THE COMPARATIVE LEAF STRUCTURE OF THE SAND DUNE PLANTS OF BERMUDA.

(With 3 plates.)

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The writer has discussed the flora of Bermuda in two papers published in the *Proceedings of the Academy of Natural Sciences of Philadelphia* and entitled "The Plant Formations of the Bermuda Islands" (1905: 695–700) and "The Hour-glass Stems of the Bermuda Palmetto" (1905: 701–704). The study of the flora presented in these papers and the study of the microscopic anatomy of the leaves of the sand dune plants herewith given is the result of a visit to the islands during the month of June, 1905.

The sand beaches and sand dunes are found typically developed along the south shore of the main island and in a few isolated places on the north shore, as at Shelly Bay. The largest sand beaches and sand dunes on the south shore are found in the vicinity of Tuckertown Bay, on the narrow strip of south shore between Harrington Sound and the ocean. The sand dunes along the south shore in the parish of Paget are also characteristic. The sand dunes, however, in the neighborhood of Tuckertown Bay are remarkable in that they have encroached on the rocky shore line and have invaded the natural arch which is one of the scenic wonders of the islands. The sand has drifted beneath the arch and has advanced so that it covers part of the top of the arch itself.

The vegetation of the beaches and dunes here and in the vicinage of the Devil's Hole is characteristically Bermudian, while the sand dunes in Paget have been colonized in part by plants introduced by man into the islands, such as the oleander, *Nerium oleander,* and a tall fennel, *Fœniculum vulgare.* These beaches and dunes are formed of coral sand which represents the finely ground masses of coral and coralline (calcareous) sea-weeds which have grown on the fringing coral reefs. Bermuda, geologically speaking, is an atoll, a ring of coral reefs surrounding a central lagoon. The elevated land was formed by the raising of the weather edge of the reef above the level of the sea. The tops of the projecting corals were broken off and along with calcareous sea-weeds and mollusk shells were ground by surf action into a fine sand, which was formed into a beach. As the top of the beach dried in the sun, the sand was blown off and was deposited in the crevices of the coral breakwater, which gradually widened. Ultimately, by wind action, sand hills were formed. The limestone rock found throughout the islands was originally derived from broken-down coral and shells. These rocks vary in texture from loose sand to compact limestone. The process by which the coral sand was converted into limestone was very simple and it involved no great lapse of time. As the sand consists almost entirely of calcium carbonate, it was easily soluble in water containing carbon dioxide. The rain water took up a little of the calcium carbonate in the form of bicarbonate, and as it percolated through the sand, it lost its carbonic acid gas and evaporating left the dissolved calcium carbonate as a thin layer of cement uniting together the grains of sand. The rocks remain permeable to water and soluble, so that this process of solution and deposition goes on constantly until even a marble-like limestone may result. The usual building material consists of blocks of limestone sawed out of the hillside. When built as a wall sufficient solution takes place so that the stones become united together into an almost solid piece. The red soils of the islands represent the one per cent. residue of solid material after the rain has leached out all of the other constituents. When the solution, owing to wave action or constant rain action, is excessive, caverns with stalactites and sinks are formed. The honey-combed eolian rock of the shore line on which characteristic Bermuda plants occur owed its origin to similar water erosion. The sand dunes thus represent stages intermediate in the geologic changes which have combined to give the present form to the islands. They represent shifting masses of coral sand, forming flat surfaces in some places, in other places heaped into conical dunes or raised into long ridges. Frequently dune hollows exist as a result of wind action in scooping out the sand. These dunes form the setting upon which the typical sand strand plants are distributed.

PLANT DISTRIBUTION.—The upper beach at the foot of the dunes is characterized by the presence of *Cakile æqualis,* which shows a more decided branching habit than the closely related species on the coasts of the American continent, *Cakile maritima.* Besides this plant, the botanist sees clumps of *Tournefortia gnaphalodes, Scævola Plumieri* and *Croton maritimus.* The shrubs, however, grow most luxuriantly on the slopes and summits of the dunes. *Ipomæa pes-capræ,* as elsewhere in the tropics (Mexico, the West Indies), is a typical plant of the upper beach; in fact, the upper beach is characterized by its presence, with its long runners growing down from the slopes of the dunes out upon the flat, sandy beaches. On the dune slopes in Bermuda it is associated with *Scævola Plumieri* and the crab grass, *Stenotaphrum americanum.*

Back of the dune crests are found *Tournefortia gnaphalodes, Ipomæa pes-capræ, Scævola Plumieri, Juniperus bermudiana* (wind-swept forms), *Sisyrinchium bermudianum, Lepidium virginicum, Euphorbia buxifolia* (a prostrate plant growing in rosettes), *Canavalia obtusifolia* (a leguminous vine) and the prickly pear cactus, *Opuntia vulgaris.* On the dunes at Tuckertown, where the sand covers the entrance to the natural arch, *Scævola Plumieri* forms extensive clumps in pure association. *Solidago sempervirens,* as in the eastern United States, is also a dune plant, together with the smooth and hairy forms of *Borrichia arborescens, Dodonæa viscosa,* a small tree with its varnished leaves, is also a tenant of the dunes. The most interesting dune plant is *Conocarpus erectus,* which is a typical mangrove tree growing with its roots affected by salt water. In Bermuda, however, it occurs perhaps more frequently on the dry upper slopes of the dunes. In one place on the south shore, it covers nearly a quarter of an acre. The crab grass, *Stenotaphrum americanum* forms close mats on the lee side of the dunes.

The high dunes on the south shore of the parish of Paget have been invaded by a number of exotic plants, introduced by man into the islands, such as *Nerium oleander, Lantana camara, L. crocea,* while *Croton maritimus, Canavalia obtusifolia, Dodonæa viscosa, Borrichia arborescens* and *Passiflora suberosa* are among the most abundant native plants. *Yucca aloifolia* forms clumps on low sand dunes at Shelly Bay, on the north shore, associated with *Ipomœa pes-capræ, Tournefortia gnaphalodes* and *Opuntia* sp.

ECOLOGIC FACTORS.—The ecologic factors, which have influenced the distribution of the typical sand strand plants of Bermuda, must be referred to briefly. As the plants of the Bermuda sand beaches and sand dunes in general show xerophytic adaptations, we must look upon these adaptive arrangements as a response to the environment. The following environmental factors must be considered as influential in producing the xerophytic structures which the leaves of the Bermuda beach and dune plants especially show:

1. The intense illumination from above is an important ecologic factor.

2. The reflection of light from the white coral sand and the foam-crested breakers beyond is important.

3. The action of the strong winds that blow across the islands must be considered as modifying plant structure.

4. The action of the salt spray blown inland by the wind is marked in the case of some plants.

5. The permeability of the sand to water, so that after a rain the surface layers quickly dry out, has its influence.

The most potent factor in the modification of leaf structure has been undoubtedly the bright illumination from above and below (by reflection) and the physiologically dry condition of the soil.

STRUCTURAL ADAPTATIONS.—The leaf adaptations to light are found in the increased number of palisade layers, their presence on the upper and under sides of the leaves, and their arrangement, so that the central part of the leaf becomes palisade tissue throughout, a typical staurophyll. The depression of the stomata below the surface, as in *Sisyrinchium bermudianum,* the distribution of the stomata in pits, as in *Nerium oleander* and *Lantana involucrata,* the development of hairs as in *Tournefortia gnaphalodes,* the varnished leaves of *Dodonæa viscosa* and thick epidermal layers and cuticle are all arrangements to reduce transpiration. The succulency of the leaves of some of the dune plants is developed perhaps for water storage and the presence of latex should be mentioned as a means by which a dune plant is protected against the untoward influences of its environment.

Light has been most marked in influencing the development of leaf structure displayed by the typical sand dune plants of Bermuda. The stimuli of light have called forth functional responses which have produced changes in form or structure of the leaves, or in both. The chlorenchyma, composed of chloroplast-bearing cells, is converted into two kinds of tissues, palisade and spongy parenchyma, as a direct result of the unequal illumination of the leaf surfaces. Palisade tissue is formed as a response to light, or to low water content, or to both. When both leaf surfaces are equally illuminated, the leaf may be termed isophotic, when unequally illuminated diphotic. Diphotic leaves which are unequally illuminated show a division into palisade and spongy parenchyma, and such leaves are called by Clements[1] diphotophylls. Isophotic leaves, equally illuminated on both surfaces have a more or less uniform chlorenchyma. Clements divides such leaves into three types: (1) The palisade leaf, or staurophyll in which the palisade tissue extends from the lower to the upper epidermis. (2) The diplophyll, or double leaf, where the intense light does not penetrate to the middle of the leaf. In consequence, the upper and lower palisade layers are separated by a central loose parenchyma, which is for water storage. (3) The spongophyll, in which the rounded, loose parenchyma cells fill the leaf without palisade tissue. The influence of the light and other environmental conditions on leaf structure is perhaps best shown in the thin and thick leaves of *Conocarpus erectus* produced on different parts of the same tree differently related to the incident rays of light. A detailed description of these structures for each plant will be given at the end of the paper. The following is a classification of different leaf structures and the plants which illustrate such adaptive arrangements:

Thick Cuticle.—*Nerium oleander, Conocarpus erectus* (thin leaf), *Scævola Plumieri.*

Thick Epidermis.—*Canavalia obtusifolia, Dodonæa viscosa, Sisyrinchium bermudianum, Stenotaphrum americanum, Ipomœa pes-*

[1] Clements, F. E., "Research Methods in Ecology," 138–145; "Plant Physiology and Ecology," 171–184.

capræ, Cakile æqualis, Borrichia arborescens (smooth leaf), *Croton maritimus.*

Two or Three Epidermal Layers.—*Euphorbia buxifolia, Nerium oleander, Conocarpus erectus* (thick leaf), *Croton maritimus, Tournefortia gnaphalodes.*

Two or More Rows of Palisade Cells.—*Passiflora suberosa, Dodonæa viscosa, Nerium oleander, Sesuvium portulacastrum, Cakile æqualis, Conocarpus erectus* (thin leaf and thick leaf), *Scævola Plumieri, Borrichia arborescens* (smooth and hairy leaves).

Stomata Depressed.—*Sisyrinchium bermudianum Heliotropium curassavicum, Sesuvium portulacastrum, Ipomæa pes-capræ, Cakile æqualis, Conocarpus erectus* (thick leaf), *Scævola Plumieri, Borrichia arborescens* (smooth leaf).

Stomata in Pits.—*Lantana involucrata, Nerium oleander.*

Succulent Leaf.—*Sesuvium portulacastrum, Cakile æqualis, Conocarpus erectus* (thick leaf), *Scævola Plumieri, Borrichia arborescens* (smooth leaf).

Hairy Leaf.—*Lantana involucrata, Nerium oleander, Borrichia arborescens* (hairy leaf), *Croton maritimus, Tournefortia gnaphalodes.*

Varnished Leaf.—*Dodonæa viscosa.*

Leaf Becoming Erect in Sun Position.—*Canavalia obtusifolia, Sisyrinchium bermudianum, Stenotaphrum americanum, Ipomæa pes-capræ.*

Overlapping Leaves.—*Euphorbia buxifolia, Sisyrinchium bermudianum, Stenotaphrum americanum.*

Latex Tissue.—*Euphorbia buxifolia.*

Gum-Resin.—*Conocarpus erectus.*

Crystals.—*Passiflora suberosa, Croton maritimus.*

Diphotophyll.—*Passiflora suberosa, Canavalia obtusifolia, Euphorbia buxifolia, Lantana involucrata, Nerium oleander* = 5.

Diplophyll.—*Dodonæa viscosa, Sesuvium portulacastrum, Ipomæa pes-capræ, Cakile æqualis, Conocarpus erectus* (thin leaf), *Scævola Plumieri,*[2] *Borrichia arborescens* (smooth and hairy leaves), *Croton maritimus, Tournefortia gnaphalodes* = 9.

[2] *Scævola Plumieri* and *Tournefortia gnaphalodes* are given twice, because it is difficult to decide whether their leaves are diplophyll, or staurophyll.

Staurophyll.—*Heliotropium curassavicum*, *Conocarpus erectus* (thick leaf), *Scævola Plumieri, Tournefortia gnaphalodes*[2] = 4.

Spongophyll.—*Sisyrinchium bermudianum, Stenotaphrum americanum* = 2. With reference to the last two plants, it should be mentioned that the leaves of these plants stand erect, thus receiving the incident rays of light on the edge of the leaf, hence the absence of palisade tissue and the presence of spongophyll structure.

DETAILED STRUCTURE OF LEAVES.—The sections of the leaves which were studied were made free-hand with a razor. After staining, the sections were mounted for permanency in Canada balsam. The drawings of these sections were made by the use of the micro-projection, electric lantern, so that in every case with the exception of *Croton maritimus,* the drawings were made on the same scale. The sketches of stomata are none of them drawn to the same scale. The description of the histologic structure of the leaves of each species follows.

Passiflora suberosa is a small, slender species of the genus found growing over the sand surface of the dunes in the parish of Paget. Its flowers are small and the branch tendrils are characteristically developed. Histologically the leaf presents an upper epidermis of large thin-walled cells, and as the whole plant is brilliantly illuminated, it has two well-marked layers of palisade cells. The loose parenchyma is narrow and some of the cells of it are filled with conglomerate crystals. The stomata are slightly raised above the general epidermal surface, and are confined to the lower side of the leaf. A diphotophyll (Fig. 1, Plate II.).

Canavalia obtusifolia, a trailing leguminous plant, has paripinnate compound leaves with a long petiole and broadly elliptical leaflets with retuse apices and petiolules, a quarter of an inch long. The upper epidermis consists of slightly thickened cells. There are two rows of palisade cells, a considerable amount of loose parenchyma, while the slightly raised stomata are found on the upper and under sides. The adaptation to the environment of the sand dunes seems to be the folding together of the two sides of the leaves along the midrib, so that the edges of the leaves are presented to the incident rays of light. A diphotophyll (Fig. 2, Plate II.).

Euphorbia buxifolia is a prostrate, tufted plant of a rosette habit.

The taproot is large and strong and from it numerous branches, six to eight inches long, are formed. The leaves are opposite, small, ovate, with an acute apex and barely petiolate. The upper epidermis consists of two rows of cells, the palisade is a single layer and the loose parenchyma is compact. The lower epidermal cells are papillate and latex is present. The adaptation to the environment is shown in the latex, the two-layered upper epidermis and the overlapping arrangement of the leaves. A diphotophyll (Fig. 3, Plate II.).

Dodonæa viscosa.—This small sapindaceous tree occurs on the inner edges of the sand dunes. Its leaves are alternate, spatulate with the base narrowed to the point of attachment. The leaves are varnished. The upper epidermal cells are thick and provided with peltate hairs. The palisade cells are disposed in two layers. The loose parenchyma is open, while next to the lower epidermis there is a row of small cells which may be considered as a lower palisade layer. Hence the leaf is a potential diplophyll. The stomata of the upper side are slightly raised above the surface, while those on the under side have developed a small projecting beak (Fig. 4, Plate II.).

Lantana involucrata is one of the plants that enters the formation of the Bermuda scrub. It also invades the dunes. The leaves are hairy on both surfaces. A section of a leaf shows that the upper epidermis is without stomata, but is provided with straight, multicellular and capitate, unicellular hairs. The lower surface shows depressions provided with the capitate hairs, while the raised portions of the leaf surface between the depressions is covered with both straight, muticellular and capitate, unicellular hairs. The palisade is a single layer. The stomata project outward beyond the general surface of the lower epidermis, but they always occur in the depressions. The depressions provided with hairs and stomata and thick, hairy upper epidermal surface are structures which fit the plant to exist on the hot, sun-exposed sand dunes of the islands. A diphotophyll (Fig. 5, Plate II.).

Nerium oleander.—The leaf structure of the oleander, a native of the Mediterranean flora, is well known. The upper epidermis is in three layers with thick cuticle, the paliside tissue in two layers, while the under surface of the leaf is pitted, the pits being filled with straight hairs that form an air-still chamber into which the projecting stomata open. The lower epidermis is two- to three-layered, and the whole leaf is decidedly tough and leathery, and thus well adapted to growing on the sand dunes of Bermuda. A diphotophyll (Fig. 6, Plate II.).

Sisyrinchium bermudianum.—The Bermuda blue-eyed grass is provided with leaves that stand more or less upright, so that the incident rays of light strike the edges of the leaves. The epidermal cells on both the upper and lower morphologic sides of the leaf are thick-walled and the stomata present on both surfaces are depressed the entire width of the epidermal cells. There is no palisade tissue, the loose parenchyma filling the center of the leaf between epidermal surfaces. The vertical leaves are, therefore, isophotic and the leaf is known as a spongophyll. The vertical leaves, the thick epidermal cells and the depressed stomata fit the plant to its environment. A spongophyll (Fig. 7, Plate II.).

Stenotaphrum americanum. The Bermuda crab grass is a tough, wiry one, well fitted to survive in the driest places on sand dunes and rock faces. The leaf blades arise from sheaths that, together with other overlapping leaf sheaths, form a tuft that arises from the nodal regions of the wiry, prostrate, creeping stem. The blades are more or less erect and folded partially lengthwise, with the upper side innermost. The spike of closely set flowers is slightly bent, suggesting a crab's claw. The upper epidermis consists of large, open papillate cells. The loose parenchyma fills the leaf section and the under surface of the leaf has a thick epidermis with numerous stomata, provided with small guard cells reënforced by two secondary cells. The bundles are toward the upper side. The vertical isophotic leaf consequently becomes a spongophyll. The adaptations to the environment are upright, rolled leaves, thick lower epidermis and overlapping, tufted leaf sheaths (Fig. 8, Plate II.).

Heliotropium curassavicum resembles in its unilateral cymose inflorescence the common heliotrope. It is a slightly woody plant that grows about a foot or two tall, with alternate, narrow, oblanceolate leaves. The cells of both the lower and upper epidermis are thin-walled, with slightly sunken stomata on both sides. The chlorophyll bearing cells of the leaf (the chlorenchyma) are arranged so that their long axes are placed in a line with the incident rays of light that strike the upper surface from above and the lower surface by reflection from the sand below. A staurophyll (Fig. 9, Plate II.).

Sesuvium portulacastrum.—The leaf structure of this member of the family Aizoaceæ is that of a typical diplophyll, but with a slight indication of the staurophyll arrangement of the cells. The stomata present on both sides of the leaf are slightly sunken and the guard cells incline inward and downwards. The upper and lower palisade tissues show four to five layers of cells. The leaves are thick and succulent. A diplophyll (Fig. 10, Plate II.).

Ipomœa pes-capræ.—This tropical, seaside morning glory is a typical plant of the sandy beaches in Mexico, the West Indies and Bermuda. It grows down off the dune slopes onto the beach sand as a creeping plant, a distance of twenty to thirty feet (Fig. 1, Plate I.). The leaves are alternate, elliptical, retuse at the apex and frequently when the sun is hot and the reflection from the sand intense, the leaves fold together along the midrib and stand vertically so as to receive the incident rays of light on the upturned edges of the leaves. The walls of the epidermal cells on both sides of the leaf are thick. The stomata on both sides are sunken about half the thickness of the epidermal cells and the palisade tissue is prominent on both sides, constricting the loose parenchyma to a narrow layer. The leaf is, therefore, a true diplophyll (Fig. 11, Plate III.).

Cakile æqualis.—This cruciferous plant grows on open, sandy beaches in a more or less scattered manner. It branches in a much more open way than *C. maritima,* found in similar habitats on the sandy beaches of the eastern United States. The leaves are fleshy and the walls of the upper and lower epidermal cells are thickened. The stomata, which are partly sunken, are found on both the upper and the lower leaf surfaces. The palisade tissue on both sides is five layers of cells thick and the loose parenchyma is restricted to a narrow layer four cells thick in the central part of the leaf. This plant is fitted to its environment by the possession of succulent leaves, epidermal cells with thick walls, and many-layered palisade tissue. A diplophyll (Fig. 12, Plate III.). Contrast the leaf section of *Cakile maritima* (Fig. 12 *A*, Plate III.).

Conocarpus erectus.—The leaves of this small tree, which is a true mangrove plant, but which has adapted itself to growth on the sand dunes in Bermuda, are thin and thick. The thin leaves are found on the branches that are placed above the surface of the sand, or in more or less protected positions, while the thick, succulent leaves occur near the surface of the sand, or in exposed, unshaded positions. There is a considerable difference in the anatomical structure. The cuticle in the thin leaf is thickened and the stomata on both sides are hardly if any sunken below the surface. The upper leaf surface shows long palisade cells, while the palisade cells of the lower side are shorter. The loose parenchyma cells form a broad band in the center of the section. A diplophyll (Fig. 13, Plate III.). The thick, succulent leaf has three rows of epidermal cells and three rows of palisade cells, the cavities of which are filled with a gummy, resinous material (not tested) of a brown color. This gummy material is found in the lower palisade as well as in the upper palisade in both the thin and thick leaves and also in some of the loose parenchyma cells of the thick leaf. The stomata in the thick leaves, by the increase in the thickness of the cuticle, are sunken below the surface with an hour-glass atrium or passage outside of the thick-walled guard cells. The parenchyma cells of the leaf center are arranged in the direction of the palisade cells. A typical staurophyll (Fig. 13 *A*, Plate III.).

Scævola Plumieri.—This plant belongs to the family Goodeniaceæ and forms dense clumps on the dune slopes (Fig. 2, Plate I.). Its leaves are alternate, elliptical, short petiolate and obtuse. They are noted for their succulency. The epidermal cells on the upper surface have a thick cuticle with numerous thick walled, sunken stomata. The epidermal cells on the lower surface are of the same thickness as on the upper surface, the stomata being likewise sunken. The palisade cells on the upper and lower sides consist in each of three or four rows of cells, while the loose parenchyma is arranged parallel to the palisade tissue. Only a single row of central cells are not so disposed. The leaf shows, therefore, partly a staurophyll and partly a diplophyll arrangement of cell (Fig. 14, Plate III.).

Borrichia arborescens.—This species of the family Compositæ exists in two distinct forms, if they are not good species. One form has smooth, thick, succulent leaves, the other has thinner, densely tomentose leaves, the *Borrichia frutescens* of the Southern States. The succulent, smooth-leaved form has both thick upper and lower epidermal cells, with the stomata on both sides, but more plentiful on the lower side. The stomata are partly sunken. The palisade layers on both sides are wide, but are broken into more or less extended patches by round parenchyma cells, which reach to the epidermis. The loose parenchyma cells form a wide central area. A diplophyll (Fig. 15, Plate III.). What the thin leaf lacks in succulency, it gains in hairiness. Both sides are densely covered with straight unicellular hairs. The palisade layers are only two in number on both sides of the leaf, and the loose parenchyma is also much reduced in amount. The succulency of the thick leaf fits it as perfectly as the hairiness of the thin leaf to the trying seaside environment, where the plants producing them grow side by side. A diplophyll (Fig. 15 *A*, Plate III.).

Croton maritimus.—The leaves of this plant studied by Kearney[8] are bifacial, both surfaces densely covered with gray scale-like pubescence, owing to presence of multicellular, stalked, stellate hairs that cover them. The upper and lower epidermal cells have thick walls and the stomata are not sunken. The palisade tissue in both the upper and the lower sides are two cell layers in width with a few sclerotic idioblasts. The leaf in the plant grown in the United States, as depicted by Kearney, has only one row of palisade cells. Large conglomerate crystals of calcium oxalate are found in the cells of the loose parenchyma. Glandular capitate hairs are found on both leaf surfaces. A diplophyll (Fig. 16, Plate III.).

Tournefortia gnaphalodes.—The leaves and stems of this plant, as well as the calices of the flowers, are covered with a dense, closely appressed, grayish tomentum, resembling that on our common *Antennaria plantaginifolia* and edelweiss, *Leontopodium alpinum*. In section the hairs are unicellular, straight and of epidermal origin. The palisade is formed on the upper and lower leaf surfaces and is two cells thick. The loose parenchyma, occupying the center of the leaf, suggests an arrangement in direction parallel to the long axis

[8] Kearney, Thomas H. "Plants of Ocracoke Island," Contributions from the United States National Herbarium V: 296.

of the palisade cells. Therefore it is a diplophyll (Fig. 17, Plate III.).

BIBLIOGRAPHY.—Little has been published on the structure of the dune plants of tropical America. The following papers are in part a contribution to our knowledge of the microscopic structure of the strand plants of the American tropics. A few of the sand dune plants are of cosmopolitan distribution and they are, therefore, described as to their morphology in the classic work of A. F. W. Schimper, "Die indo-malayische Strandflora," published as the third volume of "Botanische Mittheilungen aus den Tropen" in 1891. Thomas Kearney in 1900 published in the Contributions from the U. S. National Herbarium (V., No. 5) an important paper on "The Plant Covering of Ocracoke Island; A Study in the Ecology of the North Carolina Strand Vegetation." A chapter is devoted to the histological structure of the plants. The only plants which concern us are *Yucca aloifolia, Croton maritimus, Borrichia frutescens,* which are common also to the Bermuda strand. F. Boergesen and Ové Paulsen make a contribution to "La Vegetation des Antilles Danoises" in Revue Générale de Botanique (Tome XII., 1900), in which they discuss with figures the microscopic structure of a few of the typical strand plants. As throwing considerable light on the problems concerned in this paper on the Bermuda strand flora reference should be made to these works of general import to the botanical questions involved.

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ILLUSTRATIONS.—The reproduced photographs (Figs. 1 and 2, Plate I.) represent the dune vegetation on the south shore of Bermuda. The upper illustration shows the thicket of composite vegetation on the crest of the dune and the long, trailing stems of *Ipomœa pes-carpæ* on the upper beach with a small clump of *Cakile æqualis* to the left in the foreground. The second illustration depicts a clump of *Scævola Plumieri*, with the Bermuda cedar, *Juniperus bermudiana*, and in the background the grayish-green bushes of *Tournefortia gnaphalodes*. Reference is made to the drawings of microscopic structure in the classified description of dune plants throughout the paper.

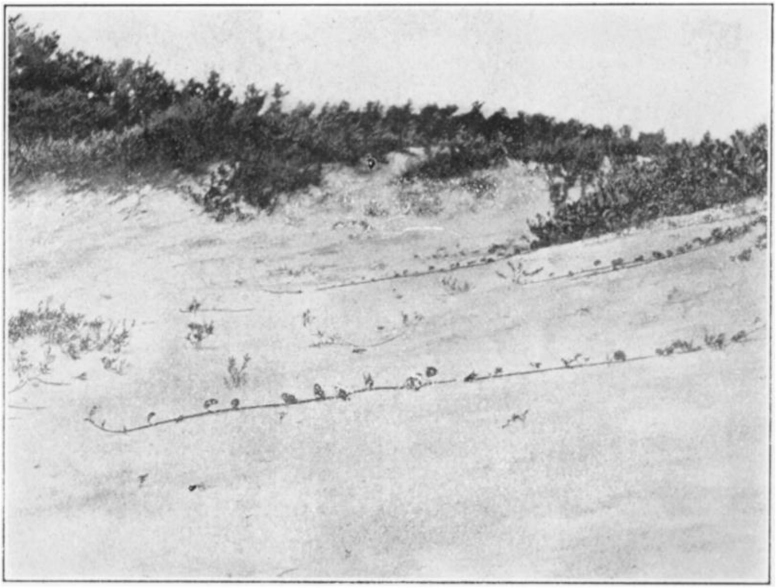


FIG. 1.

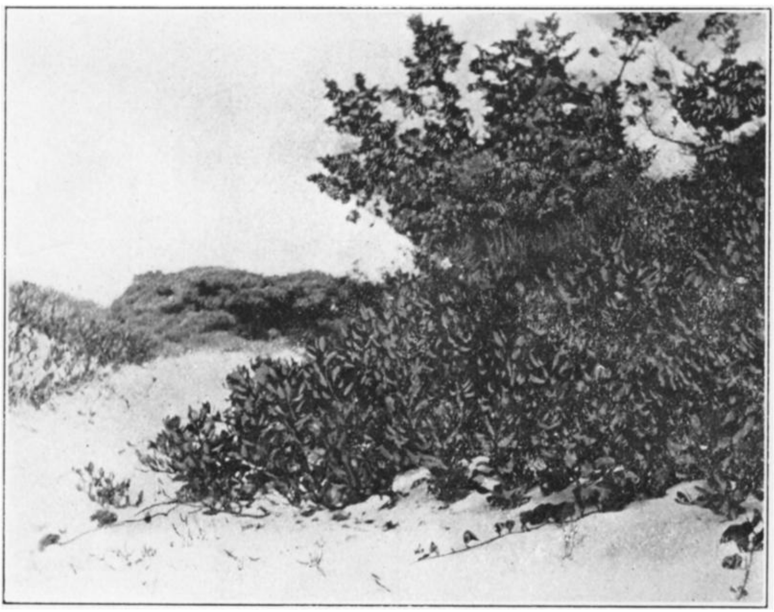
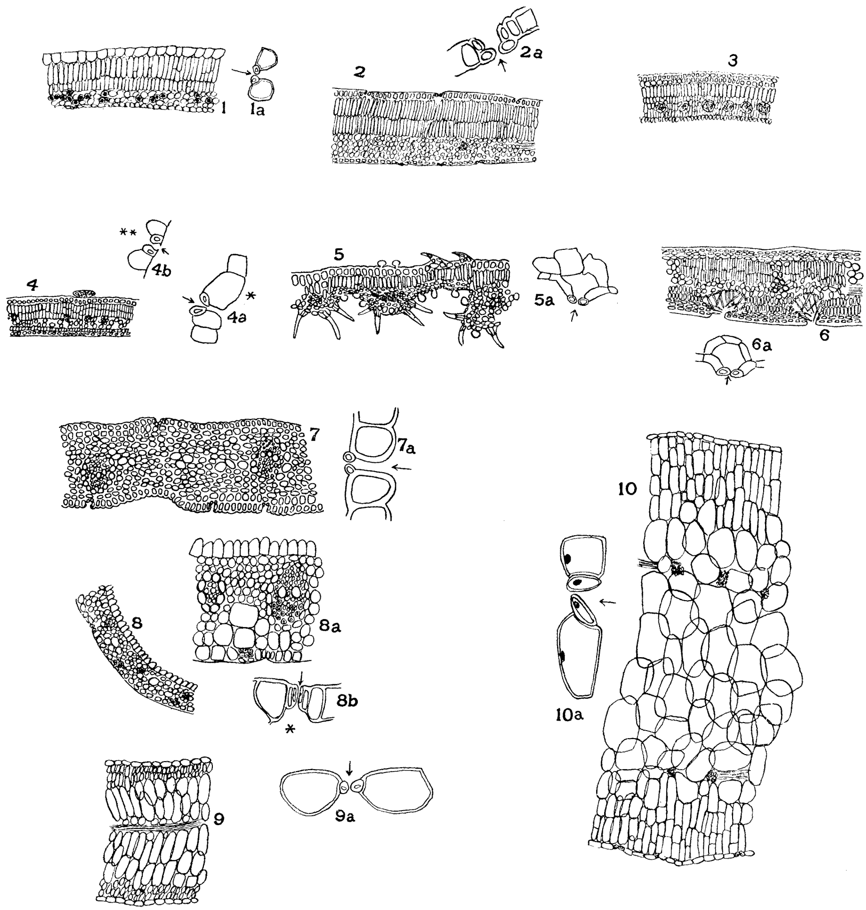


FIG. 2.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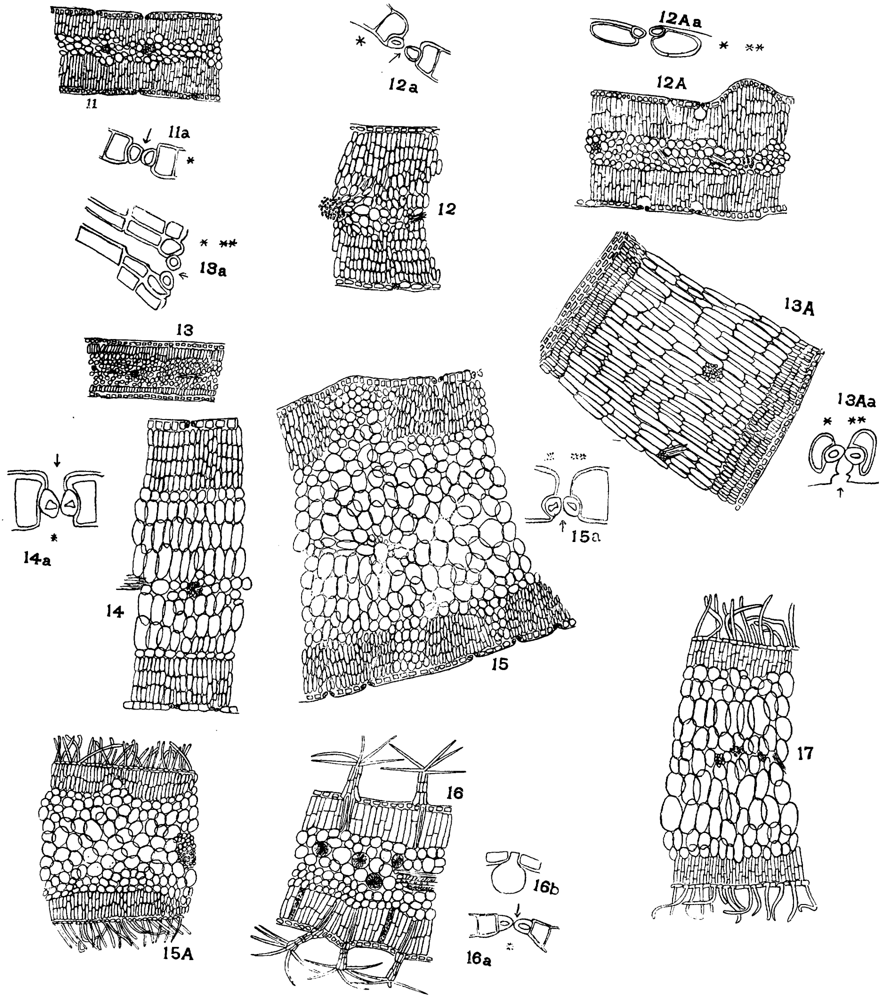
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