AN ECOLOGICAL AND SYSTEMATIC ACCOUNT OF THE CAULERPAS

OF THE DANISH WEST INDIES

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INTRODUCTION.

This treatise is based upon material collected during my three visits to the Danish West Indies in 1892, 1895—96 and now most recently in 1905—06. During my stay there I have myself collected a rather large material of algæ, and further from Mr. O. HANSEN at St. Croix I have received several collections of algæ, among them Caulerpas, for which I here bring him my best thanks. Likewise, Dr. TH. MORTENSEN who together with me visited the islands in 1905—06 has given me several collections of algæ from his dredgings, for which I am much indebted to him.

For the determination of my material of *Caulerpa* I have naturally first of all consulted the collections of the Botanical Museum, Copenhagen. Likewise during repeated visits to Lund I have been able by the kindness of Professor O. NORDSTEDT to use the Herbarium of AGARDH. Further I have had the collection of the Botanical Museum in Hamburg on loan. And finally Mme. WEBER VAN BOSSE has had the great kindness to lend me from her large *Caulerpa*-collections material of the comprehensive species *Caulerpa racemosa* and *C. cupressoides* and a few other species.

The figures are for the most part drawn by Mr. mag. sc. OVE ROSTRUP under my inspection. Miss KAREN BOYE has drawn the figures 23, 29 and 30 and I have myself drawn the figures 1, 3, 4, 27.

I. General Part.

Notes on the external conditions under which the Caulerpas live in Danish West India.

Before mentioning in more detail the ecology and classification of the Caulerpas, it seems to me advisable to give a short survey of the conditions of life in the localities where we meet with these forms.

It may at once be said that the much exposed shores which, not being sheltered by off-lying rocky islands or coral-reefs, are open to the whole power of the sea, can be left out of all consideration, as I have never met with Caulerpas at these places. This agrees also with the observations of SVEDELIUS in Ceylon, who did not find Caulerpas growing in the most exposed localities. Out in the open sea it is only in deeper water that we find the Caulerpas.

To facilitate the survey I believe that we can distinguish three types of localities which, however different they are mutually, are naturally united imperceptibly to each other. To these can be given the following delimitations: the somewhat exposed localities, the sheltered localities and the deeper water.

As to the more exposed localities where Caulerpas are to be found, these commonly consist of stretches with shallow water behind the coral-reefs which shelter them. The force of the sea is always broken by the reef which reaches nearly to the surface, but nevertheless the waves commonly wash over the reef and continue their motion, but weakly, towards the shore itself. On the open side, where the sea breaks, we do not find any *Caulerpa*; these occur only at some distance from the surf. Where on the other hand some shelter occurs, e. g. forelying islands, we can also find a few *Caulerpa*-species on the exposed side of the reef and they can likewise grow along the shores of the more or less reef-broken parts of the sea where a considerable surf can occur, at least in the larger bays e. g. on the south coast of St. Croix, where the reef often lies at a considerable distance from the shore. Thus, as the waves when they break on the reef partly wash over it, the water is constantly renewed in the basin behind the reef and an outrunning current is therefore always to be found at the places where the reef is low. This renewing of the water has also importance from the fact that the tide is wanting or in every case is of no practical significance in the Danish

West Indies, and the change in the volume of water caused by the tide does not therefore take place. With higher seas the waves naturally wash in higher degree over the reef, and the algæ, which grow behind it, are naturally exposed to a rather strong motion. The bottom, which is commonly rather fast, consists of dazzling white coral-sand often mixed with larger or smaller pieces of coral; also stationary rocks or coral-reefs are to be found; the Caulerpas occur on sand bottom as well as on the rocks and corals. When the Caulerpas grow on the corals I think the latter are always dead; on living corals Caulerpas or other algæ most probably do not occur, though one would think that where the corals live luxuriantly the algæ would also grow well there. The corals occur especially on more exposed localities, where we have some current and the renewal of the water is thus constant; even if some localities are perhaps too exposed for the Caulerpas other algæ might be able to grow there, but they are also commonly wanting. SVEDELIUS has also mentioned this fact (29, pag. 192—3); but at the same time he points out, that the Caulerpas among the algæ are just the most suited to live there and that they are also able to live betveen living corals. But as far I have seen in the West Indies it is only on dead corals that the Caulerpas grow; how far the Caulerpas may be able to fix themselves on living corals I consider as rather doubtful, and just the fact that at places where the corals grow especially luxuriant and quite occupy the bottom we do not find any Caulerpas or other algæ speaks against it; it is most probably only in localities less favourable for the corals, where dead corals also occur, that the Caulerpas are able to introduce themselves. In this connection I may also mention that certain *Corallinaceæ* seem to me to be pioneers in just as high degree as the Caulerpas with regard to getting foothold among the corals.

The water being steadily renewed is clean and quite clear and the light is therefore strongly reflected when it further meets the whitish bottom. Yet I need only point out that the water in the smaller basins can naturally be heated up somewhat by the sun, but commonly the renewal of the water is so great that this has only less importance.

The algæ which occur here in these localities are thus exposed to some surf and intense sunlight; the water is clear and fresh and the substratum sand bottom, rocks and coral-reefs.

Going now from these localities to the more sheltered, such as we find e. g. in the bays and lagoons, we meet with quite different conditions of life. Here is, firstly, complete shelter; the water can only seldom be in movement worth mentioning as the entrances to these places are commonly sheltered by off lying coral-reefs or sand-banks or what is the most common, the vegetation of the mangroves has gradually pushed from the shores into the shallow water and nearly closed the entrance to the lagoon, so that there is only connection with the sea through a narrow passage. The water in the lagoon is therefore only renewed to a small extent; it is commonly very unclear, filled up with quite small mud particles and

that often to such a degree that it is impossible to see the bottom even in quite shallow water. The bottom is soft and consists of grayish mud mixed more or less with sand. By reason of the muddy water the light is moderate and the mangroves also, where they occur, cast a rather strong shadow, which is of special importance for the Caulerpas growing on the roots. Finally it must be pointed out that the water after heavy rains may become very brackish.

The conditions of life which the algæ meet with here are therefore, firstly shelter, further moderate light, slight renewal of the water which probably is often very brackish; finally an often very soft bottom.

In spite of these, one would think anything but favourable, conditions of life we find in the lagoons an often very rich alga-vegetation covering quite densely the soft bottom. *Penicillus capitatus* is especially caracteristic for these localities but among them creep several *Caulerpa*-species often in great number (cfr. BÖRGESEN 7, p. 4 and 5, p. 51—54).

Finally, we find the Caulerpas in deeper water out in the more open sea. The conditions of life which are offered the algæ here are, firstly, quiet at least from the movement of the sea owing to the greater depth; on the other hand a relatively strong current may probably often occur here and the water is therefore constantly renewed; further, the light is moderate; compared with those in shallow water the conditions of life, e. g. the temperature, salinity etc. in deeper water, may on the whole be characterized as very uniform.

Naturally these mutually so different localities are, as I have already pointed out, connected by imperceptible transitions. The sheltering coral-reef need only be a little higher for example, so that the waves more rarely wash over it, and the water behind will then only more seldom be renewed, the bottom will be softer, the finer particles being able to precipitate, and we thus get an imperceptible transition to the stagnant water in the lagoon, quite in the same way as we have from shallow water an imperceptible transition to the deeper. I have chosen these different types of localities, not only because it seems to me that these can be considered as the chief types about which the others can be arranged, but also because we just here find characteristic forms of the algæ.

In these different localities we now find the Caulerpas, which is in good accordance with what SVEDELIUS has observed in Ceylon and quite in contradiction to the view of REINKE (27) concerning the occurrence of the Caulerpas (about which more later on).

When SVEDELIUS (30, pag. 82) however writes: "Concerning the ecology of the Caulerpas, there are in the botanical literature very few, indeed practically no reports" I can, however, not quite agree with him, even if it is quite true for the most part that we only find but little. I shall not here mention in more detail my little preliminary paper (5) on the algal vegetation in the Danish West Indies which has hitherto been unnoticed[1]) but in which, however, somewhat is said

[1]) e. g. also in OLTMANN's Morphologie und Biologie der Algen.

about the ecology of the algæ on the whole and also about the conditions under which the Caulerpas live in the West Indies. I shall here only point out some of the papers (several of them for the rest also mentioned by SVEDELIUS), where we find information as to the occurrence of the Caulerpas, sufficient in any case to show that these algæ do not at all live under quite uniform external conditions. In the works of HARVEY (15, 16), for example, we find under several species indications of the mode of living of the species. The same must be said about the paper of MAZÉ and SCHRAMM (22) where we find under every species of *Caulerpa* even fairly detailed indications concerning the occurrence of the species, e. g. in what substratum it is found, if it was growing in sheltered or exposed localities, in what depth it occurred (a single species has been dredged in 50 meters depth), if the water was clear or not etc. And as to the ecology of *Caulerpa prolifera* this species has been treated so many times in different papers of different authors that it must be said to be well-known.

We have information from recent years also, e. g. in REINBOLD's paper (26) on the algæ collected by JOHS. SCHMIDT in Siam; in Mlle. VICKERS' papers (36, 37) on the algæ from the Canary Islands and from Barbadoes, in COLLINS' paper on the algæ of Jamaica and in several others.

The rhizome and root of the Caulerpas and their variations under different external conditions.

In my preliminary notice on the algal vegetation of the Danish West Indies (5) I have pointed out that we find algæ and among them Caulerpas on rocky and coral bottom, on loose bottom, gravel sand and mud bottom and finally on the mangrove roots. That algæ are found on rocks etc. is very natural; most algæ at least in the northern seas being, as is well known, lithophile; epiphytic algæ are also what we should expect. On the other hand sand and mud loving algæ are very peculiar the first time one sees them [1]).

[1]) I may here reprint what I have said earlier about this matter. On page 52 in my preliminary paper I write the following: "Here on this loose sandbottom a rich alga-vegetation is growing, not rich in species, it is true, but on the other hand rich in individuals. We here find a group of algæ which are adapted to establishing themselves and growing on the loose bottom (psammophile and pelophile algæ) to which we have no counterpart in the northern seas. To be sure, the localities where these algæ grow are rather protected against the open sea by the coralreefs or by being situated in bays, and we therefore can not compare them with the sandy, sterile west coast of Jutland f. i. where the sandy bottom during gales is in a motion so lively, that even in a tropical climate we could not expect to find any vegetation at all; but even in more protected localities with sandy or muddy bottom in the North, fixed algae (the *Characeæ* excepted), as is well known, are entirely wanting, they occur at once, however, where a stone or some other firm object is found, to which they can attach themselves. This alga-vegetation established and growing in the loose bottom is peculiar for the warmer seas". I have further pointed out that the algæ we find here can be divided into two groups: The creeping algæ and the algæ fixed to the same spot. The last mentioned comprehend species of *Udotea*, *Penicillus* and *Halimeda* and have therefore no interest for us here whereas on the other hand the first group comprise the *Caulerpa*-species.

The question now arises if we also find in these very varied localities different types with regard to the development of the rhizome and roots and with regard to the mode of growth on the whole. SVEDELIUS for Ceylon has distinguished between 3 types, namely, the *Caulerpa verticillata* type, sand Caulerpas and rock and coral Caulerpas. This is in good accordance with the divisions I have given in my earlier paper. We have namely in the Danish West Indies the following groups: sand and mud Caulerpas, rock and coral-reef Caulerpas and finally the *Caulerpa verticillata* group which I prefer to call the epiphytic or mud-collecting Caulerpas.

(1) The epiphytic or mud-collecting Caulerpas. To this group belongs *Caulerpa verticillata*, which in the Danish West Indies is very common on the mangrove roots, as I already have pointed out in my paper (5, p. 55—56). As a thick dark-green sheath it covers the roots of the mangroves and if we try to draw it loose from these we commonly get a whole clump, which on the under side shows itself to consist of a dense tissue of the nearly thread-fine rhizomes which are woven together and between which quantities of fine mud and different organic particles are mixed together. If we try to separate the plant more without spending greater care on it, we commonly only obtain some tuft-like pieces without rhizomes such as we often find in herbaria, and is in accordance with REINKE's figure (27, pag. 7). REINKE indeed had the opinion that the plant probably had no rhizome. As I have mentioned (5, p. 56), and later on I shall come back to it in more detail, this is not right. By a careful preparation of one of the above-named dense tufts, one can commonly get somewhat easily such a plant as shown in figure 1.

As mentioned we find mud and organic objects packed in between the thread-like rhizomes and that often in considerable quantities. Even if we collect the plants in clear water and these apparently are quite clean and only touch the mangrove roots, the water directly becomes muddy from the mud present and we have commonly some work in clearing the plant before preparation.

In Ceylon SVEDELIUS did not find *Caulerpa verticillata* epiphytic but on the contrary growing on low rocks covered with mud and sand in the mouth of a stream. It was here growing in dense tufts collecting sand and mud between the rhizomes and that often to so great an extent, that there could be danger of over-sanding; but as pointed out by SVEDELIUS, the plant is by means of the oblique, even often vertically placed rhizomes soon able to grow out of the sand again; by reason of this capacity SVEDELIUS says that it "reminds us to some extent of many dune grasses". Only once have I found *C. verticillata* growing in a locality, I think, similar to those at Ceylon. In the harbour of St. Thomas on the northwest end of the Hurricane Island, in the narrow and shallow sound which lies between this Island and St. Thomas, I have found *C. verticillata* growing partly on an old bridge built of limestone and piles, partly also spreading itself from here somewhat on the stones etc. lying on the bottom itself. Likewise as on the mangrove roots it was filled with mud and organic material, but any danger of being oversanded is

scarcely present here. The locality is quite sheltered and the water for the most part quite clear as no stream is running out here from the land; only during heavy rainfalls the water mingled with mud and sand might naturally come down from the land. Out on the loose bottom itself I have not observed *C. verticillata* and as far as I can discern from the description of SVEDELIUS about its mode of life in Ceylon, I may suppose that it also keeps to a fast substratum there. That SVEDELIUS has not found it growing on the roots of the mangroves in Ceylon, I think is due to the fact that the tide there is rather strong, so that the roots of the mangroves are laid dry for a long time, a condition *Caulerpa verticillata* can not live under. SVEDELIUS also mentions expressly that it does not grow higher up than to the low water mark. That *Caulerpa verticillata* by means of this mud-collecting ability, which it has in common with the great part of the many richly ramified algæ we find on the mangrove roots, has no little importance in the accumulation of land in the lagoons, I need only just mention here.

(2) Sand and mud Caulerpas. On sand bottom often more or less mixed with mud, and on gravel bottom, we find several different species creeping on the loose bottom. In shallow water e. g., I have found *Caulerpa cupressoides* in several forms, *Caulerpa crassifolia, Caulerpa racemosa* var. *lætevirens, Caulerpa sertularioides* and *Caulerpa taxifolia*; in deeper water *Caulerpa Ashmeadi, Caulerpa prolifera, C. racemosa* var. *Lamourouxii* and different forms of *C. cupressoides*. By means of their usually vigorous rhizomes these species often grow far and wide over the loose and often soft bottom, and often form extensive growths sometimes of a single species sometimes also of mixed species. The rhizome is as mentioned vigorous, often with a pointed front end with which it can easily bore its way through the sand. The most characteristic sand *Caulerpa* is *C. cupressoides*, which especially reminds one of certain dune plants e. g. *Carex arenaria*, as I have pointed out in earlier papers (7, p. 4, 5, p. 54). With its nearly awl-shaped end of the rhizome it bores its way through the sand, and the often more than 1 meter long rhizomes, which are straight as a line and from which at short distances the erect assimilators grow up over the sand bottom, are in a sort of way like those in *Carex arenaria*.

From the rhizome at about the same distance from one another as the erect shoots, vigorous roots grow down in the sand; these roots are at first undivided but in a depth of about 2—3 cm. they divide up into numerous fine rhizoids to which sand and gravel are fastened, in such a way that one commonly when taking the plant up from the bottom, gets a whole clump of this material pasted together. Compare for example the figures 9, 12, 16, 17, 18. Quite the same way of fastening themselves is found also in other algæ e. g. *Penicillus, Halimeda* and *Udotea* growing in this loose bottom (5, p. 54); it must be said to be an excellent method of fixing the plant in the loose bottom, to knit the loose material together in such a way that it can replace a fixed substratum. As I have mentioned earlier

it is only in sheltered places, however, that we meet with these algæ; on more exposed places the bottom must be of a coarser consistency if the algæ are to be able to fix themselves. We find therefore these algæ in shallow water in sheltered localities and further in deeper water where the surf is not felt. SVEDELIUS has pointed out the same thing.

(3) Rock and coral-reef Caulerpas. It is especially forms of *Caulerpa racemosa* we find here, but several of the above-mentioned *Caulerpa*-species can also be met with on a firm substratum. They can be divided into two groups, namely, the forms which grow in exposed localities and those growing in sheltered ones.

The first group is represented by *Caulerpa racemosa* f. *reducta* which is found in the most exposed places where Caulerpas are upon the whole found. It is only in one locality that I have found it, namely, on the coral-reef to the west of Hurricane Island which connects this island with St. Thomas. The locality is not completely open to the ocean, in such quite exposed places we do not find any Caulerpas at all and when SVEDELIUS p. 87 writes that "*C. lætevirens* f. *laxa* is a pronounced, even though rare, example of a rock *Caulerpa* growing in strongly exposed localities where no other alga happens to occur" [1]), this is in no way in accordance with what is the case in the Danish West Indies, where indeed many algæ growing in much more exposed places are to be found. The locality at St. Thomas mentioned here is somewhat sheltered by a small forelying island but nevertheless the swell can run vigorously, especially through the sound east of Water Island, in such a way that the waves break steadily on the reef. In this we find the forma *reducta* growing in large patches, here and there mingled with other algæ e. g. *Cladophoropsis membranacea*, *Dictyosphæria favulosa*, Valonias etc., all species of algæ which form firm patches on which the sea breaks. If we consider a piece of the *Caulerpa*-patches, we find that it consists of a great quantity of rhizomes entangled in each other to a firm tissue. By numerous richly ramified rhizoids it is firmly fastened to the rocks. For more special description I may here refer to the special part.

Are we now going from these the most exposed places to more sheltered ones, we find that the plants are larger in all regards. The rhizome is more vigorous and well developed rhizoids attach the plant to the rocks and corals; into the fine pores of the latter the rhizoids are easily able to penetrate. It is especially the var. *clavifera*, *uvifera* and *occidentalis* we find here.

What on the whole distinguishes the rock and coral-reef *Caulerpa* from the sand *Caulerpa* is that the roots in the last mentioned first grow vigorously without division some cms. down into the bottom and then suddenly become divided into numerous rhizoids, whereas the roots of the rock and coral *Caulerpa* on the contrary are commonly directly divided into several branches, which by degrees are divided into a great multitude of thin rhizoids. But on the other hand, an even transition between the two forms is naturally to be found and as SVEDELIUS has

[1]) The emphasis is mine.

pointed out (l. c. p. 87), we can even find in the same species sometimes the one form sometimes the other according to the substratum upon which it grows. Compare also REINKE page 58.

The different types of assimilation-shoots in *Caulerpa* and their ecological adaptation to the surrounding external conditions.

Whilst, as we have seen from the preceding, there is a no small difference in the root-system of the Caulerpas according as they grow on rocky or sandy bottom, which shows plainly an ecological adaptation quite in accordance with what SVEDELIUS has found in Ceylon, we shall now examine if a similar ecological adaptation is to be found in the assimilation-shoots which in much higher degree show a multitude of morphological differences.

As SVEDELIUS has pointed out, this great multitude of forms seems just to have been the reason why REINKE arrived at the conclusion that the Caulerpas are of specially great interest, living as they do, in his opinion, under very uniform conditions but nevertheless developing this very great richness of forms. In his paper: "Ueber Caulerpa", p. 67 REINKE writes: "Die Gattung *Caulerpa* ist auch darum interessant, weil sie zeigt, dass unter gleichen äusseren Lebensbedingungen, bei im wesentlichen gleicher innerer Struktur die äussere Gestalt ausserordentlich verschieden sein kann. Sie lehrt, dass die gleichen funktionellen Aufgaben, auf denen das Leben beruht, unter den gleichen Umständen durch eine sehr verschiedenartige Gliederung des Organismus gelöst werden können. Hierin besteht das Wesen der organischen Mannigfaltigkeit; dadurch wird die Vielgestaltigkeit der Formen zu einem so wichtigen Probleme der Biologie". And REINKE continues: "Alle Caulerpen sind dem Lichtleben im Wasser angepasst; jede Art ist ein Specialfall dieser Anpassung, und alle sind verschieden geformt. Diese Verschiedenheit beruht aber nicht auf besonderen Anpassungscharakteren. Die Assimilationsarbeit lässt sich bewerkstelligen so gut mit den gleichartigen feinen Fäden der *C. fastigiata*, wie mit den breiten ungetheilten Blättern der *C. prolifera*, den grossen fiederspaltigen Blättern der *C. taxifolia* und den kleinen einfachen Blättern der *C. racemosa* und *C. Lycopodium*".

How untenable this view is, not only in the assertion that the Caulerpas live under uniform external conditions but also that they should not show any adaptation at all, I shall indicate later on in more detail. As SVEDELIUS has pointed out, it seems that REINKE himself has nevertheless had the feeling that some adaptation is to be found in the Caulerpas, which is clear from what he writes on the next page: "Mit Rücksicht auf diesen Umstand will ich auch gar nicht verkennen, dass einzelne *Caulerpa*arten ihrer Organisation nach vollkommener, ich meine den Hauptfunktionen vollkommener angepasst, andere unvollkommener genannt werden können. Bei Arten, wie *C. hypnoides*, bringt die Kleinblättrigkeit es mit sich, dass sie in jeder Lage das Sonnenlicht vielleicht besser ausnutzen, als

C. taxifolia oder *prolifera*, im bewegten Wasser dürften sich gleichfalls Vorzüge gegenüber den letzteren gelten machen."

We shall now consider a little more in detail the great difference we meet with in the assimilation-shoots of the West Indian forms of *Caulerpa*. We meet with forms which, as *C. prolifera*, have a single large undivided leaf, we find forms which like *C. sertularioides* and *C. Ashmeadi* have the leaf divided into numerous round or clavate pinnules and further others such as *C. taxifolia* and *C. crassifolia* where the pinnules are flattened, narrow in the former, broader in the latter. Further we have species where the pinnules are placed on all sides round the rachis, but where the pinnules are of very different form, e. g. nearly cylindrical in *C. racemosa* var. *lætevirens* or swollen towards the top in *C. racemosa* var. *clavifera*, var. *uvifera* and var. *occidentalis*; or the pinnules are dichotomously divided into thread-fine segments, e. g. in *C. verticillata*.

In this great multitude of forms we can distinguish the following two groups, namely, the species in which the assimilators are leaf-like, bilateral, and the species which have the pinnules arranged on all sides, constructed radially. SVEDELIUS distinguishes the Ceylon Caulerpas in a similar way in these two groups, but he has further a third type, the *C. sertularioides*-type; he keeps this as a distinct group especially because *Caulerpa sertularioides*, the only representative for it lives for the most part in shallow water while the other bilateral forms of *Caulerpa* live according to the observations of SVEDELIUS in deeper water. As this is not quite in accordance with my observations in the West Indies, as I shall show later on, I will only maintain the two groups mentioned above.

As we shall now consider a little more in detail the different forms belonging to the two groups, we may at the same time try to find among the great richness of forms of the assimilation-shoots, whether any adaptation to the surrounding condition of life occurs.

(1) Caulerpas with leaf-like, bilateral assimilation-shoots. That the leaf-like Caulerpas are derived from the radial forms which are certainly the most primitive I quite agree with SVEDELIUS. As SVEDELIUS points out, we often find on the same plant both bilateral and radial shoots, which shows that the two forms are very nearly related, but we will further find on more thorough examination that several of the bilateral species are often radial at the base of the shoots. In addition to the specimens mentioned by SVEDELIUS, viz.: *C. Lessonii*, *C. taxifolia*, f. *tristichophylla* and *C. dichotoma*, I have often found the same in the otherwise distichous forms of *C. cupressoides* (Fig. 16 and 17), and in *C. sertularioides* f. *Farlowii* (Fig. 11). Even the markedly bilateral *Caulerpa prolifera* has by experimental culture given cylindrical shoots, as KLEMM (19, p. 468—9) has shown.

We will begin with the examination of *C. prolifera*. This species occurs in the West Indies partly in the littoral region and here even in the uppermost parts, and in rather exposed but also sheltered localities, partly also common, as far as I can judge from dredging, in deeper water. In shallow water and in somewhat

exposed localities the leaf is often narrow and it has often numerous proliferations. This seems to be in good accordance with the observation of JANSE (18) in the Gulf of Naples where *Caulerpa prolifera* has in recent years spread itself out into some open, exposed parts of the Gulf. This is especially due to its many proliferations, which seem to be especially developed in turbulent seas and which when torn off are an excellent means of distribution. On the other hand it is the broad form, f. *obovata* (Fig. 5), we find especially in deep water and even if the proliferations are also fairly often to be found here they are far from being so common as in shallow water. A form nearly as broad as the one figured occurs also on the shores and that even in rather exposed places. The advantage of this broad and flat leaf is evident, the surface of assimilation being larger, but on the other hand this broad leaf also runs the risk of being lacerated when it grows in an exposed place; this is also often the case in spite of the leaf in the West Indian form being thicker and more leathery than in the European form. SVEDELIUS' description of the occurrence of *Caulerpa prolifera* is therefore not quite in accordance with what is the case in the Danish West Indies nor in the Mediterranean and the surrounding seas, where *C. prolifera* seems indeed to prefer deeper water in sheltered places, but is also to be found in turbulent localities and in shallow water.

While *C. prolifera* thus has the leaf undivided but as mentioned often lacerated and worn at the apex when living on exposed coasts, the other bilateral species have the leaf divided into more or fewer parts which when they are growing in exposed places may certainly be of advantage.

Caulerpa taxifolia has the leaf divided into many linear wings. It occurs commonly in shallow water both in sheltered and also in rather exposed places and it is further found in deeper water. The leaves grow larger here and are commonly without proliferations, just as the rhythmical growth characterizing the plant in shallow water seems to be wanting here. But when SVEDELIUS writes: "It avoids exposed localities when it grows in the upper littoral zone", this is as mentioned above not in accordance with its occurrence in the Danish West Indies where it can grow in rather exposed localities. On the other hand, SVEDELIUS' remarks suit better *Caulerpa crassifolia*, a species occurring commonly in shallow water in sheltered places, whereas on more exposed coasts it is seldom and only badly developed. In deeper water it is also to be found and here the leaf grows larger and is without proliferations or rhythmical growth.

Caulerpa Ashmeadi I have only found in deeper water in about 20—35 meters depth; how far this species elsewhere also is only to be found in deeper water I do not know. HARVEY (16) does not mention anything about this matter. *Caulerpa Webbiana* f. *disticha* I have likewise only found in deeper water in the Danish West India, even down to a depth of about 50 meters, but it is to be found in shallow water at other places.

On the other hand *C. sertularioides* is a specially littoral alga only occurring

in shallow water; it is to be found on rather exposed coasts where its finely divided leaves wave to and fro in the water; it is a smaller form f. *brevipes* we find here. In more sheltered places it grows larger and the pinnules are often thinner, viz. f. *longiseta*.

As is seen from the above, it may for the West Indian forms of *Caulerpa* be said that the bilateral forms occur both in shallow water and here not only in sheltered places but also in exposed as in deeper water. The result of SVEDELIUS' investigations is as follows: "An examination of the occurrence of the larger bilateral *Caulerpa* forms both in Ceylon and on other coasts, where anything is known of them, consequently shows that in any case they have not their main distribution in the littoral zone — even if isolated specimens occur there — but that this must be located in deeper and quieter regions". In order to reach this result he excludes *Caulerpa sertularioides* from this group and considers it as a special type. But when, we may well say, the most distinctly leaf-like *Caulerpa*, *C. prolifera*, occurs littorally and that even in rather exposed places, and further other species e. g. *C. taxifolia* also have the same habitat, I can not see any obligatory reason for considering *C. sertularioides* as a representative of a special group. The result of my investigations is therefore, that the bilateral leaf-like Caulerpas are to be found both in shallow water (in company here with the radial Caulerpas, which, as we shall see later, are restricted to shallow water exclusively in Danish West India and as it seems also elsewhere) and further in deep water where they seems to reign alone.

It has in this connection a great interest to see how the deepest-going forms of the form-rich species *C. cupressoides* and *C. racemosa* behave in deep water.

Firstly as regards *C. cupressoides*, referring for more detail to the systematic part, it appears that, as we gradually pass from exposed coasts with intense light to sheltered with more or less muddy, unclear water, the branches become more and more distichous and we finally come to specimens from deep water, 20—30 meters, which are quite distichous, where even the branches are situated in the same plane.

C. racemosa behaves in the same way. Of this very form-rich species I have some few times found a few distichous specimens in deep water in the Danish West Indies which I have referred to the var. *Lamourouxii*. In accordance with this, *C. sertularioides*, which always grows at least in the Danish West Indies in shallow water, shows a disposition to be radial (f. *Farlowii*), and SVEDELIUS found a radial form of *C. taxifolia*, f. *tristichophylla*, in a depth of about 6 meters it is true, but this depth in the tropics is of no importance. Also *C. Webbiana*, the f. *disticha* of which is found in a depth of about 50 meters at St. Jan is commonly radial in shallow water even if f. *disticha* is also found there.

If we now ask whether the bilateral form can be especially useful for the plants in deep water, it seems to me that this must be answered in the affirmative, as the leaf, at least where a current is present even though feeble, will most pro-

bably be forced to turn one of the broad sides of the leaf upwards and thus be able with the greatest possible surface to intercept the rays of light. In this connection it is also of interest that *Caulerpa Webbiana* f. *disticha*, the *Caulerpa*-species I have found deepest down and whose small ca. 1 cm. high and rather rigid leaf can scarcely be bent by the current, has its leaves curved outwards and then downwards with the flat side upwards towards the light just like a dorsiventral leaf.

(2) The radial Caulerpas. In the Danish West Indies these are represented by the two form-rich species *C. racemosa* and *C. cupressoides* and by *C. verticillata*. The last-mentioned species I have already dealt with; in the West Indies it frequents the very quiet habitat on the roots of the mangroves where its finely divided, bushy assimilators seem to be well adapted to the surrounding conditions of life. Of *Caulerpa racemosa* we have the varieties var. *uvifera*, var. *clavifera*, var. *occidentalis* and var. *lætevirens*, and of *Caulerpa cupressoides* var. *mamillosa*, var. *ericifolia* (which typically developed has not yet been found in Danish West Indies), var. *typica* and var. *plumarioides* which already has many distichous branches. In what localities do we meet with these forms? If we first consider the forms of *C. racemosa*, then var. *clavifera* and var. *uvifera* are both commonly met with in shallow water near the surface of the sea. Var. *clavifera* is so to speak met with everywhere on the coral-reefs or rocks in somewhat exposed places. It grows here in a dense carpet between corals and *Lithothamnia*, but also on rocks. And often it grows so near the surface of the sea, that at low water it is laid more or less dry. It can grow in rather exposed localities and the more exposed the shorter are the assimilators while the rhizomes grow more intertwined; thus we get the characteristic, compact carpets which upwards are formed by the densely placed ramuli downwards by the rhizomes (cfr. Fig. 25 and 26). When the plant has this form it is fastened immovably to the rocks. If we go to a little more sheltered locality or a little deeper water (one meter or two) we find that the assimilators grow longer; we meet here with forms of var. *clavifera*, of var. *uvifera* and of var. *occidentalis*; the rather long assimilators in these forms wave to and fro in the sea. These three forms are all, as far as I have seen in Danish West India, attached to rocks and coral-reefs, that is, firm bottom. Of the *racemosa*-forms I have only found the form I have called var. *lætevirens* on loose bottom in shallow water. As I have mentioned it in more detail in the systematic part, this form was found growing in a locality where the water was always unclear; it is therefore to be considered as a shadow-form which comes rather near to the forms from deep water.

The radial forms of *Caulerpa cupressoides* grow in very similar localities as those of *Caulerpa racemosa* and show quite parallel growth. Var. *mamillosa* which occurs in the most exposed localities where this species is to be found, is common on and especially inside the coral-reefs where accumulations of coral-sand are found; at the most exposed places the ramuli are quite short and occur in 6—7

rows. If we go to more sheltered places or a little deeper, we find forma *typica* with longer ramuli and commonly only 3 rows of ramuli. And finally in the quiet and often dirty water of the lagoons we get forms the branches of which are often distichous.

There can scarcely be any doubt that these corresponding forms of the two different species are due principally to the different degrees of light and exposure. And when SVEDELIUS writes about similar forms of var. *clavifera* (l. c. p. 90): "That these various forms arise directly through the influence of light, so that, for instance, obscuration favours the lengthening of the axes, while bright or intense light causes shortening of the axis system, seems very probable", I can express my agreement with this; but I believe that the different degrees of exposure influence in the same direction.

On the whole my observations agree very well with those of SVEDELIUS from Ceylon, who also found all the radial forms in the littoral region in shallow water, where they are especially adapted to live in the intense light found everywhere where the water is clear, while just the forms which live in the yet shallow, it is true, but unclear water of the lagoons, show a distinct transition to the distichous forms living in deeper water.

That the Caulerpas must therefore be regarded as ecologisms in great degree is I think clear from what I have mentioned. So far as I understood them after repeated investigations in nature itself, they are highly variable and adapted to particular growing places. That we also find other variations, however, which can not be considered as ecological is quite true. SVEDELIUS thus distinguishes 5 different kinds of variations besides the variations of adaptation.

To obtain a final opinion regarding the variations of the Caulerpas on the whole, more thorough investigations in the nature itself and especially experimental cultures would be of great importance; before we have these we can for the most part only make suppositions as SVEDELIUS also points out. Page 99 he writes: "This is of course a pure speculation, and for the solution of this, as of so many similar questions touching variation in *Caulerpa*, experiments and cultures are necessary which the traveller in the Tropics has difficulty in arranging".

It is only upon *Caulerpa prolifera* that detailed experiments have so far been made; this species is as SVEDELIUS expresses it "the physiological *Caulerpa* par préférence". We know from these experiments as mentioned above that it is highly affected by the different external conditions which are offered it, forms can arise which one would never think belonged to this species. And concerning the dichotomous form which JANSE has found in the Gulf of Naples, Mdme. WEBER VAN BOSSE writes (l. c. p. 279): "Ces formes sont très curieuses puisque nous voyons ici s'effectuer, sous nos yeux, une transformation si complète de la

fronde du *C. prolifera* qu'on prendrait les deux formes, vues séparemment, pour des plantes distinctes". But when we know this we have good reason to suppose that other Caulerpas will also show themselves to be highly changeable under altered external conditions of life and therefore that many variations may arise from this variability.

When we e. g. find in *Caulerpa cupressoides* that the number of rows of branchlets (pinnules) decrease as we go from exposed coasts with shallow water to sheltered localities and especially to deep water, and when we find a similar tendency in other species e. g. *C. racemosa* under similar conditions and when we further know that we have the radial species in shallow water and chiefly the bilateral species in deeper water, then I think this decrease in the rows of branchlets goes to show an ecological adaptation, and it is therefore quite natural that we should often find in the same plant a different number of rows of branchlets, as is indeed often the case in localities which might be considered as intermediate. Thus e. g. in the lagoons, which can be considered as intermediate localities between exposed coasts and deep water, we meet with forms of *C. cupressoides* which are just characterized by having a varying number of rows of pinnules. Also the form itself of the pinnules is certainly highly dependent on the external conditions. On exposed coasts these are commonly short and broad, on sheltered coasts longer and more cylindrical, which is clearly expressed in the two form-rich species *C. racemosa* and *cupressoides*.

The conclusions I have thus reached arise solely from studies in nature, but when one has seen there how often quite small variations are immediately reflected in the individuals in such a way that they are steadily altered in a fixed direction, there must be good reason for believing that by experimental cultures we may reach to similar results. For the rest I believe that by exhaustive examination of nature itself we may yet obtain very much. When SVEDELIUS in mentioning a dwarf-form, forma *interrupta* of *C. taxifolia*, thus writes (l. c. p. 100): "in which stunting has perhaps been produced by lack of light, owing to the great depth, for *Caulerpa*, at which it grows (more than 10 m.)", then the poor development of this form can scarcely be ascribed to a "great depth" as SVEDELIUS thinks, since I have found in nearly three times the depth large and well-developed specimens of *Caulerpa taxifolia* (cfr. fig. 10) just as in still greater depths (about 40—50 m.) I have found well developed specimens of other species. When SVEDELIUS repeatedly calls 10 m. a great depth it only shows that he has not succeeded in dredging in greater depths, which as I know from experience is often difficult in the tropics. I have as mentioned above succeeded in getting sea-weeds in about 50 meters depth, but I am quite sure as already pointed out (6, page 769) that a fixed algal vegetation may be found in twice the depth and perhaps more in the tropics.

And when SVEDELIUS regarding *C. prolifera* writes p. 83 (cfr. also p. 88): "(It) is in the Mediterranean apparently a pronounced still-water form, which even

if it can occur at the surface (0.5 metre BERTHOLD) yet seems to prefer deeper localities down to a depth of about 15 m.", then it appears from my investigations that it does not hold good in the West Indies, where it is to be found in shallow water on even rather exposed coast. Thorough comparative investigations in nature can therefore yet give much important information. By means of these and especially in connection with comprehensive experimental cultures, we can first hope to get at the bottom of the variability of the Caulerpas and thus also reach to greater clearness regarding the definition of the species.

II. Systematic Part.

1. Caulerpa verticillata J. G. Agardh.

J. G. Agardh, Nya alger från Mexico, p. 6, the note.
" " Till Algernes Systematik, I. p. 6.
Weber van Bosse, Monographie des Caulerpes, p. 267.
Exsicc. Wittrock & Nordstedt, Algæ exsicc. No. 1020.
Collins, Holden and Setchell, Phycotheca Bor. Am., No. 665.

f. *typica*. The opposite or verticillate ramuli, arranged in distinctly separate whorls. (Fig. 1.)

f. *charoides* (Harv.) Web. v. Bosse. The ramuli are scattered over the erect shoot[1]). (Fig. 2.)

This nice little plant is very common on the shores of the Danish West Indies in the more sheltered places. Its real home is the lagoons, where as I have already mentioned in my paper (5, p. 55—56) it is one of the most common algæ in the very characteristic algal vegetation, which covers the mangrove roots. As a dark-green 6—7 cm. high covering it grows quite dense on the mangrove roots and like most of the other richly ramified mangrove algæ gradually collects mud and organic particles between its fine ramifications, and that often in such great quantities that the water immediately

Fig. 1. *Caulerpa verticillata* J. Ag.
From the lagoon of Christianssted, St. Croix. ($1^1/_2 : 1$.)

[1]) A type-specimen of this form, Harvey, Friendly Islands Algæ, No 97, to be found in the Botanical Museum of the University of Copenhagen, has however the ramuli rather distinctly arranged in whorls. Harvey's paper, List of Friendly Islands Algæ, I have not been able to see.

becomes muddy when one touchs the plant. The mangrove algæ and with them *Caulerpa verticillata* contribute therefore, probably not inconsiderably, to the gain of land which is to be found where *Rhizophora* grows.

By reason of the exceedingly dense mode of growth, arising from the fact that the creeping rhizomes on the mangrove roots are woven together and form often a thick layer composed of the intertwined rhizomes, mud etc., and from the fact that the older rhizomes die away by degrees, there will gradually arise a great many separate plants the bases of which often consist of fragments of rhizomes only, so that it is often rather difficult to see that the plant really has a creeping rhizome. This has been, I think, the reason why REINKE, who most probably had only such small dense clumps for examination, questions whether the plant really has a creeping rhizome (27, p. 7). In my paper above cited I have pointed out as already mentioned in the general part that this apprehension is not right and I have there given the figure which I again reproduce here (Fig. 1). SVEDELIUS (30, p. 109) without knowing my paper has emphasised the same point and has given a similar figure. *Caulerpa verticillata* grows in Danish West India in sheltered places only and it shows also in this fact a difference in comparison with its occurrence in Ceylon where as mentioned by SVEDELIUS it is to be found on rather exposed coasts; on p. 93 SVEDELIUS (30) mentions it together with *C. lætevirens* f. *laxa* and *C. sertularioides*, the species of *Caulerpa* which in Ceylon grow on the most exposed localities.

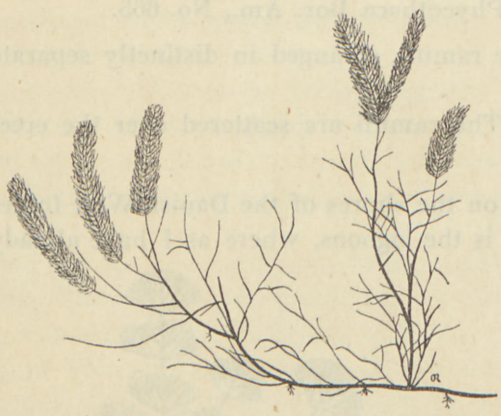

Fig. 2. *Caulerpa verticillata* J. Ag. f. *charoides* (Harv.) WEBER VAN BOSSE. From the lagoon of Krause (St. Croix). (About 1 : 1.)

In the adjoining illustration, fig. 3 *a* shows the uppermost part of an erect growing shoot (assimilator, REINKE) with two whorls of leaves of which the uppermost is yet quite young consisting only of roundish swellings; the lowermost are already dichotomously divided. Fig. 3 *b* shows a somewhat older more developed leaf. In the fully developed leaf the outermost apices are 2—4 divided (fig. 3 *c*). Finally, fig. 3 *d* shows the ends of a pair of rhizomes.

ØRSTED was the first who found the species in St. Croix and his specimens have at any rate partly served J. AGARDH as material for his description of the species. It is very common on the shores of the Danish West Indies in sheltered localities in lagoons with mangroves; f. *charoides* I have only found in Krause's lagoon on the south coast of St. Croix, where it grows abundantly on the roots of the *Rhizophora* on the outside of the mangrove forest in the south-west corner of the lagoon. It grows here together with the forma *typica* but is recognizable by the colour which is of much lighter green.

Geogr. Distrib.: The West Indies, Brazil, The Friendly Islands, Siam, East India, Ceylon etc.

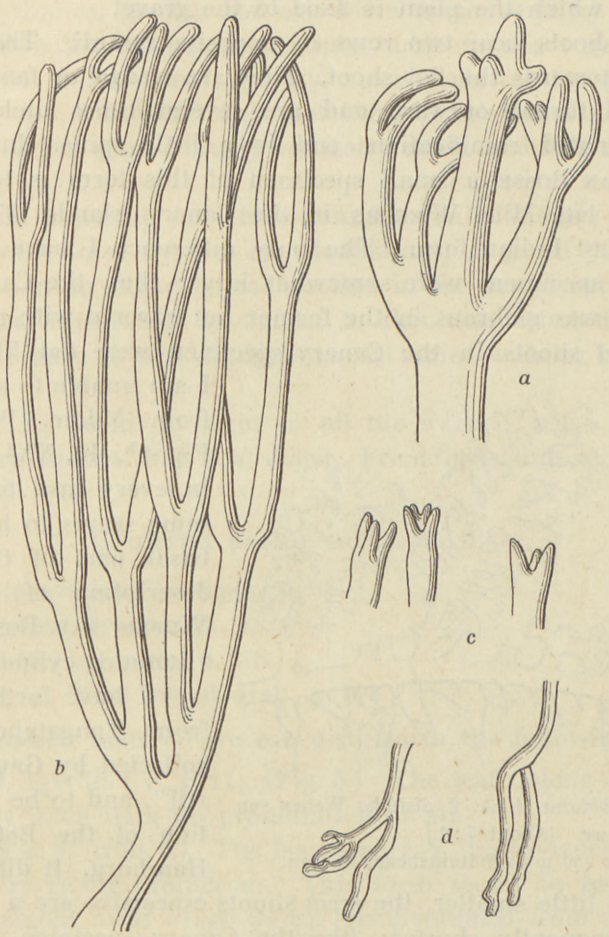

Fig. 3. *Caulerpa verticillata* J. Ag. (compare text). (About 50 : 1.)

2. **Caulerpa Webbiana** Montagne.

Montagne, C., De l'organisation et du mode de reproduction des Caulerpes, et en particulier du *Caulerpa Webbiana*, espèce nouvelle des îles Canaries (Ann. des sciences naturelles, 2. sér., t. 9, botanique, Paris 1838).

Weber van Bosse, A., Monographie, p. 269.

f. *disticha* Weber van Bosse l. c. p. 270. (Fig. 4.)

This very nice little plant is found twice in the sea around the island St. Jan, one time at a depth of about 30 meters another time in more than 50 meters. It grows together with other algæ e. g. *Anadyomene stellata* and creeps on the

bottom fixed to gravel and pieces of coral. The rhizome on its under side bears numerous rhizoids which are sometimes finely ramified, sometimes end in small discs by help of which the plant is fixed to the gravel.

The erect shoots bear two rows of opposite ramuli. These are compressed, the edge turned towards the flat shoot. They are wedge- or fan-like in shape with the broadest end turned outward and are several times dichotomously divided. The last emarginated ramifications end in a little spine. In the herbarium of Mdme. WEBER VAN BOSSE a small specimen of this form is to be found; it was collected by the late Mlle. WICKERS in the Canary Islands (37) and agrees very well with my West Indian form. The only difference I have observed was that the West Indian specimens were somewhat larger than the Canary specimen and that the rhizome was glabrous in the former but covered with ramuli in the latter. How far the erect shoots in the Canary specimen were flat like the West Indian I am unable to say exactly; judging from Mdme. WEBER VAN BOSSE's Fig. 1[b], Pl. XXI the midrib seems in every case to be round and the same seems to be the case with the basal part of the ramuli; in the description of the species Mdme. WEBER VAN BOSSE writes, p. 269: "Ramules cylindriques à la base".

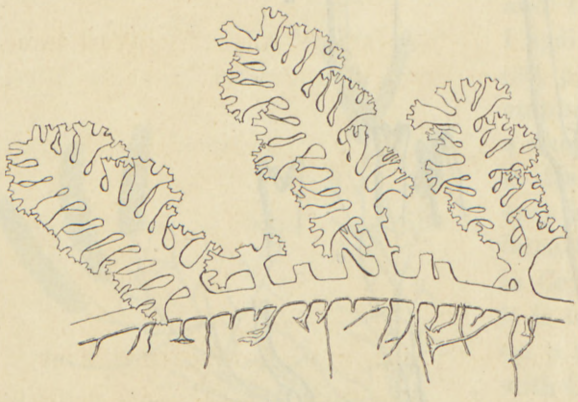

Fig. 4. *Caulerpa Webbiana* Mont., f. *disticha* Weber van Bosse. (About 7 : 1.)
From deep water (50 m.) off Ramshead, St. Jan.

I have further had a specimen from Tongatabu for comparison, collected by GRUNOW "am Corallenriff", and to be found in the collection of the Botanical Museum in Hamburg. It differs from my specimens by being a little smaller, the erect shoots especially are a little narrower and the ramuli consequently shorter; like the Canary specimen and in contrast to mine the plant from Tongatabu has scattered ramuli.

Judging from a specimen of mine preserved in formalin and collected in about 50 meters, the shoots are first erect but bend soon to the side in such a way that they turn the flat side upward, probably an adaptation so as to be able to intercept the greatest possible amount of light.

The greater breadth of the erect shoots is also perhaps to be considered as an adaptation both to the quiet place and feeble light where it grows.

While it is a common thing in other forms of this species, e. g. f. *tomentella*, that the erect leaf-bearing shoots bend downwards at an early stage, obtain rhizoids and grow further on like the rhizomes fixed to the bottom, this is not to be found in the admittedly small material from the West Indies I have had at my disposal.

If we consider the figure 4 it will easily be observed, that the erect shoots

show a very distinctly rhythmical growth; every three, or more seldom four, pairs of ramuli are especially well developed and from these the next decrease gradually in size. Such a rhythmical growth has also often been found by SVEDELIUS in the Ceylon *Caulerpa*. How far the segments which arise in this way correspond with the growth of a year I am unable to say but it seems to me quite natural that this should be the case; I should think that the greatest increase occurs about the month of June when the sun is nearly vertically above and the light therefore the most effective.

The species has hithertho only been found twice in the sea around the island of St. Jan and both times by Dr. TH. MORTENSEN, e. g. off Ramshead on the south coast of St. Jan in about 50 meters and in the sound between St. Thomas and St. Jan near the little island St. James in about 30 meters depth; at the last mentioned locality I have myself dredged several times without being so fortunate as to found it.

Geogr. Distrib. Seems to occur in all the warmer seas: The West Indies, Pernambuco, Canary Islands, Red Sea, Japan, Friendly Islands etc.

3. **Caulerpa prolifera** (Forsk.) Lam.

LAMOUROUX, Mémoire sur les Caulerpes, p. 30.
J. AGARDH, Till Algernes Systematik, I, p. 11.
WEBER VAN BOSSE, Monographie, p. 278.
Fucus prolifer FORSKÅL, Flora ægypt.-arab. p. 193.

In the West Indian material we can distinguish the following two forms:

f. *obovata* J. Agardh l. c. p. 11. (Fig. 5.) The leaf oblong-obovate, with few or very often with no proliferation at all.

f. *zosterifolia* n. f. (Fig. 6.) The leaves narrow lineate-lanceolate, interrupted and very richly proliferous. This form seems to be rather near the dichotomous form which JANSE has mentioned from the Gulf of Naples (Pringsh. Jahrb. Bd. 21, p. 168—9; Pl. 6, fig. 6 and 7).

On the shores of the Danish West Indies *Caulerpa prolifera* is to be found both littoral and in deeper water, and on exposed and sheltered coasts. Forma *obovata* I have especially found in deeper water down to a depth of about 40 meters; the leaves are here often quite without proliferations at all or if these are present there are only some few. The leaves are broad and short, often nearly ovate; at the apex they are often rather deeply emarginate. Forma *obovata* also occurs in shallow water near the shores and on even rather exposed localities, I have e. g. found it on the south shore of St. Croix rather near Sandy Point where there is often rather a strong surf and the leaves were also distinctly marked by it. It grows here on low-lying coral reefs in and a little below the surface of the sea and swings to and fro with the action of the waves. The leaf has here a somewhat smaller size, is rather thick and of a leathery consistency

most likely an adaptation to the exposed locality, while the specimens growing in deeper water are thinner. Though it seems to me that the West Indian specimens are throughout thicker than the specimens I have seen living in the Mediterranean and surrounding seas e. g., from the bay at Ajaccio and especially in great quantity from the bay at Cadiz. KÜTZING has also designated the West Indian form (Tab. phyc. bd. 7, tab. 3 *d*) as "forma *firma*".

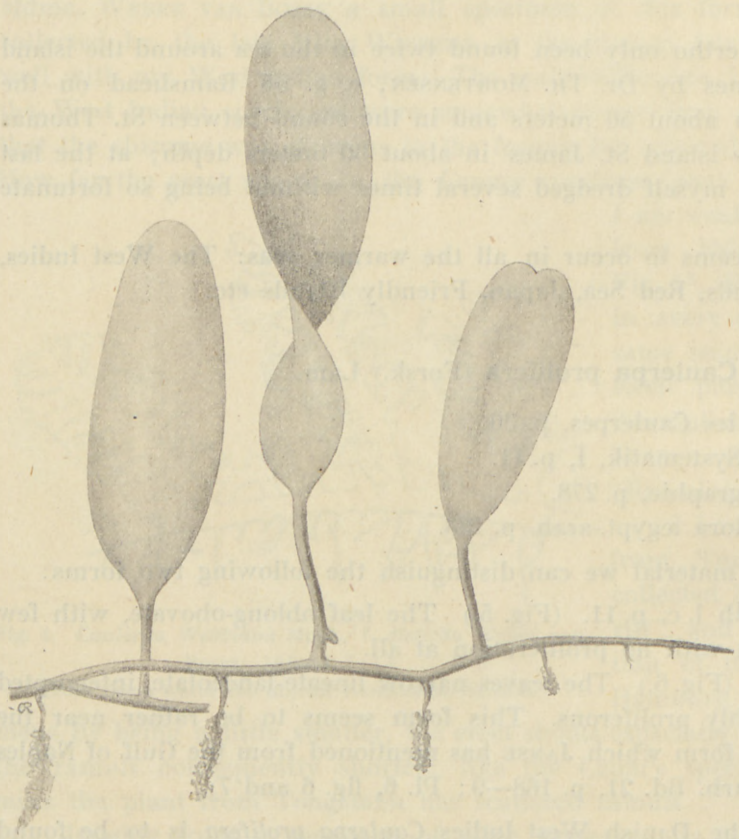

Fig. 5. *Caulerpa prolifera* (Forsk.) Lam. f. *obovata* J. Ag. In the sea to the west of Water island (St. Thomas). (About 1 : 1.)

Forma *zosterifolia* I have only found in shallow water from the surface of the sea down to some few feet. This form is distinguished by having a narrow leaf of only about 5—6 mm broad. It is as a rule very richly proliferous and shows often a distinct twisting.

This form grows richly between sea-grasses e. g. *Thalassia testudinum* and *Cymodocea manatorum* in shallow water in the neighbourhood of Krause's Lagoon on the south coast of St. Croix. A very weak surf can here enter from the sea and in this the leaves of *Caulerpa prolifera* wave to and fro.

From what has been said above, it will be evident that SVEDELIUS's supposition as to the mode of life of *C. prolifera* (l. c. p. 88) in the West Indies is not in accordance with the facts. And as to its occurrence in the Mediterranean I can not quite agree with him. From the remark of JANSE (18, p. 166) that after a very strong gale in the Gulf of Naples he found great quantities of *Caulerpa prolifera* washed ashore, SVEDELIUS (l. c.) concludes that this alga is a deep water form which cannot withstand a turbulent sea. He writes: "It is evident, therefore, that if such broadleafed forms are to have any chance of living it must

be in sheltered places, and, of course, especially at considerable depths that are not disturbed by heavy sea". It is quite correct that *Caulerpa prolifera* often grows in rather deep water where there is complete quiet; but it can live even in the Mediterranean in rather exposed places. JANSE tells us on the next page (l. c. p. 167) how *C. prolifera* had distributed itself in recent years since the investigations by BERTHOLD over the eastern part of the gulf of Naples. He connects this with the fact, that *C. prolifera* in exposed localities has a great tendency to be proliferous, which means that *C. prolifera* has a method of propagating by means of its leaves. He writes: "In wie weit die Eigenschaft der Blätter, neue Organe bilden zu können, dabei von Einfluss gewesen sein muss, geht wohl schon ohne Weiteres aus dem Umstande hervor, dass die Stelle, wo sich der Rasen befindet, in keinerlei Weise durch davor liegende Inseln oder Halbinseln geschützt ist, wie dieses an vielen Stellen im Golf von Pozzuoli der Fall ist, sondern überall der durch Stürme hervorgerufenen, zumal im Frühjahr öfters sehr starken Bewegung des Wassers direct ausgesetzt ist. So lange *Caulerpa* sich also im ruhigen Wasser befand, war die Verbreitung eine langsame, im stark bewegten Theil des Golfes verbreitete sie sich aber sehr schnell." From this description it follows that this alga must grow in even very exposed localities. The observations of JANSE agree very well with what is to be found in the West Indies, where as mentioned above *Caulerpa prolifera* in deep water has a broad leaf which is only very little proliferous, often not at all, in shallow water on the contrary, where we have some surf, *Caulerpa prolifera* has a narrow leaf which is very richly proliferous.

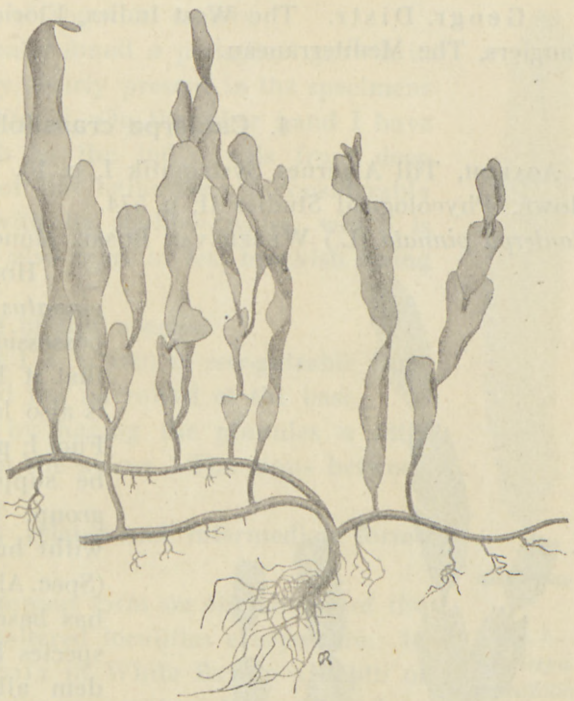

Fig. 6. *Caulerpa prolifera* (Forsk.) Lam. f. *zosterifolia* n. f. From the lagoon of Krause, St. Croix. (About 1 : 1.)

Besides the two forms mentioned above, I have also found some few specimens whose leaves were $1^1/_2$ cm. broad and 17 cm. long and thus on the whole rather like the common European form; in its more leathery consistency it was however somewhat different. This form was found at White Bay on the south side of St. Croix in about half a meter of water on a rather exposed coast.

Caulerpa prolifera is rather common on the shores of Danish West India.

Forma *zosterifolia* is found in several places at St. Croix, e. g. in the seagrass-formation west of Krause's Lagoon and in Limetree Bay to the east of this Lagoon on the south coast of the island; further, on the north side on the shores of Green Cay estate where the leaf nevertheless was a little broader. Forma *obovata* is found in shallow water in several localities near Sandy Point on the south coast of St. Croix, in deeper water it is found in great quantities in the sea to the west of Water Island at St. Thomas in about 20—30 meters of water, and at St. Jan in the sound between St. Thomas and St. Jan and in the sea to the north of America Hill and west of Tortola.

Geogr. Distr. The West Indies, Florida, Bermudas, Canary Islands, Cadiz, Tangiers, The Mediterranean.

4. Caulerpa crassifolia (Ag.) J. Ag.

J. Agardh, Till Algernes Systematik I, p. 13.
Howe, Phycological Studies II, p. 574.
Caulerpa pinnata (L.) Weber van Bosse, Monographie p. 289.

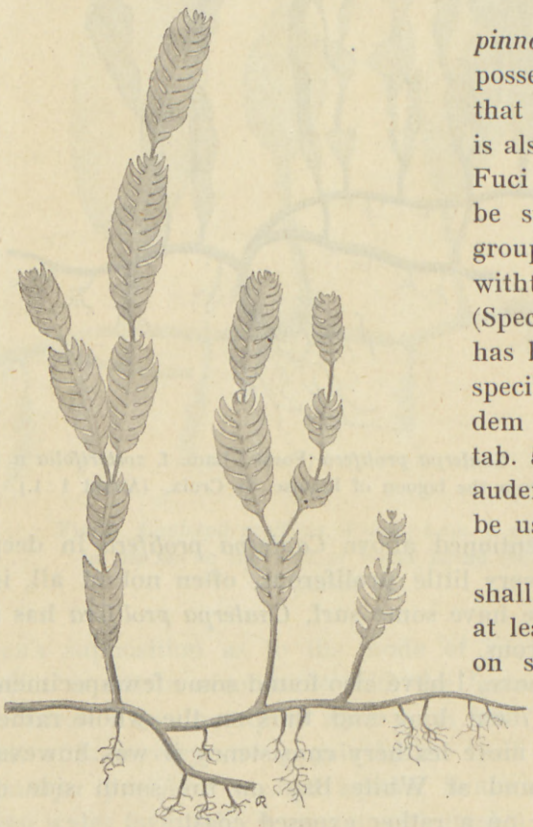

Fig. 7. *Caulerpa crassifolia* (Ag.) J. Ag. In shallow water from the lagoon at Christianssted. (About 1 : 1.)

Howe has found in a specimen of *Fucus pinnatus* in Linné's Herbarium, now in the possession of the Linnean Society in London, that it has distinctly cylindrical pinnules, as is also later figured and described by Turner, Fuci I, pl. 53, which shows a form which must be supposed to belong to the *C. racemosa*-group. This form has therefore nothing to do witht he *Caulerpa taxifolia β crassifolia* C. Ag. (Spec. Alg. p. 436) on which variety J. Agardh has based his species, and in the remarks to species he also writes: "utrum synonyma ibidem allata (*F. pinnatus* Linn. & Turn. Hist. tab. 53) ad eandem pertineant, dicere non auderem." Agardh's name must therefore be used.

Fucus crassifolius is to be found both in shallow water and deeper down to a depth of at least 30 meters. It prefers sheltered coasts; on somewhat exposed places it can exceptionally be found but it is rare here and the specimens are only badly developed. At Cane Bay on the north side of St. Croix I thus found some small and few specimens growing behind a small coral reef near the shore and at White Bay I have

found it in about ½ meter of water growing among other algæ. In the last-mentioned locality, somewhat far out to sea in the open bay between the last westerly part of the long coral reef which stretches along the south coast of St. Croix and the land I have found it growing on *Halimeda*-gravels in about 10 meters depth. But its real home is partly the well-sheltered places, especially the lagoons, partly deeper water. In the first mentioned places it grows very commonly in 1—2 feet of water, creeping on the soft bottom with its nearly thread-like rhizome; a few times I have also found it growing even on the roots of the mangroves. In deep water, where it also finds a quiet growing place, I have as mentioned taken it down to a depth of about 30 meters.

While SVEDELIUS only exceptionally found a periodical growth in his material from Ceylon, this is very clearly present in the specimens from shallow water in the lagoons (Fig. 7). On the other hand I have not seen such a rhythmical growth in the individuals from deep water (Fig. 8), where the conditions of life naturally are considerably more uniform than in the lagoon with its shallow water, which is very easily heated by the sun and is also more or less brackish owing to the heavy rains.

Two forms can be distinguished of this species.

Forma *typica* (WEBER VAN BOSSE l. c. p. 290) is recognizable from having the pinnules nearly linear and not narrowed at the base.

Forma *mexicana* distinguished by having the pinnules a little narrowed at the base and broader at the apices. The sinus between the pinnules is roundish.

The two forms are very nearly related and intermediate forms occur very often.

Forma *mexicana* is the most common form on the shores of the Danish West Indies and occurs in sheltered localities everywhere. In deeper water I have got it at St. Croix in White Bay in a depth of about 10 meters, at St. Thomas in the sea west of Water Island in about 20—30 meters and at St. Jan off Christiansfort and America Hill in the same depth.

Forma *typica* I have only found in the sea west of Water Island in about 30 meters of water.

Geogr. Distrib. The West Indies, Florida, Guyana, Bermudas, Canary Islands etc., Red Sea, Indian Sea, Friendly Islands etc.

Fig. 8. *Caulerpa crassifolia* (Ag.) J. Ag. In deep water off Christiansfort (St. Jan). (About 1 : 1.)

5. Caulerpa taxifolia (Vahl) Ag.

C. AGARDH, Spec. Alg. p. 435.
WEBER VAN BOSSE, Monographie p. 292.
Fucus taxifolius VAHL, Skrivter af Naturhistorie-Selskabet, t. V, 2det Hefte, 1802, p. 36.

This species which in the Danish West Indies does not seem to show any appreciable variations in form is found in very different localities. It is thus found in shallow water near the surface of the sea in rather exposed localities, e. g. on the north side of St. Croix at Green Cay estate and on the south coast at White Bay. In both localities it is gregarious growing in rather large tufts on rocks and stones; in the first-mentioned locality it was partly laid dry. Further, it is found in quite sheltered localities in lagoons, e. g. in the lagoon of Christianssted, where it creeps round on the muddy bottom. Also in deeper water it seems to occur commonly. In White Bay I have thus taken it in about 10 meters depth, where it was creeping on the *Halimeda*-gravel which here covers the bottom in great quantities. And in the sea at St. Jan I have taken it off America Hill in about 30 meters. All the specimens were in all essentials the same form, only with regard to the size was some difference evident, the leaves of specimens from deep water being very long (16 cm. or more, Fig. 10), while the leaves of specimens from shallow were much shorter (Fig. 9). Moreover, in the specimens from deep water the leaves show a very uniform growth while these in the specimens from shallow water have a very distinct periodical growth, quite in the same way as in *C. crassifolia*.

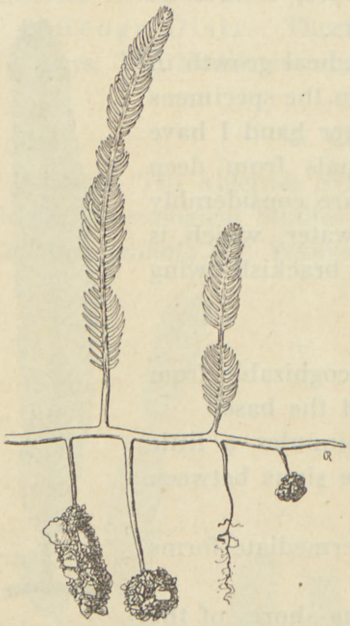

Fig. 9. *Caulerpa taxifolia* (Vahl) Ag. In shallow water from the lagoon at Christianssted. (About 1 : 1.)

Fig. 9 shows a small specimen from St. Croix, from which island this species, as is well known, was originally described and which is quite like the specimens to be found in the Botanical Museum in Copenhagen upon which Vahl founded his description. They are in good accordance with the description of Weber van Bosse l. c. and with the forma *typica* of Svedelius (l. c. p. 112), Syn. *Caulerpa falcata* Kütz., Tab. phyc. Bd. VII, tab. 5, fig. V.

This species is rather common on the shores of the Danish West Indies.

Geogr. Distrib. The species is found in the West Indies, Florida, Ceylon, Floris and the Sandwich Islands.

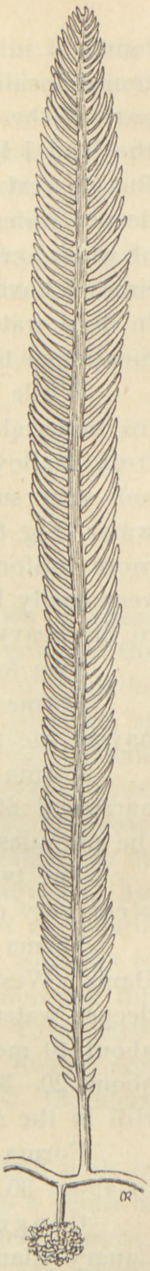

Fig. 10. *Caulerpa taxifolia* (Vahl) Ag. From deeper water off America Hill (St. Jan). (About 1 : 1.)

6. Caulerpa sertularioides (Gmel.) Howe.

M. A. Howe, Phycological studies II, p. 576.
Fucus sertularioides Gmelin, Historia Fucorum p. 151, tab. 15, fig. 4.
Caulerpa plumaris (Forsk.) Ag., Weber van Bosse, Monographie p. 294.
Exsicc. Wittr. & Nordst., Algæ exsiccatæ, Nr. 1585.

That *Fucus sertularioides* Gmel. l. c. is without doubt the same as *Caulerpa plumaris* (Forsk.) Mme. Weber van Bosse has already expressed in the following way: "D'après les lois de la priorité le nom de sertularioides proposé par Gmelin devrait être réinstallé, car Gmelin a non seulement décrit la plante, mais il en a aussi donné une figure très exacte. On s'est cependant tellement habitué à employer le nom de *C. plumaris*, que ce nom est consacré par l'usage." Even if I sympathise with this last remark of Mme. Weber van Bosse, one is I think, at all events in a case like this where there is no doubt in the matter, forced to follow the laws of priority, and therefore as Howe has done call the plant with the name first proposed by Gmelin.

f. *typica* (compare below).
f. *brevipes* (J. G. Ag.) Weber van Bosse, Monographie p. 294.
f. *longiseta* (J. G. Ag.) Weber van Bosse, Monographie p. 295.
f. *Farlowii* Weber van Bosse, Monographie p. 295. (Fig. 11.)

Caulerpa sertularioides is a distinctly littoral alga which is very common from the surface of the sea down to a depth of some few meters. It occurs both on rather exposed coasts and in quite sheltered localities. On exposed coasts it is partly what I call f. *typica*, characterized by its rather thick, not very densely placed pinnules, partly forma *brevipes* that occur. They often grow in rather large tufts sometimes together with other Caulerpas, e. g. *C. taxifolia*, and wave to and fro in the swell.

In localities where it is steadily exposed to some swell, e. g. at the landing place at Christiansfort in St. Jan, I have found a form distinguished by having a long and narrow leaf which I think is to be considered as a wave-beaten form, similar to the forms of *C. racemosa* var. *occidentalis* and var. *uvifera* with long erect shoots I have found in the same locality and which will be mentioned later on.

While the two above-mentioned forms are for the most part to be found on more exposed coasts, forma *longiseta*, characterized by its longer, thinner and densely placed pinnules, is especially restricted to the more sheltered localities. It is thus rather common in the lagoons, e. g. the lagoon of Christianssted, where it creeps in the soft bottom; but I have also found this form in a somewhat more exposed locality, e. g. behind Long Reef near Little Princess on the north side of St. Croix, but here it is united by many transitional forms with the typical form or with forma *brevipes*. In shallow water it occurs down to a depth of about 2—4 meters. In such greater depths as 10—15 m. in which Svedelius (l. c. p. 115) has found it on the shores of Ceylon I have never seen it.

In somewhat deeper water in a depth of about 6 meters I have once found a little form of dwarfish growth. It was dredged off Frederikssted at the west end of St. Croix, therefore in the open sea. It grew on a bottom of coral sand. The erect leaves were only some few cm. high and bear some few rather thick and widely separated pinnules. I have only found a small specimen of this rather remarkable form and I may confess that I do not feel quite convinced that it belongs to this species.

The form of this species which shows the most interest is f. *Farlowii*, of which fig. 11 gives an illustration. As the figure shows, one finds in the same rhizome leaves which are quite normal like those of f. *typica* and further those which, instead of having the pinnules arranged as normally distichously, bear pinnules in

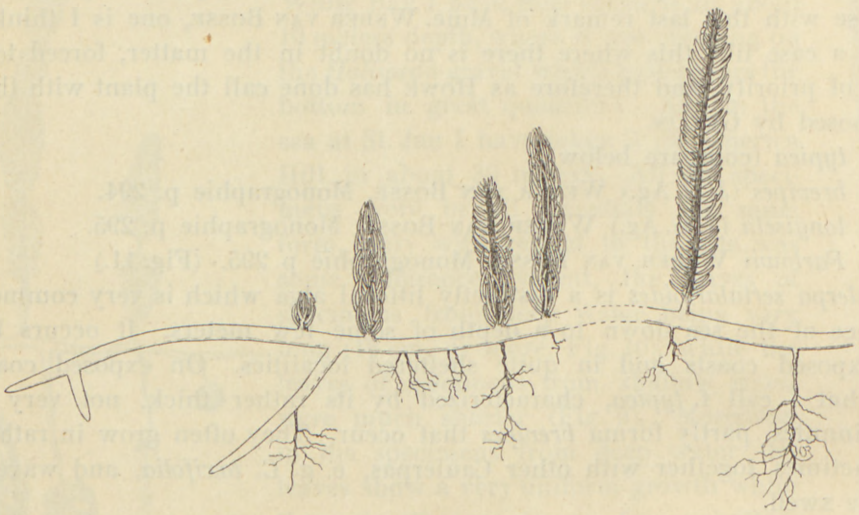

Fig. 11. *Caulerpa sertularioides* (Gmel.) Howe. f. *Farlowii* Weber van Bosse. From Durloes Bay (St. Jan). (About 1 : 1.)

several rows. One can even find the two cases represented in the same leaf as the figure shows, where the third leaf from the growing point is radial at the base but distichous in the uppermost part. The erect shoots with pinnules in all direction are, as Mme. Weber has pointed out, quite like those in *Caulerpa Selago*, to which species *C. sertularioides* seems to be very nearly related, quite in the same manner as the forma *tristichophylla* of *C. taxifolia* connects this species with *Caulerpa falcifolia*. Forma *Farlowii* is found on the beach in shallow water quite near the surface of the sea and was growing on coral-sand in a smaller basin with fresh water and with some swell.

A rhythmical growth quite like that described by Svedelius l. c. p. 114 and which I have already mentioned for other species is also often to be found in this species in the West Indies. It is present e. g. in the specimens I have distributed in Wittrock and Nordstedt, Algæ exsiccatæ Nr. 1585.

Caulerpa sertularioides is a very common species along the shores of the Danish West Indies. Forma *typica* and *brevipes* are commonest in more exposed localities, e. g. St. Croix: Limetree Bay, White Bay, behind Longreef etc. St. Thomas: The harbour, St. Jan: The bay at Christiansfort etc. Forma *longiseta* is most common in lagoons, e. g. St. Croix: the lagoon of Christianssted, behind Longreef in sheltered localities with sea-grass, in the Bovoni lagoon at St. Thomas etc. Forma *Farlowii* was only found once at St. Jan in Durloes Bay (leg. Dr. H. MORTENSEN).

Geogr. Distrib. The West Indies, Florida, Red Sea, Ceylon, Friendly Islands etc.

7. **Caulerpa Ashmeadi** Harv.

HARVEY, Nereis Boreali-Americana, p. 18. pl. 28, fig. A.
J. AGARDH, Till Algernes Systematik, I, p. 16.

This splendid species I have found several times in the sea around St. Thomas and St. Jan. It is distinguished by its distichous, sometimes spread, sometimes oppositely placed ramuli. These are cylindric-conical as the figure 12 shows, being evenly thicker upward with the apex stubby, rounded. The species seems to vary very little, only regarding the size there is some variation. The largest specimens I have found do not quite reach the size of HARVEY's plant, the smallest were only 3 cm. high and the whole plant both the rhizome and the leaves were proportionally small.

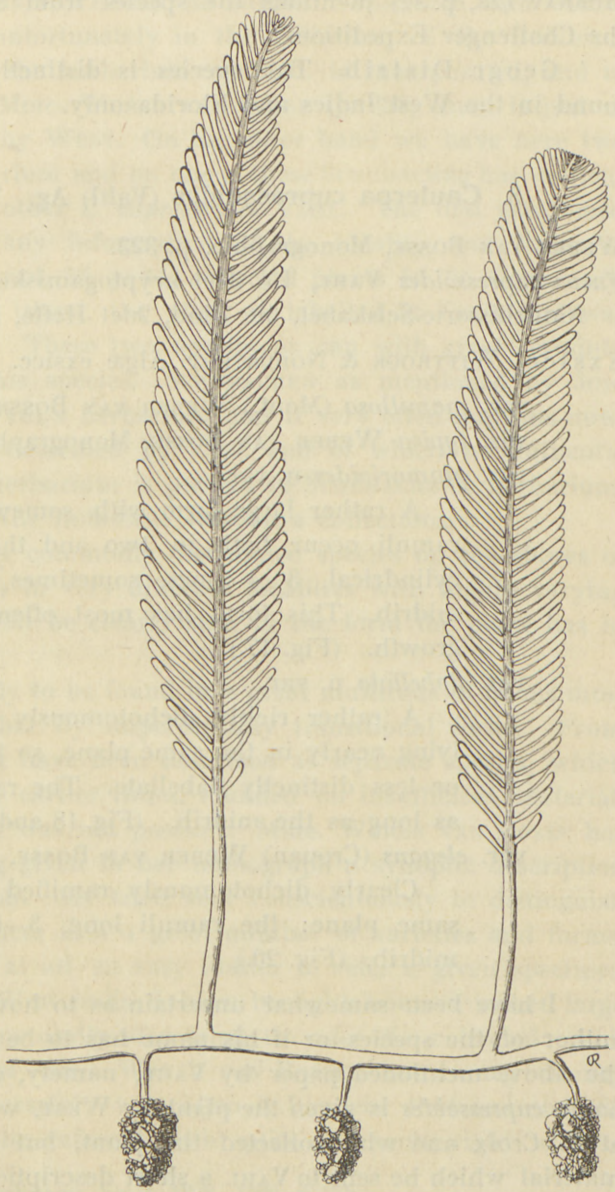

Fig. 12. *Caulerpa Ashmeadi* Harv.
In deeper water off America Hill (St. Jan). (About 1 : 1.)

The plant is found in a depth of about 20—30 meters where it creeps on the sandy bottom.

It has hitherto been found: at St Thomas in the sea west of Water Island; St. Jan in the sound between St. Thomas and St. Jan off Christiansfort; in the sea to the north of St. Jan west of Tortola and off Moho Bay and Linster Bay. MURRAY (23, p. 32) mentions the species from St. Thomas where it was found by the Challenger Expedition.

Geogr. Distrib. This species is distinctly Atlantic-American species and is found in the West Indies and Florida only.

8. **Caulerpa cupressoides** (Vahl) Ag. WEBER VAN BOSSE emend.

WEBER VAN BOSSE, Monographie, p. 323.

Fucus cupressoides VAHL, En deel kryptogamiske Planter fra St. Croix. Skrivter af Naturhistorie-Selskabet, 5te Bind, 2det Hefte, Kiøbenhavn 1802, p. 29.

Exsicc. WITTROCK & NORDSTEDT. Algæ exsicc.

var. *mamillosa* (Mont.) WEBER VAN BOSSE, Monographie, p. 332. (Fig. 13.)

var. *typica* WEBER VAN BOSSE, Monographie, p. 327. (Fig. 14, 15, 16.)

var. *plumarioides* n. var.

A rather large form with somewhat flabby, spread branches. The ramuli occur both in two and three rows; they are bent upward, cylindrical, 3—4 times, sometimes even longer, the breadth of the midrib. This form has most often a very clearly marked periodical growth. (Fig. 17.)

var. *flabellata* n. var.

A rather richly dichotomously ramified form with the branches lying nearly in the same plane, so that the erect shoot becomes more or less distinctly flabellate. The ramuli are rather short, 1—3 times as long as the midrib. (Fig. 18 and 19.)

var. *elegans* (Crouan) WEBER VAN BOSSE, Monographie, p. 336.

Clearly dichotomously ramified with the branches lying in the same plane; the ramuli long, 3—6 or more times longer than the midrib. (Fig. 20.)

I have been somewhat uncertain as to how far VAHL is really to be kept as author of the species or if his name has to be replaced by WEST. If we look in the above mentioned paper by VAHL, namely, we find not only that the species-name *cupressoides* is given the plant by WEST, who was a teacher in Christianssted at St. Croix and who collected the plant, but that he also transmitted with the material which he sent to VAHL a short description, which is reprinted by the latter. In retaining VAHL as the author of the species my view is that the species must be said to be described under the authority of this author. VAHL also writes in the

title of his paper: Plants etc. described by MARTIN VAHL. WEST is surely only to be considered as the collector; as information to VAHL on collecting the plant he wrote a short description of the plant and amongst other things gave it the very appropriate designation *cupressoides* which VAHL has also used as species-name, after assuring himself that it had not been used earlier.[1])

As emphasised by Mme. WEBER VAN BOSSE, no authentic specimen with VAHL's own handwriting is to be found unfortunately in the collection of the Botanical Museum in Copenhagen in which the herbarium of VAHL is incorporated, and in contradiction to the indication of Mme. WEBER VAN BOSSE (p. 328) there is just as little any specimen authenticated by WEST. On the other hand we have here two specimens from SCHUMACHER's herbarium and on one of these SCHUMACHER has written: *C. cupressoides* WEST, and on the other *C. cupressoides* VAHL. The first mentioned was collected by RYAN without any information of the locality, but RYAN, as mentioned in Botanisk Tidsskrift, vol. 23, p. 44, collected plants in St. Croix so it can very well originate from this island, the other is labelled St. Croix and was most probably collected by WEST. These two specimens can with great certainty be considered as the types for this species. SCHUMACHER as mentioned by JOH. LANGE[2]) received duplicates from VAHL's herbarium and it very often happens now, that a specimen which has been described by VAHL and of which no authentic specimens are to be found in his herbarium is present in SCHUMACHER's herbarium, which is likewise incorporated in the Botanical Museum's collections.

Caulerpa cupressoides is a very commonly distributed species on the shores of the Danish West Indies and occurs in very different localities with highly varying external conditions of life; this can be clearly seen in the form the plant has in a given locality.

Caulerpa cupressoides is namely to be found in a great multitude of forms most often mutually united to each other by imperceptibly transitional forms. From time to time several of these forms have been described as separate species, which were naturally often, especially in earlier times, founded on insufficient material, so that a comparative examination was not possible. Mme. WEBER VAN BOSSE has therefore the great merit of having given in her monograph a synoptic description of this great multitude of forms; she has tried very conscientiously to distinguish the one from the other, dividing them into a great number of varieties and forms. Nevertheless, it is very often not at all an easy matter to refer a given specimen to a certain form. From Danish West India I have brought home a rather large material of this species and have naturally also tried to refer the collected specimens to the varieties and forms of Mme. WEBER VAN BOSSE; but I may confess that I have not always been successful; very often it happens that one and the same specimen seemingly might be referred with quite the same right to two,

[1]) Cfr. for the rest: URBAN, Symbolæ Antillanæ, Vol. I, 1898—1900, p. 175.

[2]) JOHAN LANGE: Erindringer fra Universitetets botaniske Have ved Charlottenborg 1778—1874 (Bot. Tidsskrift, 3. Række, 1. Bind, 1876, p. 53).

sometimes to several forms, as Mme. WEBER VAN BOSSE herself indeed has emphasised over and over again.

I have therefore given up trying to refer the single specimen to these, often only very little different forms, and prefer to divide them into groups according to the external conditions under which they live, at the same time pointing out the forms which occur in the different localities. By means of my investigations in nature I believe, namely, that I have come to a clear understanding, that the different forms, for a great part at least, are only to be considered as ecological adaptions to this or that locality, as they are greatly restricted to certain localities each with its own peculiar conditions of life.

Several of the forms which occur at each of the different localities may by themselves be very diverse, so that one could perhaps entertain doubts whether it was not most correct to consider them as separate species; but on the other hand, they are commonly so connected with intermediate forms, often the same specimen shows so considerable variation in the one or other direction, that it seems to me until further information is obtained most natural to keep them together. We can only settle the matter definitely by the help of artificial culture experiments, e. g. transplant specimens from exposed to sheltered localities and vice-versa, an experiment which would surely not be difficult in practice. Should it then appear that a certain form even after having been cultivated for some time had not changed its external form, it would most probably be right to consider such a fixed form as a species. Unfortunately I only stayed a short time in the different parts of the islands and it was therefore impossible for me to untertake such experiments.

Besides the large number of forms which were already referred by Mme. WEBER VAN BOSSE to *C. cupressoides*, it cannot be denied that several forms referred to other species also show an exceedingly great likeness with *C. cupressoides*. This is, for example, the case with *Caulerpa Lessonii* f. *tuticorinensis* described by SVEDELIUS; it must be admitted that the figure of SVEDELIUS (l. c. p. 117, fig. 12) shows an exceedingly great likeness to *C. cupressoides*. SVEDELIUS is of opinion that the difference between the two species must especially be looked for in the fact that *C. Lessonii* has a broader midrib up to 2 mm. in breadth, and as shoots with such a broad midrib are now and then, though far from always, e. g. not at all in the specimens in the herbarium of AGARDH in Lund, present in the specimens of FERGUSON he has referred these specimens to *C. Lessonii*. Mme. WEBER has considered FERGUSON's alga as a form of *C. plumifera* which species SVEDELIUS however considers as a synonym to *C. Lessonii*. As I have no material of this form I shall not discuss the matter further here; so much may be said: *C. Lessonii* and *C. cupressoides* are in form very nearly related, as SVEDELIUS also seems to suppose when he writes: "It seems to me not improbable that perhaps several of these forms classed by WEBER VAN BOSSE among the comprehensive *C. cupressoides* might with equal reason be transferred to the *Lessonii* group".

Further we have some forms which Mme. WEBER VAN BOSSE has referred to

C. Urvilliana which are very similar to *C. cupressoides*; it is especially the forms which she has referred to forma *tristicha* (cfr. WEBER VAN BOSSE, Monographie, pl. XXVI, fig. 8 a and b and fig. 9; especially the last mentioned figure), which remind one much of var. *flabellata* described by me. Finally, certain forms of *Caulerpa Freycinetii*, especially the forms Mme. WEBER VAN BOSSE refers to the var. *pectinata*, show a great likeness to *C. cupressoides*, as she also has emphasized herself, and in this connection I can quite agree with her statement (l. c. p. 316): "Il est presque impossible de tracer une limite entre ces algues, car plus on cherche, plus on trouve de formes intermédiaires qui effacent les distinctions qu'on croyait avoir trouvées". So long as we do not have experimental cultures to rely upon, our limitations of the species and forms in such a numerous group as *C. cupressoides* will always be very much a matter of chance.

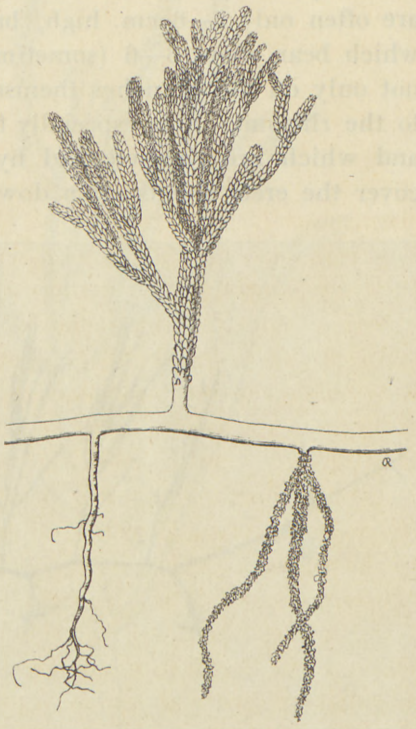

Fig. 13. *C. cupressoides* (Vahl) Ag. var. *mamillosa* (Mont.) Weber van Bosse. From shallow water. Longford (St. Croix). (About 1 : 1.)

In passing now to a more detailed description of the forms I have found in Danish West India, I may just mention that each of these is directly connected with a definite locality. Regarding the localities I may here refer to what I have said on this matter in the introduction. I need only mention here, that *Caulerpa cupressoides* is to be found on more exposed coasts behind the coral reefs creeping here in dazzling white coral sand, that it occurs in sheltered localities in the interior of the lagoon in the often very muddy water we find there, growing in the soft muddy bottom, and finally that it is found in deeper water down to a depth of about 20—30 meters; but just as there is a very even and gradual change between these in themselves very different localities, in the same way the forms of *C. cupressoides* in the different localities are united by transitional forms. But it is just in the above-named localities, where the conditions of life are so very dif-

Fig. 14. *C. cupressoides* (Vahl) Ag. var. *typica* Weber van Bosse. In shallow water. Protestant Cay (St. Croix). (About 1 : 1.)

ferent, that we find the types of alga round which the remaining forms group themselves in a natural way.

If we now first consider the specimens we meet with in the more exposed localities behind the coralreefs, it will appear that these are characterized by being relatively small, but on the other hand rather strongly developed. The erect shoots are often only 5—6 cm. high, but richly ramified with densely-crowded branches, which bear about 3—6 (sometimes still more) rows of ramuli. These are present not only on the branches themselves but also often on the main shoot quite down to the rhizome. It is especially forms of the var. *mamillosa* (Fig. 13) we have here and which are characterized by the short obovate, densely-placed ramuli which cover the erect shoots often down to the rhizome (see Fig. 13, cfr. also Weber, 34, Pl. XXVIII, fig. 3 5 and 6).

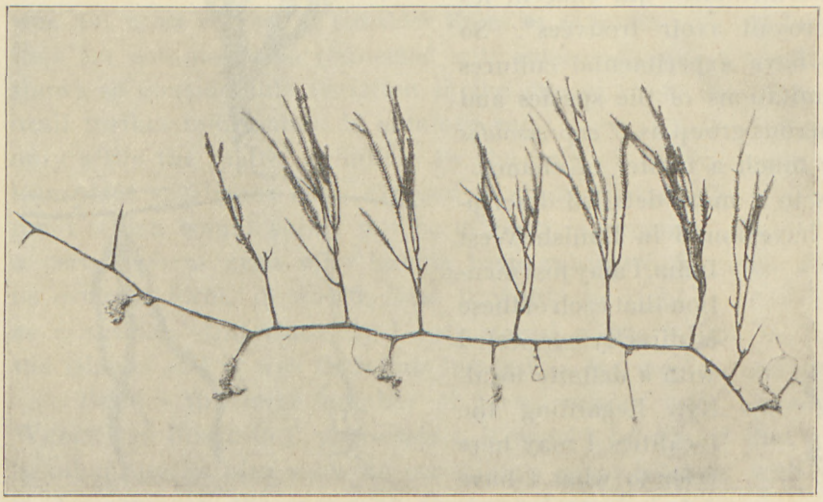

Fig. 15. *Caulerpa cupressoides* (Vahl) Ag. var. *typica* Weber van Bosse. In shallow water. The lagoon of Christianssted. (About 1 : 4.)

When the ramuli are a little longer and more widely placed, being commonly 3 or 4 rows, we get forms of the var. *typica* (Fig. 14), which also occur in these localities, perhaps however in places a little more sheltered or in deeper water. Even small differences in the local conditions of life seem often to give a corresponding difference in the specimens occurring. On the shores of the pilot isle, Protestant Cay as it is called, at Christianssted, I have thus found in shallow water near the surface of the sea, where it was somewhat exposed, a low compact form with 4—5 rows of ramuli, which in my opinion must be considered as an intermediate form between var. *mamillosa* and var. *typica*; but further from the shore where the bottom fell steeply, the var. *typica* was growing in about 6—8 feet of water with only about 3 rows of somewhat longer ramuli. Fig. 14 shows one of the forms of var. *typica* we meet here; compare also Mme. Weber van Bosse, Monographie, pl. XXVII. fig. 1 and especially pl. XXVIII, fig. 1.

I have not found any specimens which I believe might be referred to the typical var. *ericifolia* (cfr. Weber van Bosse, Monographie, p. 335, pl. XXVIII, fig. 8) and I cannot therefore from personal observation say where this form has its real habitat;

most probably it is however in the same locality, judging from a specimen which Dr. MARSHALL A. HOWE has most kindly sent me. It was collected in the Bermuda Islands and as to the locality he writes: "In a tide-pool". On the other hand I have some specimens from Danish West India which are intermediate between var. *mamillosa* and var. *ericifolia* and which are found in these more-exposed localities.

If we now go to the more sheltered localities and first consider those, where the water is still clear, we find here specimens whose erect shoots are about 6—12 cms. high, more or less richly ramified and with rather spread branches (see Fig. 15 and 16). These bear commonly 3 rows of ramuli, more seldom a higher number; often especially in the upper part of the branches however we find only two rows. The ramuli are ovate to oval-cylindrical or quite cylindrical with a short spine at the apex; they are commonly about twice as long as the breadth of the midrib and in the distichous branches often opposite. The forms we meet with here are of the var. *typica* and commonly agree with the figures 2 and 3 in Plate XXVII in Mme. WEBER'S Monograph and with REINKE'S figure 42, l. c. If we pass further into the lagoon where the water is often muddy and the light therefore less, the forms become gradually larger

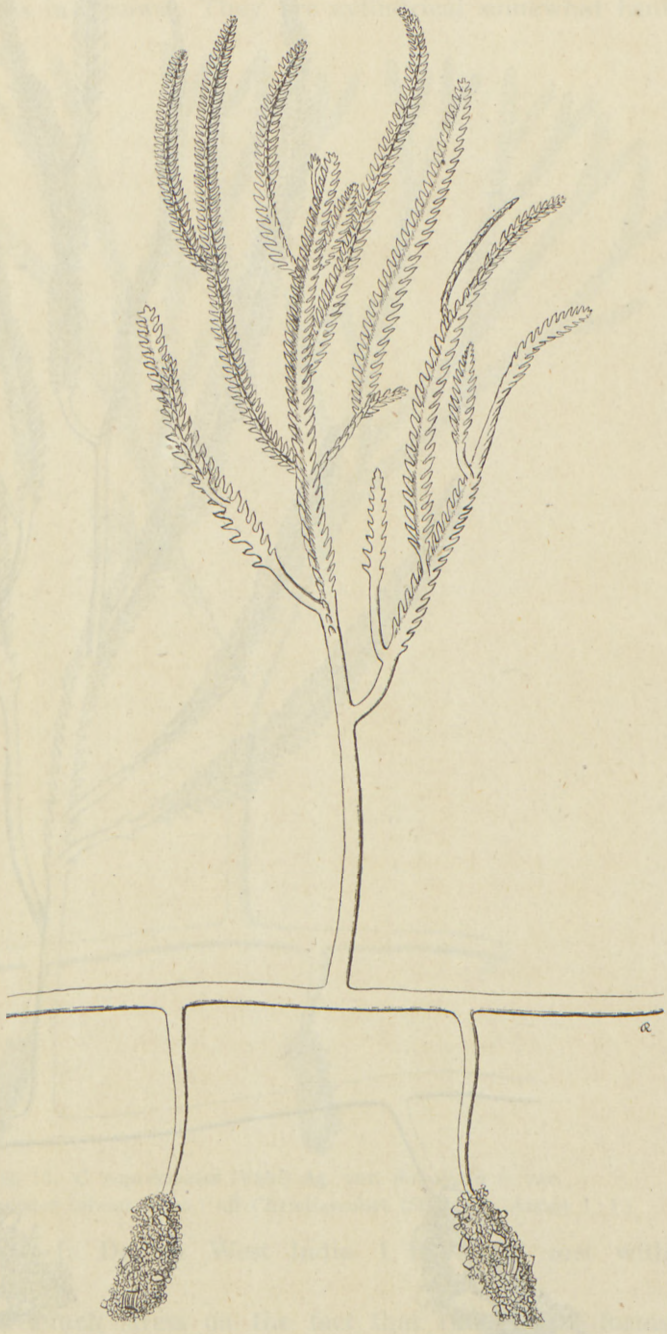

Fig. 16. *C. cupressoides* (Vahl) Ag. var. *typica*. In shallow water. The lagoon of Salt River (St. Croix). (About 1:1.)

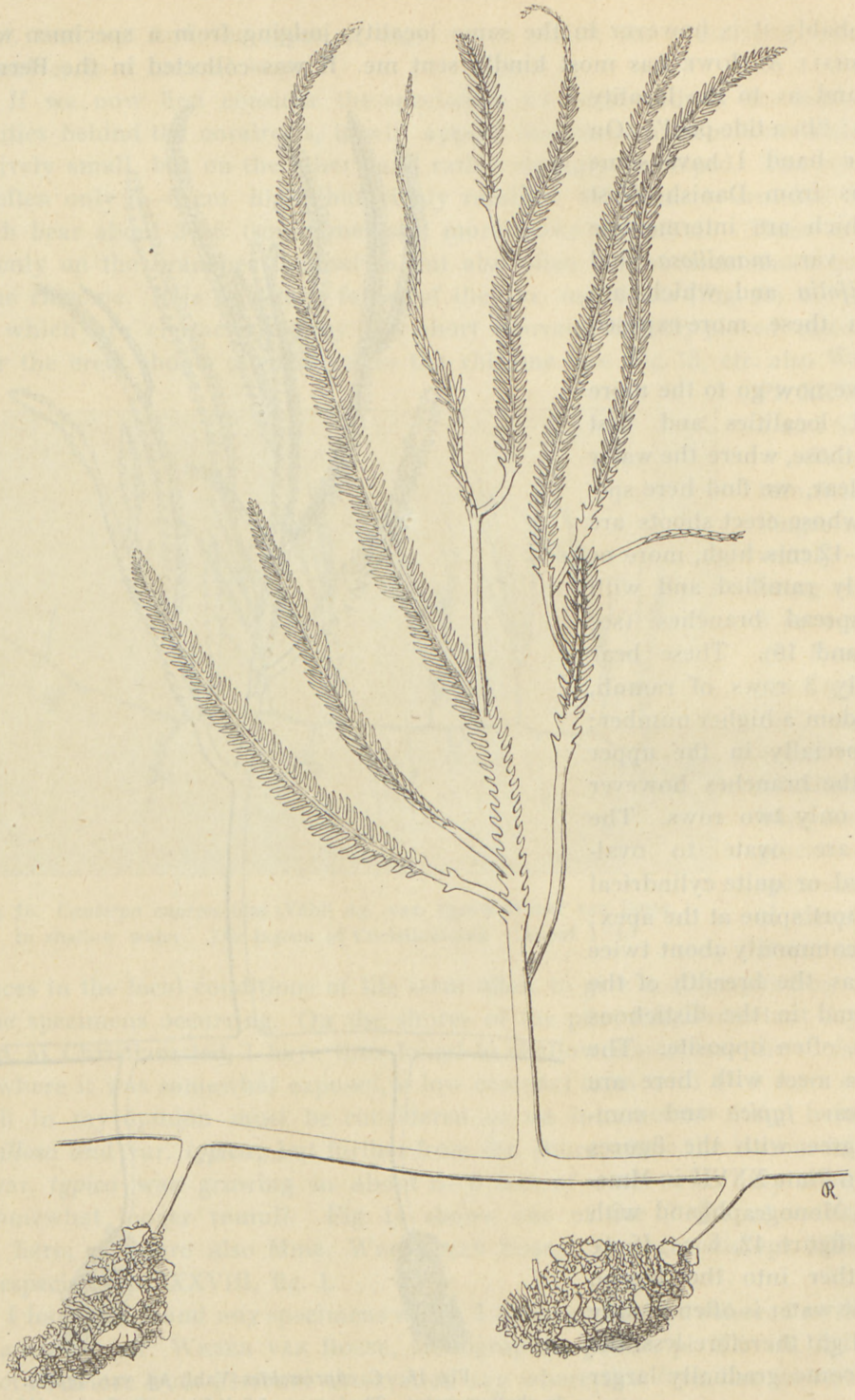

Fig. 17. *C. cupressoides* (Vahl) Ag. var. *plumarioides* n. var.
In shallow water from the lagoon of Christianssted. (1 : 1.)

up to 20 cm. high sometimes even higher and moreover more flabby; commonly they are also less ramified. The branches are somewhat spread out having the ramuli placed sometimes in 3 sometimes in 2 rows. They are cylindrical somewhat bent upwards, 3—4 times the breadth of the midrib, often even more. These forms have a great likeness to the figures 8, 12 and 13 of pl. XXVII and figures 10 and 12 of pl. XXVIII in Mme. WEBER VAN BOSSE's Monograph. These specimens I propose to call var. *plumarioides* (Fig. 17). They are the forms which Mme. WEBER VAN BOSSE has called f. *elegans*, f. *alternifolia* and f. *amicorum*, and are referred by her to the var. *lycopodium*, This name I prefer to use only for the typical form (*C. Lycopodium* J. Ag.) which is characterized by having the long cylindrical ramuli placed in several rows. Beautiful specimens of this form are present in Mme. WEBER's Herbarium originating from the Barbados, where they were collected by Mll. VICKERS. In Danish West India I have not met with this form.

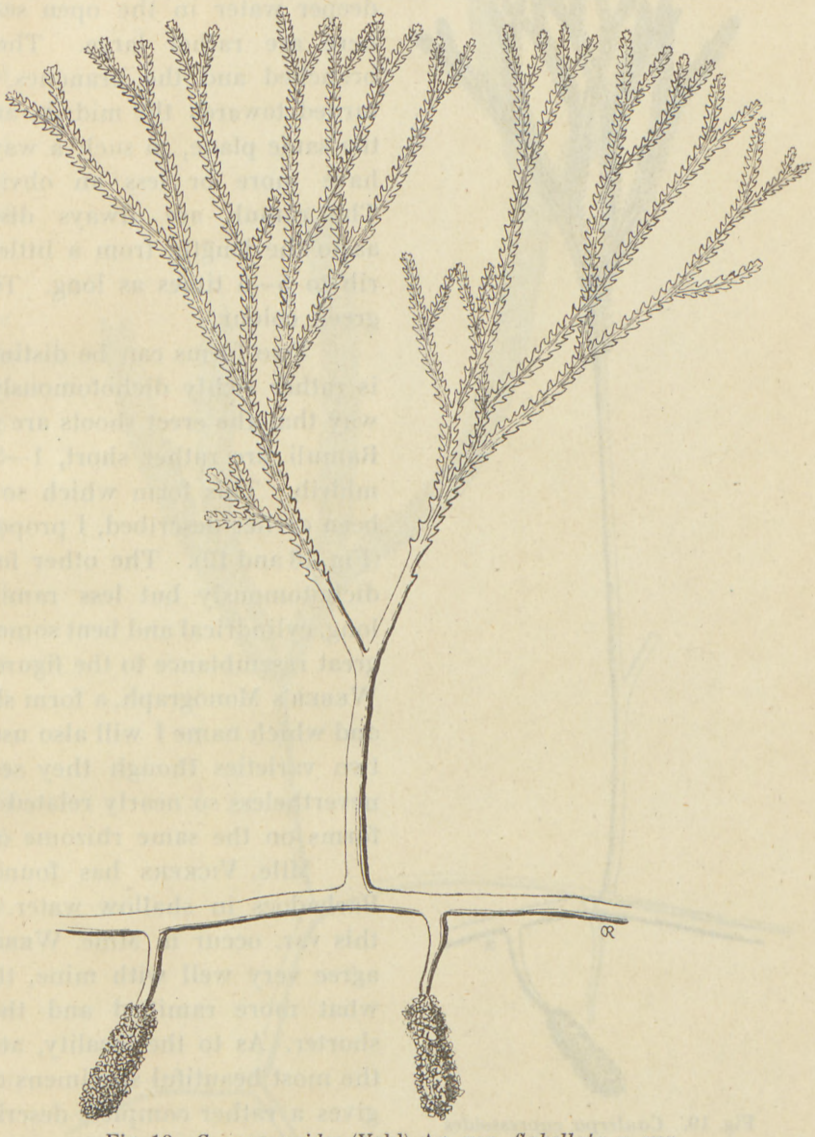

Fig. 18. *C. cupressoides* (Vahl) Ag. var. *flabellata* n. var.
In deep water (about 20 m.) off Christiansfort (St. Jan). (About 1 : 1.)

I cannot however lay too much stress on the fact that transitional forms occur in great number between the var. *typica* and var. *plumarioides* and for a

great number of my specimens e. g. from Christianssteds Lagoon, it is impossible to decide to which form they belong.

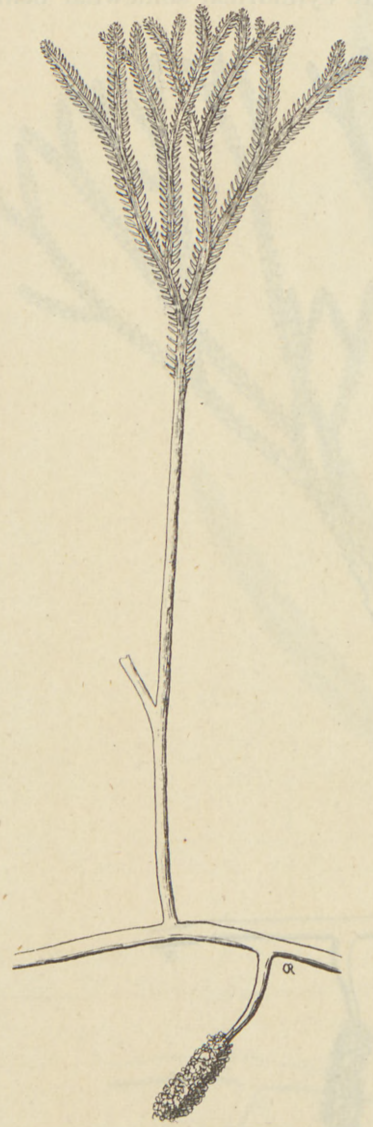

Fig. 19. *Caulerpa cupressoides* (Vahl) Ag. var *flabellata* n. var. In deep water (about 25 m.) off America Hill (St. Jan). (About 1 : 1.)

Finally, we meet with *Caulerpa cupressoides* in deeper water in the open sea. The forms we find here are rather large. They are dichotomously branched and the branches, which have the edge turned towards the midrib, are all placed in nearly the same plane, in such a way that the erect shoots have more or less an obviously flabellate form. The ramuli are always distichous and variable as to the length, from a little longer than the midrib to 5—6 times as long. The plant is of a fresh-green colour.

Two forms can be distinguished. One of these is rather richly dichotomously branched in such a way that the erect shoots are more or less flabellate. Ramuli are rather short, 1—3 times as long as the midrib. This form which so far I can see has not been earlier described, I propose to call var. *flabellata* (Fig. 18 and 19). The other form is likewise clearly dichotomously but less ramified. The ramuli are long, cylindrical and bent somewhat upward. It has a great resemblance to the figure 9, pl. XXVII in Mme. WEBER's Monograph, a form she has called f. *elegans* and which name I will also use here (Fig. 20). These two varieties though they seem very different are nevertheless so nearly related that one can find both forms on the same rhizome (see Fig. 21).

Mlle. VICKERS has found var. *elegans* at the Barbadoes in shallow water. Several specimens of this var. occur in Mme. WEBER's Herbarium. They agree very well with mine, though generally somewhat more ramified and the ramuli also a little shorter. As to the locality, at Hastings, from where the most beautiful specimens originate, Mlle. VICKERS gives a rather complete description in the introduction to her paper. She writes: "Au bout de la longue plage d'Hastings se trouve le coin délicieux qui se nomme Worthing. C'est un cap formé de grands rochers surplombants, sous lesquels s'étend une petite baie où l'eau peu profonde est toujours calme. Cette baie est encore protégée par un récif". From this it is evident that the plant has been growing in rather shallow water and

further in perfectly quiet water. Whether the water has been clear or not, or whether the plant has grown in more or less shadow from the rocks or stones we do not know. I do not think there has been any great difference between this locality and the growing place in the lagoons where I found var. *plumarioides*, and some of Mlle. VICKERS' specimens show also a considerable resemblance to the broadest specimens from the lagoon, and form in this way a transition to the specimens of var. *elegans* I have found in deep water.

C. cupressoides is a rather common species along the shores of the Danish West Indies.

Var. *mamillosa* is found at St. Croix on the south coast at Longford and on the north side at Cane Bay. Var. *typica*, St. Croix: Christianssted; Saltriver; St. Thomas; The lagoon at Bovoni. Var. *plumarioides*, St. Croix: The lagoons of Christianssted and Saltriver. Var. *flabellata*, St. Thomas: West of Water Island in about 30 m. St. Jan: off Christiansfort in about 30 meters

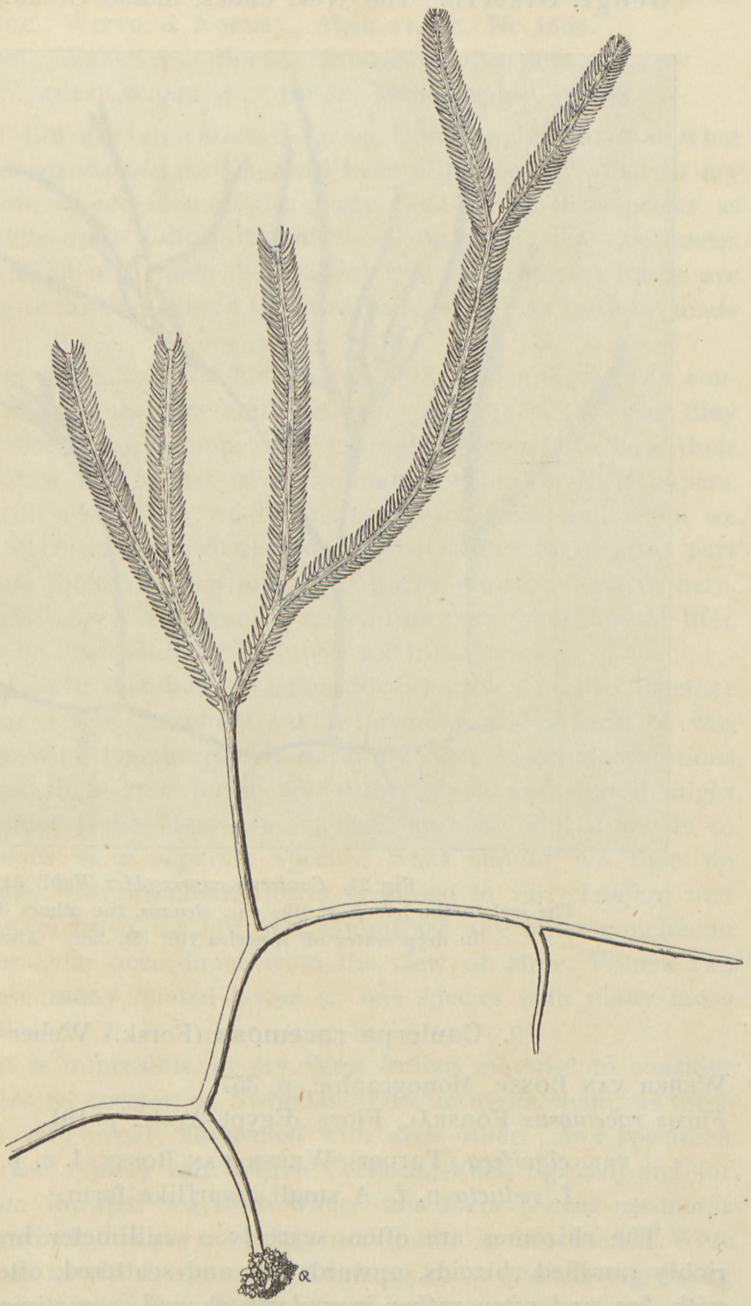

Fig. 20. *Caulerpa cupressoides* (Vahl) Ag. var. *elegans* (Crouan) Weber van Bosse. In deep water (about 25 m.) off America Hill (St. Jan). (About 1 : 1.)

and in Lt. Maho Bay in about 20 meters. Var. *elegans*, St. Jan: America Hill in about 30 meters and in Lt. Maho Bay in about 20 meters.

Geogr. Distrib. The West Indies, Indian Ocean, Pacific.

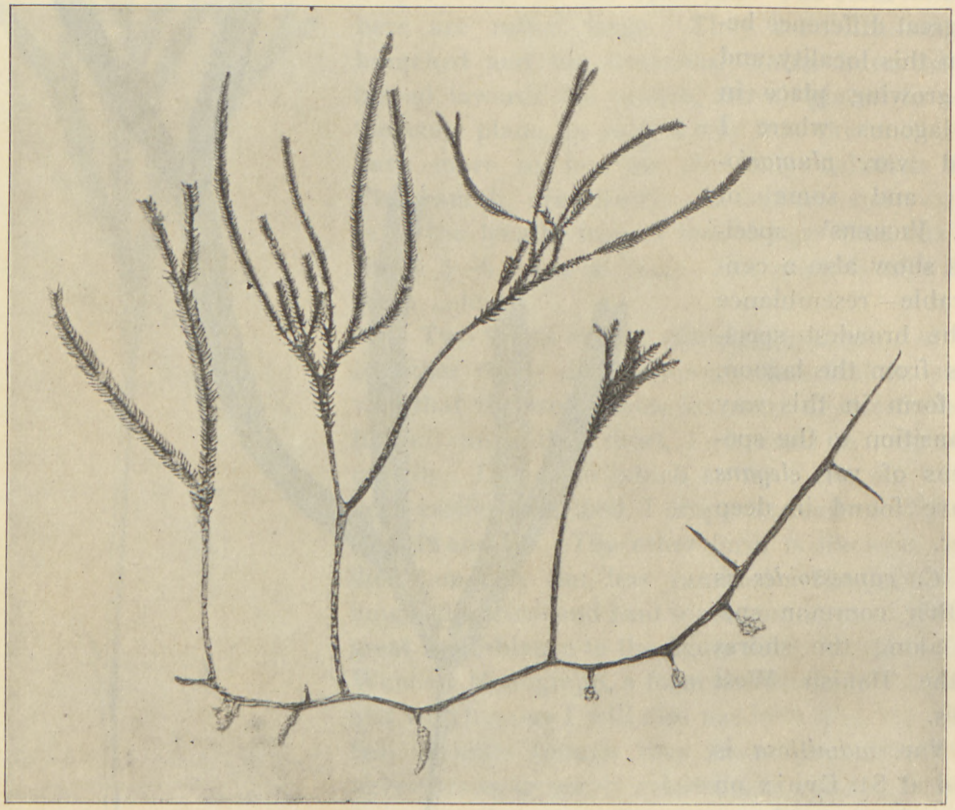

Fig. 21. *Caulerpa cupressoides* (Vahl) Ag.
The leaf to the left most like var. *elegans*, the others like var. *flabellata*.
In deep water off America Hill (St. Jan). (About $^1/_2$: 1.)

9. Caulerpa racemosa (Forsk.) Weber van Bosse.

Weber van Bosse, Monographie, p. 357.
Fucus racemosus Forskål, Flora Ægypt.-Arab., p. 191.

var. *clavifera* (Turner) Weber van Bosse, l. c. p. 361.
f. *reducta* n. f. A small dwarflike form.

The rhizomes are often scarcely a millimeter broad and downwards bear richly ramified rhizoids, upwards few and scattered, often a centimeter high shoots with few and often rather irregularly shaped, sometimes cylindrical ramuli; only seldom has it normal ramuli swollen at the apex.

var. *uvifera* (Turner) Weber van Bosse, Monographie, p. 362.
var. *occidentalis* (J. Ag.). Syn., *C. Chemnitzia β occidentalis* J. Ag., Caulerpa p. 37. Svedelius, l. c. p. 130. *C. racemosa* var. *Chemnitzia*, Reinke, l. c. p. 38, fig. 57. Exsicc. Wittr. & Nordst., Algæ exsicc. Nr. 1586.
var. *laetevirens* Mont., Weber van Bosse, Monographie, p. 366.
var. *Lamourouxii* (Turner) Weber van Bosse, Monographie, p. 368.

Before describing all the above-mentioned forms I may point out that what I have said concerning *C. cupressoides* holds good here also, namely, that in my opinion it seems impossible to consider all the many varieties of this species as separate species; I may thus quite follow the views of Mme. Weber van Bosse. If one has a large material it will soon be evident that the different forms are often united to such a degree by transitions that the boundaries can only be made quite arbitrarily.

It may willingly be granted that the forms which the older algologists considered as species really often seem very well defined. But the fact is that they often had only some few sometimes perhaps only a single specimen to base their species on. It is very often a description of individuals we find in their papers. If we have a large material containing all these many variations, and when we further have good reason to believe that these owe their existence for a great part to the influence of external factors (experimental cultures may be decisive here, we know only how variable *C. prolifera* can be under different conditions of life), then it will soon prove to be impossible to maintain all these species.

It is quite true that I have found in the same locality, even matted together in the same tuft, the two varieties, namely var. *occidentalis* and a form of var. *uvifera* which were thus growing together under quite the same external conditions of life. This goes to show that these forms are rather fixed and that it might therefore be right to consider these forms as separate species. But if we do so and consider var. *occidentalis* as a separate species, what should we then do with the intermediate forms, with which this form is united to var. *clavifera* and var. *uvifera* and to var. *laetevirens*. I for my part cannot see any other conclusion than that it is most natural, in accordance with the view of Mme. Weber van Bosse, to consider all these many related forms as one species with many more or less differentiated varieties.

Thus, I believe that it is impossible in my West Indian material to consider var. *clavifera* and var. *uvifera* as species, as Svedelius tries to make them, as these forms in my material are very evenly connected with each other. Any specimen quite in accordance with the typical var. *uvifera* (Turner, Fuci, fig. 230) and for the rest like specimens from the Red Sea from where this form (*Fucus racemosus* Forsk.) was originally described, I have certainly not found in the Danish West Indies. The typical form is surely a true sand *Caulerpa* most probably growing in shallow water and in strong light; how far it would be most correct to consider this the typical form as a particular species, I shall not try to explain here, having

no knowledge of the appearance and mode of growth of the plant in the living condition; but in advance I am most inclined to believe that Mme. Weber van Bosse is right in considering it as a variety of the comprehensive *Caulerpa racemosa*.

With regard to my West Indian forms of var. *clavifera* and var. *uvifera* they are all to be considered as rock and coral-reef forms, growing generally in quite shallow water often rather exposed to the swell and in intense light. Svedelius who, judging from his figure 15 has had a rather typical form of var. *uvifera* (nevertheless it seems also to be rather near var. *occidentalis*, cfr. Svedelius p. 130), tries in various ways to show differences between the two forms. Thus he writes (pag. 122): "What constitutes the main difference between the *clavifera* and the *uvifera* series is that in the latter (Fig. 15) the vertical axes (assimilators Reinke) reach a higher degree of development, while at the same time they are not so close. They are, as a rule, somewhat longer and have more numerous extremely close branchlets, which are situated around the vertical main axis". This is indeed quite in accordance with my view when we consider typically developed specimens, but nevertheless numerous specimens are to be found which may be called *clavifera* but have well developed erect shoots. The figure of *Fucus clavifer* Turner has really also very well developed erect shoots. The main point must be laid stress upon, as Svedelius also demonstrates that in var. *uvifera* the ramuli are more closely placed, in var. *clavifera* more open. The forms delineated here (Fig. 22 and 23) of var. *uvifera* I therefore do not consider as specially typical even if the assimilators are very well developed, the ramuli being rather openly placed, and further it had very densely placed assimilators, growing as it did in a rather compact tuft.

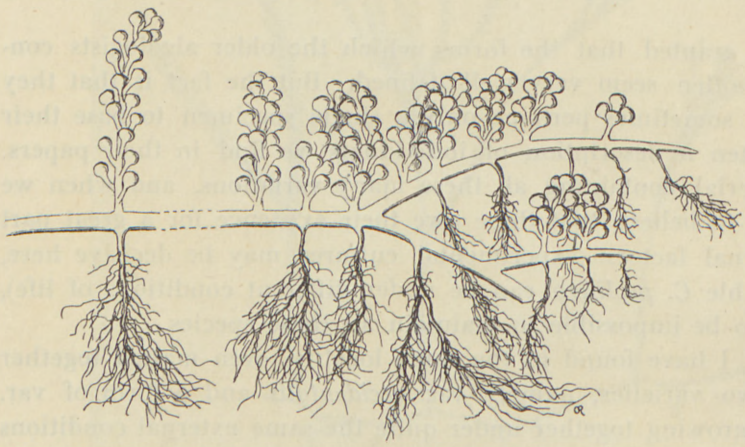

Fig. 22. *Caulerpa racemosa* (Forsk.) Weber van Bosse var. *uvifera* (Turner) Weber van Bosse. From Longreef (St. Croix). (About 1 : 1.)

Svedelius then looks for a difference in the root-system between the var. *uvifera* and var. *clavifera*; the first one is said to have a very strongly developed root-system, the last mentioned a feeble one and the reason for this is said to be that var. *uvifera* grows in sand and mud, whereas var. *clavifera* is to be found on stone and corals. But such a difference I have in no way found in my West Indian forms, which all generally possess a very well developed root-system; in this con-

nection I need only refer to Nr. 1204 in WITTROCK & NORDSTEDT, Algæ exsiccatæ, where I have published a form of *Caulerpa racemosa* var. *clavifera* which has a very well developed root-system and which form SVEDELIUS l. c. p. 121 approves to be var. *clavifera*. That this form is common on coral-reef and rocky shores and that on the other hand the typical var. *uvifera* from the Red Sea is a sand plant is quite right. SVEDELIUS found var. *uvifera* on loose bottom consisting of mud mixed with sand, and the specimens I have seen of the typical var. *uvifera* belonging to the Botanical Museum in Hamburg were collected by SCHIMPER "in arena repens, 3—4 Fuss tief". The typical var. *uvifera* is most probably, as mentioned above, a form growing in intense light on the white coral-sand and on rather open shores; but under such conditions I have never met with *C. racemosa* var. *uvifera* in Danish West India where it is always found in shallow water growing on rocks or coral-reef. Typical var. *uvifera* like TURNER's figure I have as mentioned not found in the Danish West Indies. This form is as pointed out by Mme. WEBER VAN BOSSE (l. c. p. 363) characterized: "par son port plus robuste, et ses ramules serrés, en général de forme obovoïde, et assez grands". The forms I have referred to var. *uvifera* are most like f. *intermedia* Web. van Bosse (l. c. pl. XXXIII, fig. 24 a) distinguished by the ramuli being rather long-stalked with a ball-shaped swelling at the apex. As the name indicates, this is to be considered as an intermediate form between the typical var. *uvifera* and var. *clavifera* (see my fig. 22 & 23) and is at least the West Indian form connected by numerous intermediate forms to the var. *clavifera*. Some flattening of the ramuli as mentioned by Mme. WEBER VAN BOSSE and also found by SVEDELIUS who gives this form the name *planiuscula* I have never seen in the West Indies.

Fig. 23. *Caulerpa racemosa* (Forsk.) Weber van Bosse var. *uvifera* (Turner) Weber van Bosse. From Cruz Bay (St. Jan). (About 1 : 1.)

Var. *clavifera* is characterized by shorter erect shoots and especially by the fact that these have fewer ramuli. In somewhat exposed localities it often forms on rocks and coral-reef large flat tufts, which on the upper side consist of the densely placed, grape-like short erect shoots, on the downward side of the close tissue of the rhizomes, which twisted and entangled together form the underside of the tufts and by means of numerous finely ramified rhizoids are firmly fastened to the sub-

stratum. The grape-like short assimilators are thus put together nearly in a horizontal layer on the surface of the patches (Fig. 24 and 25), as is described by SVEDELIUS p. 120 and as I have already myself mentioned briefly in my paper (5, p. 51).

The locality gradually becoming more exposed the erect shoots grow shorter and shorter and the plant on the whole smaller. As the assimilators often consist only of a single ramulus and are at the same time more and more distantly placed, the plant becomes like the figure 26, where one sees between the assimilators the

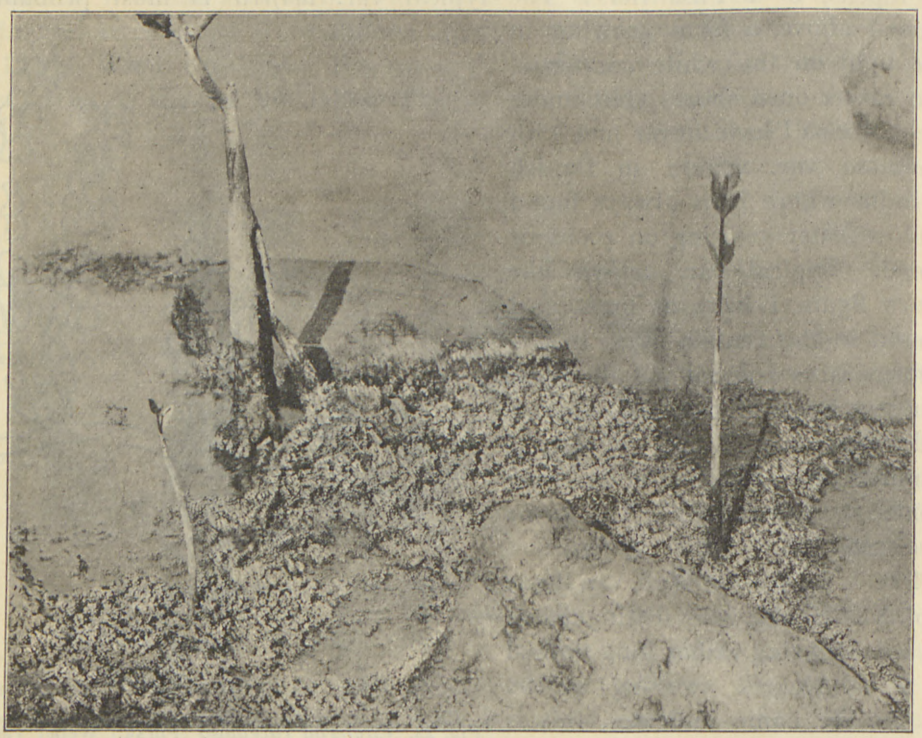

Fig. 24. *Caulerpa racemosa* (Forsk.) Weber van Bosse var. *clavifera* (Turner) Weber van Bosse. Growing on cliffs of coral in the bay behind Christiansfort (St. Jan). F. B. fot.

numerous densely entangled rhizomes. The figure shows a little piece of a large tuft preserved in formalin; the tuft has over the whole the same appearance as the small compact part shows. On especially exposed localities the assimilators grow smaller and smaller, at the same time being less numerous; in such localities the plant nearly entirely consists of the rhizomes.

In the most exposed localities the plant becomes so reduced and different in appearance that I will describe it as a special form: f. *reducta* (Fig. 27). This form is characterized by its in all respects dwarf-like organs. The rhizomes are scarcely a millimeter thick and bear on the downward side numerous richly ramified

rhizoids, by means of which it is firmly fastened to the substratum. On the upward side the rhizomes are either naked or have short often only a centimeter high assimilators with more or less irregularly shaped, often nearly cylindrical ramuli; only more seldom do we find more normally developed ramuli swollen at the apex. The ramuli often grow out to new rhizomes (see Fig. 27 *d* and *e*) and contribute thus to producing the entangled tissue of the rhizomes. This form was found in large mats covering the most exposed places where *Caulerpa* is to be found at all. The sea breaks fiercely over the alga which motionless bids defiance to the waves and just in its firmness possesses the necessary protection. Following the plant from these the most exposed places to more sheltered we have the most even transitions to the typical form of var. *clavifera*.

Fig. 25. *Caulerpa racemosa* (Forsk.) Weber van Bosse var. *clavifera* (Turner) Weber van Bosse. From Longreef (St. Croix). Creeping on a dead coral and intermingled with a Corallinacé. (About 1 : 1.)

Of all Caulerpas occurring in the Danish West Indies, this is certainly the one which can grow in the most exposed places, and it is therefore of interest to make a comparison with *C. lætevirens* f. *laxa* of SVEDELIUS growing in the most exposed places of all Caulerpas living in Ceylon. In the way in which these two forms are fitted to grow

Fig. 26. *Caulerpa racemosa* (Forsk.) Weber van Bosse var. *clavifera* (Turner) Weber van Bosse. From the reef between the Hurricane Island and St. Thomas. (About 1 : 1.)

in these exposed places they show themselves as complete contrasts. For, while var. *clavifera* f. *reducta* as mentioned above behaves quite passively against the sea, fastened motionless to the rocks and admitting the waves to run over it, *Caulerpa lætevirens* f. *laxa* takes part in the motion of the sea as its "slender assimilators swing to and fro in the waves" (SVEDELIUS, p. 124). It reminds one here as SVEDELIUS has pointed out (p. 85) of different algal associations from northern seas, which can be designated by the name used by GRAN "Bølgeslagsformationer" (wave-beaten formations) while f. *reducta* on the contrary may rather be compared with the crust-algæ occurring often on the beach.

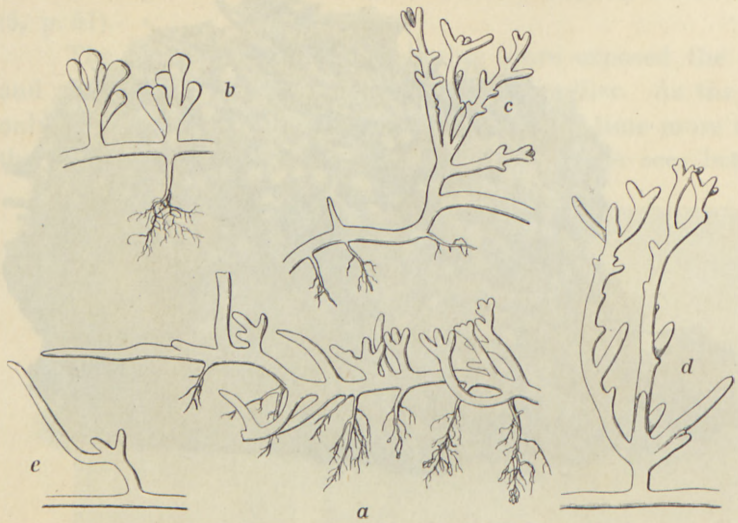

Fig. 27. *Caulerpa racemosa* (Forsk.) Weber van Bosse var. *clavifera* (Turner) Weber van Bosse f. *reducta* n. f. From the reef between the Hurricane Island and St. Thomas. (About 5 : 1.)

Yet a third form of *Caulerpa racemosa* is found on rocks and coral-reefs, namely, the form to which I have above given the name var. *occidentalis* (Fig. 28). This variety which I earlier in agreement with REINKE referred to var. *Chemnitzia* and under which name I have distributed it in the Exsiccatæ of WITTROCK & NORDSTEDT, I now believe on more thorough examination to be separated from the *Chemnitzia*-group and that it should be considered as a special variety. I have used the name of J. AGARDH for it, as I think it is without doubt that my form is identical with the form of AGARDH, as SVEDELIUS (l. c. p. 130) has also maintained. J. AGARDH gives the following short dia-

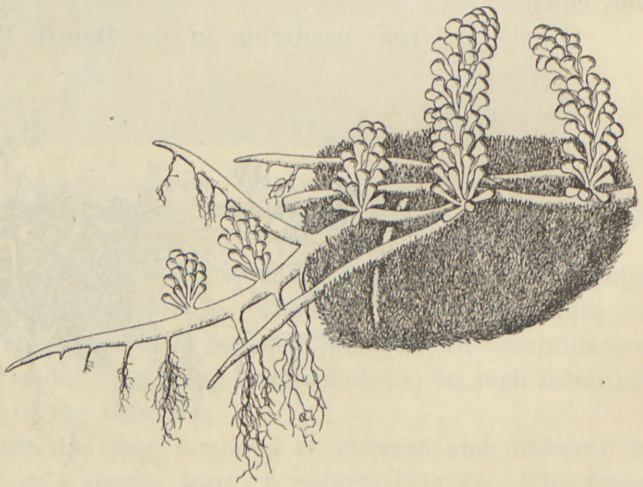

Fig. 28. *Caulerpa racemosa* (Forsk.) Weber van Bosse var. *occidentalis* (J. Ag.). From Longreef, St. Croix. Creeping on a piece of a Corallinacé. (About 1 : 1.)

gnosis (l. c. p. 37): "frondibus erectiusculis fere clavæformibus, inferne laxe ramentaceis superne dense imbricatis". And in the description further down on the page he adds: "In forma *occidentali* sæpius ramenta ad rachidis partes supremas densiora, immo dense imbricata fiunt, parte apotheciiformi extrorsum oblique versa, rachides ita omnino obtegentia; frondes his locis immo digitum minorem crassæ". From var. *Chemnitzia* this form differs by having the uppermost swollen part of the ramuli convex and not more or less disciform or even concave. The lowest ramuli

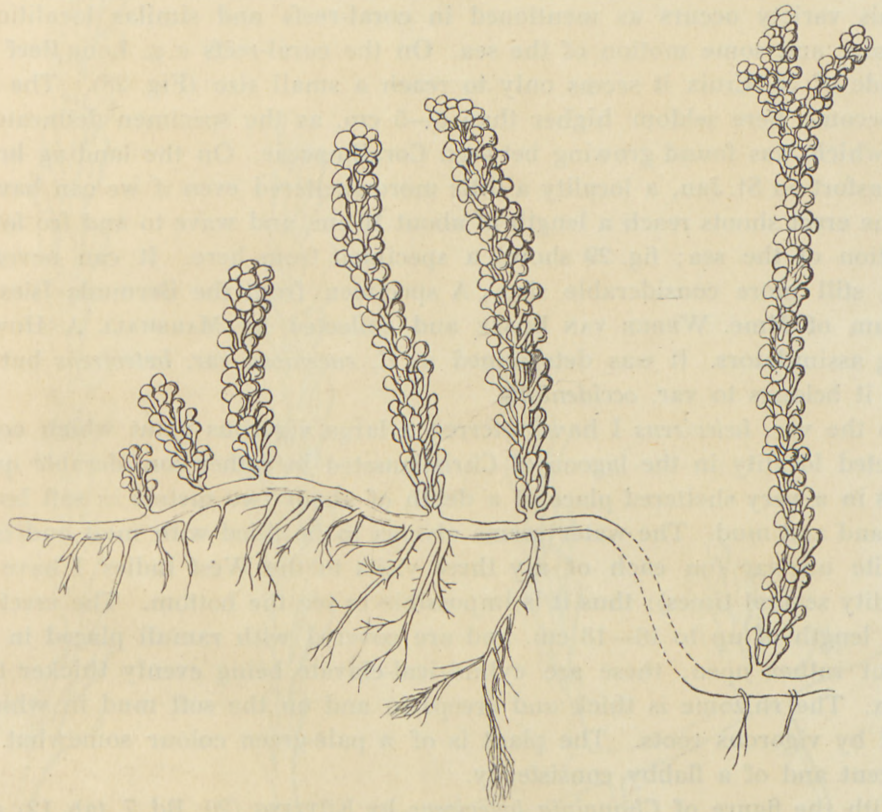

Fig. 29. *Caulerpa racemosa* (Forsk.) Weber van Bosse var. *occidentalis* (J. Ag.). From Christiansfort (St. Jan). (About 1 : 1.)

are commonly more or less cylindrical, higher up they become more and more swollen at the apex; they have a rather long thin stalk often over $^3/_4$ of the length of the whole ramulus and then swell suddenly. The swollen part is flattened convex in the uppermost, outwardly bent side. The figure quoted of REINKE gives a very good illustration of this variety; cfr. also the figures given here (Fig. 28 and 29). SVEDELIUS has delineated (l. c. fig. 30) a related form from Ceylon, which shows a transition to var. *uvifera* and he is of the opinion that it is probably such forms which have caused Mme. WEBER VAN BOSSE in her Monograph to refer var. *Chemnitzia* to *C. racemosa* and not to *C. peltata*. For the rest Mme.

WEBER VAN BOSSE does not mention var. *occidentalis* J. Ag. in her Monograph nor does she give var. *Chemnitzia* from the West Indies, where the true var. *Chemnitzia* perhaps also does not occur.

This variety besides often showing a great resemblance to var. *uvifera* can also bear a great likeness to var. *lætevirens* Mont.; but while the characteristic for this form is, that the ramuli are, either cylindrical or grow evenly thicker upwards the ramuli in var. *occidentalis* become suddenly swollen at the apex.

This variety occurs as mentioned in coral-reefs and similar localities with fresh water and some motion of the sea. On the coral-reefs e. g. Long Reef on the north side of St. Croix it seems only to reach a small size (Fig. 28). The assimilators become here seldom higher than 3—5 cm. as the specimen delineated here shows, which was found growing between Corallinaceae. On the landing bridge at Christiansfort on St. Jan, a locality a little more sheltered even if we can have some surge, the erect shoots reach a length of about 10 cm. and wave to and fro following the motion of the sea; fig. 29 shows a specimen from here. It can nevertheless reach a still more considerable size. A specimen from the Bermuda Isles in the herbarium of Mme. WEBER VAN BOSSE and collected by MARSHALL A. HOWE had feet-long assimilators. It was determined as *C. racemosa* var. *lætevirens* but in my opinion it belongs to var. *occidentalis*.

To the var. *lætevirens* I have referred a large vigorous plant which occurs in a restricted locality in the lagoon of Christianssted in rather considerable quantity. It grows in a very sheltered place at a depth of about two meters in soft bottom of mixed sand and mud. The water seems always to be filled with mud and is therefore quite unclear (on each of my three visits to the West Indies I have visited the locality several times); thus it is impossible to see the bottom. The erect shoots reach a length of up to 16—18 cm. and are covered with ramuli placed in several rows but rather open; these are cylindrical-clavate being evenly thicker towards the apex. The rhizome is thick and creeps in and on the soft mud in which it is fastened by vigorous roots. The plant is of a pale-green colour somewhat glassy, translucent and of a flabby consistency.

With the figure of *Chauvinia lætevirens* by KÜTZING (20, Bd. 7, tab. 12) my specimens have a great resemblance; often the ramuli are however, as the illustration given here shows (Fig. 30), somewhat more openly placed than in the figure of KÜTZING; but specimens are to be found which quite agree with this. On the other hand the figure of MONTAGNE has more and more closely placed ramuli than the West Indian specimens and the same is also the case by comparison with a little piece of an original specimen from the herbarium of MONTAGNE collected at "île de Toud", which is to be found in the herbarium of Mme. WEBER VAN BOSSE. The ramuli in my specimens are more scattered and the erect shoots and most probably the whole plant longer than that of MONTAGNE, but the form of the ramuli is about the same and the likeness seems to me on the whole very great.

As pointed out by Mme. WEBER, var. *lætevirens* may show a not inconsiderable

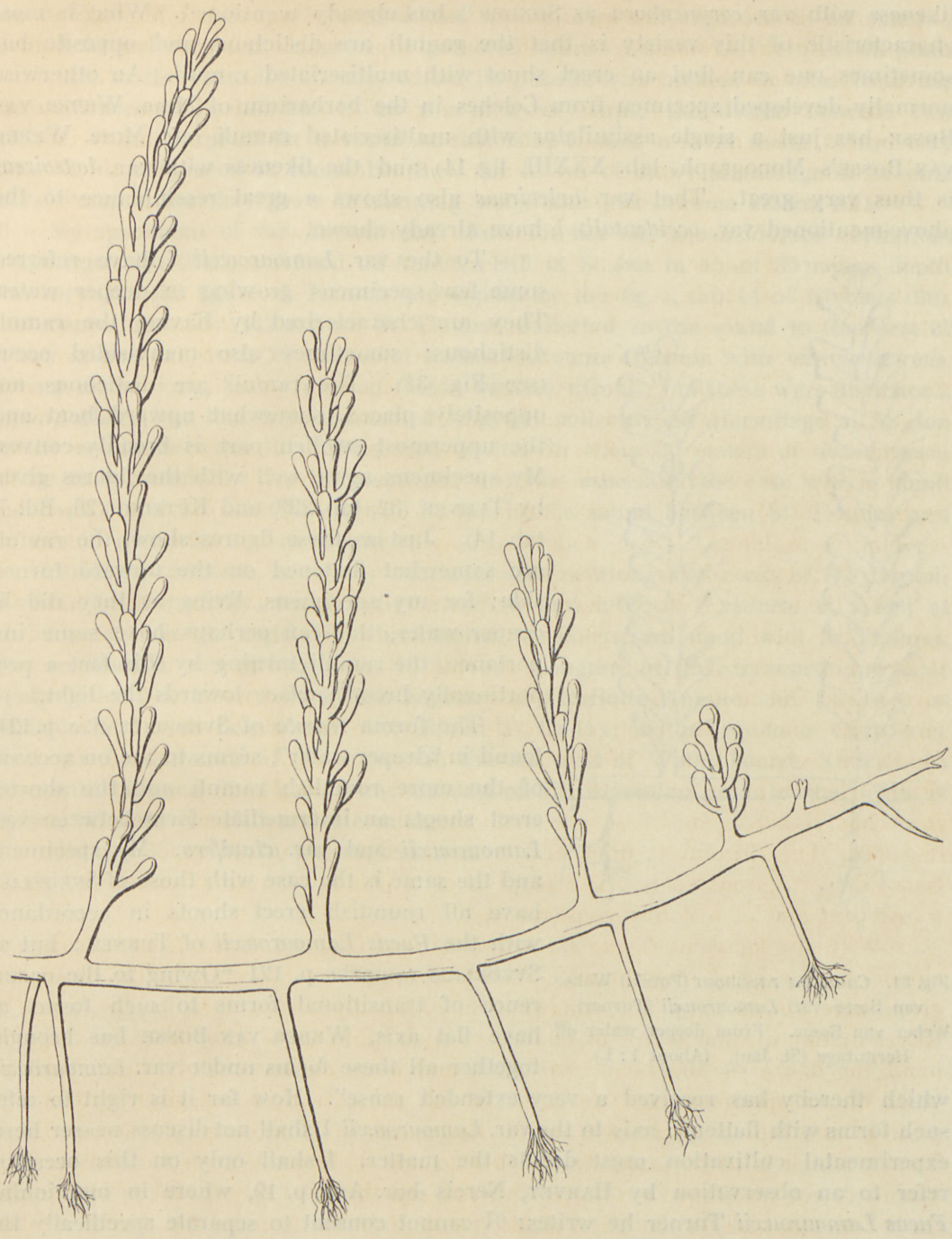

Fig. 30. *Caulerpa racemosa* (Forsk.) Weber van Bosse var. *lætevirens* Mont.
From the lagoon of Christianssted. (About 1 : 1.)

likeness with var. *corynephora* as SONDER [1]) has already mentioned. What is most characteristic of this variety is that the ramuli are distichous and opposite but sometimes one can find an erect shoot with multiseriated ramuli. An otherwise normally developed specimen from Celebes in the herbarium of Mme. WEBER VAN BOSSE has just a single assimilator with multiseriated ramuli (cfr. Mme. WEBER VAN BOSSE's Monograph, tab. XXXIII, fig. 14) and the likeness with var. *lætevirens* is thus very great. That var. *lætevirens* also shows a great resemblance to the above-mentioned var. *occidentalis* I have already shown.

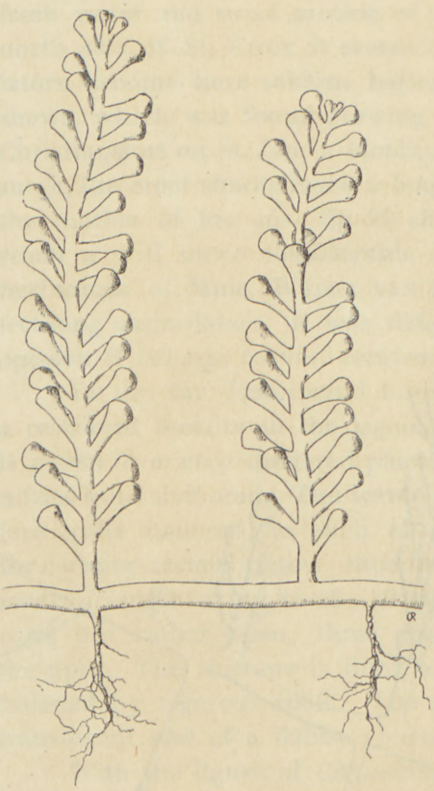

Fig. 31. *Caulerpa racemosa* (Forsk.) Weber van Bosse var. *Lamourouxii* (Turner) Weber van Bosse. From deeper water off Hermitage (St. Jan). (About 1 : 1.)

To the var. *Lamourouxii* I have referred some few specimens growing in deeper water. They are characterized by having the ramuli distichous; sometimes also many-sided occur (see Fig. 31). The ramuli are distichous not oppositely placed, somewhat upward bent and the uppermost swollen part is broadly convex. My specimens agree well with the figures given by TURNER (32, tab. 229) and KÜTZING (20, Bd. 7, tab. 14). Just as these figures show, the ramuli are somewhat flattened on the upward turned side; for my specimens, living as they did in deeper water, this can perhaps have some importance, the ramuli turning by this fact a proportionally broad surface towards the light.

The forma *remota* of SVEDELIUS (l. c. p. 121) found in "deeper water", seems to me on account of the more roundish ramuli and the shorter erect shoots an intermediate form between var. *Lamourouxii* and var. *clavifera*. My specimens and the same is the case with those of SVEDELIUS have all roundish erect shoots in accordance with the *Fucus Lamourouxii* of TURNER; but as SVEDELIUS remarks p. 121 "Owing to the occurrence of transitional forms to such forms as have flat axis, WEBER VAN BOSSE has brought together all these forms under var. *Lamourouxii* which thereby has received a very extended sense". How far it is right to refer such forms with flattened axis to the var. *Lamourouxii* I shall not discuss nearer here, experimental cultivation must decide the matter. I shall only on this occasion refer to an observation by HARVEY, Nereis bor. Am. p. 19, where in mentioning *Fucus Lamourouxii* Turner he writes: "I cannot consent to separate specifically the forms figured by TURNER, and above indicated as varieties. I fear also that *C. oligo-*

[1]) SONDER, W., Die Algen des tropischen Australiens, p. 65. Hamburg 1871.

phylla Mont., if I rightly understand that species, must be regarded as an extreme form, nearly destitute of *ramenta*. I gathered what I take to be MONTAGNE's plant at Vavau, in the Friendly Islands, where its peculiarities seemed to arise from the circumstances of its habitat, which was in a very rapid tide-stream between two islets". That the plant in a rapid stream adopts such a form seems to me very natural, we only need to remember how the leaves of many phanerogams become transformed when they grow in running water and just become ribbon-like.

My specimens of var. *Lamourouxii* show for the rest a considerable variation. A specimen (Nr. 2036) collected off America Hill at St. Jan in about 30 meters depth was very like the figure of TURNER and especially the fig. c, tab. 14 of KÜTZING (20). Other specimens (Nr. 1121) from St. Thomas collected in the sound to the west of Water Island in about 20 meters of water had some likeness with var. *lætevirens*, having rather long, but somewhat feeble swollen ramuli, but these were distichous. Again, others like that here delineated (Fig. 31) collected off Hermitage at St. Jan in the sound between this island and Tortola in about 30 meters of water, seem to me to approach the var. *corynephora*; this was especially the case with a small specimen found off Christiansfort at St. Jan in the sound between St. Thomas and St. Jan in about 25 meters of water.

Caulerpa racemosa is a very common species along the coast of the Danish West Indies especially the varieties *clavifera* and *uvifera*; f. *reducta* is found at St. Thomas: on the coral-reef which unites the Hurricane Island with St. Thomas. Var. *occidentalis* was gathered in St. Croix: Longreef at Christianssted and near Sandy Point, St. Thomas: in the harbour at Charlotte Amalie and St. Jan: at Christiansfort; var. *lætevirens* is only found St. Croix: in the lagoon of Christianssted; var. *Lamourouxii* St. Thomas: in the sea west of Water Island, St. Jan: in the sound between St. Thomas and St. Jan off Christiansfort and to the north of St. Jan off America Hill and Hermitage.

Geogr. Distrib. In all tropical seas.

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