Cash Balances, December 31, 1953:

Current Fund, W. Knoxville Br. Hamilton N. Bank	1,244.07
Current Fund, Home Federal Savings and Loan	1,010.41
Life Membership Fund, Nashville Trust Company	537.92
Endowment Fund, Third Natl. Bank, Nashville	353.18
Total balance	3,145.58
Balance plus expenses	$6,604.37

The Auditing Committee of the Tennessee Academy of Science has examined the books of James W. White, Treasurer, and it has found them to be correct and in order for the year 1953.

J. A. Cooley, Alvin H. Nielsen, *Auditing Committee*

THE MOSQUITOFERN (AZOLLA CAROLINIANA WILLD.) IN TENNESSEE

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MOSQUITOFERN
Azolla caroliniana Willd.

This very small floating water-fern has much the appearance of a very small-leaved duck weed (*Lemna* sp.) or a moss. It has been called "mosquito fern" because it may entirely cover or blanket the surfaces of still ponds and sloughs and this has been said to prevent the breeding of mosquitoes there. It is known that *Azolla caroliniana* multiplies asexually very rapidly by the breaking apart of the branches. Benedict (1924) reports that 20 colonies of this or a very similar species planted in the spring (May 15) in a branch and pool that were dry in winter, increased to at least 200 colonies in one month. Clute (1928, p. 182) states that R. S. Cocks reported in the Fern Bulletin for 1904 that a pond about one acre in size in Audubon Park, New Orleans, Louisiana, had no less than fourteen cartloads of *Azolla* weighing a total of seven tons, removed between June and September.

The appearance of the floating mat of these plants is well shown in figure 241. In color the plants are green with more or less red. It has been assumed that the plants growing in the sun are more or less reddish and those in the shade greenish. The lower lobes and the border of the upper lobes of the leaves are often reddish with the center of the upper lobe either green or reddish (Small, 1938). Sometimes the entire plant, with the exception of the roots, is reddish. The changes of colors from summer through autumn have been described by Benedict (1923), probably from *A. filiculoides* (Svenson, 1944, and personal letter from Dr. Benedict, 1953). He found that the red color of leaf margins became more intense with the advent of cold. In shaded plants there was less color and in greenhouse plants, none at all. The color cannot be due to drying. It

seems that it must be induced by cold. Green plants placed in the brook May 15 when the water was still cold soon turned red with the red mainly marginal (Benedict, 1924). The Tennessee plants which I have for study are herbarium specimens and there are no data as to whether they grew in the shade or in the sun. The dates however furnish some seasonal information.

This floating plant will need to be recognized in the sterile condition for fertile plants are extremely rare (Svenson, 1944). The plants are small, about ¼ inch to ½ inch long with a slightly larger width in the Tennessee material which I have studied. As seen from above, the leaves appear to be very small (1/50-1/30 inch in diameter), entire,

Fig. 241. *Azolla caroliniana* (the dark plants) on the surface of a lagoon, Blue Bank, Reelfoot Lake, Lake County, Tennessee, September 8, 1934. The light-colored plants are duck weeds.

flattened parallel to the water, two-ranked, alternately attached to a very delicate branching stem, and so close together that they overlap or almost overlap like shingles on a roof. A very similar floating plant (*Salvinia rotundifolia* Willd.) has two ranked leaves but the leaves are from ¼ inch to over ½ inch long and the stem is unbranched. It is an introduced plant that is sometimes cultivated in Tennessee and has been said (Fernald, 1950, p. 51) to spread to pools, ponds, and marshes elsewhere. Such escapes have not as yet been reported from Tennessee.

There are two or possibly three species of *Azolla* that theoretically might be found sometime in Tennessee. There are *A. mexicana* Presl whose boundary with *A. caroliniana* is uncertain and, according to Svenson (1944, p. 74), ". . . probably lies in the Texas-Louisiana region," *A. filiculoides* Lam., an introduced plant sometimes found in the eastern United States, and *A. caroliniana* which is a plant occurring along the Mississippi River as far north as Wisconsin as well as along the Atlantic and Gulf Coasts.

Svenson (1944, p. 74) in a "Synopsis of Species" separated these three species by these characters:

"A. Glochidia not septate; plants small (0.5-1 cm. diam.), dichotomously branched, the nearly orbicular, divaricate leaves small (0.5 mm. long), nearly smooth, not closely imbricated; microsporangia 8-40 in an indusium. Eastern United States and the West Indies. 1. **A. caroliniana** . . .

"AA. Glochidia not septate, or rarely with 1 or 2 septae at apex; plants elongate (frequently 2-6 cm. long), with closely appressed, imbricate, papillose oblong to ovate leaves (1 mm. long); microsporangia 35-100 in an indusium; massulae 4-6; megasporangia with raised, irregularly hexagonal markings.—Guatemala to Alaska; Andean and southern South America; occasionally introduced in the eastern United States, Hawaii, and Europe. 2. **A. filiculoides** . . .

"AAA. Glochidia many septate; plants dichotomously branched, 1-1.5 cm. diam., with upper leaf lobes 0.7 mm. long, the under ones much larger. microsporangia usually with 4 massulae; megaspore pitted. Mexico and of scattered occurrence in the lowlands southward to French Guiana and Bolivia, northward to Utah and British Columbia, and eastward to Wisconsin and Illinois. 3. **A. mexicana** . . ."

Sexual reproductive stages are very rare in *Azolla caroliniana,* megasporocarps apparently being unknown and microsporocarps so scarce that Svenson (1944, p. 75) found them only in *"Tryon and Godfrey* no. 907, from Clarendon County, South Carolina, and Garber's collection from Sanford, Florida, in 1876," despite diligent search. Thus one is forced in most cases to separate these species on vegetative characters which might be summarized from Svenson (1944, p. 74) as follows:

	A. caroliniana	*A. filiculoides*	*A. mexicana*
Size of plant in cm.:	0.5-1	Often 2-6	1-1.5
Leaves:			
Length in mm.:	0.5	1	0.7
Shape:	Nearly orbicular	Oblong to ovate	-------
Arrangement:	Not closely imbricated Divaricate	Imbricated; closely appressed	-------
Upper surface:	Nearly smooth	Papillose	-------

Svenson also points out (1944, p. 73) ". . . the elongate-frondose character and curled leaves of well-developed *A. filiculoides*. . . The dichotomous branches of *A. caroliniana* with their unusually small leaves are also characteristic; *A. mexicana* is of similar texture, but larger and more compact. . . In *A. filiculoides* . . . the leaves are most

frequently an ashy-gray color with broad, scarious, irregularly curled margins."

However, he states (p. 74) "Finally, the reader must not be too optimistic about the identification of sterile material," but mature, well-collected specimens can usually be assigned to species.

The author has a very limited amount of material from Tennessee (Fig. 243) for study: three sheets from near Walnut Log Lodge, Reelfoot Lake, Obion County (two sheets of *Southern Appalachian Botanical Club* 644, collected by T. N. McCoy, May 29, 1947: one sheet kindly loaned to me by the Gray Herbarium and one sheet by the University of Tennessee Herbarium. The University also loaned me the material listed below from Chester and Shelby counties, and a sheet, *A. J. Sharp, E. Clebsch,* and *A. Clebsch* no. 6245, collected on the bayou, Aug. 14, 1947); four sheets from a lagoon at Blue Bank on Reelfoot Lake, Lake County, Sept. 8, 1934 (*Shaver* nos. 1997, 1998, 1999, and 2896), one sheet from a slough in the bottoms of the South Fork of the Forked Deer River east of Henderson, Chester County, July 9, 1948 (*A. J. Sharp, E. Clebsch,* and *A. Clebsch* no. 9423); one sheet from a small pond near the entrance to Shelby Forest, September 13, 1950, *Gentry* (no number); and a jar of formalin-preserved material collected by Dr. Frances Bottum from Radnor Lake, Davidson County, July 29, 1949. Gattinger (1901, p. 30) reported this fern from "On a weir or millpond, near Briceville, McMinn County, and W. Tenn. cypress swamps," and apparently at one time there was an *Azolla* labeled *Azolla caroliniana,* "Bradley county, 1856, Gattinger" at the University of Tennessee prior to the fire which destroyed the herbarium. Anderson (1929, p. 37) mentions this fern as being found in eastern Tennessee ". . . but it occurs chiefly in Reelfoot Lake and other lakes of the western part of the state," and later (1931, p. 67) he cited a Bradley County specimen (1856 Gattinger) without stating the herbarium where it was deposited. However, it is known that Anderson's papers were based largely on his studies of the specimens in the University of Tennessee herbarium and in the Gray Herbarium. This Bradley County specimen is not now at the University of Tennessee. Dr. Robert C. Foster of the Gray Herbarium has kindly looked over the North American material of *Azolla* and reports (in a personal letter) that ". . . there is no material of that genus in the Gray Herbarium which was collected by Gattinger."

The two sheets collected by T. N. McCoy have scanty material (one sheet has only one plant and the other sheet three plants); there is abundant material on the other sheets but it is all sterile with the exception of three sheets from Lake County, Tennessee, collected by me, September 8, 1934. These plants are fertile, but bear only microsporocarps.

Description. Azolla caroliniana is primarily a floating plant of quiet bayous, sloughs, and ponds in association with species of *Spirodela, Lemna, Wolffia,* and *Riccia.* Individual plants are very small because they fragment easily. However, they grow so rapidly that the entire surface of a pond or slough may be nearly covered by an almost pure growth of *Azolla.* Most of the plants

measure about ¼-⅜ inch in length. There are few roots and these are unbranched and very slender and long.

The stem is glabrous and branches in a dichotomous fashion. From above, the stem sometimes appears zig-zag, first a bend to the right to give off a right leaf, and then a bend to the left to give off a left leaf. In some cases the stems are almost straight. The leaves appear more or less imbricated being poorly or not at all imbricated on old stems and strongly imbricated near the stem apices (Fig. 242, *A*, and *B*). The leaves are almost sessile and branch into two lobes. The lower and slightly larger lobe seems to be glabrous and one-celled or mostly one-celled in thickness without or with few chloroplasts in the cells. This lobe is nearly orbicular to ovate in shape and with an entire margin. These

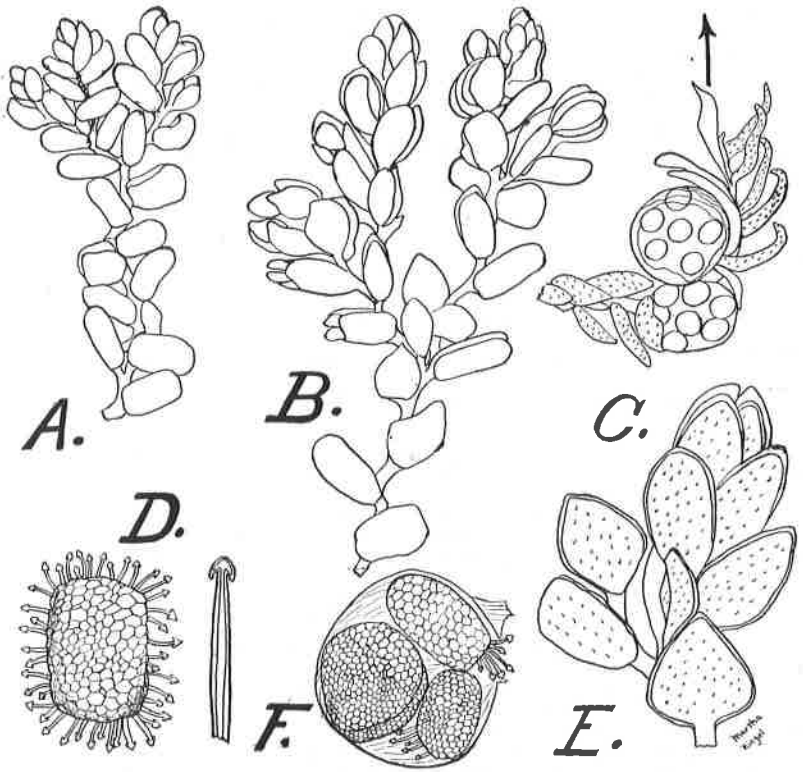

Fig. 242. Details of *Azolla caroliniana* Willd. *A*, Small plant, upper side, from Radnor Lake, Davidson Co., Tenn. Note zig-zag stem branching dichotomously X 15. *B*, Small plant from the Gray Herbarium (no. 644, *South. Appalachian Bot. Club*), Reelfoot Lake, Obion Co., Tenn., X 15. *C*, Two microsporocarps from Blue Bank, Reelfoot Lake, Lake Co., Tenn., with enclosed microsporangia. The dots represent papillae which are on the upper lobes of the leaf. There are no papillae on the lower lobes of the leaves and consequently no dots on this part of the sketch. The arrow points in the direction of the apex of the plant, no. 1999, X 15. *D*, Massula (diagrammatic) with its surrounding fringe of projecting glochidia, no. 1999, much magnified, as seen through the low power (50 X) of a compound microscope. To the right is a greatly magnified drawing of a single glochidium as seen through the high power (250 X) of the microscope. *E*, Leaves from above, *South. Appalachian Bot. Club* no. 644 (Univ. of Tenn. herbarium), X 25. *F*, Microsporangium, much magnified, with four massulae bearing glochidia, no. 1999 (somewhat diagrammatic).

lobes appear to float on the surface of the water as stated by Svenson (1944, p. 70). However, Smith (1938, p. 354) says that this lower lobe is submerged and that it is thought to take in water rather than the roots.

The upper lobe of the leaf is almost orbicular to ovate in shape, reddish-green, or sometimes entirely red in color, with a narrow and almost transparent scarious margin which is often variously tinted with red. The upper surface, according to Svenson (1944, p. 74), is supposed to be almost smooth, but, in the Tennessee specimens which I have studied, there are minute papillae present. The upper lobes, which I have measured, range from about 1/60 to 1/40 inch in length with one exception (*South. Appalachian Bot. Club* no. 644, in Univ. of Tenn. herbarium) which has some leaves as long as 1/30 inch in length. The cavity in the upper lobe cannot be seen through a binocular microscope probably because it is hidden by the layer of tall palisade cells with their many chloroplasts.

The veins in the leaf lobes must be very poorly developed for they cannot be seen with the binocular microscope used. If a plant is teased apart by needles and examined under the low power of a compound microscope, colonies of the blue-green alga, *Anabaena Azollae* Strasb., may be easily seen. Smith (1938, p. 354) says that these algae are in the chamber of the upper lobe of the leaf and in the space at the apex of each branch enclosed by the over-arching juvenile leaves.

Most of the herbarium material examined has the upper leaf lobes strongly ascending, appressed, and with the apical portion curved adaxially as may readily be seen from the side of the plant (Fig. 242, *C*). The lateral margins are usually curved adaxially, also. These curved portions often modify the appearance of the upper lobe so that when seen from above it may seem to have an oblong shape (Fig. 242, *A*, and *B*).

Despite very careful and prolonged study of all available sheets of this fern from Tennessee with a low power binocular microscope, fertile material was only found on plants from a slough at Blue Bank, Reelfoot Lake, Lake County, Tennessee. Three of the four sheets collected at this place from the lagoon between the road and the state club house on September 8, 1934, had microsporocarps. These sheets (nos. 1997, 1998, 1999) apparently had no megasporocarps. Svenson (1944, p. 75) seems to indicate that megasporocarps of *Azolla caroliniana* are unknown and microsporocarps very rare.

Microsporocarps seem in this material to usually occur in pairs but I found one case where only one microsporocarp was present. In my macrostudy (no sections having been prepared or studied) it has not been possible to determine exactly the relation of each microsporocarp to the other microsporocarp of a pair. They appear to lie side by side and sessile in or near the axil of a leaf (Fig. 242, *C*). I do not know precisely their position with respect to the upper and lower lobes of the leaf but Smith (1938, p. 356) says that they are in the axil of the upper lobe and Tryon *et al.* (1940, p. 114) in the axil of the lower lobe. Each microsporocarp is about 1/30 inch in diameter and spherical or slightly flattened where the two sporocarps touch. The wall of the microsporocarp is white or whitish, membranous, thin, glabrous, and somewhat translucent. Inside the microsporocarp may be seen some or all of the large, white, microsporangia present. Counts of these, as seen through the sporocarp wall with a binocular microscope (20 X), seemed to indicate that there were from 6 to 12 microsporangia per microsporocarp with about 8 being the usual number. A dissection of two of these microsporocarps showed that there were present more sporangia than had been previously counted; as a matter of fact, there were about twice as many. This would make the actual number vary from about 8 to about 24 with about 16 being most usual.

When dissected out of the microsporocarp, the microsporangia are seen to be glabrous, white spheres, each atop a very long and slender stalk. Some of these sporangia show tetrads (Fig. 242, *F*). When the sporangia are crushed on a slide under a cover glass and examined under the low power (50 X) of a compound microscope, separate large granular masses or massulae may be seen. Each massula is regarded as a mass of spores. It has many small spines or glochidia, as they are called, (Fig. 242, *D*), projecting from its surface, each ending in a barb with two recurved teeth.

The author has indicated on the map (Fig. 243) the distribution of *Azolla caroliniana* Willd. in Tennessee as known to him but he has the feeling that a more prolonged and careful search of the ponds and sloughs along the Mississippi River and its tributaries in western Tennessee would extend its known distribution in this region. General distribution is apparently up the Atlantic Coast, Florida to North Carolina and sporadically New York, Massachusetts, Ohio, Indiana, along the Gulf coast from Florida to Louisiana, and up the Mississippi River to Wisconsin.

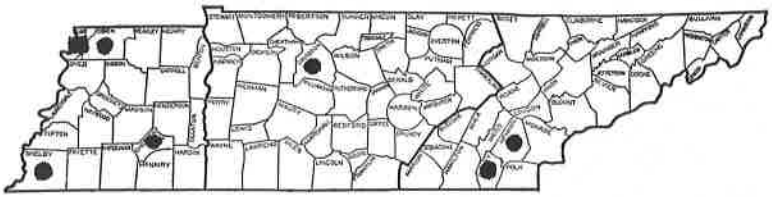

Fig. 243. Distribution of *Azolla caroliniana* Willd. in Tennessee. Black squares represent the collections of Shaver, black circles the collections of others as follows: Bradley Co., 1856, *Gattinger* (? as to sp.); Chester Co., *A. J. Sharp, E. Clebsch, A. Clebsch* no. 9423 (Univ. of Tenn. herbarium); Davidson Co., specimens preserved in formaldehyde by *Dr. Frances R. Bottum*, from Radnor Lake, July 29, 1949 (Geo. Peabody College); McMinn Co., *Gattinger*, 1901, p. 30 (? as to sp.); Obion Co., *South. Appalachian Bot. Club* no. 644 (Gray Herbarium, Univ. of Tenn. herbarium); Shelby Co., *Glenn Gentry*, Sept. 13, 1950 (Univ. of Tenn. herbarium).

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