ART. III.—*Studies in the Cyperaceæ*; by THEO. HOLM.
 V. *Fuirena squarrosa* Michx. and *F. scirpoidea* Vahl. With
 19 Figures (pp. 25, 26).

THESE two species are natives of the eastern United States, *F. squarrosa* showing a distribution from Massachusetts as far south as subtropical Florida, while the other species is confined to Georgia and Florida alone. It is a marked characteristic of the genus that a true perianth is developed, in our species represented by six leaves in two alternating whorls, those of the inner being spatulate, while the others are merely bristle-shaped like those of *Dulichium*, *Rhynchospora*, etc.; this, the outer, whorl of the perianth is, however, undeveloped in several of the foreign species of *Fuirena*, as well as in *F. umbellata*, upon which Rottböll established the genus, first discovered in Surinam by Rolander, who described it as "*Scirpus tripetalos*." The genus is closely related to *Scirpus*, with which it, also, shows a great resemblance in regard to the general habit, but is well distinguished by the spatulate shape of the perianth as also by the hairy bracts of the flowers, which are smooth in the species of *Scirpus*. When compared with each other, our two *Fuirena*-species show several external characters, by which they are readily distinguished, viz: the reduction of the stem-leaves in *F. scirpoidea* to sheaths with a minute blade, while *F. squarrosa* has well-developed leaf-blades. The bracts of

the flowers are broad and very short-pointed in *F. scirpoidea* (fig. 13), but rather narrow and long-awned in the other species (fig. 11). The inflorescence is a spike, there being one terminal and several lateral, often situated close together or scattered on long peduncles from the axils of the stem-leaves as in *F. squarrosa*. A clado-prophyllon is present and is short, very broad and distinctly bidentate in *F. scirpoidea* (fig. 12), while it varies from oblong, slightly emarginate to long and tubular in *F. squarrosa* (figs. 6 and 10), in accordance with its place on the very short rhachis of the lateral spike or at the base of the long peduncles, which bear several spikes at the apex, and which are commonly developed in the axils of some of the lower stem-leaves in *F. squarrosa*.

Another character is to be observed in the shape of the inner perianth-leaves, which, although they are spatulate in both species, are almost obtuse in *F. scirpoidea*, but vary from short-pointed to long-awned in the other species; a similar variation in regard to the respective length may, also, be noticed in the bristles. The rhizome of our species shows a very considerable difference, being stout and extensively creeping in *F. scirpoidea* in contrast to that of *F. squarrosa*, which is almost caespitose with ascending, not creeping, shoots and which, also, possesses some tuberous organs, each of which represents a single internode.

We see from these divergencies that our two *Fuirena*-species do not lack morphological characters; all of which are of specific value, and we shall show, later on, in this article that their internal structure is no less important for their specific distinction. We must, however, not neglect to consider our plants also from a biological point of view; and we shall try to demonstrate, at least, a part of their life-history, based upon our investigations and compared with the more important studies of similar kind, which we have met with in our literary research. There are, for instance, in regard to the germination of *Fuirena* a few points of interest, which deserve notice, although they are not new; nevertheless, when we discuss them, it is merely on account of the very defective knowledge we have of the seedlings of this group of plants, the *Cyperaceæ*, and we thought, also, that a brief historical sketch of this early stage of their life-history might be of some interest to the reader.

The principal difference, that exists between the germination of the *Cyperaceæ* and the *Gramineæ*, consists in the fact that in the *Cyperaceæ* the plumule is the first to push out through the caryopsis, while in the *Gramineæ* the primary root is the first to appear. In *Fuirena* as in the other *Cyperaceæ*, which so far have been examined, the plumule is covered

by a membranous sheath at the base of which a small, roundish wart soon becomes visible, and which represents the primary root. The cotyledon, on the contrary, stays inside the seed, its function being to absorb the endosperm. These are the general features of the germination, and it may, at first glance, seem to be a very easy matter to define these various organs, which as we have shown constitute the seedling. We may, by considering our figure 1*b*, define the conical body (C) as representing the cotyledon and as being identical with the scutellum of the *Gramineæ*; we may define the sheathing leaf (*Sh*) as the second leaf, and *L'* as the first developed green leaf. The primary root (R) is already relatively long and covered with root-hairs. By comparing now this figure (1*b*) with our figure 1, we notice the same organs, besides a stem-part (*j*) which separates the cotyledon (C) from the sheathing leaf (*Sh*); a secondary root (*r*) has developed from this stem-part, and another one (*r'*), but much younger, has started to break out through the base of the sheathing leaf (*Sh*). One should, according to these figures, never doubt the morphological identity of these organs, as we have defined them above, especially when we point out the long internode (*j*) which lies between the cotyledon (C) and the sheathing leaf (*Sh*), viz: that these organs should not be independent of each other. It seems, nevertheless, to be a most difficult task to define them correctly, so as to bring them in strict conformity with the corresponding organs in the other monocotyledonous plants, and at the same time avoid bringing their anatomical structure in contest with their rank in a morphological respect. If we, for instance, consider the body at C as the cotyledon, its structure must correspond with that of a leaf, and if we, also, define the sheathing organ at *Sh* as a leaf, this must not be in any connection with the other one at C; furthermore, if the stem-part (*j*) is really an internode, it must show a structure in conformity herewith. The difficulty is, however, that these organs do not exactly show the anatomical structure as they "ought," according to our idea, and even if a morphological consideration may seem more natural, we cannot feel justified in overlooking the structural characters. We will, therefore, in our attempt to explain this matter, strive to establish a conformity, so that the morphological peculiarities may be brought in accordance with the anatomical ones, and we believe this may be attained by presuming that some modification exists in the development of some of these organs. A literary research upon this question is exceedingly instructive, and there are, indeed, few stages in the plant life that have required so many and such able investigations in order to become understood, as has the germination of the *Gramineæ* and the *Cyperaceæ*.

The *Gramineæ* seem, however, to have attracted a good deal more attention than the *Cyperaceæ*, although their seedlings agree in most respects. It is, now, interesting to see from the literature how many and very diverse opinions have been expressed by the morphologists in order to define the organs of these seedlings; and even if so eminent an anatomist as Van Tieghem has tried to pacify the contesting parties by submitting a most excellent and detailed account of the internal structure of these germinating plantlets, it seems, nevertheless, that the morphological standpoint taken by Warming, in adherence to the views expressed by Poiteau, Mirbel and Turpin, may prove satisfactory to all concerned.

The most important difference between the seedlings of these two families consists in the presence of a very small organ like a rudimentary leaf, which in some *Gramineæ*, but not in all, is to be observed on the anterior face of the seedling, and in alternation with the so-called scutellum. This scale-like appendage had been observed and figured by Malpighi as far back as the year 1675, and it has since that time been repeatedly described and given a number of names, the best known among these being the "lobule" of Mirbel, and the "épiblaste" of Richard. While Poiteau, Mirbel and Turpin considered this organ as an independent leaf or even as a "second, but small cotyledon," the majority of the other authors have only understood it as a part of the cotyledon. It is strange, that the most modern and generally adopted idea is now that of Gärtner (l. c.), who more than a hundred years ago defined the scutellum as the median part of the cotyledon, the épiblaste or lobule as an appendix to this, while the sheathing leaf (*Sh*) should represent the ascending sheath of the cotyledon, thus these three organs should all constitute the cotyledon, and the first green leaf (*L'*) should then be the first leaf of the plant next to the cotyledon. This rudimentary organ, the épiblaste, is not known to exist in the *Cyperaceæ*, and we have therefore great difficulty in finding proofs for our explanation, according to which the cotyledon and the sheathing leaf should represent organs, independent of each other. It will be seen from our drawings (figs. 1 and 1*b*) that the sheathing leaf (*Sh*) is situated just above and at the same side of the axis as the cotyledon (*C*), indicating a leaf arrangement as "uniseriate" which would be too unnatural to be acceptable. But when we compare our *Fuirena*-seedlings with similar ones of *Gramineæ* "with or without the épiblaste," the suggestion arises that this little organ has been suppressed in the *Cyperaceæ*, as in a number of the *Gramineæ*. Seedlings of grasses with a developed épiblaste show the same biseriate arrangement of the leaves as we find later on in the mature

plants, counting the cotyledon as the first, the épiblaste as the second and the sheathing leaf as the third leaf of the young plant. We might be allowed to suggest that the épiblaste has become undeveloped in the *Cyperaceæ*, but without influencing or rather without disturbing the normal arrangement of the leaves, as we find them in *Fuirena* and all the others examined. It was the frequent development of a stem-part between the cotyledon and the sheathing leaf, which led Warming to adopt the explanation of these three organs, including the épiblaste, as independent; but, strange to say, Warming does not in his paper upon this subject (l. c.) enter into any discussion as to the severe objections raised by Van Tieghem against this theory. Van Tieghem denounces the épiblaste as a leaf, because it does not receive any mestome-bundles from the axis; the sheathing leaf will, therefore, necessarily be situated above and "at the same side" as the scutellum, and can consequently not be independent of this. He, finally, demonstrates that the supposed internode (*j*) is only a node according to its anatomical structure, but a node, which has become unusually stretched, so that the cotyledon and the sheath have become somewhat separated from each other. These very serious objections are, of course, a heavy blow to the theory regarding the existence of three independent leaves, an explanation which otherwise seems so very natural and in good conformity with the rules of morphology. We venture, however, to suggest that the épiblaste may be a leaf-primordium and that it stays as such with no mestome-bundles developed, and as a leaf, which is often suppressed entirely. We will, also, state that we cannot find any decided objection in considering the cotyledon as a leaf, independent of the épiblaste and of the sheathing leaf, even if, as Van Tieghem has proved, the stem-part is only a node. There is among the numerous and most important agrostologic papers by Duval-Jouve one (l. c.) in which he describes the nodes of *Eleusine*, *Cynodon* and other *Gramineæ* as bearing more than "one leaf," from one to two or even three! This same fact is very familiar to us, when we remember the peculiar, dense-leaved nodes of *Diplachne*, *Munroa*, *Buchloë* and several other North-American grasses. We might also state, that it is not quite certain that the épiblaste is constantly present only as a rudimentary organ, since Didrichsen (l. c.) has figured this organ taken from *Avena sativa*, where it shows a distinct nervation, corresponding to a very finely lobed margin. We believe, however, that a continued research will throw a clearer light upon this subject, and there is no doubt that seedlings of our native grasses and sedges will show some facts that may be helpful for the explanation of this remarkable manner of germinating. We will,

also, at this place, call attention to a work by Klebs (l. c.), wherein is given a summary of the different manners of germination, considered from a morphological as well as from a physiological point of view, besides that this author has enumerated the most prominent works upon the subject, which, of course, is a most valuable guide for literary research.

Having discussed now the germination of our plants, let us examine them at a later stage, when their vegetative organs are fully developed; and we may begin with the rhizome. We have already mentioned above, that the rhizome of our two species shows a very marked difference in external structure, although their manner of ramification is exactly the same in both species. We find here a true sympodium, and the difference lies merely in the tuberos development of some internodes in *F. squarrosa*. While the sympodial ramification is very common in the Phanerogames, especially in their rhizomes, there are, nevertheless, only a few which exhibit the sympodium so plain as our *Fuirena scirpoidea*. Figure 7 illustrates the anterior part of a rhizome of this species, and we have, also, redrawn the apex of the same, but on a larger scale in order to represent the exact position of each organ (fig. 8). The rhizome is horizontally creeping and consists of distinct internodes with scale-like leaves. At certain intervals, in our species, between each two leaves, a flower-bearing stem arises, while an axillary bud develops at the same time, continuing the growth of the rhizome in the same direction, as if it was the terminal bud. By comparing figs. 7 and 8, we notice the scale-like leaf B, which is borne on the main axis (ax^1) and which at the same time supports another, but secondary axis (ax^2), which is readily seen to be axillary. These two axes (ax^1 and ax^2) have fused together and form partly a single internode, but there is a somewhat depressed line to be seen where the fusion has taken place, and the axillary branch is, always, well-marked by having its first leaf developed as a bicarinate prophyllon (pr in fig. 8) with its characteristic position in regard to the main-axis. The rhizome of *F. scirpoidea* does not branch much to the sides, but when such branches develop, they always originate from the axil of the lowest situated leaf of a flowering stem (fig. 9), while we have not observed any to be developed from the scale-like leaves, excepting from the apex of the rhizome, as described above.

The same sympodial ramification is, also, to be found in the other species, *F. squarrosa*, some parts of the rhizome of which are illustrated in figures 2 and 4, in addition to some diagrammatical drawings in figs. 3 and 5 of the same parts. Figure 3 shows, for instance, the apex of an old rhizome (fig. 2) where B is a scale-like leaf from the main stem, the continuation of

which (ax^1) attains a peculiar tuberous development of the internode above the leaf (b). Another shoot pushes out from the axil of the scale-like leaf B, which is, consequently, of second order (ax^2), and which develops into a leaf-bearing shoot of normal structure. We find this same manner of development if we consider figure 5, which represents an enlarged portion of the rhizome (fig. 4). We see, also, here the two systems of axes (ax^1 and ax^2) one of which (ax^1) shows the same tuberous internode (i^2) as described above. The axillary shoot (ax^2) bears here two scale-like leaves (b^1 and b^2), of which the upper one (b^2) supports the shoot, ax^2 , well distinguished as axillary by its prophyllon (pr). This figure shows, then, the development of the axis of first order either as a flower-bearing stem with stretched internodes, or as a tuberous shoot with the growing-point arrested in its further development; the axis of second order seems, also, in this species to stay underground as purely vegetative. In regard to the tuberous development of one of the internodes of *F. squarrosa*, we must state, that this seems to be a very rare case in the *Cyperaceæ*, while tubers of several internodes are known from a few species of *Cyperus*, e. g. *C. esculentus* and *C. phymatodes*, which have been described in a very clear and comprehensive manner by Seignette (l. c.) In the *Gramineæ*, on the contrary, such single tuberous internodes are not very rare, and Hackel (l. c.) enumerates quite a number of grasses, representing a development like that of *Fuirena squarrosa*. These grasses are mostly inhabitants of regions of which a periodical drought is characteristic, and Hackel mentions for instance the Pacific species of *Melica*, some Mexican species of *Panicum*, the genus *Ehrharta* from the Cape Colony, besides several species from the Mediterranean.

In regard to the stem above-ground, this is in *F. scirpoidea* built up of a number of rather short internodes, of which all the leaves are merely present as sheaths, the blade being only a rudiment; the stem of the other species is of usual form, but none of the internodes is, however, long enough to be defined as a scape. The leaves of *F. squarrosa* have long, linear blades, like the tubular sheath very hairy; a ligule is, also, developed as usual in the long-leaved *Cyperaceæ*, and it is very strange that this organ seems almost constantly to have been overlooked in this family, although it is very distinct, when developed.. Baillon (l. c.) and Bentham and Hooker have even considered the ligule as one of the generic characters of *Fuirena*, viz: "foliorum vagina ligula coronata." It is, on the other hand, just as incorrect when the authors of botanical manuals constantly attribute this same organ, the ligule, to all the *Gramineæ* without exception, although it is absent in

many, e. g., all the broad-leaved species of *Panicum*, viz: *P. microcarpon*, *viscidum*, *clandestinum*, etc. We have already described the structure of the inflorescence and of the single flowers, and having not observed any other characters of morphological interest, we will proceed to the anatomical part of our paper.

The rhizome.

This shows a very firm structure in *F. scirpoidea*, since the bark-parenchyma contains a concentric ring of small groups of very thick-walled stereome, besides that a closed ring of several layers of this same tissue, the stereome, surrounds the central-cylinder. The mestome-bundles seem to be all collateral, and are supported by stereome on their hadrome-side; they are not arranged in any order, but scattered in the large mass of fundamental tissue. We mentioned in our previous article upon *Dulichium* the presence of tannin-reservoirs, which we have noticed again in both species of *Fuirena*. These reservoirs are quite numerous in the rhizome, especially in the outer layers of the bark-parenchyma.

By examining the rhizome of *F. squarrosa*, the internodes of normal thickness showed a large quantity of starch deposited in the bark and in the fundamental tissue, which occupies the greater part of the central-cylinder. Immediately inside the epidermis some small groups of stereome are to be observed, and this tissue appears again in about three or four strata, forming a closed ring inside the bark, and surrounding the central-cylinder. A thin-walled endodermis is very distinct, and the collateral mestome-bundles are arranged very regularly in three alternating bands, with their hadrome-side supported by thin-walled stereome; similar, but smaller, mestome-bundles were, also, observed in the bark. Tannin-reservoirs were observed to be quite numerous and of large size in the bark.

If we now compare this structure with that of a tuberous internode, we notice the almost complete disappearance of the stereome, and also that there is here only one single band of collateral mestome-bundles, located a very short distance from the epidermis. The fundamental tissue occupies the greatest part of the internode and is filled with starch. It appears from this, that the function of these thickened internodes is for the storage of nutritive matters; in the *Gramineæ*, however, their function is different, according to Hackel's observations, who states that he was unable to find any deposits of starch in their swollen internodes, although these were examined at different seasons of the year. He, therefore, concludes that they may represent a kind of water-

reservoirs, which might be of some use to these plants in the dry seasons. A different view has, meanwhile, been expressed by Seignette, who (l. c. p. 39) describes the structure of *Avena elatior* var. *bulbosa* (*A. bulbosa* Willd.), and who found a large quantity of starch deposited in the fundamental tissue.

The stem above-ground.

It is cylindric, but furrowed in *F. scirpoidea*, and, as already stated, consists of numerous internodes. The epidermis-cells are relatively small, perfectly smooth, and stomata are, of course, well represented in this tissue. The bark-parenchyma shows a very characteristic palissade-tissue of several layers, and is interrupted by large groups of stereome. The inner part of the bark passes gradually over into a colorless tissue, which occupies the interior part of the stem; the mestome-bundles are arranged in a band and are to be observed in the green bark, just inside the groups of stereome, which border on their colorless parenchyma-sheaths. A very few mestome-bundles are, also, noticed in the fundamental tissue, and these show a much larger lacune in the hadrome-part than is to be observed in the bundles of the outer band. The stem of *F. squarrosa* shows a somewhat different structure; it is terete, furrowed and smooth, but much weaker than that of the preceding species. The cells of epidermis are large and very thin-walled, and the green bark consists only of about seven strata, in which lacunes are to be observed. The mestome-bundles are arranged in two alternating bands and located in the very large, colorless-parenchyma, which occupies the central-cylinder; the bundles are supported by large groups of stereome, which reach through the green bark to the epidermis itself. Characteristic of the stem of this species is the presence of lacunes, one between each of the two mestome-bundles and several in the fundamental tissue, rendering the stem almost hollow.

The leaf

of *F. scirpoidea* has a long, tubular sheath but only a minute, rudimentary blade. A transverse section of the blade (fig. 17) is thick, but very narrow. The epidermis consists of rather large cells, but none of them are, however, developed as "bulliform," although some of the cells above the midrib are considerably larger than the others; stomata (fig. 18) are especially abundant on the inferior face of the small leaf-blade as well as on the sheath. These stomata are not prominent, but almost in niveau with the surrounding cells. The mesophyll (the black tissue in fig. 17) consists of rather closely-packed

roundish or polyëdric cells, none of which are differentiated as palissade-cells. There are only a few, about seven, mestome-bundles, of which the median one is the largest; they are all surrounded by thin-walled and colorless parenchyma-sheaths inside of which we meet with a typical mestome-sheath. The hadrome-part is rather large, and contains a number of vessels. There are groups of stereome on the leptome-side of the mestome-bundles, while this tissue is almost wanting on the hadrome-side, excepting in the median bundle. Reservoirs of tannin were noticed as being very abundant in the mesophyll. A more complete structure is shown by the long leaf-blade of *F. squarrosa* (fig. 14). Epidermis consists of very large cells on the superior face of the blade, and is developed as "bulliform-cells" above the midrib and two of the largest mestome-bundles. Hairs are abundant in this species, and are present as very short ones on the superior face of the blade, while those of the margins and the inferior face are long and sharply pointed. The stomata (fig. 15) are very prominent, and seem only to be developed on the inferior face of the blade. The mesophyll is well developed, consisting of hexagonal very closely-packed cells, while a large lacune is to be seen between each of the two mestome-bundles. These last are surrounded by colorless, thin-walled parenchyma sheaths as well as by the usual mestome-sheath, and the larger bundles are on both faces supported by some small groups of stereome.

The root

of *F. scirpoidea* agrees in most respects with that of the other *Cyperaceæ*, having a hypoderm inside the epidermis, and with the characteristic radial arrangement of the bark-cells, of which the innermost layer, as usual, is differentiated as an endodermis. This endodermis shows, however, a very peculiar development, since the cells, which are exceedingly thin-walled, are stretched radially, as shown in our figure 19. The pericambium is, also, here interrupted by protohadrome, and there are five distinct groups of leptome in alternation with five large vessels, while the innermost part of the root is occupied by fundamental tissue. The root of *F. squarrosa* shows a much weaker structure, since the bark-parenchyma shows many lacunes on account of the radial collapsing of the cell-walls. The cells of the endodermis (*End* in fig. 16) are of normal shape and slightly thickened. A large vessel occupies the center of the root, and tannin-reservoirs were observed in the epidermis as well as in the outer bark-parenchyma.

We see from this brief anatomical sketch that there are several structural characters, by which these two *Fuirena-*

species may be distinguished, although their morphological characters are so prominent as to leave the anatomical distinction unnecessary. But it is, nevertheless, quite interesting to compare their structure in order to ascertain whether there may be some connection between the structure of their tissues and the character of the climate and soil wherein they grow. *Fuirena scirpoidea* has several features in common with some of the most pronounced desert-plants, viz: the reduction of the leaf-blades in contrast to the other species of the genus. It grows in dry, sandy soil and is a very common plant in sub-tropical Florida. The anatomy of its almost leafless stem shows us a well differentiated palissade-tissue in the bark, thus the stem has taken the function of the leaf; the very thick-walled epidermis is another character by which *F. scirpoidea* approaches itself to the desert plants, e. g., *Panicum turgidum*, as described in Volkens' excellent work upon desert-vegetation (l. c.). We must not, however, consider our *Fuirena* as an exception from most of the *Cyperaceæ* because its leaf-blades are not developed; this very same external structure is, as we remember, very common in species of *Scirpus*, *Eleocharis* and in many *Juncaceæ*. But these almost leafless species grow always in wet soil, in marshes, etc., while our *Fuirena* prefers the dry sand, although not entering in the "Scrub" vegetation, which to a certain extent constitutes a desert-vegetation in Florida.

The anatomical characters are, otherwise, to be observed in the root, viz: the peculiar endodermis in *F. scirpoidea*, the lacunes in the bark in *F. squarrosa*, while the leaf shows us a dense hairy covering and very prominent stomata in *F. squarrosa* in contrast to *F. scirpoidea*; the stem of *F. scirpoidea* with its firm structure and the bark developed as palissade-tissue is very different from the weak stem of *F. squarrosa* with its large lacunes.

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EXPLANATION OF FIGURES.

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- FIGURE 1 and 1b.—Seedlings of *Fuirena squarrosa*. 9 × natural size.
(For explanation of the letters see the text.)
- FIGURE 2.—Rhizome of *F. squarrosa*; natural size.
- FIGURE 3.—Part of figure 2, enlarged.
- FIGURE 4.—Branch of a similar rhizome; natural size.
- FIGURE 5.—Same, enlarged.
- FIGURE 6.—Clado-prophyllon from the lateral spike-bearing peduncle of *F. squarrosa*; $1\frac{1}{2}$ × natural size.
- FIGURE 7.—Rhizome of *F. scirpoidea*; natural size.
- FIGURE 8.—Same, enlarged.
- FIGURE 9.—Part of a similar rhizome; natural size.

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- FIGURE 10.—Prophyllon from the base of a lateral spike of *F. squarrosa*; much enlarged.
- FIGURE 11.—Bract from a spike of *F. squarrosa*; 6 × natural size.
- FIGURE 12.—Prophyllon of *F. scirpoidea*; much enlarged
- FIGURE 13.—Bract of same; 6 × natural size.

FIGURE 14.—Transverse section of stem-leaf of *F. squarrosa*. Ep. sup. and Ep. inf. = epidermis of the superior and the inferior face; 75 × natural size.

FIGURE 15.—Stoma from the same leaf, transverse section; 320 × natural size.

FIGURE 16.—Transverse section of the root of *F. squarrosa*: B = the bark: End = the endodermis; Pr = the pericambium; PH = the protohadrome; 320 × natural size.

FIGURE 17.—Transverse section of the leaf-blade of *F. scirpoidea*; *Ep. sup.* = epidermis of the superior face; *M.* = the mesophyll; *H.* = the hadrome; *L.* = the leptome; *PS.* = the parenchyma-sheath; *St.* = the stereome; 75 × natural size.

FIGURE 18.—Stoma from the same leaf; 320 × natural size.

FIGURE 19.—Transverse section of the root of *F. scirpoidea*; letters as in figure 16; 320 × natural size.

(The black in figures 14 and 17 indicates the chlorophyll-bearing tissue, the mesophyll.)