549, *G*, no. 8074. *B*, A branch of a fruiting panicle showing the two-ranked sporangia each of which has opened by a transverse slit, no. 12, X 1.0. *E*, Pinnule showing lobes, serrulate margins, and veins, no. 2199, X 2. *H*, Roots and rootstock, no. 2186, X 0.5. *I*, Unfolding bud, no. 3248, X 4.5.



B.



A.



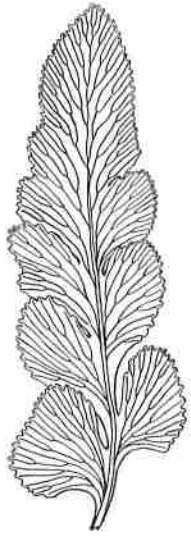
I.



C.



D.



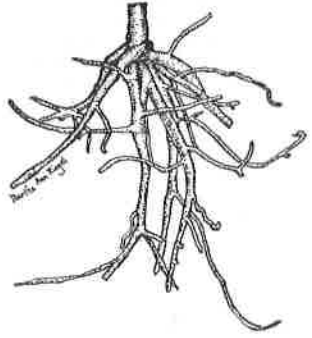
E.



F.



G.



H.

acteristics. This was discovered by comparing the detailed description of *B. dissectum* forma *obliquum* with the detailed description previously prepared of *B. dissectum* var. *typicum*. The comparison seemed to indicate that the one description, which had been given for the variety *typicum*, would be adequate except for the sterile leaf blades which are very different in the two ferns and must be described separately. However, it seemed that it would be worthwhile to record some characters noted in this study of forma *obliquum* that were not noted, or appeared poorly developed, in variety *typicum*.

*Description.* This description, unless otherwise indicated, is of *B. dissectum* forma *obliquum* only. The thick roots are sometimes as thick as  $\frac{1}{8}$  inch in diameter and are transversely corrugated. The bud at the apex of the rootstock is white or yellowish in color, more or less conical in shape, and pilose with long, somewhat appressed white hairs. When these hairs are removed from a developing bud, the apex is seen to be of two parts each reflexed with the upper part ending in a group of three small conical points with small projections on their sides. This I assume to be the beginning of the ternate sterile blade. The lower part seems to end in a group of linear, closely appressed segments which I take to be the primitive branches of the fertile spike (Fig. 227, I). A membranous sheath or sheaths around the petiole at its base, when present, usually seems small. The petiole or common stalk varies from  $\frac{5}{8}$  inch (no. 8248) to  $1\frac{1}{8}$  inches (no. 10889) long with an average length (based on 38 plants) of about 3 inches. The sterile branch averages about 3 inches in length (57 plants) with extremes of one inch and  $6\frac{1}{4}$  inches. The fertile branch varies from  $3\frac{3}{4}$  inches to  $11\frac{3}{4}$  inches in length with an average of about  $7\frac{5}{8}$  inches (43 plants). These three stalks (the common stalk, the sterile branch, and the fertile branch) are often about the same diameter as in the variety *typicum* but occasionally they are thicker and therefore stouter.

The sterile blades of forma *obliquum* vary in color on the upper surface from a very dark green to a yellowish-green. On the lower surface, the color is a lighter or whiter green. The blade persists over the winter and usually turns a bronzy or coppery color but Clausen (1938, p. 50) indicates that a "... considerable number remain quite green." There is a minute greenish meal on the under surface but this is scanty or entirely absent on the upper surface. Otherwise, the sterile blade is glabrous with the exception of scattered white hairs about  $1/16$  inch long on the lower side of the rachis, the costae, and the costules. The blade is polymorphic and this makes description difficult. The method used here is to describe what seems to be average plants, pointing out the more usual types of variations and then later taking up the larger or more unusual variations separately.

In shape the sterile blade is usually ovate or sometimes almost orbicular; it is rarely triangular. It varies greatly in size, from as small as  $1\frac{1}{8}$  inches wide (no. 2185) and  $1\frac{1}{2}$  inches long (no. 10294) to as large as  $6\frac{7}{8}$  inches wide (no. 9998C) and  $6\frac{1}{2}$  inches long (no. 9664). The average of 64 blades was about  $4\frac{3}{8}$  inches wide and  $3\frac{3}{4}$  inches long. The leaf blade is ternately decomposed with each lateral division (here called the first or basal pair of leaflets) usually arranged opposite or almost opposite its mate on the rachis. The median division is in general very similar in cutting and shape to the lateral divisions. It is a little longer, a little broader, and more symmetrical in that the basal division or leaflet on one side is very similar to the basal division on the other side.

The basal pair of leaflets are triangular to broadly ovate in shape and range from  $1\frac{3}{8}$  to  $4\frac{1}{2}$  inches in length with an average of about  $2\frac{3}{4}$  inches (based on 64 basal leaflets, only one from a single leaf). They are often widest at or near the base with the width varying from  $\frac{3}{4}$  inch to 4 inches, the average being about 2 inches. Their stalks or petiolules are about  $\frac{1}{2}$  inch long. Ordinarily each basal leaflet is once (sometimes twice) pinnate basally, pinnatifid into pinnule-like segments medially, and ends in an elongated terminal segment (Fig. 227, A, C, D, F, G.). The inferior proximal pinnules

are usually larger, more lobed, and closer to the rachis than the superior proximal pinnules. These inferior pinnules may be unlobed (no. 2179), but this is uncommon, pinnatifid below into variously shaped segments, or rarely compound. When pinnatifid, the basal segments are often obliquely obovate to ovate, broadly attached, and with rounded or obtuse apices. Sometimes these segments are large, lanceolate oblong, or oblong, acutish, and constricted at the base. These oblong segments may even have basal lobes of their own. The bases of the proximal pairs of pinnules are mostly obliquely

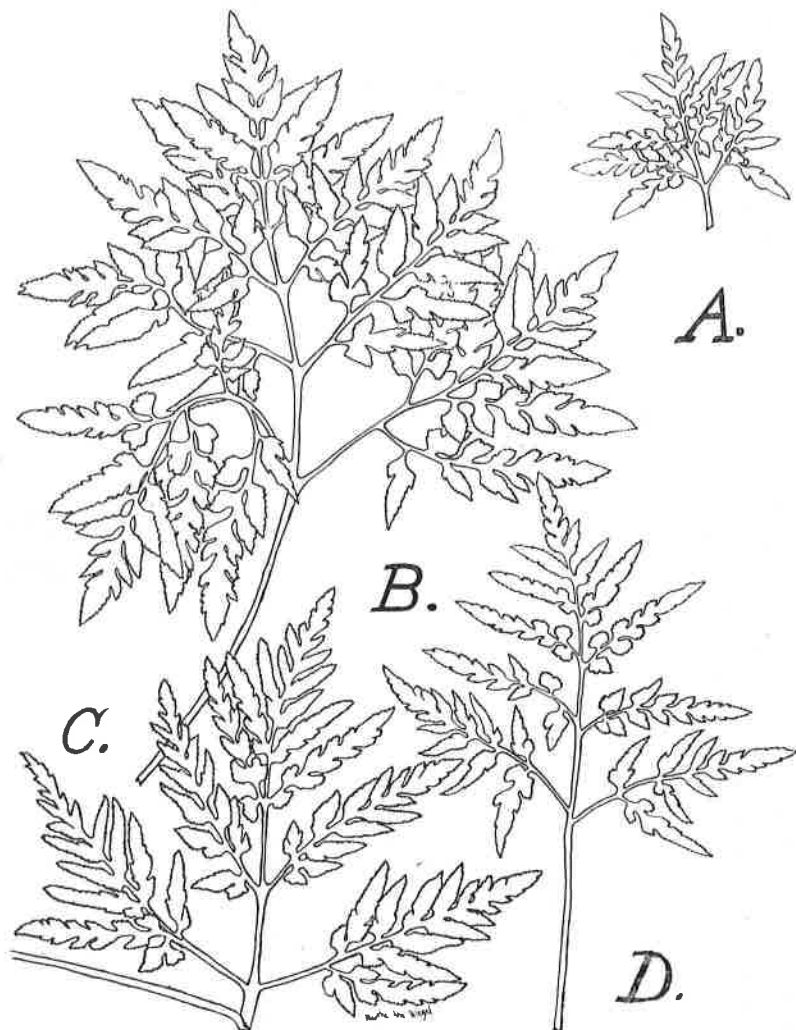


Fig. 228. *Botrychium dissectum* forma *obliquum*. A, B, C, D. Some types of leaves occasionally found, X 0.5 A, no. 2182; B, no. 9885; C, no. 1094; D, no. 7896.

truncated and their apices acutish to obtuse. Succeeding pairs of pinnules may be similar to the proximal pairs in lobing but they are often unlobed and then they are mostly oblong in shape with their bases usually truncated and

their apices acutish or obtuse. Following the pinnules, are pinnule-like segments which may be narrowed near their base and acute or obtuse apically. Each basal leaflet has an elongated, oblong, or ovate terminal segment which may have near its base one or more pairs of lobes (or it may be unlobed) and an acute or obtuse apex. The margins of the pinnules and segments are commonly very shallowly serrated with the tips of the teeth rounded. Rarely, the tips of the teeth are acute or the teeth so shallow that the margin appears entire. The margin is marked by a narrow hyaline border. Oblique veins are mostly two times forked but are three times forked when the pinnules are wide as near their bases. Near the pinnule apices, the veins may be unforked. It is usual for the veins to end in the teeth a little short of the actual margin but in a few cases they seem to end at the very end of the serrations (Fig. 227, E).

The second pair of leaflets may be compound basally, pinnatifid medially, and terminated by a single elongated segment. Sometimes the leaflets are pinnatifid basally only or are rarely unlobed. The basal pairs of pinnules or segments are obliquely orbicular, ovate, or oblong with a truncated or rarely a cuneate base and acutish or obtuse apices. The pinnule-like segments of the median portion of the second pair of leaflets are sometimes in part obliquely orbicular, obovate, or broadly oblong, and with rounded apices. Often they, and the terminal segments, are much like the corresponding segments in the basal pair of leaflets.

The third pair of leaflets may be very similar to the second pair of leaflets or pinnule-like and lanceolate-oblong with a truncated or somewhat cuneate base, acutish or obtuse, and lobed or unlobed basally. In most plants, the region above the third pair of leaflets bears pinnule-like lateral segments and a terminal segment, all of these being very similar to the corresponding parts of the basal leaflets. The margins and veining of all of the segments and pinnules above the basal pair of leaflets are similar to those already described for the pinnules of the basal leaflets.

The fertile spike varies from  $1\frac{1}{2}$  inches to  $7\frac{1}{2}$  inches in length, the average of 42 specimens being  $3\frac{1}{2}$  inches. Its characteristics are essentially the same as those already given for *Botrychium dissectum* var. *typicum* (Fig. 227, B) even to their being a plant bearing sporangia with a single longitudinal frill per sporangium. Mature sporangia are often a beautiful golden color and in one case (no. 9820) from Sumner County, Tennessee, they are a beautiful reddish-orange.

#### SOME UNUSUAL OR INTERESTING VARIANTS

I. A fern (no. 9885) resembling somewhat the old *Botrychium obliquum* forma *Habereri* (Gilbert) Waters (not now recognized as a distinct form), as pictured by Waters (1911, p. 335) in the cutting of the sterile leaf blade. The blade is large, being about  $7\frac{3}{4}$  inches wide and about 5 inches long. Some measurements in inches are: petiole about  $1\frac{1}{4}$ , sterile stalk  $3\frac{7}{8}$ , fertile stalk 10, and the fertile spike 5 inches long. It seems as if the immature sporangia would mature and open in September. The sketch (Fig. 228, B) indicates the character of the lobing. This fern is here regarded as belonging to forma *obliquum* because of the thick stalk and the very numerous pinnules and pinnule-like segments that are themselves much divided into lobes, most of which are pinnule-like. The leaf is thin and this is characteristic of var. *tenuifolium*. Occasionally this character is present in forma *obliquum*. The margin is finally serrated but the serrations are not very prominent. However, there is a specimen in the United States Herbarium (no. 1735556) collected in central Florida by Edward P. St. John and called by him in 1934, *Botrychium obliquum* Muhl., which resembles very greatly my plant. In 1938, R. T. Clausen examined St. John's plant and called it *Botrychium*



*dissectum* v. *tenuifolium* (Und.) Farwell.

II. In the northeastern part of Tennessee, one occasionally finds ferns (no. 10941, for example) with numerous narrow, elongated segments that have some resemblance to Water's picture (1911, p. 336) of *Botrychium obliquum* var. *elongatum* except that the inferior proximal segments of the inferior proximal pinnules are not longer than one-half the length of these pinnules. The left half of Water's picture shows these segments short like my plants but the right half has these segments long as they are supposed to be. As previously mentioned, I regard *elongatum* as a trivial form. This fern, which is not *elongatum*, is also a trivial form. The type of cutting is well shown by figure 228, C. The sterile blade illustrated is from a fertile plant and is fairly large, being about  $5\frac{7}{8}$  inches wide and  $4\frac{3}{8}$  inches long. Some measurements in inches are given here: petiole  $2\frac{5}{8}$ , sterile stalk  $4\frac{1}{2}$ , fertile stalk  $8\frac{3}{4}$ , fertile spike  $4\frac{5}{8}$  inches long. This fern tends to exhibit some characteristics of var. *tenuifolium* such as medium thick to narrow stalks and somewhat serrated leaves. It is here kept in forma *obliquum* because of the moderately thick leaf and the very numerous pinnules and pinnule-like segments which are much divided.

III. Another variant (no. 7896) of the narrow-segment type of ferns (Fig. 228, D) has a small sterile blade which is about  $4\frac{1}{2}$  inches wide and  $3\frac{3}{4}$  inches long. The pinnules and pinnule-like segments of the basal leaflets are very narrow, lanceolate, and acute. The segments on the second pair of leaflets are broadly lanceolate or ovate and acute with the exception of a single rounded segment. Each of the third pair of leaflets is very long and narrow with short rounded segments. The leaflet-like segments above the third pair of leaflets are narrow and long and when lobed have low, rounded lobes. Serrations are small. This plant is a very puzzling one possessing, as it does, the narrow stalks and thin leaves of var. *tenuifolium* coupled with the numerous segments having the truncated bases and serrulate margins of forma *obliquum*. While I have placed these plants in forma *obliquum*, they could have been placed in var. *tenuifolium* almost equally as well.

IV. A rather small plant (no. 2182) from White County, Tennessee, measuring in inches: petiole  $\frac{3}{4}$ , fertile stalk  $5\frac{3}{4}$ , fertile spike  $2\frac{5}{8}$  in length, sterile stalk  $1\frac{1}{2}$ , with a sterile blade only  $2\frac{1}{2}$  inches wide by  $1\frac{15}{16}$  inches long. All stalks are slender; a condition somewhat characteristic of var. *tenuifolium*. The pinnules and segments, with the exception of the proximal pairs, and the second pairs of pinnules on the basal pair of leaflets, are very small and short. The inferior proximal pinnules of the basal leaflets are especially long relatively (Fig. 228, A). This type of variation is represented in my collection by two other Tennessee plants: no. 10372 from Cocke County, and no. 9747 from Sullivan County. The sterile blade of the Cocke County plant is a little larger (about  $2\frac{1}{2}$  inches wide by 2 inches long) and the cutting is a little different from that illustrated in the figure. The basal leaflets are broadly triangular and their proximal pairs of pinnules are only slightly longer than the

second pairs of pinnules. The pinnule-like segments are elongated and some even have rounded lobes near their bases. The second pair of leaflets has fairly long pinnules and segments but the other leaflets have oblong segments with their apices rounded. The Sullivan County plant (no. 9747) differs from the Cocke County one in minor details only and these need not be mentioned here. Despite the narrow stalks and the moderately thin leaves, which are regarded as characteristic of var. *tenuifolium*, I am keeping these plants in forma *obliquum*. They have numerous pinnules and pinnule-like segments, many of which are divided into lobes, inconspicuous serrations, and a truncated, or at most a poorly cuneate base; all characteristics of forma *obliquum*.

V. Two characteristics of fern no. 10549, from Montgomery County, Tennessee, namely, the very narrow and the very long pinnules and pinnule-like segments, stand out. Some of these pinnules on the basal leaflets are as long as  $1\frac{3}{8}$  to  $1\frac{7}{8}$  inches and are only  $\frac{1}{4}$  to  $\frac{5}{16}$  inch wide at the widest part near the base where there may be some low rounded segments. The inferior proximal pinnules of the basal leaflets are, of course, much longer ( $1\frac{3}{4}$  and 2 inches) and are pinnatifid into narrow, elongated segments, the inner or inferior proximal segments being more than one-half the length of each of the inferior proximal pinnules of the basal leaflets (Fig. 227, F). This would then be the fern which Fernald (1950, p. 21) gives as *Botrychium dissectum* forma *elongatum* (Gilbert and Haber) Weatherby and which I regard as a trivial form. Even the terminal segments are much narrower and longer than usual. The second and third pairs of leaflets are deeply pinnatifid into very narrow, elongated segments. The fourth pair of leaflets are narrow, long pinnules with some low, rounded lobes near their bases. Above these leaflets are several pairs of very long and narrow pinnule-like segments. Altogether there are a great number of pinnules and pinnule-like segments. The pinnules are obliquely truncate at the base and are—together with the pinnule-like segments—narrowly oblong, acute, and very finely serrated; as are the terminal segments, except that the terminal segment is wider being lanceolate-oblong in most cases. The stalks are thick and the blade is thick. The long and narrow pinnules and pinnule-like segments suggest var. *tenuifolium* but the thick stalks, the thick blades, the truncated pinnule bases and the very fine serrations put it in forma *obliquum*.

VI. This is a very large, fertile plant (no. 9820) from Sumner County, Tennessee, that has a sterile blade about  $6\frac{3}{4}$  inches wide and 5 inches long with stout petiole, stout sterile stalk, and stout fertile stalk. The blade is ternate but approaches a pinnate condition with the basal pair of leaflets broadly ovate, about  $3\frac{3}{8}$  inches wide by  $3\frac{7}{8}$  inches long and with a petiolule about  $\frac{7}{8}$  inch long. The type of cutting is well indicated by figure 227, A, of a basal leaflet. The second pair of leaflets has similar elongated pinnules and pinnule-like segments except that their basal lobes are fewer in number with no lobes greatly elongated. Only the basal lobes of the inferior proximal pinnules are acute, all the other lobes being rounded. The

third and fourth pairs of leaflets are pinnatifid into narrow pinnule-like segments which are poorly and shallowly lobed basally and that only for the proximal pairs of pinnule-like segments of the third pair of leaflets. The fifth, sixth, and seventh pairs of leaflets are narrow, elongated, and pinnule-like with their basal lobes rounded. Above these leaflets are unlobed pinnule-like segments and above these the elongated, oblong, terminal segment. This terminal segment has a few deeper notches between groups of teeth but is not really lobed.

The common grapefern is often found on gentle slopes near the foot of hills near streams, in fairly open woodland, occurring especially in the level area between the forks of a small stream. Swamps, and especially their wooded margins, and the wooded bottom lands of creeks and rivers are good habitats. In all of these places, an old, unpaved wagon road through the area increases greatly its attractiveness for this fern.

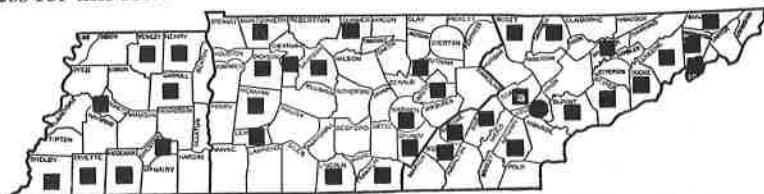


Fig. 229. The distribution of *Botrychium dissectum* forma *obliquum* in Tennessee by counties. Black squares represent the collections of Shaver; the black circles the collections of others as follows: Loudon County (Correll, 1939).

The distribution of *Botrychium dissectum* forma *obliquum* in Tennessee as known to the author is given in the map (Fig. 229). Since there are many plants in Tennessee intermediate between this fern and *Botrychium dissectum* var. *tenuifolium* (Underwood) Farwell, I may have placed here specimens which might have been placed equally well in var. *tenuifolium*. The distribution of the *obliquum* entity, according to Clausen (1938, p. 52), is “. . .from Nova Scotia and New Brunswick west to Wisconsin and Iowa and south to South Carolina, Georgia, and Louisiana. . .”

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### SOUTHERN GRAPEFERN

#### **Botrychium dissectum** Spreng. var. **tenuifolium** (Underwood) Farwell

This fern belongs to the genus *Botrychium* and therefore has the sporangia borne on a branch separate from the compound sterile blade. Furthermore, it belongs to the group of the genus which has the sterile blades divided into three nearly equal divisions, that is, they are ternately compound (Fig. 231, *F*).

Ferns belonging to the ternate-leafed group of *Botrychium* have been separated in a key given under *Botrychium dissectum* forma *obliquum* (which see). In this key, we find that *B. dissectum* var. *tenuifolium* has both the fertile and the sterile branches stalked, the stalks narrow, and the leaves thin. Typically, the elongated pinnules are relatively few in number, narrowly oblong in shape with a small number of lobes, and have cuneate bases and acute apices (Fig. 231, *C*). The margins of the sterile blades are prominently serrate; they are never lacinate. Variations from this typical condition are considered under other headings further on in this study.

*Description.* *Botrychium dissectum* var. *tenuifolium* is a low-growing, evergreen fern having above ground a very short and narrow common stalk or petiole which divides near the surface of the ground into two slender branches: one, the fertile branch, bearing a compound spike of numerous sporangia high above the sterile leaf, and the other, the sterile branch, bearing the ternately compound sterile leaf blade. Below ground, the common stalk is attached to the apex of the short, vertical rootstock. There are quite a number of fleshy or sometimes almost fibrous roots (Fig. 232, *B*) present and some of the very large fleshy roots often show prominent, transverse corrugations. Thus the general appearance of this fern is very similar to that of any other fern in the *Botrychium dissectum* group.

This similarity to *B. dissectum* var. *typicum* is so great in the case of

the root system that no further description seems needed. In the rootstock, the only addition needed is to note that it is usually slightly narrower than in the other varieties or forms of *Botrychium dissectum*. The common stalk, the fertile stalk, and the sterile stalk are likewise narrower in *B. dissectum* var. *tenuifolium* but in length they agree fairly closely as indicated by the following measurements from fertile plants: average lengths of (1) common stalk (46 plants)  $1\frac{1}{4}$  inches, (2) fertile stalk (50 plants)  $7\frac{3}{8}$  inches, (3) sterile stalk (51 plants) about 3 inches. The corresponding maximum lengths are: (1)  $2\frac{5}{8}$  inches (no. 9674 #2), (2)  $11\frac{1}{4}$  inches (no. 10909A), (3)  $5\frac{1}{4}$  inches (no. 9674 #2). The corresponding minimum lengths are: (1)  $\frac{5}{8}$  inches (no. 10910D), (2)  $3\frac{3}{8}$  inches (no. 2190), (3)  $1\frac{1}{2}$  inches (no. 2197). There are 47 plants in this collection with a single sterile stalk and blade and without a fertile branch. The average length of these sterile



Fig. 230. *Botrychium dissectum* var. *tenuifolium*.

stalks is  $4\frac{3}{8}$  inches which is almost the same as the average length of the common stalks ( $1\frac{1}{4}$  inches) plus the average length of the sterile stalks (3 inches) from fertile plants from the same general region.

The sterile blade of var. *tenuifolium* is ternately divided as has already been mentioned, and is about the same general shape and size as the sterile blade of *B. dissectum* forma *obliquum*. Measurements of blades of var. *tenuifolium* give an average width of  $3\frac{1}{2}$  inches and an average length of  $2\frac{3}{8}$  inches. Maximum width is  $6\frac{7}{8}$  inches (no. 2193) and maximum length  $4\frac{5}{8}$  inches (no. 10901A); minimum width is  $1\frac{1}{16}$  inches (no. 10897E), and minimum length 1 inch (no. 10897E).



## TYPICAL SPECIMENS

In the plants which are regarded as typical, the basal pair of leaflets are divided into greatly elongated and very narrow unlobed pinnules or pinnule-like segments (no. 10896) (Fig. 231, C, F). Usually the bases of these pinnules and segments are cuneate and, in the case of the pinnules, often adnate to the costules or even to the costae (midribs of the leaflets). The pinnule-like segments are frequently cuneately-narrowed basally to the place where they are broadly attached to the costae. The smaller segments and especially those more distally placed on the costae may not be narrowed near their place of attachment. Pinnules and segments are acute and have serrated margins. These serrations usually have rounded tips (no. 10286B); they rarely have very sharp points (no. 10286A), or shallow serrulations (no. 2192). The inferior segments are longer than the superior ones. The segments terminating the basal leaflets sometimes are wider than the other segments and narrowly elliptic in shape. They are acute apically and may have basally a few shallow acute lobes.

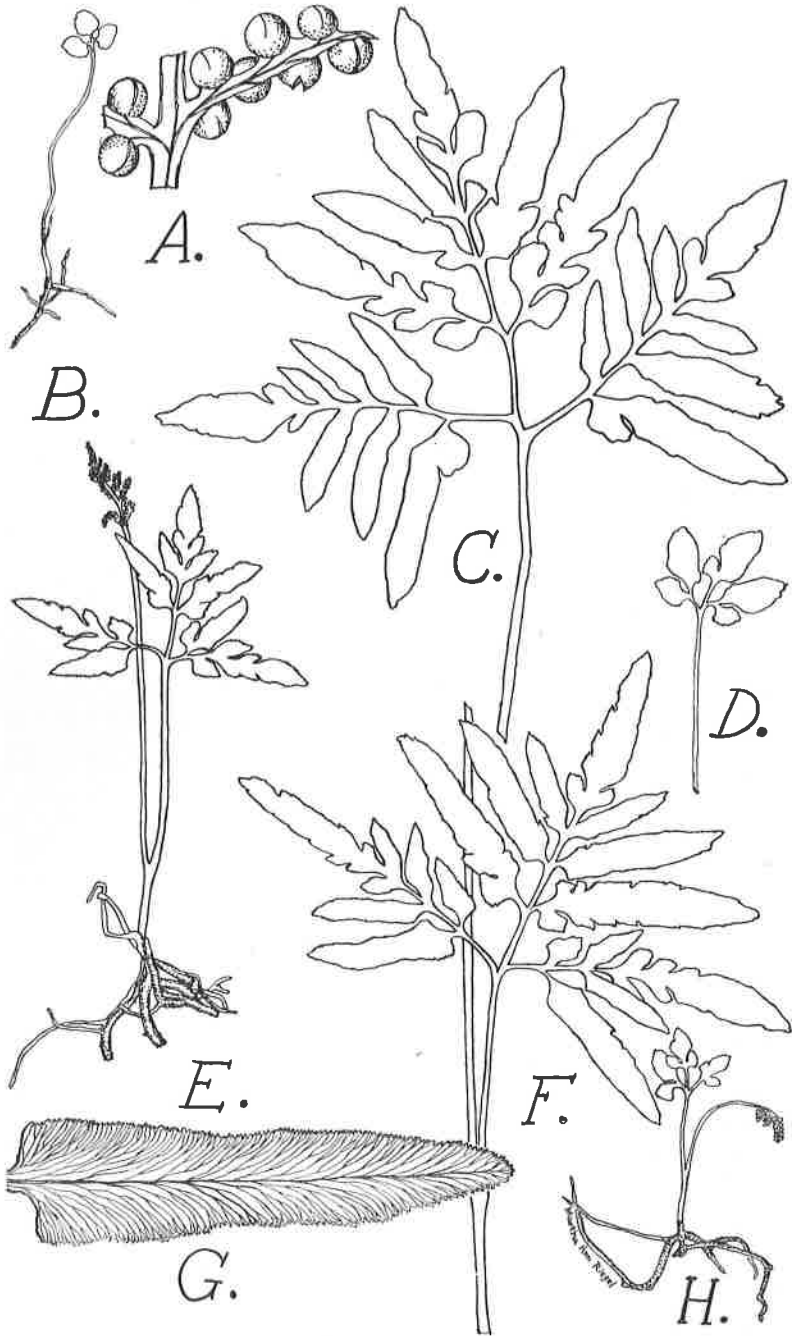
Each of the second pair of leaflets is an elongated, narrowly oblong pinnule or pinnule-like segment sometimes with a more or less rounded basal lobe on the inferior side, and acute apices and serrated margins (Fig. 231, G). More distally appearing leaflets are broadly attached, unlobed, narrowly oblong, acute, pinnule-like segments with bases that are often slightly narrowed. The terminal segment is similar to the terminal segments of the basal leaflets.

Some plants have many more pinnules and pinnule-like segments on the basal leaflets with a few of these with short and rounded or acute basal lobes. Terminal segments may have more basal lobes and some of these may be rounded. The second pair of leaflets may have a considerable number of rounded lobes and some of the more distal leaflets may likewise have a few rounded lobes. This tendency towards increasing the number of lobes is expressed in ferns like no. 9998C by two or three inferior pinnules on each basal leaflet being cut into a number of narrowly oblong acute lobes. As many as three pairs of leaflets above the basal pair may have a number of elongated, narrowly oblong, and acute lobes (no. 9998C) (Fig. 232, A). Veining of the pinnules seems essentially similar to the veining in forma *obliquum* and need not be considered here (Fig. 231, G). The fertile branch bears usually a rather open spike mostly twice, or sometimes partly three times compound with a relatively small number of sporangia borne on thin branches (Figs. 231, A; 233, D).

A MINIATURE FORM OF *B. DISSECTUM* VAR. *TENUIFOLIUM*

There is a very small fern, which I regard as a form of var. *tenuifolium*, found occasionally in very low wooded creek and river bottoms (Fig. 231 B, D, H.). Most of these little plants are sterile with their leaf blades about 2¾ inches above the rootstock which must mean 2 inches or less above the soil. I have only 16 of these sterile plants for measurement from five stations: one station in East Tennessee and four stations (one station each from four counties) in West Tennessee. Two fertile plants were found, one from each of two stations and these were slightly shorter (about 2 inches from the rootstock to the fertile spike) than the sterile plants, due, it seems, to the rootstocks of the fertile plants being relatively close to the surface of the soil. All stalks are very narrow and the sterile blades very thin. As a rule the segments of the blades have margins with prominent teeth. However, some specimens (from Shelby County, for instance) have their margins serrulate and the Bradley County specimens have almost entire margins. (These latter may really be very young plants of *B. dissectum* forma *obliquum* but

Fig. 231. (Opposite page.) Details of *Botrychium dissectum* var. *tenuifolium*. A, A group of sporangia, no. 10887, X 3.5. B, D, H, Three miniature plants from bottom land near creeks and rivers, showing the wide blades usually present, X 0.5, B, no. 10884, D, no. 10888, H, no. 10886. C, F, Typical sterile blades and stalks of var. *tenuifolium*, X 0.5, C, no. 10901; F, no. 10887. E, A plant with many characters of *B. dissectum* forma *obliquum*, X 0.5, no. 10887. G, Inferior proximal pinnule from basal leaflet, X 1.5, no. 10887, showing veining and margins of typical *B. dissectum* var. *tenuifolium*.



I have kept them in var. *tenuifolium* because of the very narrow stalks, thin blades, elongated narrowly elliptic or lanceolate segments, and the cuneate pinnule bases.)

The sterile blades vary in width from  $\frac{1}{2}$  inch to  $1\frac{5}{8}$  inches and in length from  $\frac{5}{16}$  inch to  $1\frac{1}{4}$  inches; an average blade being about 1 inch wide by  $\frac{3}{4}$  inch long. The sterile stalk ranges from  $1\frac{11}{16}$  to  $4\frac{1}{8}$  inches long with an average of  $2\frac{3}{4}$  inches. Ordinarily, the ternate condition is shown in these plants by a single basal segment or leaflet on each side and a single terminal segment. Each of these segments in the simplest condition is unlobed (Fig. 231, B). In most cases, they are lobed; the basal leaflets having a single inferior lobe or a single inferior lobe plus a single superior lobe (Fig. 231, D, H). These lobes may be broadly ovate to broadly obovate with an obtuse or acutish apex. The basal leaflets are usually broadly ovate to broadly oblong or elliptic in shape with acutish, obtuse or (rarely) rounded apices, and truncated or slightly cuneate bases. There is a sheet of similar small ferns in the United States National Museum (U. S. N. M. no. 1433497) collected from rotting logs and hummocks, deep tupelo swamps, San Augustine County, Texas, Sept. 10, 1917, E. J. Palmer no. 12706. It comprises 11 plants: 5 fertile, 2 fertile with the fertile spike broken off and lost, and 4 sterile. These were checked by D. L. C. in 1947 and determined—correctly, I think—as *Botrychium dissectum* var. *tenuifolium*. The Bradley County plants (no. 10904) have basal leaflets that are narrowly lanceolate and acute, with a single short inferior ovate and obtuse basal lobe each.

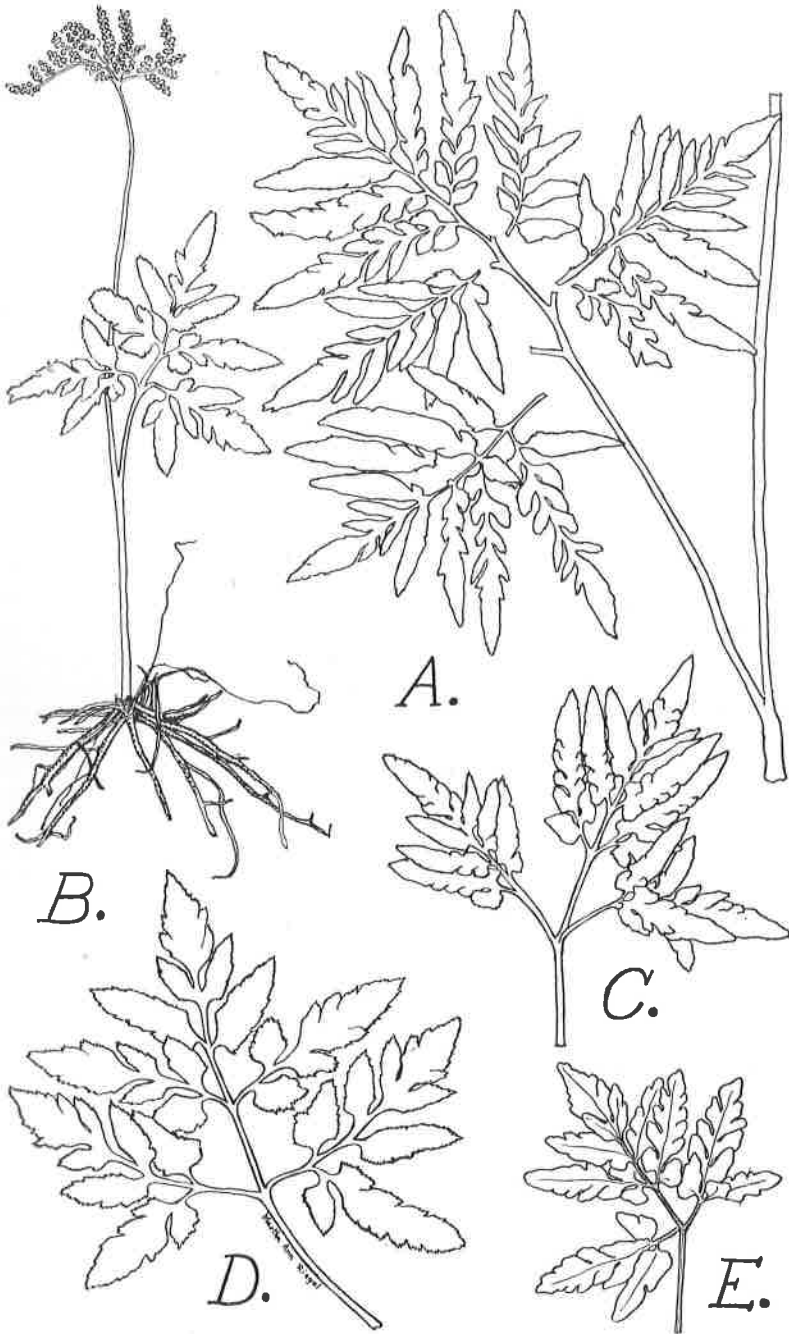
The terminal segment or leaflet is sometimes unlobed but usually it is lobed basally with a single shallow rounded or obovate lobe on each side. It is usually broadly ovate, oblong, or elliptic, with an acutish or obtuse apex. The Bradley County plants have their terminal leaflets narrowly elliptic with acute apices and cuneate bases, and also a second pair of narrowly elliptic, acute, and cuneate leaflets between the terminal leaflets and the basal pair of leaflets.

The size of the fertile plants may be indicated by the following series of average measurements given in inches: common stalk,  $\frac{7}{8}$ ; sterile stalk,  $1\frac{3}{16}$ ; fertile stalk,  $1\frac{13}{16}$ ; sterile blade: width 1, length  $\frac{3}{4}$ ; length of compound spike,  $\frac{1}{2}$ . These plants are similar to the sterile ones in all essential characters except that they have a fertile branch. This fertile branch is very slender and is topped by a very short, compound spike bearing a relatively small number of sporangia.

#### VARIATIONS TOWARDS BOTRYCHIUM DISSECTUM FORMA OBLIQUUM

*Botrychium dissectum* var. *tenuifolium* is quite variable in the degree of cutting of the sterile blade and in the shape of the pinnules and segments. The variations in the direction of *B. dissectum* forma *obliquum* make intermediates some of which have been placed in forma *obliquum* but most have been retained in variety *tenuifolium*. A brief treatment of intermediates of this type has already been given under forma *obliquum*. It remains here to emphasize the characteristics that are considered important in placing intermediates in var. *tenuifolium*. First are the possession of narrow stalks and thin sterile blades which give a generally lax appearance to the plants. The pinnules and segments may be few or many but tend to be small in number and with few lobes in the most typical specimens. If all or at least a few of the pinnules or segments are narrowly oblong, it suggests var. *tenuifolium* as does also the presence of some segments with cuneate bases or segments with prominent serrations.

Fig. 232. (Opposite page.) *Botrychium dissectum* var. *tenuifolium*. A, A specimen with many pinnules and segments, no. 9998C, X 0.5. B, C, D, E, A group of plants whose sterile leaves vary in the direction of *B. dissectum* forma *obliquum*, X 0.5. B, no. 10885B, C, no. 2173, D, no. 10184, E, no. 2199.



All those intermediates which I have placed in var. *tenuifolium* have the narrow stalks and thin sterile blades which are characteristic of this variety. These seem very important characters to the author, for thinness must represent a partly generalized morphological condition. These ferns usually have the fairly broad pinnules and segments which one expects in forma *obliquum*. Indeed, plants with ovate-oblong to lanceolate-oblong pinnules (no. 10788) or with lanceolate pinnules or pinnule-like segments (no. 10699B) are common. With the broader pinnules appear obliquely truncated pinnule bases (no. 2285). While these truncated bases are regarded as more characteristic of forma *obliquum*, they also occasionally occur in var. *tenuifolium* especially when the pinnules of *tenuifolium* are broader basally than usual. Prominently serrated margins are usually present on the intermediates and these are characteristic of variety *tenuifolium*. While most pinnule apices are acute, sometimes they are obtuse (no. 2197) or, rarely, rounded (no. 2285). Often the compound fruiting spike is poorly developed having a relatively small number of sporangia and being once or twice compound; all characters frequently found in var. *tenuifolium*. A series of sketches has been made to indicate some of the types of leaf cutting present in these intermediates (Fig. 231, E; 232, B, C, D, E; 233, H).

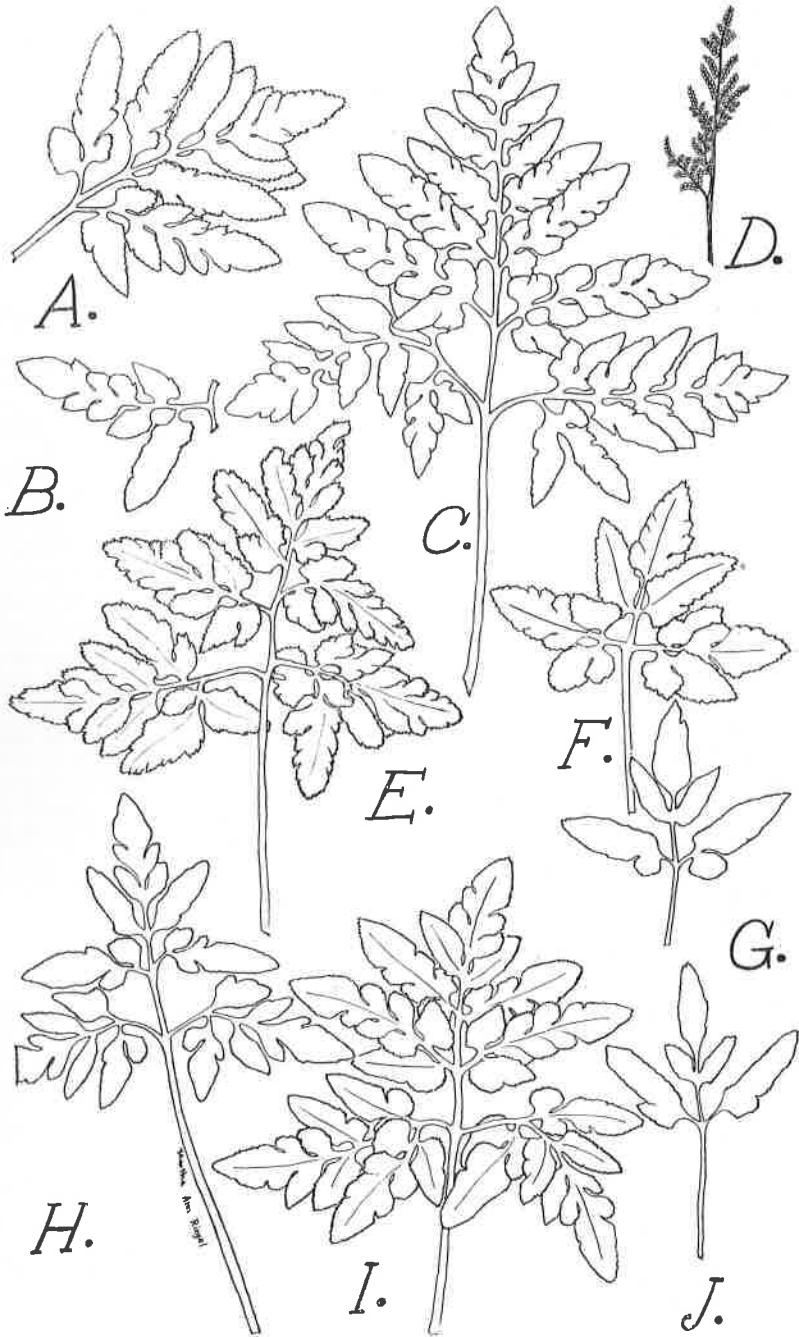
#### VARIATIONS TOWARDS *BOTRYCHIUM DISSECTUM* VAR. *ONEIDENSE*

Another type of variation in var. *tenuifolium* is towards broad pinnules and segments with obtuse or rounded pinnule and segment apices, *i. e.*, the variations are in the direction of var. *oneidense*. In these plants segment bases may be broadly cuneate or, as seems usually to be the case, broadly and obliquely truncate. Bases of the segments of var. *oneidense* are obliquely truncate or sometimes even slightly cordate (see the left plant, U. S. National Herbarium no. 674819). Margins are mostly prominently serrate—a characteristic of var. *tenuifolium*. All stalks of these intermediates are narrow. While small plants of var. *oneidense* may have narrow stalks, well-developed plants usually have stout and sturdy stalks. Both varieties have thin blades and so the thin blades of the intermediates were to be expected.

The intermediates, for the most part, have many segments and many lobes, some of which may be lanceolate. Var. *oneidense* usually has few segments and the segments have few lobes, the ones present being small and orbicular. Also it has a tendency towards a pinnate condition instead of the ternate condition so characteristic of var. *tenuifolium* and the intermediates. The series of sketches (Fig. 233) are representative of the types of sterile blades found.

Fig. 233. (Opposite page.) Details of *Botrychium dissectum* var. *tenuifolium*. A, B, Basal leaflets of forms with wide pinnules and segments, X 0.5. A, no. 10281, B, no. 2179. C, E, F, and I, Broadleaved forms with rounded apices, X 0.5. These seem to vary in the direction of *B. dissectum* var. *oneidense*. C, no. 2196; E, no. 7900; F, no. 2194A; I, no. 10265. D, A fertile compound spike, no. 2199, X 0.5. G, J, Young plants of typical var. *tenuifolium*, X 0.5. G, no. 9711; J, no. 9998, #2. H, A leaf varying in the direction of *B. dissectum* forma *obliquum*, no. 10892, X 0.5.





*Botrychium dissectum* var. *tenuifolium* grows along with *B. dissectum* forma *obliquum* in the types of low woods already mentioned under the latter form. A miniature form of *B. dissectum* var. *tenuifolium* occurs in the low wooded bottoms of creeks and rivers especially in the western part of the state.

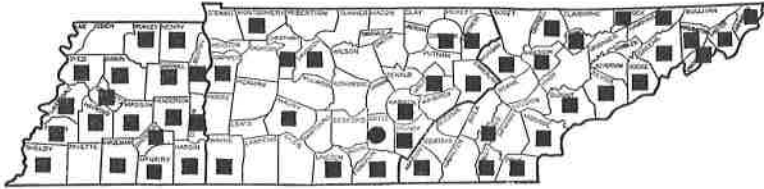


Fig. 234. *Botrychium dissectum* var. *tenuifolium* distribution in Tennessee. The solid squares indicate county distribution as shown by specimens collected by Shaver; the solid circles, distribution based on the collections of others which I have examined as follows: Coffee County (University of Tennessee herbarium).

The distribution of *B. dissectum* var. *tenuifolium* in Tennessee, so far as known to the author, is given in the map (Fig. 234). Clausen (1938, p. 54) gives its distribution for the country as a whole as from ". . . eastern Texas to Florida and north at least to Missouri, southern Indiana, and the coastal plain of Virginia and Maryland. . ."

In the study of this and related forms, varieties, and species, I am greatly indebted to Dr. C. V. Morton, Curator of Ferns, Smithsonian Institution, Washington, District of Columbia; Dr. R. M. Tryon, Jr., Curator of Ferns, American Fern Society, Missouri Botanical Garden, St. Louis, Missouri; Dr. A. J. Sharp, Head of the Department of Botany, The University of Tennessee, Knoxville, Tennessee, for the loan of herbarium material.

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## ALABAMA GRAPEFERN

### *Botrychium alabamense* Maxon

*Botrychium alabamense* Maxon has a ternately decompound sterile blade at the end of a moderately long sterile stalk which joins the fertile stalk near the surface of the ground. The common stalk extends from this union of sterile and fertile stalks downward to the apex of the vertical rootstock where it entirely covers and conceals the erect bud. The ultimate sterile segments are about the same size and shape and the terminal segments are not elongated. Instead, they are flabellate in shape, with broad and rounded apices, cuneate bases, and minutely serrated margins. It appears that their sporangia mature in the autumn. The characteristics mentioned above, when considered in connection with the key given under *Botrychium dissectum* forma *obliquum*, should make identification certain.

This fern is known so far from only two stations in Tennessee and there is only a single plant in my collection from each station, namely: no. 10906, a small sterile plant from a wet pine hillside by the road up Tellico River, about 16.2 miles from the entrance to Cherokee National Forest near Tellico Plains, in Monroe County; no. 10920, a fertile plant that had lost the fertile branch—probably by being eaten by cattle—from a small depression at top of ridge with pine forest and some Japanese honeysuckle, just south of Cherokee Park and near the Holston River, in Hamblen County.

Since there are only two specimens of the Alabama grapefern known from Tennessee, it seems worth while to give a general description of each. The best developed of these specimens is the plant from the wet pine lands of Hamblen County, no. 10920. This plant has a common stalk or petiole about  $\frac{5}{8}$  inch long and is yellowish or yellowish-brown in color. It forks into a sterile branch and a fertile branch with only about one inch of the fertile branch being present. This portion is brown in color and has a few whitish hairs. The sterile stalk is about  $1\frac{5}{16}$  inches long and yellowish brown in color. All stalks are of average thickness or perhaps they are some narrower.

The sterile blade is about  $4\frac{1}{16}$  inches long by about  $5\frac{3}{4}$  inches wide. It is very lax due in part to the narrow rachis and other branches, and in part to the thinness of the blade. The blade is broadly ovate or almost orbicular in shape. Its leaflets are long-stalked and alternately arranged along the rachis. The rachis and the petiolules of the first (basal) and second pairs of leaflets are light brown basally but this color fades apically into green.

The basal pair of leaflets are  $4\frac{1}{4}$  and  $3\frac{3}{4}$  inches long including petiolules of  $1\frac{5}{8}$  and  $1\frac{1}{16}$  inches. In width, the basal leaflets are about  $2\frac{3}{8}$  and  $2\frac{1}{4}$  inches, being widest at the proximal pair of

pinnules. The pinnules are alternately arranged and are narrowly oblong to lanceolate in shape and dissected into mostly oblong, obovate, or ovate segments, with rounded or obtuse apices. These segments may be so constructed basally as to be practically pinnules with slightly winged costules. Such is the case with the basal segments of the proximal pinnules which are abruptly and broadly cuneate basally and have one or two rounded basal lobes. Most of the other segments are narrowed more or less basally where they broadly or narrowly join the costae. The terminal segments of the pinnules and of the basal leaflets are wider and somewhat larger than the other segments and they are mostly ovate in shape with one, two, or three rounded basal lobes. Just back of the terminal segments of the basal leaflets are three or four segments broadly or narrowly attached to the costae.

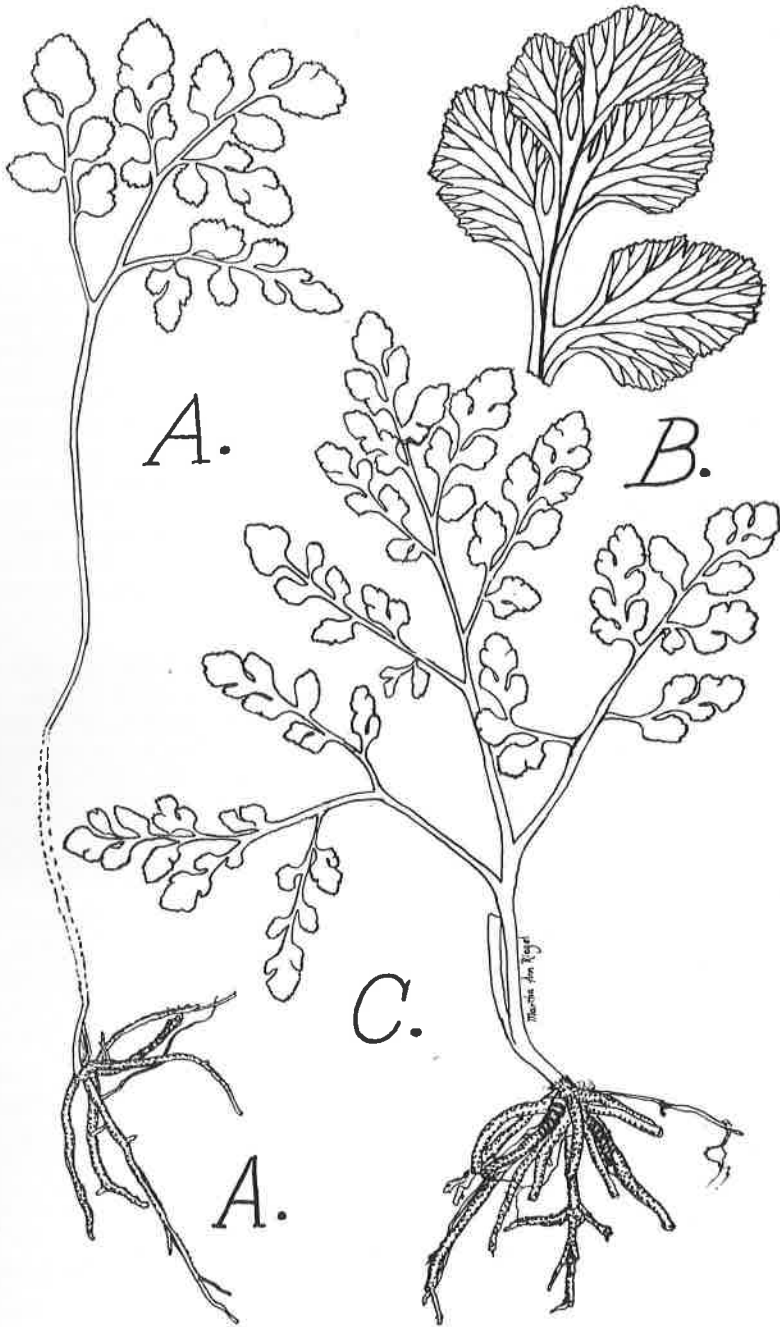
The second pair of leaflets is very similar in shape and cutting to the proximal pinnules of the basal leaflets but the second pair of leaflets is somewhat larger. The third pair of leaflets is also very similar in shape and cutting to these same pinnules but the third pair of leaflets is slightly smaller. The fourth pair of leaflets consist of two relatively small lanceolate pinnules with about three rounded lateral lobes and the broad terminal segment. Distal to the fourth pair of leaflets is a pair of broadly attached segments, one of which has a rounded basal lobe, and the ovate terminal segment with its cuneate base, broadly rounded apex, and a rounded basal lobe.

The Monroe County sterile plant (no. 10906) has a sterile stalk  $4\frac{1}{8}$  inches long and a sterile blade  $3\frac{3}{8}$  inches wide by 3 inches long. The sterile stalk, the rachis, and the costae, are very narrow, and the blade is thin. The basal part of the sterile stalk is white or yellowish-white but this color soon changes above into the light brown color of the upper stalk and rachis. The basal pair of leaflets is very similar in shape, cutting, and size to the second pair of leaflets of the Hamblen County specimen. Indeed, the entire sterile blade of the Monroe County plant resembles the portion of the Hamblen County blade distal to the basal pair of leaflets. It differs only in minor details such as the terminal segments being a little wider and the other segments being some larger and more constricted basally so that these segments appear pinnule-like (Fig. 235).

The ultimate segments are serrate, the teeth being acutish or sometimes with rounded tips. The teeth stick straight out and are not very wide basally. Although these teeth are not very long, some authors speak of the margins as being fimbriate. There is a narrow hyaline border to the margin. The type of branching of the veins is given by figure 235. A vein appears to enter each tooth and to end before reaching its tip or it may actually reach the apex of the tooth.

The rootstocks of these two plants are very short being about  $\frac{1}{4}$  inch and  $\frac{1}{8}$  inch long. They are erect and give off many dark brown,

Fig. 235. (Opposite page.) *Botrychium alabamense* Maxon. A. Details of a sterile leaf, no. 10906, X 0.75, from Monroe County. C. Details of a fertile plant (fertile branch missing), no. 10920, X 0.75, from Hamblen County. B, Segments from near the apex of a basal leaflet showing veining and margins, no. 10920, X 1.5.





fleshy, spindle-shaped, branching roots. Some of the roots are transversely corrugated. The roots seem typical of those found in the ternate group of *Botrychium* and so need not be described further here. The buds of these two plants were dissected out from the bases of the leaf stalks which entirely surrounded and concealed them. They are erect and conical, about  $\frac{3}{16}$  inch long by  $\frac{3}{32}$  inch in diameter, obtuse or rounded apically, white in color, and with white erect hairs clustered around the apices.

Since neither of the two plants collected in Tennessee has a fertile branch, I have examined five fertile and one sterile plants (*Gray nos. G-1 to G-6*) collected by F. W. Gray in November near Charlotte, North Carolina, and kindly loaned to me by Dr. A. J. Sharp of the University of Tennessee. These have a sterile stalk which averages  $2\frac{1}{8}$  inches in length, and a fertile stalk which averages  $8\frac{1}{2}$  inches long. Here the fertile stalk is four times the length of the sterile stalk. The average length of the compound spike is  $3\frac{1}{2}$  inches. It seems to be three or four times compound with not too many sessile sporangia arranged in two rows on one side of each flattened branch. Each sporangium appears to be typical in size and structure to the sporangia described for *B. dissectum forma obliquum*. These fertile plants were collected in late autumn. The sporangia on all but one plant had already opened and shed their spores. The single plant had mature plumb sporangia.

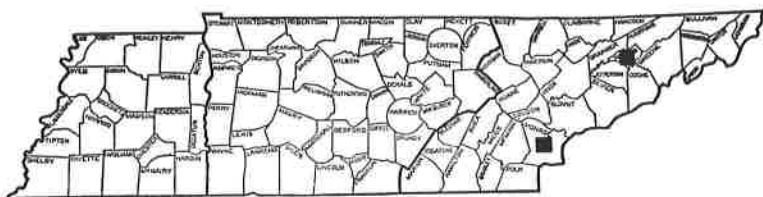


Fig. 236. The distribution of *Botrychium alabamense* in Tennessee in so far as known to the author.

The two known Tennessee stations (Fig. 236) for the Alabama grapefern are from wet pinelands. Small (1938, p. 377) mentions pineland as the usual habitat in Florida and Georgia and McVaugh and Pyron (1951, p. 134) add "on dry hillsides" to under pines. They also mention its occurrence in wetter wooded ravines.

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## RATTLESNAKEFERN

### *Botrychium virginianum* (L.) Sw.

The rattlesnakefern has a single vertical common stalk topped by a ternately compound sessile, or almost sessile, sterile blade and a stalked two to three times compound fertile spike (Fig. 237). The sporangia mature in the springtime—in Tennessee usually between May 1-15 in the lowlands and later in the mountains. Shortly afterwards the apical portion of the fertile spike begins to shrivel and by midsummer the entire upper half of the branch may be dried up and the remains of the sporangia gone. The bud for next year's leaf is surrounded by the base of the common stalk in the spring, but is often partly exposed by the split base of the common stalk in late summer and autumn, thus differing from the other ternate species of *Botrychium* which have the bud entirely enclosed by the sheathing base of the common stalk. *Botrychium virginianum* is a deciduous fern while the varieties and forms of *Botrychium dissectum* are evergreen. The characteristics mentioned above are sufficient for positive identification when fertile plants are available.

When the fertile branch is absent, as is sometimes the case, identification is more difficult and must be mainly on the basis of the sterile leaf blade. In the rattlesnakefern, this blade is ternately compound, two of the three divisions forming the basal pair of leaflets. The leaflets are compound into pinnules which have segments variously cut (but not laciniately) into toothed lobes. The general shape and cutting of these sterile leaf blades are shown in the illustrations (Figs. 237; 238, A, B, C, E, F; 239, C, H, I.). These should help much with identification.

*Description.* *Botrychium virginianum* is a low-growing, erect deciduous fern with a single common stalk which arises from a short vertical rootstock. The rootstock is about 1/16 inch in diameter and about 1/4 inch long. It is usually yellowish-brown to dark-brown in color being almost the same color as the numerous fleshy roots which arise from it. Both rootstocks and roots are glabrous. The roots often branch, the branches either being fleshy or narrow and slender. All roots become narrow and slender distally. Sometimes the roots are very long with few branches. For example, the four longest roots from a fertile plant (no. 4173) from Coffee County were: one root 7 1/2 inches with one short branch, one root 7 1/4 inches with no branches, one root 5 1/4 inches with no branches, and one root 4 1/2 inches with no branches (Fig. 239, A). When the roots are very thick and fleshy, portions may become transversely corrugated.

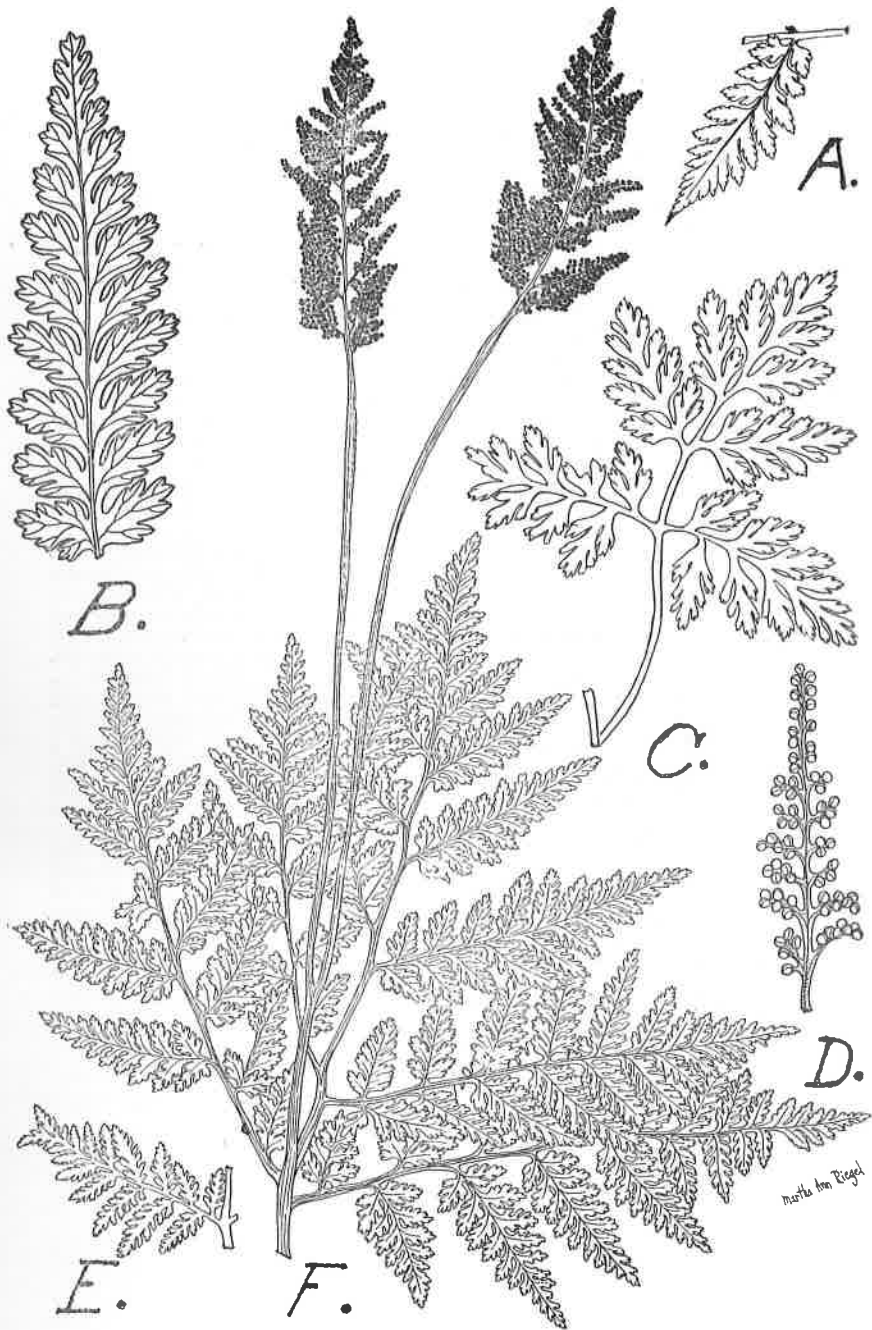
At the apex of the rootstock is a bud for next year's leaf. It is very hairy (pilose) with long white to slightly brownish hairs, and folded in such a way that the rudiments of the sterile blade seemingly bend back earthward over the rudiments of the fertile spike; the bend appearing to be towards the common stalk. The fertile branch seems also to be bent in the bud with its branches facing the vertical part of the sterile blade (Fig. 239, D). The bud is partly exposed in most cases late in the season by a split in the sheathing base.

The common stalk is glabrous except occasionally a few hairs may be present. Young plants appear to have more hairs than old ones. The common stalk is greenish-stramineous to yellowish-brown (rarely dark-brown except for young plants) in color. However, the relatively thin and membranous



Fig. 237. *Botrychium virginianum* showing habit of growth. White Co. May 9, 1936.

Fig. 238. (Opposite page.) Some details of *Botrychium virginianum*. A. The third inferior pinnule on a basal leaflet showing a very acuminate apex and acute segments and lobes, no. 10657, plant B. X 0.5. B. An enlarged pinnule showing typical segments, lobes, and veining, no. 2217, X 1.5. C. A rather small leaf with wide leaflets and pinnules, no. 10657, plant A, X 0.5. D. A portion of a compound spike enlarged to show unopened sporangia, no. 2217, X 2.5. E. Basal leaflet of a small leaf, no. 2251, X 0.5. F. Sterile blade and fertile branch divided almost to the base so as to form two branches each bearing a compound fertile spike, no. 2217, X 0.5.



sheath-like basal portion around the bud on one side is brown to reddish-brown. The main part of the basal stalk is usually yellowish-green or stramineous and has the vascular tissue that makes it strong and sturdy. The thin basal sheath around the bud is attached by each side to the main part of the common stalk and differs from this stalk by having a rich brown color. On this sheath near where it is attached to the common stalk are a few to many hairs, with most hairs being on the apical portion. Measurements of the common stalk from fertile plants give a range from  $4\frac{1}{4}$  inches (no. 2255B) to  $12\frac{3}{8}$  inches (no. 9152) in length with an average of about  $6\frac{3}{4}$  inches (based on the measurement of 65 plants). The common stalk of entirely sterile plants (based on 25 plants) is some shorter averaging about 5 inches in length with a maximum length of  $6\frac{1}{2}$  inches (no. 10132).

The sterile blade is ovate to triangular in shape, broadest at the base, and ternately compound. The basal pair of leaflets may be arranged opposite each other on the rachis or alternately, as is the usual rule with the leaflets above the basal pair. Sterile blades from fertile leaves were measured and the following results secured: average width (94 plants) about 7 inches, maximum width  $12\frac{3}{4}$  inches (no. 2274), minimum width  $2\frac{1}{2}$  inches (no. 8080); average length (102 plants) about  $4\frac{3}{4}$  inches, maximum length  $9\frac{1}{8}$  inches (no. 2243), minimum length  $1\frac{5}{8}$  inches (no. 8080). When only a sterile blade is present, measurements are some smaller as indicated by these results: average width (28 plants) about 6 inches, maximum width  $11\frac{5}{8}$  inches (no. 10064); average length (31 plants) about 4 inches, maximum length  $8\frac{1}{4}$  inches (no. 10064). Blade apices may be acute or obtuse; rarely they are rounded.

Basal leaflets are ovate, elliptic, or oblong in shape, with pinnules which are usually alternately arranged along the costa; the superior proximal pinnules being nearest to the rachis of the leaf. This contrasts strongly with the condition in the varieties of *Botrychium dissectum* in which the inferior proximal pinnules are most often nearest to the rachis. Basal leaflets average (129 leaflets) about 4 inches in length and  $3\frac{1}{4}$  inches in width with a range in length from  $1\frac{1}{4}$  inches (no. 8080), to  $7\frac{3}{8}$  inches (no. 2243), and in width from  $\frac{3}{4}$  inch (no. 8080) to  $5\frac{3}{8}$  inches (no. 2234). Basal leaflets from sterile plants are smaller averaging (40 leaflets) about  $3\frac{1}{4}$  inches in length and about  $1\frac{3}{4}$  inches in width with a maximum length of  $5\frac{3}{8}$  inches (no. 10818) and a maximum width of  $3\frac{1}{2}$  inches (no. 2244). The other pairs of leaflets, which are distal to the basal pair, are very similar in shape and cutting to the leaflets just described. However, the leaflets get progressively smaller from the base of the leaf towards its apex (Fig. 238, F).

The pinnules are usually pinnatifid into ovate, oblong, or obovate lobed segments, which are broadly or narrowly attached to the costules, and are acute, obtuse, or (rarely) rounded apically. Each lobe of a segment may consist of a single tooth, of two teeth, or of three or more teeth, the teeth usually being acute or obtuse. In some cases, a very thin hyaline border can be seen at the margin of the teeth. The common veining arrangement is for there to be a single vein in each segment which gives off a single vein to each lobe. This single vein gives off a single branch vein to each tooth. Sometimes this vein will have a short branch vein where there is only the one tooth, thus giving two veins to this tooth (Fig. 238, B).

(To be continued)