whole climbing part of the fern plant is a leaf and the stem is entirely underground.

In Tennessee, this fern is often called the climbing fern—a very appropriate name for no other native fern has this climbing habit. There are other ferns whose leaves sometimes grow up through vegetation and partly support themselves in it by their leaflets but no other native fern twines around the stems and leaves of other plants while climbing. Another name for this fern is hartfordfern, said to have been applied because of its former abundance near Hartford, Connecticut. There is another climbing fern, the Japanese climbing fern, *Lygodium japonicum* (Thunb.) Sw., that has been introduced into the coastal states of the South. This fern may eventually spread into Tennessee. It can easily be separated from the hartfordfern by the sterile pinnules. In the Japanese climbing fern, these pinnules are compound but in the hartfordfern, the sterile pinnules are simple and palmately lobed.

Description. The climbing leaves of *Lygodium palmatum* arise singly from the upper side of a very slender, horizontal, and branching rootstock and may be two to four feet tall. The rootstocks bear a few leaves and some short leaf buds separated from each other by about 3/4 to 1 inch (Fig. 193, *H*). The rootstock is black, about 3/64 inch in diameter, and has a great many shining red hairs on the younger part. These hairs are usually perpendicular to the rootstock. They occur in some numbers on the very base of the petiole but in variable numbers on the older parts of the rootstock where they may be very scarce or in places very numerous. Sometimes they are shining black or stramineous or tawny in color. Some of the stramineous and tawny hairs may appear crumpled and flattened. Each well-developed red hair seems to be cylindrical and formed of cells placed end to end and separated by black cross-walls. These hairs appear to be about 1/20 inch in length and somewhat stiff. Each tapers gracefully to a small rounded point. The roots are black, not very numerous, and arise from the lower side of the rootstock. They may have a great number, or only a very few, white or grayish hairs which seem very thin, delicate and flattened, and appear to consist of a single cell. However. I think that I can see an occasional hair with cross partitions. The longer of these hairs seems to be much thinner and slightly longer than the red hairs of the rootstock, and appear to be about 1/15 inch long. Of course, most of these hairs are much shorter. Very similar hairs occur on parts of the leaf especially on the lower side of the pinnule blades and on the wings and on other parts of the petiolule and of the pinnule stalks (Fig. 193, *F*); elsewhere they are rare.

Most of the petiole and most of the rachis are brownish but occasionally both are stramineous or greenish. The younger leaves and the more apical parts of the older leaves are more apt to have stramineous or greenish rachises. The petiole is very slender and wiry with a black base. In cross section, it is almost circular at its base but a short distance up it becomes somewhat flattened on one side. Towards the first leaf, this somewhat flattened side of the petiole becomes bounded on each side by a very small ridge. One of these ridges runs onto the petiolule of the basal leaflet and the other ridge continues on the rachis to run onto the petiolule of the second leaflet. The petiole is usually glabrous except for the reddish hairs which have already been mentioned as occurring at the base. I believe that the petiole is usually untwisted but occasionally a petiole will be found with a very slight twist which, it seems, may be in either a clockwise or a counter-clockwise direction. A total of twenty-nine petioles was measured in order to determine their length. The average petiole was found to be about 4 1/4 inches long, and the range in length from 1 3/4 inches (left plant, no. 4078 to 9 1/2 inches (left plant, no. 1813).

The rachis near the petiole is very similar to the petiole in being slender, wiry, and somewhat flattened on one side. This flattened region is bounded on each side by a slightly raised ridge. One of these ridges just above the first leaflet is a continuation of one of the two such ridges on the petiole and, as has already been mentioned, it runs onto the petiolule of the second leaflet. The other ridge on the rachis just above the first leaflet arises near this leaflet axil and continues on the rachis past the second leaflet to run onto the petiolule of the third leaflet. This ridge seems to originate just above the axil of the first leaf (Fig. 193, *H*). In some cases, it appears to be joined with the wing of the petiolule that seems to originate in this same axil. This scheme of one ridge passing onto the petiolule of one leaflet while the other ridge bypasses this petiolule to continue up the rachis and pass onto the petiolule of the very next leaflet, seems to be followed in both the sterile and fertile portions of the leaf. It is also true that a new ridge arises in or just above the axil of a leaflet and extends up the rachis by the very next leaflet to pass onto the petiolule of the third leaflet up.

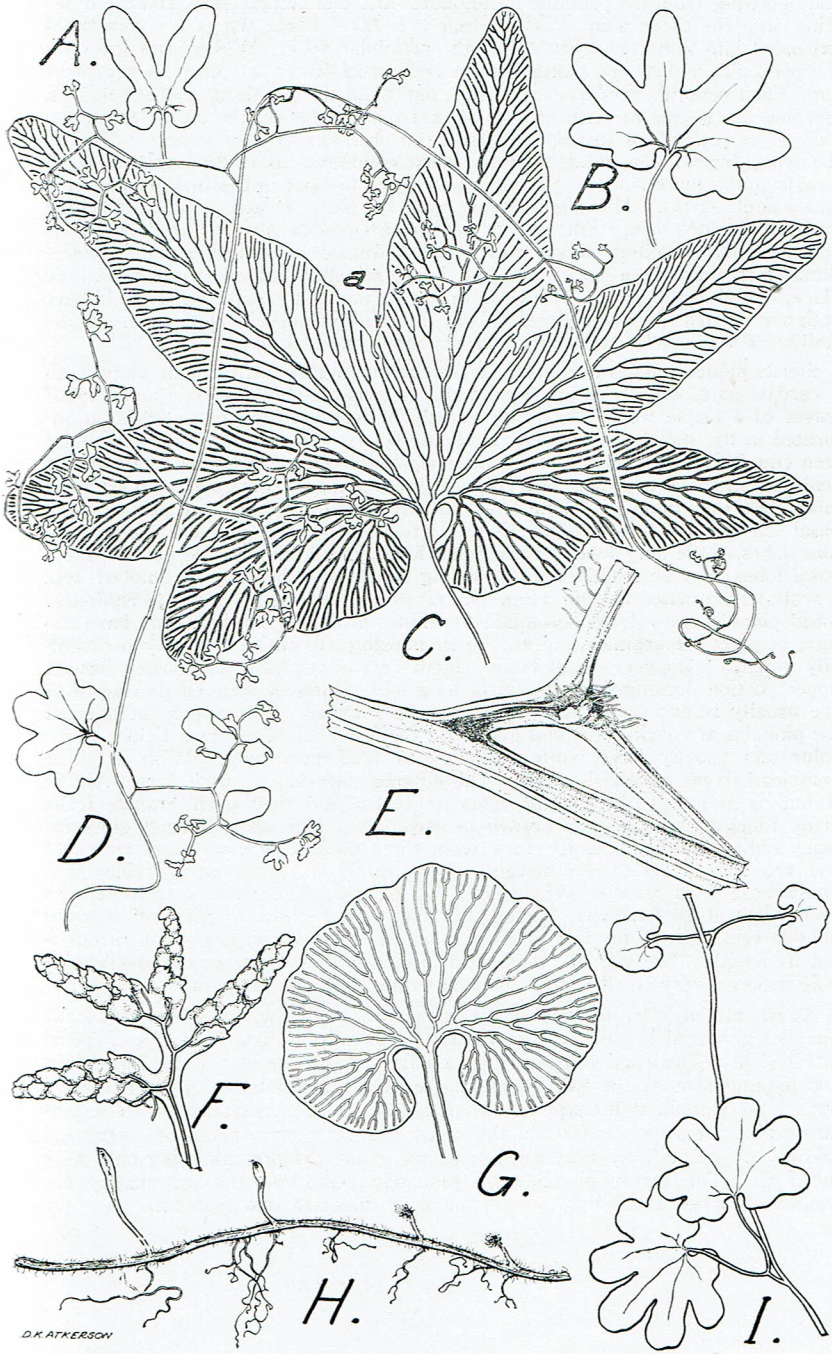
The twisting of the rachis seems difficult to interpret. I have not been able to satisfy myself entirely about the situation and so shall limit myself here to a few observations to indicate the nature of the difficulties. In a mature, well-developed leaf, the rachis may be either untwisted or slightly twisted for the basal eight to twelve inches. Then comes a twisted portion bearing sterile leaflets, followed by a twisted portion with fertile leaflets, and apically by an untwisted, or slightly twisted, portion. The twisting may be in a clockwise or in a counterclockwise direction and both types of twisting may be in the same rachis. A good example of this type of twisting is shown in herbarium specimen no. 9691 which has the rachis twisting as follows: (1) just above the fifth sterile leaflet, clockwise; (2) just above the sixth sterile leaflet, counterclockwise; (3) just above the seventh sterile leaflet, clockwise; (4) just above the eighth sterile leaflet, clockwise, and farther up but below the ninth sterile leaflet, counterclockwise (thus twisting in two opposing directions in the space between two leaflets); (5) above the first fertile leaflet, clockwise; (6) just above the second fertile leaflet, clockwise, farther up near but below the third fertile leaflet, counterclockwise. This example may seem to be extreme but actually it is not for this irregular type of twisting is really the rule. The twisting of the rachis probably is related to the twining habit of the leaf, but the herbarium specimens which I have for study have been untwined from vegetation during collecting (but see Fig. 192) with the exception of leaves of this fern with their rachises twined about each other. In this later case one rachis only may be the main or only twining one. It seems to twine counterclockwise but my material here is so meager that my observations cannot be regarded too highly. However, there seems little relation between the direction of twining and the variable twisting of the rachis. This entire problem of the direction of twining and the direction of twisting of the rachis should be studied in relation to each other in the field and perhaps both should be studied in relation to light. In the region of much twining and twisting, the flattening of the rachis and the accentuation of its bounding ridges become more pronounced.

Each sterile leaflet has a very short petiolule about 1/8 inch, more or less, long that has on the upper side a groove between two thin raised wings. One wing has already been described as a prolongation of a ridge occurring on the petiole or on the rachis below the leaflet. The other wing on the other side of the petiolule goove appears to arise in the axil of the petiolule and is about the same size as the first wing. The petiolule soon forks into two pinnule stalks

Fig. 191. (Opposite page.) The hartfordfern (climbing fern) on Mr. Whittle's estate near Gatlinburg, Sevier Co., Tenn. Photographed Sept. 4, 1935. The maple-leaf like sterile pinnules show well but the fertile pinnules in the taller shrubs are almost invisible.

Fig. 192. A mass of fertile pinnules with a few sterile pinnules of the hartfordfern, Cumberland Plateau, Cumberland Co., Tenn., near Pleasant Hill. Photographed June 17, 1934. A fertile portion of a leaf is seen twining counterclockwise.

Fig. 193. (Oppostie page.) Some details of *Lygodium palmatum*. *A*, A form of sterile pinnule that is not uncommon at the apex of a sterile leaf, no. 1807, X .75. *B*, One of the most common types of sterile pinnules from near the middle of a leaf no. 1807, X .75. *C*, Veining in a sterile pinnule, no. 9591, X 2.00. Most veins end free but note the single anastomosis at *a*. *D*, The fertile portion (terminal) of a leaf, no. 1805, X .75. The first leaflet has a sterile pinnule to the left and a partially fertile pinnule to the right. Pinnules intermediate between sterile and fertile pinnules are common. *E*. The ridges and hairs on pinnule stalks, a petiolule, a petiole to the left, and a rachis to the right, no. 1800, X 8.00. *F*, Four fertile pinnule segments showing the two rows of scale-like indusia on each and a few of the hairs present. no. 1801, X 4.00. *G*, The type of veining present in one of the orbicular pinnules shown in *I*, *Shanks, Sharp*, and *E. Clebsch* no. 3987, X 4.00. *H*, Rootstock with hairs, leaf buds above, and roots below, no. 1804, X .75. *I*, Normal sterile pinnules below, and small, orbicular ones above, X .75.


A.
B.
a
C.
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D.K. ATKERSON

and one wing from the petiolule is continued onto one pinnule stalk and the other wing onto the other pinnule stalk (Fig. 193, *H*). These wings are sometimes expanded into thin crests just below the petiolular fork. White hairs grow on the petiolules and on the pinnule stalks and especially on the crests when present. Each petiolule thus has two wings, one from the petiole or rachis below it, and one that seems to arise in its axil or from a ridge on the rachis above the axil. The petiolule is usually untwisted but occasionally it is twisted. Besides the wing from the petiolule that has been mentioned as continuing onto each pinnule stalk, there is another wing which seems to arise in the fork between the two pinnule stalks. There is a groove near the base of each pinnule stalk base between the two wings but farther out the groove flattens out and the wings become small bounding ridges which are continued to join the pinnule blade. Sometimes there is a small bud-like knob, which is usually dark-brown or black, seated in the fork. Often one or both pinnule stalks are twisted. Where both are twisted, they sometimes (always?) twist in opposite directions. These stalks are very slender and wiry and are about one inch long.

Sterile pinnule blades are mostly orbicular or slightly reniform in shape with a cordate base, and are palmately lobed. In general they resemble small lobed leaves of a maple tree. They vary greatly in size and number of lobes, as indicated in the sketches (Fig. 193, *A, B, C, G, I*). One of the largest pinnules seen (no. 9691) was about 2 3/4 inches wide and about 1 3/4 inches long. It was reniform in shape with five long elliptical lobes and two short and rounded basal lobes. An even number of long lobes, usually four or six, and one pair of short basal lobes is the most characteristic relation. However, pinnules having two long lobes, three long lobes, or five long lobes, in addition to the pair of short basal lobes, may be readily found. Young sterile pinnules may be unlobed with a shallowly crenated margin (Fig. 193, *G, I*). The long lobes in the palmately lobed pinnules vary from lanceolate to elliptic to oblong in shape and have obtuse, or rarely emarginate, apices. Their margins are entire or rarely occasionally notched with very small teeth. Each very short basal lobe often has its upper portion prolonged into a fairly long lobe. Sinuses between the segments are usually acute; occasionally they may be rounded. The upper surfaces of the pinnules are dark-green and glabrous; the lower surfaces are a lighter-green color and usually have white hairs up to 1/25 inch long. With age, the pinnules become yellowish-green. The pinnule stalk has a single large vein in it but as it enters the pinnule blade it forks, and then each branch forks many times to send a main branch to each lobe. This main branch gives off many oblique branches which fork from three to five, or even more times, to end free just short of the margin. Very rarely one vein near a sinus will anastomose with another vein (Fig. 193, *C, a*). The main branch vein to each segment is somewhat zigzag, bending to the right to give off a right oblique vein, then to the left to give off a left oblique vein, and so on throughout its length. The way the main vein branches at the base of the sterile pinnule makes a very small cuneate portion to the blade at this point.

As has already been mentioned, the upper portion of the leaf bears the fertile pinnules arranged in pairs, as are the sterile pinnules (Figs. 192; 193, *D*), and attached to a short petiolule which is usually 1/8 inch or less long. The origin and arrangement of the two wings on the fertile petiolule and their extension out on the pinnule stalks seems much the same as in sterile leaflets. The pinnule stalks are very slender and the wings are very narrow and are separated midway of the stalk by a flattened side; the groove, if present, being only near the fork. The fertile pinnules are pinnately compound into alternately arranged branches which may be compound or dissected into segments.

(To be continued)