ART. VI.—*Anemiopsis Californica* (Nutt.) H. et A. An anatomical study; by THEO. HOLM. (With six figures in the text drawn by the author.)

WITH Bentham and Hooker *Anemiopsis* H. et A. and *Gyrotheca* Desne. are included in *Houttuynia* Thunbg., but they all have been kept separate by Eichler* on account of their floral structures. *Houttuynia* is described as possessing only three stamens opposite the three carpels, while in *Anemiopsis* and *Gyrotheca* the flower has six stamens and three carpels in the former, but four in the latter; the ovary is, moreover, perfectly inferior in *Gyrotheca*. The arrangement of the stamens in *Anemiopsis* is somewhat peculiar, as already described by Payer, there being two in front and two behind the ovary, with one on each side of this; this position of the stamens was, also, observed by the writer in the several inflorescences examined. Furthermore, DeCandolle† has treated our genus as distinct from the others.

Anemiopsis Californica does not seem to be very well known anatomically, and since the writer has lately received some fresh and carefully collected specimens from California through our friend Mr. Thos. H. Kearney, we have examined the plant and offer now the following notes as a small contribution to the knowledge of this peculiar genus.

The thick rhizome is horizontal with several strong and quite fleshy roots; its ramification is monopodial, the apical bud being purely vegetative, while the stolons and flower-bearing stems are all lateral, proceeding from the axils of the leaves, which form an open rosette. While, as already pointed out by Eichler (l. c.), the flowers are destitute of prophylla, such occur at the very base of both the stolons and flower-bearing stems, thus representing clado-prophylla.‡ These leaves are two in number and situated to the right and left of the stems; they are membranaceous, scale-like and prominently carinate, but simply one-nerved. The flower-bearing stems are often branched, there being one terminal and two or three lateral inflorescences preceded by one or two green leaves. The stolons show the same structure, but with vegetative shoots instead of inflorescences.

Considered from an anatomical viewpoint the *Piperaceæ*§ have always attracted a good deal of attention, and they figure

* Blüthendiagramme, vol. ii, 1878, p. 6.

† Prodrômus, vol. xvi, 1869, p. 237.

‡ Compare Casimir DeCandolle: Mémoire sur la famille des Pipéracées. (Mém. Soc. phys. Genève, vol. xviii, 1865, p. 234.)

§ The anatomy of the order has been described in Dr. H. Solereder's work: Systematische Anatomie der Dicotyledonen. Stuttgart, 1899, p. 775.

prominently in works upon general anatomy. Not less than four types of stem-structure are described by Dr. Solereder (l. c.), and characteristic of the tribe *Saurureæ*, to which our genus belongs, is one normal ring of collateral mestome-bundles. In regard to the leaf-structure the stomata are said to be confined to the lower surface; in *Anemiopsis*, however, we observed these to be present also on the upper, and even more numerous. Most peculiar is the development of a hypoderm, so very prominent in *Peperomia*, besides the hydathodes. Secreting cells abound in the leaves and stems of both *Piperæ* and *Saurureæ*, while secreting ducts are only known from some species of *Piper*. Very little seems, however, to be known about *Anemiopsis*, thus we take the opportunity to describe herewith the structure of the various organs in detail.

The leaf-blade.

The cuticle of both surfaces is quite thick and prominently wrinkled, which is especially distinct when we examine the epidermis from above (fig. 1). Epidermis consists of relatively small cells with the outer wall moderately thickened except in the secreting cells (*SC* in fig. 2). For, as may be seen from this figure, secreting cells occur, also, in the epidermis; they are thin-walled throughout, much larger than the ordinary epidermis-cells and sunk below the level of these, thus forming round depressions in the leaf-surface. Long hairs abound on the lower surface and consist of from eight to twelve cells in one row with the cuticle thin and smooth. As stated above, we observed stomata on both surfaces, and they appeared even to be most numerous on the upper; they have no specialized subsidiary cells, but are surrounded by a somewhat indefinite number of ordinary epidermis cells, from four to six, as may be seen from our fig. 3; viewed in transverse sections, the stomata are level with epidermis (fig. 4). A hypoderm of one layer of cells (*H* in fig. 2) is developed on both faces of the blade, but of different structure; the cells are very large and cone-shaped on the upper face with the point towards the palisade-tissue; on the lower face the hypodermal cells are relatively smaller and of a roundish outline (fig. 2).

The leaf is dorsiventral and possesses a distinct palisade-tissue of several layers on the upper face, interrupted here and there by secreting cells; the palisades are rich in chlorophyll and surround the conical, hypodermal cells, but without reaching the epidermis. A pneumatic tissue of irregular, oblong cells, with wide intercellular spaces, occupies the dorsal part of the blade. The mestome-bundles, except the mediane, are small and completely imbedded in the mesophyll; they are surrounded by a colorless parenchyma-sheath. The midrib is

quite broad and projects on the lower surface, where it borders on a large mass of thin-walled, colorless parenchyma. It is composed of seven separate mestome-bundles, each with a parenchyma-sheath and having a support of several layers of stereomatic tissue, especially on the leptome-side.

Anemiopsis Californica.

FIG. 1.—A cell of epidermis from the leaf, showing the wrinkled cuticle, seen from above.

FIG. 2.—Transverse section of the leaf; *C* = cuticle; *Ep* = epidermis; *SC* = secreting cell of epidermis; *H* = hypoderm.

FIG. 3.—Epidermis with stomata of the leaf, seen from above.

FIG. 4.—Transverse section of leaf, showing a stoma.

FIG. 5.—Epidermis with twin-stomata, seen from above.

FIG. 6.—Transverse section of a part of the central-cylinder of the root; *L* = leptome, outside a secondary vessel *V*; *C* = cambial layers; *H* = the primordial rays of hadrome; *P* = pith; *Cp* = secondary cortical parenchyma.

The petiole.

The cuticle shows the same structure as described above; the epidermis possesses stomata, but no hairs, and is rather small-celled. A hypoderm is, also, developed here, but it is uniform and consists only of one layer of roundish cells. The

cortical parenchyma, at least the peripheral strata, contains chlorophyll, and is very open from the great width of the intercellular spaces; secreting cells occur, also, here, but are not very frequent. Separating the cortex from a central group of parenchymatic tissue, a pith, is a circle of twelve collateral mestome-bundles, each with a thin-walled parenchyma-sheath, and surrounded besides by strata of stereomatic tissue. The stereome, however, is confined to the periphery of the mestome-bundles themselves, and does not connect these as a continuous ring of mechanical tissue as is the case with the stem. Characteristic of the mestome-bundles in the petiole is their elliptical outline in cross-section with the leptome, forming a narrow, linear group in contrast to the broad group of hadrome with numerous, narrow vessels.

The prophylla.

As already mentioned, the stolons and flower-bearing stems are axillary; they bear at their base two scale-like, membranaceous fore-leaves, the structure of which is as follows: The cuticle is very distinctly wrinkled on the outer, the dorsal face, but smooth on the inner, the ventral. Epidermis is thin-walled and consists of relatively small cells throughout with neither trichomes or stomata; the outermost portion of the margins is merely composed of epidermis in two layers corresponding to the dorsal and the ventral. The mesophyll is very poorly represented except in the sharp keel; it is quite open and does not contain chlorophyll, neither is it differentiated as a palisade or pneumatic tissue, but constitutes a homogeneous tissue of roundish, thin-walled cells. There is only one mestome-bundle, which is located in the keel; it has a support of two or three layers of slightly thickened stereome and contains mostly leptome.

The involucre.

The involucreal leaves at the base of the inflorescence are very conspicuous, being large and white; they are prominently papillose on the ventral face, each epidermal cell being extended into an obtuse papilla, while the dorsal face is perfectly smooth. Stomata and secreting cells occur in the dorsal epidermis. A hypoderm of large, roundish cells is developed underneath the epidermis on both faces of the involucre. The mesophyll is almost destitute of chlorophyll; it is homogeneous and traversed by wide, intercellular spaces, besides by several very small mestome-bundles.

The floral bracts.

The cuticle and the epidermis exhibit exactly the same structure as observed in the involucre, while the hypoderm is absent

from the ventral face and but slightly differentiated on that of the dorsal. The homogeneous, somewhat open mesophyll contains a little chlorophyll, and about seven very small mestome-bundles are located in the middle of this tissue.

The stem.

The long stolons above ground and the flower-bearing stems show the same structure. They are nearly cylindric, slightly hairy, but perfectly smooth. We notice, also, here a wrinkled cuticle, covering an epidermis of relatively small cells of which the outer wall is distinctly thickened; none of the epidermal cells were transformed into secreting cells. Underneath the epidermis is a hypoderm of only one layer of very large, roundish cells, much larger than those of the adjoining cortex. This tissue, the cortex, consists of about fifteen strata, of which only the peripheral contain chlorophyll; the innermost layer is differentiated as a thin-walled endodermis, surrounding a continuous ring of about fifteen layers of very thick-walled stereome. Directly bordering on the stereome is a circle of twenty-four collateral mestome-bundles separated from each other by broad medullary rays; they are oval in cross-sections and contain both leptome and hadrome, the latter consisting of a few, but wide vessels. But there is no parenchyma-sheath and no mechanical support on the sides of these mestome-bundles or around the hadrome. The central pith is very thin-walled and open. Secreting cells abound in the cortex and in the pith.

The rhizome.

The horizontal rhizome is cylindric, glabrous and smooth; towards the apex it is densely covered with sheathing, green leaves, and is not exposed to the light. Its free portion, behind the rosette of leaves, becomes soon deprived of both the epidermis and hypoderm, but protected by many layers of cork. The cortical parenchyma consists of about fifteen layers with wide intercellular spaces; the cells are filled with starch or contain a secretion of a reddish brown color. The very numerous mestome-bundles are narrow oblong in transverse sections, and are nearly all arranged in a circle separated from each other by rays of the very broad, central pith, which contains starch. The leptome occupies only a small portion of the mestome-bundles, and between this and the very prominently developed hadrome are several strata of cambium.

The root.

All the roots were so far advanced that they showed only a secondary stage of growth. By the increase in thickness the

tissues from epidermis to pericambium had been thrown off and replaced by some, five to six, layers of cork and a very large parenchyma of secondary cortex, filled with starch or sometimes interspersed with secreting cells. Towards the central cylinder the cells of the cortex decrease in size and the innermost layer shows somewhat the structure of a secondary endodermis by its darker color and its power to resist the effect of concentrated sulphuric acid. The central cylinder, however, shows a part of its original structure, viz: a circle of nine short hadromatic rays, each consisting of a few, narrow vessels (*H* in figure 6). These rays alternate with nine collateral mestome-bundles in which the vessels are quite wide (*V* in fig. 6), and mostly more thin-walled than the primordial. Several layers of cambial tissue (*C* in fig. 6) are developed outside the old vessels and inside the groups of leptome, where the secondary hadrome has become developed. A broad and compact pith occupies the inner part of the central cylinder, thus the structure of the root corresponds very well with that of the stem, if it were not for the presence of the primordial rays of hadrome between the collateral mestome-bundles.

Summary.

Being an inhabitant of moist, saline localities our plant may, perhaps, be regarded as a Halophyte. The structural peculiarities of this category of plants has been studied to some extent, but as yet too little has been ascertained to enable us to draw the line between Halophytes and Xerophytes or even the Hydrophytes. Moreover, there are certain orders of plants in which the structural peculiarities appear as characteristic of the order and to some extent inherited, rather than being an expression of a certain mode of adaptation, such as the epharmonic characters.

Now in regard to *Anemiopsis Californica*, it certainly appears as if the structure may be defined more properly as simply "pipereous" than either halophilous or xerophilous. The most conspicuous characters—the prominently developed hypoderm and the abundance of secreting cells throughout the various tissues—are in conformity with the general structure of the order rather than with the Halophytes, for instance, and these characters are very important. Then when we compare the tables of "leaf-anatomy of salt-marsh species" in Mr. Kearney's interesting paper on this subject,* we notice several points by which our plant differs from his salt-marsh species.

*The plant covering of Ocracoke Island. Contrib. U. S. Natl. Herb., vol. v, Washington, 1900, p. 310.

Most of the species examined by this author possess isolateral leaves; several of these have hypodermal collenchyma or the mestome-bundles are supported by real stereome. On the other hand, Mr. Kearney observed a wrinkled cuticle and a like distribution of stomata on both leaf-surfaces, both of which characters, as we remember, are also to be observed in *Anemiopsis*. A similar result is reached when we compare the species examined by Professor Warming,* none of which possess such striking peculiarities as those characteristic of the *Piperaceæ*, nor do the features of his Halophytes in general agree with those of our plant; only a few points and of no particular interest or of seemingly great importance may be found common to both. As stated by Professor Warming, the lack of stereome seems to be characteristic of the Halophytes, so far as concerns their leaves, and only these have been examined. In this respect *Anemiopsis* would show some likeness to the Halophytes, since the leaves contain very little stereome and only near the midrib. But if we compare the other parts of the plant, the stem and the petiole for instance, we then observe this tissue to have reached a very high development, especially in the flower-bearing stems and the stolons.

It would, thus, appear as if *Anemiopsis* so far as concerns the structure, gives a better illustration of one of the several types of the *Piperaceæ* than of any specialized type modified in accordance with the environment, halophilous for instance.

Brookland, D. C., October, 1904.

* Halofyt-Studier, Kgl. Danske vid. Selsk. Skr., 6th series, vol. viii, Kjöbenhavn, 1897, p. 175.