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HOVEDKOMMISSIONÆR: ANDR. FRED. HØST & SØN, KGL. HOF-BOGHANDEL

BIANCO LUNOS BOGTRYKKERI A/S

1909—31

THE MARINE ALGÆ OF DENMARK

CONTRIBUTIONS TO THEIR NATURAL HISTORY

VOL. I

RHODOPHYCEÆ

BY

L. KOLDERUP ROSENVINGE

WITH TWO CHARTS AND EIGTH PLATES

D. Kgl. Danske Vidensk. Selsk. Skrifter, 7. Række, naturvidensk. og mathem. Afd., VII. 1—4

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PART I

INTRODUCTION. RHODOPHYCEÆ I.

(BANGIALES AND NEMALIONALES)

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1909

PREFACE.

The study of the marine Algæ engaged my interest at an early period. Originally certain morphological, cytological and physiological questions were the objects of my studies, but later the plan to procure a general view of the Algæ found in the Danish waters gradually developed. In 1890 I began to make systematic collections in the Danish waters and continued during the following years, especially in 1891—95, when I became able to make extensive dredgings in all the Danish waters inside Skagen (Kattegat to Baltic) by means of official support during 4 years (from "Kommunitetet") and permission from the ministry to sail with the fishery control-steamers S. S. "Havørnen" and S. S. "Falken" and the fishery inspection-ship, the gunboat "Hauch". During the following years I have as occasion offered continued these collections partly onboard the Biological Station's S. S. "Sallingsund", especially on a cruise round Bornholm in 1901, the life-saving steamer S. S. "Vesterhavet" and the lightship transport S. S. "Nordsøen" in 1905 in the North Sea, the deep-sea research-ship S. S. "Thor" in the Skagerak, Kattegat and the Sound in 1907, a former revenue-cutter "Ragna" in private possession in 1904—1906 and partly in fishing boats, especially at different places on the north-western coast of Jutland.

The reason why my work has extended over such a long period is chiefly, that different works regarding Greenland's flora, vegetation and marine Algæ, have during a series of years taken up so much of my time that until 1898 I was mostly obliged to content myself with collecting material, while the working up of this could not begin until after that time. Another cause of the slow progress of the work is the abundance of the material collected, and lastly the scope of my work was gradually somewhat enlarged. From the beginning the aim of my investigations was, not only to state what species are found in the Danish waters, but to elucidate their extension here and also their variation and if possible their dependence on the external conditions. While working with the single species my investigations came more and more to have to do with morphology and the developmental history, and I saw how desirable it would be for the task I had undertaken if I could contribute as much as possible to the elucidation of the natural history of the separate species on the whole in Danish waters; I have also expressed this in the title of my work. I feel quite well, that I have not given nearly so much as I could have wished in this direction, and I am by no means blind to the defects in my work just in this respect. But it is also quite clear to me, that if I do not wish to postpone the publication of my work until an uncertain future period, thus running the risk of never getting it finished, I must have it published, even if my investigations are not complete on many points.

On account of the extent of the work I have decided to have it published in small portions, to begin with the Rhodophyceæ. Of this family the well-known specialist, the conservator Mr. M. FOSLIE, several years ago undertook to determine the *Melobesieæ* and Mag. sc. Mr. HENNING E. PETERSEN undertook to work up the genus *Ceramium*. Mr. FOSLIE has already given the preliminary results of his work in several publications, but they will be dealt with in more detail in the present memoir. Mr. PETERSEN's work on the genus *Ceramium* was really destined to be embodied as a part of the same, but as it was finished before mine and was of considerable extent it was preferred to have it published separately[1].

Besides the two mentioned groups of red Algæ a large portion of the blue-green Algæ I have collected was worked up by Dr. JOHS. SCHMIDT in 1899[2]. It may also be mentioned here, that mainly on the basis of my own collections and investigations I have been able to enumerate not a small number of species, which have not been known before in the Danish waters, in my work on the Algæ in ROSTRUP's Guide to the Danish flora[3].

My thanks are due to many persons, who during the many years that have passed since I began my investigations have rendered me valuable assistance in different ways. I would here mention especially the different captains, the late fisheries supervisor Mr. A. BLOCH, Commander P. GROVE, the former fisheries supervisor Mr. HOLSTEIN, the present fisheries supervisor Mr. W. LARSEN, Captain ROSENKILDE, the retired Captain C. TROLLE; further the director of the Danish Biological Station Dr. C. G. JOH. PETERSEN and Dr. JOHS. SCHMIDT; also Dr. F. BØRGESEN, Dr. TH. MORTENSEN, Dr. C. H. OSTENFELD, Mag. A. OTTERSTRØM, Mag. OVE PAULSEN and Mag. HENN. PETERSEN, who have placed their collections of Danish marine Algæ at my disposal.

I desire here also to express my best thanks to the Directors of the Carlsberg Fund for the assistance they have given to defray various expenses in connection with the publication of this work, especially the charts and photographs of plants.

[1] HENNING E. PETERSEN, Danske Arter af Slægten Ceramium (Roth) LYNGBYE. K. D. Vidensk. Selsk. Skr. 7. R. 5. B. No. 2 1908.

[2] JOHS. SCHMIDT, Danmarks blaagrønne Alger (*Cyanophyceae Daniae*) I. Hormogoneae. Botanisk Tidsskrift Bd. 22.

[3] E. ROSTRUP, Vejledning i den danske Flora. »Anden Del. Blomsterløse Planter. København 1904.

INTRODUCTION.

Earlier sources of our knowledge of Denmark's marine Algæ.

When on searching for the oldest statements in the literature on the Danish marine Algæ, we come upon OEDER's Enumeratio plantarum Floræ Danicæ[1], we might expect to find important information there, as the work deals specially with the "*Cryptantheræ*" i. e. the cryptogams. A considerable number of species of the genera *Conferva*, *Ulva* and *Fucus* are certainly mentioned there, but these are not known to occur inside the boundaries of the Danish kingdom. As the author, according to his own statement, had not studied the lower plants very closely, he contents himself with giving a good many North-European species, which he supposes might be found here. This paper therefore does not contain any more information about the Danish marine Algæ than that found in "Flora Danica", to which work reference is made for all the species figured there. OEDER has certainly mentioned not a small number of species in this monumental pictorial work, which began to appear in 1761, but they are almost all from Norway and Iceland or without indication of the locality. Only two species are noted from Denmark, namely Tab. 166, *Fucus siliquosus* (1763) [*Halidrys siliquosus* (L.) Lgb.] and Tab. 393, *Fucus fastigiatus* (1768) [*Furcellaria fastigiata* (Huds.) Lamx.].

In the parts of the same work edited by O. FR. MÜLLER (1775—1782) only a few marine Algæ from Denmark were mentioned (Tab. 763, *Ulva prolifera* [*Enteromorpha prolifera* (Müll.) J. Ag.]; Tab. 771, 2, *Conferva Linum* [*Chætomorpha Linum* (Müll.) Kütz.]; Tab. 821, *Fucus Filum* [*Chorda Filum* (L.) Stackh.]; Tab. 882 *Conferva flexuosa* [*Cladophora* sp.]; Tab. 889, *Ulva Linza* [*Enteromorpha Linza* (L.) J. Ag.]), and none at all in the parts edited by MARTIN VAHL. At the end of the 18th century information was thus present about only a very small number of species of marine Algæ found on the coasts of Denmark.

In 1803 SCHUMACHER[3] gives 26 species of Algæ from the coast of Sealand. A considerable proportion of these are however so insufficiently described that

[1] G. C. OEDER, Enumeratio plantarum Floræ Danicæ. Cryptantheræ. Hafniæ 1770.

[2] Icones Floræ Danicæ. Hafniæ 1761—1883 (Edit.: OEDER, O. F. MÜLLER, M. VAHL, HORNEMANN, LIEBMAN, JOH. LANGE).

[3]) C. F. SCHUMACHER, Enumeratio plantarum in partibus Sællandiæ septentrionalis et orientalis. Pars posterior, Hafniæ 1803.

they cannot be identified. Besides three species formerly known as Danish, the following may be mentioned: *Enteromorpha intestinalis* (L.) Link (*Conferva int.* Schum.), *Cladophora rupestris* (L.) Kütz. (*Conferva rup.* Schum.), *Chordaria flagelliformis* (Müll.) Ag. (*Ceramium longissimum* Schum.), *Ahnfeltia plicata* (Huds.) Fr. (*Ceram. plicatum* Schum.), *Fucus serratus* (L.), *Fucus vesiculosus* L. and *Rivularia atra* Roth (*Linckia hemisphærica* Schum.). Further LYNGBYE believed that he was able to identify *Elachista fucicola* (Vell.) Fr. (*Conferva ferruginea* Schum.) and *Chondrus crispus* (L.) Lgb. (*Fucus ceranoides* Schum.)[1].

No further information on Denmark's marine Algæ appears in the 2nd edition of HORNEMANN's "Plantelære"[2] published 3 years later. Only 11 species, all referred to the genus *Fucus*, are noted, but not a single one is expressly mentioned as found in Denmark.

It was only in the 2nd decade of the 19th century that a more exact study of the Algæ was begun in this country, first by N. HOFMAN BANG, the owner of Hofmansgave on the north coast of Fyen, and at his instigation also by H. C. LYNGBYE, private tutor at Hofmansgave from 1812—1817. The publisher at that time of Flora Danica, HORNEMANN, who was in close connection with these two investigators of Algæ, included in this work during the years 1813—1818 25 species of marine Algæ from Denmark, mostly until then unknown in its flora; the number of the species was by this addition more than doubled, but a decisive change was not accomplished until the publication of LYNGBYE's hydrophytology[3]. This work was originally written in 1817 as an essay to which the University had awarded a prize in the previous year, but it was enlarged so much later that the Algæ from Holstein, the Færoes, Iceland, Greenland and also partly from Norway all came to be included in it. On the whole 323 species are mentioned here, for Denmark about 100 species with 12 varieties of marine Algæ; Denmark thus rose at once to the level of the countries, in which the algal flora was relatively well investigated. This work holds a good place as one of the main works among the earlier descriptive phycologies by reason of its careful descriptions of species and its numerous good figures. With regard to Denmark it is essentially based upon numerous collections by HOFMAN BANG and by LYNGBYE at Hofmansgave and upon studies of the latter at the same place, in less measure upon collections in the Sound, while other localities are very incompletely represented. Consequently it deals relatively exhaustively with the algal flora of the north coast of Fyen, while it gives very little

[1] Among these species *Ceramium cartilagineum* (l. c. p. 112) must also be mentioned. LYNGBYE who had the opportunity to examine SCHUMACHER's specimen, found between Amager and Sjælland, discovered that it really belonged to *Fucus cartilagineus* Turner (= *Gelidium cartilagineum* (Turn.) Gaill.) a species, the native place of which is at the Cape of Good Hope, and he found that, in regard to the epiphytic animals it also agreed with samples of this species from that place, consequently he was right in concluding that it in some way, e. g. by a ship, had been transported from its original, far-off home (LYNGBYE Hydr. p. 56).

[2] J. W. HORNEMANN, Forsøg til en dansk oekonomisk Plantelære. Kjøbenhavn 1806.

[3] H. C. LYNGBYE, Tentamen Hydrophytologiæ Danicæ. Hafniæ 1819.

information about the distribution of the species within the Danish area. As LYNGBYE's work will be cited in the following pages when dealing with the single species, its importance to the knowledge of the Danish marine algal flora need not be more closely explained here.

During the following years several Danish marine Algæ were included in the parts of Flora Danica published by HORNEMANN, without anything essentially new being given in addition to what is found in LYNGBYE's work.

A greater increase in the number of Danish species appears in the 3rd edition of HORNEMANN's "Plantelære"[1], the number here reaching 127. The real increase was however far from being so great. Thus, two of the species mentioned belong to the animal kingdom (*Alcyonidium diaphanum* and *flavescens*); some seem to have been included by mistake as found in Denmark, as they have not been discovered here by others and no Danish specimens are known (*Sphærococcus ciliatus, S. laciniatus, Zonaria dichotoma*). Several of the new species are scarcely sufficiently distinct from others found earlier, e. g. several *Hutchinsia*-species, *Vaucheria litorea* Ag. (*V. clavata* Lgb.) etc. But even after these reductions, a number of real additions remain of which the most important are:

Calothrix fasciculata Ag.
Rivularia pellucida Ag.
Bryopsis plumosa Ag.
Ectocarpus tomentosus Ag.
Zonaria deusta Ag. (*Ralfsia verrucosa*)
Chordaria divaricata Ag.
Bangia atropurpurea Ag. (*B. fuscopurpurea*)
Halymenia palmata Ag. (*Rhodymenia palmata*)
Rhodomela dentata Ag. (*Odonthalia dentata* Lgb.)
Callithamnion roseum Ag.
Ptilota plumosa Ag. (*Plumaria elegans*)
Halymenia edulis Ag. (*Dilsea edulis*)

Two years later LIEBMAN[2] made some new additions to the Danish marine algal flora. A great part of these species were however not really new in the flora; thus his *Laminaria latifolia* is only a form of *L. saccharina, Asperococcus echinatus* = *Scytosiphon Lomentaria, Punctaria cæspitosa* = *Phyllitis Fascia, Sphacelaria cæspitula* not identical with LYNGBYE's species of that name but perhaps only small specimens of *Sphacelaria cirrosa, Polysiphonia lepadicola* = *P. urceolata.* — New to the flora are however at all events *Callithamnion pyramidatum* Liebm. = *C. fruticulosum* J. Ag. and *Lyngbya lutescens* Liebm. = *L. lutea* (Ag.) Gom., and probably *Ptilota plumosa.* His *Dictyota dichotoma* is also new, but however, as the specimens prove, is *Taonia atomaria*; but this Atlantic species cannot have grown on the coasts of Denmark, but must probably have been transported by a ship.

A smaller contribution to the flora was given by ØRSTED in 1841 in an account of an excursion to an alluvial deposit at Hofmansgave[3], where some blue-

[1] J. W. HORNEMANN, Dansk oeconomisk Plantelære 3. Udg. 2. Del. 1837.

[2] F. LIEBMAN, Bemærkninger og Tillæg til den danske Algeflora. KRØYER's Naturhist. Tidsskrift 2. Bd. 5. Hefte, 1839.

[3] A. S. ØRSTED, Beretning om en Excursion til „Trindelen", en Alluvialdannelse i Odensefjord. KRØYER's Naturhistorisk Tidsskrift 3. Bd. 1841, p. 552.

green Algæ were especially mentioned, amongst others a new species *Spirulina subsalsa*.

ØRSTED's dissertation[1], published three years later, in which the distribution of the marine Algæ in the Sound is discussed, is of greater importance. In this paper, which deals with the geographical, geological, botanical and zoological conditions of the Sound, all the species of Algæ are mentioned, which were found there by the author, but the single species are not described in detail, which is the reason why it is not always possible to know the meaning of a name given by the author. A number of species, considered by him as new, are however described in the comments under the text, but mostly so briefly and incompletely, that the plant cannot be recognised; and the result has been, that none of the genera and species, given by ØRSTED, have been maintained. Some of them have later been published in Flora Danica. The systematic value of the paper in thus very small, but its importance for our subject lies in this that it is based upon systematic investigations by means of dredgings, with the result, that for the first time the Algæ are not only discussed in regard to their horizontal distribution but also in regard to their vertical. It cannot be determined what new species have been added to the flora by ØRSTED's work without examining his specimens.

Already several years before the appearance of ØRSTED's work, LYNGBYE in 1836 had written a treatise of a somewhat kindred character, but, on account of special conditions, it was not published before 1880[2]. In floristic regard it is not of so much importance in enriching the flora, as in its being based upon investigations in the southernmost part of the Kattegat off Gilleleje, a region not investigated before, and especially by its containing more exact data on the distribution of the Algæ in relation to the depth. Neither his nor ØRSTED's divisions into regions of depth need be mentioned here.

Since ØRSTED's work there has not until the end of the 19th century appeared any noteworthy, floristic or systematic contribution to the Danish literature on the Danish marine Algæ. In Flora Danica marine Algæ from Denmark were included up to 1861, but very few new species were added beyond those mentioned by LIEBMAN and ØRSTED. *Helminthocladia purpurea*[3], found by Miss CAROLINE ROSENBERG, is perhaps the most interesting addition. During the same period publications which partly deal with the algal flora in Danish territory have appeared

[1] A. S. ØRSTED, De regionibus marinis, elementa topographiæ, historiconaturalis freti Øresund. Hauniæ 1844.

[2] H. C. LYNGBYE, *Rariora Codana* (Opusculi posthumi pars). Vidensk. Meddelelser fra den naturh. Foren. i Kjøbenhavn, 1879—80, p. 215.

[3] In "Nomenclator Floræ Danicæ" published by JOH. LANGE in 1881 a systematic summary, prepared by myself, was given of all the Algæ mentioned in this work with data on their occurrence. This general summary, which in regard to the determination of the species, is essentially based upon the references available in the literature and consequently in part out of date, comprises the following Danish marine Algæ: 47 *Rhodopyceæ*, of which two are however incorrectly named as Danish, 38 *Phæophyceæ* (1 incorrectly named Danish), 18 *Chlorophyceæ* and 7 *Cyanophyceæ*. By accident the *Characeæ* were omitted in this work.

in the neighbouring countries. Bornholm's algal flora has thus been investigated, in connection with that of the inner Baltic, by Krok[1] who gave valuable information regarding this region, not investigated until then. During the years 1870—1875 two expeditions were made from Kiel respectively to the Baltic and to the North Sea, on which occasions some dredgings were also made in the Danish waters, mostly in the Great Belt, and reports on these have been given by P. Magnus[2]. By these dredgings the existence of Algæ at great depths was determined in the Great Belt, among which were some species not found before in the Danish waters (*Antithamnion Plumula, Chylocladia clavellosa* (*Lomentaria clavellosa*), some *Lithothamion*-species and the new species *Callithamnion* (*Rhodochorton*) *membranaceum* Magn.).

The marine Algæ have not in general been included in the Danish local floræ, or only the most obvious mentioned *en passant*; in J. P. Jacobsen's list of the plants[3] found in Læsø and Anholt only some few species of marine Algæ from each of these islands have also been mentioned. Collin's work on the marine fauna[4] of the Limfjord contains some remarks about the flora of this fjord, in which some of the most important species in the composition of the flora are mentioned, partly from the information given by J. P. Jacobsen. The number of the species stated is however also here too small to be of any importance in floristic regard. One of the species mentioned, *Rhodomenia mamillosa* (*Gigartina mamillosa* (Good. et Woodw.) J. Ag.) is however of interest, as it had not previously been found on the coasts of Denmark.

For two smaller groups however we find special contributions in the literature. The *Characeæ*, which in this country have not usually been studied in connection with the other Algæ, were included in two editions af Lange's manual[5] and were later exhaustively studied by P. Nielsen, especially in South West Sealand[6]. In 1880 I published a preliminary report on the submarine *Vaucheria*-species, the number of the known Danish species being thereby augmented[7].

Collections employed for the present work.

My work is naturally mostly based upon my own collections, but it need hardly be said that I have also employed all the marine Algæ accessible to me

[1] Th. O. B. N. Krok, Algfloran i inre Östersjön och Bottniska viken. Öfversigt af K. Vet. Akad. Förhandl. 1869.

[2] P. Magnus, Botanische Untersuchungen der Pommerania-Expedition vom 3. bis 24. August. Aus dem Bericht über die Expedition .... Pommerania. Kiel 1873.

P. Magnus, Die botanischen Ergebnisse der Nordseefahrt vom 21. Juli bis 9. Septbr. 1872. II. Jahresber. der Kommission z. Unters. d. deutsch. Meere in Kiel. Berlin 1874.

[3] J. P. Jacobsen, Fortegnelse over de paa Læsø og Anholt i 1870 fundne Planter. Botan. Tidsskrift. 11. Bind 1879.

[4] Jonas Collin, Om Limfjordens marine Fauna. Kjøbenhavn 1884.

[5] Joh. Lange, Haandbog i den danske Flora. 2. edition 1859, 3. edition 1864.

[6] P. Nielsen, Exsiccatsamling af Characeer, navnlig fra Danmark. 1869. Idem, Sydvestsjællands Vegetation. Botanisk Tidsskrift 2. R. 2. Bd. 1873.

[7] Botanisk Tidsskrift Bd. 12, p. 11.

which have been collected in Danish waters by others in earlier and more recent times.

Other collections. LYNGBYE's herbarium of Algæ, kept in the Botanical Museum of Copenhagen, is of the greatest importance for the study of the Danish marine Algæ, as it contains the original specimens of LYNGBYE's Hydrophytology. The specimens in this herbarium have not been particularly well prepared, but they are furnished with exact indications of the place and time of collecting; most of them originate from the neighbourhood of Hofmansgave on Fyen.

The Botanical Museum's Danish herbarium contains a considerable number of specimens of marine Algæ. The majority of these come however, like LYNGBYE's herbarium, from the neighbourhood of Hofmansgave and have been collected mainly by HOFMAN BANG and Miss CAROLINE ROSENBERG. The latter, who passed the greater part of her life (┼ 1902) at Hofmansgave, has from there during a long series of years sent a large number of carefully prepared specimens of marine Algæ, many of which have come to be housed in the Botanical Museum's herbarium. As they have been collected at different seasons, they provide a good material for following the development of the single species during the course of the year. Further, specimens are also present from HORNEMANN, LIEBMAN and ØRSTED, by which the determinations of the latter can be controlled, and also from J. VAHL, C. M. POULSEN, JOH. LANGE, CHR. THOMSEN (mostly from Samsø), J. P. JACOBSEN (mostly from the Limfjord), E. ROSTRUP, C. RASCH and others.

Since I began my systematic collections, some material collected by others has further been left to me. Dr. TH. MORTENSEN has thus placed at my disposal a valuable collection principally from the Limfjord procured at different seasons in 1894—95; and Dr. F. BØRGESEN has permitted me to examine the Algæ dredged on two expeditions with the fishery-inspection ship S. S. "Guldborgsund" in 1897 and in 1898 in the Skagerak, Kattegat and the Baltic. Smaller collections have been given me by Dr. C. H. OSTENFELD, Mr. A. OTTERSTRØM, Mag. OVE PAULSEN and Mag. HENNING E. PETERSEN.

My own collections. I began my first collections of Danish marine Algæ already towards the end of the seventies, but it was not until 1890 that I made extensive and systematic collections and they were carried on most energetically during the years 1891—1895, whilst later they have been continued almost every year though less extensively. My aim has been to make as uniform an investigation of the Danish waters as possible and also, as far as possible, to investigate them at different seasons; for that purpose I have made dredgings at more than 700 different places and besides made collections at numerous harbours and at other places close to the land; I have made these collections during all the months of the year, chiefly however during May—September. The dredgings have almost all been made by means of a triangular dredge with sharp steel teeth (Reinke's model), more rarely with a quadrangular dredge without teeth or with seine. The greater part of the material has been preserved as herbarium specimens, of which I possess ca. 8000 samples, averaging at the least twice as many specimens. I have also preserved several hundreds of specimens in alcohol or formalin and likewise a considerable number of samples of stones and the like with incrusted Algæ. Neither the conditions nor time have as a rule permitted a more exact examination of the collected material at the place investigated; the aim was to keep or at least to note all the species present at the single dredging localities. I have however, during longer stays at some places on the Danish coasts, been able to make closer microscopical examination of fresh material. The main portion of my investigations is however based upon preserved material.

Remarks on the Danish waters.

As the present work does not intend to give a complete account of the floristic conditions nor of all the algal communities, the natural conditions of the Danish waters need not be described in detail here, but only the most important points, which may serve as a guide for understanding the distribution of the separate species and their biological conditions.

The boundaries of the region. These are partly determined by the political limits. Thus, my investigations extend southward in the North Sea to the boundary towards Slesvig, and east of Jutland as far as a line drawn between the German and Danish territories thus to the boundary of the region investigated by Reinke[1]. I have made dredgings in the North Sea as far out as the lightship on Horns Reef and the eastern side of the Jutland Reef ca. 24 miles from land, in the Skagerak ordinarily only to 4 miles from the land except north of Vendsyssel where the distance is greater. In the Kattegat my investigations have extended to the eastern channel and the grounds in and near it, and in the Sound to the deep channel east of Hveen in order to obtain the flora belonging to the salt under-current there. The waters surrounding Bornholm constitute a special region, which is however connected with the waters east of Møen by some few scattered dredgings.

The conditions of depth. A general view of these is obtained from the charts, which show that a deep channel (the eastern channel) passes from the Skagerak southward through the eastern Kattegat, while the water in the western part of this sea is relatively shallow. Narrower channels lead further from the eastern channel through the Sound and the Belts, of which that through the Great Belt is the most important. At Gjedser--Darsserort this channel meets with a barrier, the maximum depth over which is 18 meters, whilst a similar barrier, which has a maximum depth of only 8 M., occurs at Saltholm and forms the southern boundary of the deep channel through the Sound. South of Schonen the depth increases in the Baltic, but becomes specially considerable north and east of Bornholm. For the rest, reference may be made to the charts.

[1] J. Reinke, Algenflora der westlichen Ostsee deutschen Antheils. 1889

The nature of the bottom. The most important kinds occurring in the Danish waters, are (1) stony bottom, (2) sand-bottom and gravel-bottom, (3) mixed bottom consisting of a mixture of sand and clay or mud and (4) soft bottom consisting of clay or mud. To these may be added (5) rocky bottom and (6) compact clay (tertiary or glacial). I shall not endeavour here to describe more closely the distribution of these kinds of bottom, as the nature of the bottom is very variable from place to place. With regard to the Kattegat reference may be made to C. G. Joh. Petersen's chart[1]. For the rest some information is given below in the list of my dredgings; it may however be remarked, that I have chiefly dredged at places with stony bottom. The rule is, that sand-bottom is connected with shallower water, soft bottom with the deeper and mixed bottom with the intermediate depths. The stones are mostly found in shallow water and on reefs, which are for a great part noted on the charts. There are grounds, however, the surface of which is exclusively or predominantly sand, e. g. Horns Reef, Anholt's N. W. Reef and Gjedser Reef, which is the reason, why they are not overgrown with Algæ. The extent of the true stone-reefs, the surface of which consists only of stones, is relatively small; on the larger banks and flats stony bottom is ordinarily intermixed with gravel, sand or even clay. In deep channels with strong current stony bottom is often found, which is kept clean by the current. Rocky bottom is found at several places near Bornholm, but elsewhere is scarcely known with certainty; it occurs perhaps at some places in the Skagerak near Hanstholm and Bulbjerg. On the other hand, firm glacial clay occurs at many places in the Skagerak and firm tertiary clay at all events in the Little Belt.

The salinity and temperature of the sea-water. As these conditions are of the greatest importance in understanding the distribution of the species, the conditions which are of special importance for our subject may briefly be discussed here; for the rest, reference may be made to the hydrographical works mentioned below[2]. In consequence of the fact that the salinity in the North Sea is more than 32‰, while in the true Baltic (east of Gjedser—Darsserort) it is ordinarily less than 10‰, the greater part of the Danish waters is a mixed region with complicated and variable hydrographical conditions, the most important moment in which is that the heavy North Sea water from the Skagerak penetrates along the bottom through the deep channel in the eastern Kattegat and further as

[1] C. G. Joh. Petersen, Kanonbaaden Hauchs Togter, 1893, Kort III.

[2] Martin Knudsen, Havets Naturlære. Hydrografi med særligt Hensyn til de danske Farvande. Skrifter udg. af Kommissionen for Havundersøgelser. Nr. 2. København 1905.

De internationale Havundersøgelser 1902—1907. Skrifter udg. af Kom. f. Havundersøg. Nr. 4. 1908.

J. P. Jacobsen, Mittelwerte von Temperatur und Salzgehalt, bearbeitet nach hydrographischen Beobachtungen in Dän. Gewässern 1880—1907. Meddel. fra Komm. for Havundersøgelser Ser. Hydrografi. Bind I, Nr. 10. 1908.

Nautical-meteorological Annual 1902—1906, published by the Danish Meteorological Institute.

I am much obliged to Mr. J. P. Jacobsen for placing at my disposal some unpublished lists with hydrographical averages. I am much indebted to Mr. Martin Knudsen and Mr. J. P. Jacobsen for various pieces of information regarding the hydrography of the Danish waters.

a bottom-current through the channels in the Sound and the Belts, especially the Great Belt, while a surface-current streams out from the Baltic in an opposite direction. On account of the rotation of the earth this northward so-called Baltic Current is forced eastward and consequently remains on the eastern side of the Kattegat along the Swedish coast, and for the same reason the north-going surface-water moves more rapidly in the Sound than through the Belts. Vice versâ the salt bottom-current is forced westward. The boundary between the two water-layers is very distinct in summer, while the transition is uniform in winter.

The salinity does not vary much in the North Sea. At the lightship on Horns Reef the conditions in the years 1880—94[1] were:

	Temperature		Salinity	
	Mean minimum	Mean max.	Mean minimum	Mean max.
0 M.	2,2° (Febr.)	15,8° (Aug.)	32,7 ‰	33,2 ‰
23 -	2,6° (March)	15,5° (Sept.)	33,1 ‰	33,7 ‰

The numbers are the averages of the monthly means; the variations are thus a little greater than indicated by the numbers. Along the coast a narrow and not very deep margin occurs with a somewhat lower salinity.

The conditions in the part of the Skagerak which lies nearest Jutland are essentially like the corresponding part of the North Sea, the water mainly streaming from the North Sea towards the Swedish coast.

In the waters inside the Skaw (Skagen), at every place where the depth is considerable, an upper, relatively not very salt layer, the temperature of which almost constantly follows that of the air, can be distinguished from a deeper layer with salter water and with special conditions as to temperature. With regard to the surface water, the highest temperature of the year is commonly observed in the beginning of August and is in the greater part of the waters on an average 16°, while the lowest temperature of the year, which on an average is 2°, is ordinarily observed in the middle of February. In fjords and bays, where the renewal of the water is not considerable, the maximal temperature is however higher and falls in July, and the minimal temperature is lower in winter. In the deeper and salter water-layers both the maximal temperature and the minimal temperature occur later than at the surface, and the maximum temperature is lower than at the surface, the minimum temperature higher. The differences from the surface are various but are essentially regulated by the depth.

With regard to the hydrography of the Limfjord only some few observations are available. In this shallow water there is only a small difference between the surface and the deeper water-layers. The water in the western part is most like that of the North Sea, the eastern part like the surface-water of the Kattegat. It is only for Oddesund and Aalborg that continuous observations on the surface-water are available. In 1902—1906 the salinity at Oddesund was on an average

[1] Meteorologisk Aarbog for 1896.

29,3 ‰ (the monthly mean was 26,3—32,4 ‰); at Aalborg it was during the same period on an average 23,5 ‰ (18,4—27,7 ‰). At the same time the monthly mean temperature at Oddesund alternated between ÷0,2° (Febr.) and 18,5° (July). At Aalborg it alternated between ÷1,4° and 18,3°. The conditions characteristic of the Limfjord are: a relatively high salinity, especially in the western part, a higher summer temperature than in the open waters and the absence of a salter underlayer with smaller alternations in the temperature.

In the northern Kattegat, north of Læsø, an active exchange takes place between the surface-current and the under-current, which is the reason why the salinity decreases considerably in both from north to south. As a rule the salinity of the water streaming in at Skagen is between 30 and 35 ‰, and the salinity of the surface-water is ordinarily more than 25 ‰. According to J. P. JACOBSEN the result of daily observations for 1880—1905 shows, that the temperature and salinity at Skagens Reef vary on an average in the following manner;

	Temperature	Salinity
0 M.	2,5°—16,2° (mean 8,8°)	27,3—31,4
20 -	3° —15°	32,3—33,8
38 -	4° —13,9° (mean 8,2°)	33,3—34,5

At Læsø Trindel the salinity, according to the charts in J. P. JACOBSEN's paper, is: at 0 M. 23—27 ‰, at 10 M. 28—29 ‰, at 20 M. 31—32 ‰.

In the eastern Kattegat the salinity of the surface water gradually decreases southward; not nearly so great an exchange however occurs here as in the northern Kattegat.

At Anholt's Knob the salinity is at 0 M. 19—23 ‰, at 10 M. 23—25 ‰, at 20 M. 29—31 ‰ and at the same place the temperature alternates at the surface between 1,6° (mid. Febr.) and 17° (ca. 1. Aug.) at a depth of 28 M. between 4,2° and 13,5°, at a depth of 40 M. between 4° and 11,5°.

In the western Kattegat (Km.), which is only of small depth, the salt bottom water is absent, except in Læsø Channel. At the lightship in Læsø Channel in 1880—94 the averages were:

	Temperature		Salinity	
	mean minim.	mean max.	mean minim.	mean max.
0 M.	2,2° (Febr.)	16,1° (July)	22,3 ‰	27,8 ‰
24 -	3,4° (March)	13,9° (Aug., Sept.)	32,2 ‰	33,9 ‰

The salt water coming through the Læsø Channel causes on mixing the water in this region to become relatively saline, especially to the north and along the coast of Jutland. In the greater part of the region the salinity at the bottom is however not more than 25 ‰.

In the Southern Kattegat and the waters east of Samsø the salinity at the surface is fairly uniform. In this area there is, especially in summer at a depth of 10—20 M., a very distinct limit between an upper layer, which has ca. 20 ‰

salinity, and an under layer, which has 28—32 ‰. Where the depth is greater the salinity is even higher. At Schultz's Grund it increases during the summer months, when it is greatest, up to 32—33 ‰ at a depth of 26 M. During the winter months the salinity at the bottom is less (at Schultz's Grund ca. 29—30 ‰), while at the same time the surface salinity increases on account of the intermixing. The maximal temperature at the bottom is relatively low, lower than it is both north and south of the region. The mean temperature of the bottom-waters for the year is 7°. According to J. P. Jacobsen (l. c.) the conditions at Schultz's Grund are the following:

0 M.	10 M.	20 M.	26 M.
Salinity	Salinity	Salinity	Salinity
16—21,6 ‰	19,9—23,3 ‰	27,8—31,5 ‰	29,1—32,9 ‰
Temperature	Temperature	Temperature	Temperature
1,5° (Febr.)—17° (Aug.)	2° (Febr.)—16,5° (Aug.)	3,3° (Mch.)—13° (Aug.)	3,8° (Mch.)—12° (Aug.)

In the area between Samsø, Jutland and Fyen the depths are mostly not more than 20 M. The salinity at the surface increases considerably towards the Jutland coast, where it is greater than in the adjacent regions, which is caused by the salt bottom-water here being nearer the surface and mixed with the surface-water. On account of this also the surface water's maximum temperature is here 1° lower than in the Kattegat. At a depth of 20 M. the salinity is 25—30 ‰, the temperature 2,5—13,5.

To illustrate the conditions in the Isefjord the following averages for the surface-water at Rørvig, near the mouth, and at Frederikssund, half way up Roskildefjord, during the years 1902—1906 may be given:

	Salinity	mean temperature in February (the coldest month)	mean temperature in July (the warmest month)
Rørvig..........	19,4 ‰	0,6° (÷ 0,9—+ 1,8)	17,3° (16,1—18,7)
Frederikssund...	15 ‰	0,4° (÷ 0,6—+ 1,9)	18,0° (16,6—19,7)

In the Great Belt the salinity of the surface-water is very variable. Thus, at Sprogø it varies between 10 ‰ and 20 ‰. The highest salinity is found at the coast of Fyen. A salt bottom-water is found here, but the boundary between this and the surface-water is here not so distinct as in the Kattegat. At a depth of 20—25 M. the temperature alternates between 3° and 13°, at the same depth the maximum salinity is reached in July and is 27 ‰.

The following averages for 1895—1902 illustrate the conditions (manuscript lists). The western part of the Great Belt; 55°18′ N. L. 10°54′ E. L.

	Temperature		Salinity	
	Min.	Max.	Min.	Max.
0 M.	2,2 (March)	16,6 (Aug.)	13,4 ‰	18,3
15 -	2,2 (March)	13,9 (Sept.)	17,1 -	24,3
23 -	2,4 (March)	13,2 (Sept.)	18,7 -	27,6

In the Little Belt there is only a small difference between the salinity at the surface and in deep water; it is about 20 ‰ or a little less. The temperature at the surface is comparatively low in summer (during 1902—1906 on an average 13,7° in June, in July 15,2°, in Aug. 15,1°), comparatively high in winter (during the same period 2,5° in January, 1,7° in Febr.). There is generally a strong current, especially in the narrowest part of the Belt.

In the Sound a salt bottom layer is found as far as Saltholm Tærskel, sometimes however passing it. The salinity greatly decreases southward in the upper layers. The salinity of the bottom-layer also decreases southward: north of Hveen it is 25—28 ‰ at a depth of 20 M. In deep hollows the salinity may be 30—32 ‰ and here the temperature in winter is constant for a long time. The following numbers found at the lightship on Lappegrunden are very instructive.

Average of 1883—94 (Meteorol. Aarbog):

	Temperature		Salinity	
	Min.	Max.	Min.	Max.
0 M.	1,0° (Febr.)	17,0° (July)	12,0 ‰	16,7 ‰
11 -	3.1° (March)	15,7° (Aug.)	21,0 -	26,2 -
17 -	4,1° (March)	11,5° (Sept.)	28,3 -	32,8 -
23 -	3,5° (April)	11,3° (Oct.)	28,3 -	34,0 -

North of Saltholm (1880—1907):

Salinity 0 M. 10—13 ‰, 10 M. 13—16 ‰.

In the western Baltic there is also, at any rate in the summer, a contrast between the surface-water and the salt bottom-water, but as a considerable mixing occurs the surface-water west of Fehmarn is comparatively salt, 11—18 ‰, and has a somewhat lower temperature in summer than in the true Baltic. The salt bottom-water has its maximal salinity in July and August, when it is ca. 20 ‰ at a depth of 20 M. In the area between Fehmarn and Gjedser—Dars—Tærskelen the salinity decreases considerably in the upper water-layers eastwards. The salinity also decreases somewhat in the bottom-water (ca. 15—20 ‰ at a depth of 20 M.).

At the lightship on Gjedser Reef the average salinity was in 1880—94:

0 M.	8,7—12,8 ‰
8 -	9,8—13,6 -
11 -	11,1—14,1 -

In the Baltic round Møen, from Gjedser to Sweden, the salinity and temperature are fairly uniform from surface to bottom. At Møen the salinity at the surface is on an average ca. 8 ‰, at a depth of 20 M. 8—10 ‰. From this place the salinity increases both at the surface and at the bottom towards the two entrances, the Gjedser—Dars—Tærskel and the Drogden Tærskel.

To illustrate the hydrography of the Baltic round Bornholm it may be mentioned that the salinity of the surface-water at Christiansø in 1902—1906 was on an average 6,7 ‰ (the monthly means varying between 5,5 and 8,8 ‰). A salter bottom-water is found here, but only at a rather considerable depth. At a station north of Bornholm, 55°26′ N. L. 14°46′ E. L., the salinity of the surface-water is ca. 7—8 ‰, of the bottom-water ca. 13—15 ‰. The boundary lies at a depth of about 60 M. The salinity however increases somewhat above this boundary, as will be seen from the following numbers found by the international investigations during the years 1903—1907 (Bulletin trimestriel).

North of Bornholm 55°26′ N. L., 14°46′ E. L. The salinity were at depths of:

0—30 M. . . .	8 ‰
40 - . . .	7,32—11,56 ‰
50 - . . .	7,38—11,94 -
60 - . . .	10,61—14,89 -

The currents in the Danish waters are complicated and variable; they depend not only on the above-mentioned exchange between the waters of the North Sea and the Baltic, but also on the wind, in a less degree on the tide and of course on the configuration of the coast and the bottom. When the wind is strong it determines the strength and direction of the surface currents. Thus, with westerly winds salt surface-water streams from the Skagerak into the Kattegat, and from the Kattegat a northerly current brings relatively salt water in through the Sound and the Great Belt. Easterly winds produce the contrary effect. A sudden change in the direction of the wind often causes a strong current, especially in the narrow belts and sounds. There is on the whole almost always a more or less strong current in the latter, e. g. in the Little Belt, in the Sound at Helsingør, sometimes as strong as in a river. That currents can be produced by the tide is not only seen at the most southerly part of the Jutland west coast, south of Skallingen, but also at some single places inside Skagen, for instance in the bay inside Korsør and in some of the Sounds in the Smaaland Sea, where the current, at any rate during calm conditions of the weather, regularly changes with the tide (every 6 hours).

The height of the water-level at the Danish coast is only in a small degree dependent on the tide. This is only at the southern part of the Danish North Sea coast of a fairly considerable magnitude. North of Thyborøn channel and in the waters inside Skagen its greatest height is only at some few places 1 foot or a little more, at other places it is only some few inches, and at Bornholm there is no tide at all. According to “the Danish Pilot”[1] the following heights occur:

The North Sea and Skagerak		Waters inside Skagen	
mean high-water above mean low-water		the mean height of the spring-tide	
Esbjerg.	5 feet	Frederikshavn . .	1 foot
Nordby (Fanø).	4 — 9 inches	Aarhus	1 — 2 inches
Blaavands Huk	5 —	Fredericia	„ — 11 —
Nyminde Gab	3 —	Korsør	„ — 11 —

[1] Den danske Lods; 4. edit. 1893, p. 29.

The North Sea and Skagerak			Waters inside Skagen		
mean high-water above mean low-water			the mean height of the spring-tide		
Thyborøn channel	1 foot	6 inches	Slipshavn	1 foot	
Agger	1 —	1 —	Helsingør	„ —	5 inches
Hirshals	1 —	„ —	Copenhagen	„ —	7 —
Skagen	1 —	„ —			

The figures for the places inside Skagen are so small that they are often neutralized by the change of level caused by the winds. The wind's influence on the height of the water-level is at many places very distinct and well known. Thus, westerly winds cause a high level of the water in the Kattegat on account of the influx of water from the Skagerak, while easterly winds cause a low level of the water. With the variable winds, so pronounced in our country, the changes in the level of the sea are also very variable; but as certain directions of the wind are predominant at certain seasons, others at other seasons, the average height of the water-level is also different at different periods of the year. From Adam Paulsen a general summary is given here of the average deviations of the water-level at three different places on the Danish coasts from the height of the mean water-level during the twelve months of the year, calculated as the averages of observations made during the years 1889—1902[1].

The annual variation of the height of the water-level.

Station	Jan.	Febr.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	cm	cm	cm	cm	cm	cm	cm	cm	cm	cm	cm	cm
Hirshals	—0,3	—4,6	—8,8	**—10,8**	—10,7	—2,2	5,2	7,2	8,8	6,6	3,7	6,6(4)
Frederikshavn	1,2	—4,7	—7,4	**—11,6**	— 9,6	—3,2	3,9	5,5	6,6	6,7	5,3	7,3(5)
Fredericia	0,6	—2,7	—4,5	**— 6,6**	— 5,4	—2,6	1,3	2,8	5,1	6,0	3,4	2,6(2)

The numbers in parenthesis for December indicate the annual mean-height of the water during this month, when the extraordinary mean-height for December 1898 is left out of consideration.

It appears from this, that the lowest water-level at all three places is in April, and it is in agreement with this, that easterly winds according to simultaneous observations are most predominant in April. This condition is of the greatest importance to the upper littoral vegetation, and it is the reason why an upper belt of vegetation, which has grown perfectly well during the course of the winter, is killed every spring.

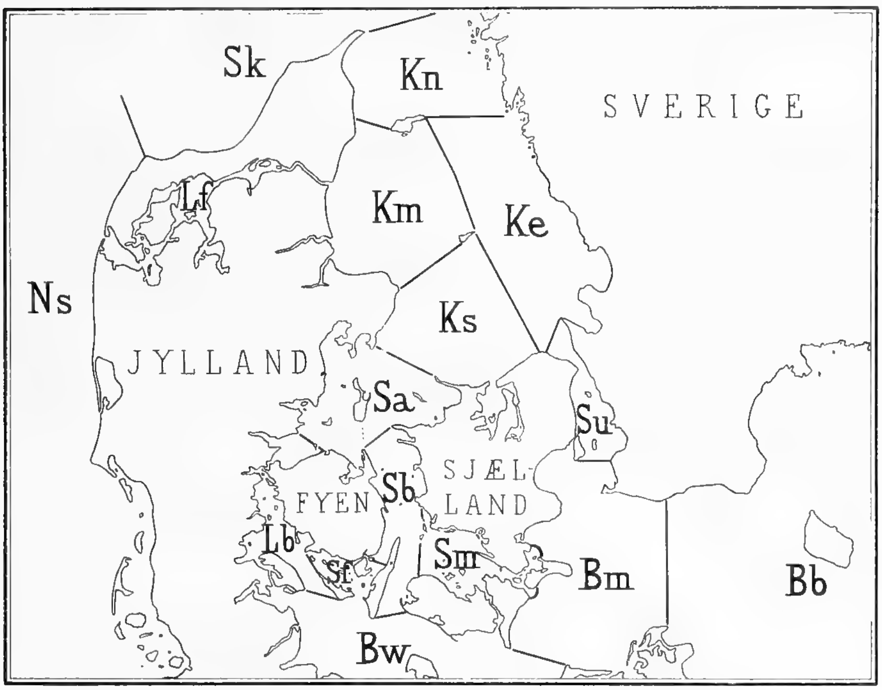
Division of the Danish waters. To facilitate the summary over the distribution of the Algæ, I have not only maintained the ordinary divisions, but have also made further subdivisions in the Kattegat and Baltic. These will be found

[1] Adam Paulsen, Meddelelser om det danske meteorologiske Instituts Vandstandsmaalinger. (Account of the measurements of the height of the sea-level, carried out by the Danish Meteorolog. Institute. Nautisk-Meteorologisk Aarbog 1906, København 1907.

on the present chart, and the boundaries are more exactly indicated below. The limits between the waters are for the most part those commonly accepted (see e. g. "The Danish Pilot"); I have however moved the boundary between the Kattegat and the Sound a little to the south-east for the purpose of including the Ostindiefarer Grund and Søborghoved Grund, and I have moved the southern boundary of the Sound up to the southern point of Amager, as a distinct biological boundary is found nearly at this place.

North Sea. **Ns.** Boundary towards the Skagerak: Hanstholm point.

Skagerak. **Sk.** The boundary towards the Kattegat is a line from Skagen to the Paternoster rocks at Marstrand.



The northern part of the Kattegat. **Kn.** The boundary to the south is a line from Sæby to Læsø north-west Reef, the north coast of Læsø, and a line from the east point of Læsø due east.

The eastern part of the Kattegat. **Ke.** The boundary to the west is marked by the Kobber Grund and a line from its south point to the east point of Anholt and thence to Gilbjerg Hoved on Sealand; the boundary towards the Sound is a line from Nakkehoved to the point of Kullen.

The central part of the Kattegat. **Km.** The boundary to the south is a line from the south point of Anholt to Fornæs Point.

The southern part of the Kattegat. **Ks.** The boundary to the south-west is a line from the end of the Sjællands Odde to Hjelm.

The Samsø area. **Sa.** The boundary towards the Little Belt is a line from Æbelø to Bjørnsknude and towards the Great Belt a line from Fyens Hoved to Refsnæs Point.

The Little Belt (Lillebælt). **Lb.** The boundary to the south is a line from Pøls Huk on Als to Vejsnæs on Ærø, and towards the South Fyen waters a line from Hornenæs to Skjoldnæs.

The South Fyen waters (Sydfynske Øgaard). **Sf.** The boundary towards the Great Belt is a line between Turø Reef and Næs Hoved on Langeland.

The Great Belt (Storebælt). **Sb.** The boundary to the south is a line between Gulstav at Langeland and Kappel church on Lolland, towards the Smaaland Sea a line from Korsør passing Egholm, Agersø, Omø and the south-westerly Omø Staal Grund to the eastern point at Onse Vig in Lolland.

The Smaaland Sea. **Sm.** The boundary towards the Baltic off Grønsund is a line round Tolken, towards the Baltic off the Bøgestrøm a line round the sand shallows to the Bøgestrøm buoy.

The Sound (Øresund) **Su.** The boundary towards the Baltic off Grønsund is a line from the south point of Amager eastward.

The western Baltic. **Bw.** To a line between Gjedser and Darsserort.

The Baltic round Møen. **Bm.** To a line from the north end of Rügen northward.

The Baltic round Bornholm. **Bb.** The waters surrounding Bornholm.

Remarks on the dredging localities.

I have considered it useful to make a list of all the localities where I have dredged and to give information about the depth, the nature of the bottom and the vegetation at each. They are also indicated on the accompanying charts by signs, illustrating the vegetation. By means of this it will be possible in the following to give a detailed account of the occurrence of the single species in the Danish waters without too great prolixity, and, by means of the list and the charts, to contribute perhaps to the characterization of the separate waters with regard to the vegetation, even if the dredging localities are not so near each other, that they can serve as base for a chart showing the distribution of the vegetation. To obtain this, much more numerous observations than I have been able to make are necessary. The Danish waters are so complicated, and the nature of the bottom often so variable from place to place, that it is not possible, from the dredging at one place to draw conclusions as to the conditions at another close by. It may also be remembered, that the aim of my investigations was not so much to determine, to what extent the bottom was overgrown, as to study the distribution and the mode of occurrence of the single species. That is why I have usually preferred to dredge at places where I could expect the bottom to be overgrown. If the result has nevertheless been, that so great a number of the dredging localities have proved to be without vegetation, the reason is, that a relatively large part of the bottom in the Danish waters is not overgrown, especially in the more open waters. This is especially the case with regard to the North Sea, which is quite without vegetation except at some few places in the most northern part of the region referred to here. In the Skagerak the greater part of the bottom is also quite without vegetation, even on stony bottom Algæ are often lacking. Here and there some small overgrown plots are however found, but it is only at some few places that a more abundant vegetation is found, especially near the land, e. g. at Hirshals and Bragerne. Also in the other waters large tracts are without vegetation, especially the soft bottom, which in the Kattegat and the Baltic extends over wide areas in the greater depths.

A main rule is, that the total quantity of the vegetation is generally the greater the more sheltered the place is. It must however be remembered, that in the more sheltered waters we have the *Zostera*, which grows on sand bottom or on mud bottom more or less mixed with sand[1], while the algal vegetation is found on stony bottom. The last applies not only to bottom exclusively or predominantly consisting of stones but also to sand bottom or soft bottom with scattered stones. On the last mentioned kind of bottom there is commonly, according to the conditions, scattered algal vegetation or *Zostera* vegetation with Algæ, which is indicated on the charts by a special sign. But also on true stony bottom scattered algal vegetation is often found especially in deeper water. In such cases the locality is however indicated on the charts with the same sign as those with uninterrupted algal vegetation. Only when the vegetation is practically lacking, but where however some few scattered specimens of Algæ were found, is the locality indicated with ⊙.

It is important to distinguish between Algæ grown on the dredging locality and those found loose[2]. In some cases where such Algæ occur they have been brought by chance from another locality, in other cases they appear in large quantities and always at the same place, where they keep living for a long time. Such collections of loose Algæ are found e. g. at some places near Anholt and near Møen; they are given a special sign. Of a different nature is a number of more or less transformed loose forms of different algal species connected with the *Zostera* vegetation; probably they have been carried into this vegetation after having been torn loose, but when there have been kept among the *Zostera* plants and have gone on living perhaps for a long time, propagating by division, while reproduction by spores has ceased and the appearance has become more or less transformed[3].

[1] C. H. Ostenfeld, Aalegræssets (*Zostera marina's*) Væxtforhold og Udbredelse i vore Farvande. Beretn. fra den danske biologiske Station. XVI. 1908. (Report from the Danish Biological Station. XVI.)

[2] Such a distinction has not been made in C. G. Johs. Petersen, "Kanonbaaden Hauchs Togter" where the signs indicating the *Zostera*, *Laminaria* and some other higher Algæ in the Kattegat are given on the Atlas, Plate III (1893). In some single cases at any rate, plants are here noted as growing at localities, where according to my experience the bottom is quite without vegetation.

[3] The largest and perhaps the best known is *Ascophyllum nodosum* f. *scorpioides*; of others may also be mentioned: *Phyllophora Brodiæi*, *membranifolia* and *rubens*, *Ahnfeltia plicata*, *Polysiphonia nigrescens* and *violacea*, *Cladostephus verticillatus*, *Halopteris filicina* and *scoparia*, *Sphacelaria cirrosa* etc.

In the following list of the dredging localities are indicated for each locality the most common and predominant species, which above all others contributed to the characterization of the vegetation, the most important first, the less predominant in parenthesis. With regard to the indication of the locality it must be remarked that the bearings are always by compass. Besides the localities mentioned in the list, I have also made collections at many harbour-piers, stone-reefs and at other places near the land, which are for the most part indicated by a mark on the charts together with the name of the place concerned. In the list the localities are arranged for the North Sea from south to north, for the Skagerak and the Limfjord from west to east, for the rest of the waters generally from north to south, or from without inwards, in the Baltic however essentially from west to east. In the Samsø region the area east of Samsø is distinguished from that west of this island. The same method as in the lists will be kept in the following pages. To facilitate the orientation the detailed list is supplemented by a chronologically arranged summary of the dredging localities with indications of the waters where they are situated.

List of stations arranged according to the different waters.

North Sea. (Ns)

aH. $^5/_8$ 1905. Vyl light-ship N.W. by W. $^1/_2$ W., 6 miles. — 20 meters. — Fine grey sand with shells. — No vegetation (at the same station Dr. A. C. Johansen took, in 1903, several fresh *Laminaria* together with *Halidrys* and *Furcellaria* in trawl, but it was uncertain whether they were growing on that spot).

aL. $^5/_8$ 05. Vyl light-ship S.E. $^1/_2$ S., $6^1/_3$ miles. — 25 meters. — Coarse sand with small pebbles. — No vegetation.

aI. $^5/_8$ 05. Vyl light-ship S.W. $^1/_4$ W., $6^1/_3$ miles. — 9,5 meters. — Firm coarse sand (with small pebbles). — No vegetation.

aK. $^5/_8$ 05. A little more south than aI. — 8 meters. — Coarse sand with pebbles. — No vegetation.

aQ. $^8/_8$ 05. A tract immediately N. of the light-buoy at the south end of Slugen (Horns Reef). — 7,5 to 19 meters. — We searched here with grapnel for a wreck and dredged several times, but only bare sand without vegetation was found; the shells were without Algæ.

aN. $^5/_8$ 05. Horns Reef light-ship N.W. $^2/_3$ W., a good 6 miles. — About 23 meters. — Sand with small pebbles. — No vegetation.

aM. $^5/_8$ 05. Horns Reef light-ship N.W. by W. $^1/_4$ W., 7 miles. — 16,5 to 18 meters. — Coarse sand with a few small pebbles. — No vegetation.

aM [1]. $^5/_8$ 05. A little more to the south. — 22,5 meters. — Coarse sand. — No vegetation. — 24,5 meters. — Sand, pebbles. — No vegetation.

aR. $^8/_8$ 05. Double broom at Søren Bovbjergs Knob S.E. by E. $^2/_3$ E. $1^1/_4$ miles. — 13 meters. — Sand. — No vegetation.

aS. $^{8}/_{8}$ 05. The light buoy at the north end of Slugen W.N.W $^{1}/_{4}$ W. 3 miles. — 9,5 meters. — Sand. — No veg. (loose *Fucus vesiculosus*).

aP. $^{5}/_{8}$ 05. Horns Reef light-ship W. $^{3}/_{4}$ N. a good $6^{1}/_{2}$ miles. — 11,5 meters. — Sand. — No vegetation.

aO. $^{5}/_{8}$ 05. 1 mile E. of Horns Reef light-ship. — 30 meters. — Partly sand, partly stony bottom. — No vegetation.

aB. $^{27}/_{7}$ 05. Off Harboøre; Bovbjerg light-house S. $^{1}/_{4}$ W., $6^{1}/_{2}$ miles. — 24,5 meters. — Sand, thereafter stones. — No vegetation.

aA. $^{27}/_{7}$ 05. Thyborøn beacon E. $^{1}/_{2}$ N., ca. 10 miles. — 22 to 25,5 meters. — Coarse sand. — No vegetation.

ZZ. $^{27}/_{7}$ 05. Thyborøn beacon S.E. by E., 5 miles, 4 miles off land. — 24,5 meters. — Sand. No vegetation.

aC. $^{27}/_{7}$ 05. Thyborøn beacon S.E. by S. $^{1}/_{2}$ S., 3 miles. — 21 meters. — Sand, firm clay. — No vegetation.

ZR. $^{24}/_{7}$ 05. Lodbjerg light-house E. $^{7}/_{8}$ N., $10^{2}/_{3}$ miles, near the 15 meter shallow. — 28 meters. — Sand. — No vegetation.

aF. $^{1}/_{8}$ 05. Thyborøn beacon S.E. $^{1}/_{2}$ E., $14^{1}/_{2}$ miles. — 31 meters. — Sand with small pebbles to coarse gravel with pebbles. — Vegetation very poor to rather rich: *Ectocarpus siliculosus*, *Brongniartella*, *Chorda Filum* and *Ch. tomentosa*. . . .

ZQ. $^{24}/_{7}$ 05. Jutland Reef; Lodbjerg light-house E. by S., $26^{1}/_{2}$ miles. — 24,5 meters. — Gravel with small and partly a little larger pebbles. — In two dredgings *Chorda Filum*, (*Laminaria saccharina* and *hyperborea* (?), fragment . . .); in one dredging *Phyllophora membranifolia* a. o.

aG. $^{1}/_{8}$ 05. Thyborøn beacon S.E. $^{1}/_{2}$ E., $19^{1}/_{2}$ miles. — 38 meters. — *Ectocarpus siliculosus*.

aD. $^{27}/_{7}$ 05. Lodbjerg light-house S.E. $^{3}/_{4}$ S., ca. $4^{1}/_{2}$ miles. — 23,5 meters. — Stones. — a) *Ectocarpus siliculosus*, *Desmarestia viridis*, *Flustra foliacea* with *Derbesia* a. o. — b) *Ectocarpus*, *Desmarestia aculeata*.

aE. $^{27}/_{7}$ 05. Lodbjerg light-house S. by W. $^{1}/_{2}$ W., $7^{1}/_{3}$ miles. — 16 meters. — Sand. — Some few *Ectocarpus* and *Brongniartella*. (The dredge foul).

XR. $^{9}/_{8}$ 00. Off Ørhage (by Klitmøller), at most 1 mile off land. — 11 to 13 meters. — Stones. — *Cystoclonium*, *Delesseria sangvinea*, *Spermothamnion*. Vegetation scare, partly wanting.

Skagerak. (Sk)

YT. $^{7}/_{8}$ 02. N. and W. of Helshage (Hanstholm).

1) N. of the point. — 5,5 to 7,5 meters. — Stones. — Very few Algæ (*Delesseria sangvinea*, *Phyllophora membranifolia*).
2) A little farther from land. — 9 to 11 meters. — Stones. — Very few Algæ (*Phyllophora membranifolia*).
3) A shallow about off the light-house. — About 5,5 meters. — Stones. — Richer vegetation (*Dilsea edulis*, *Laminaria hyperborea*).
4) Farther from land. — About 15 meters. — Stones. — Very scarce Algæ (*Deless. sangvinea*).
5) Another shallow farther S. — About 13 meters. — Stones. — Richer vegetation: *Laminaria saccharina*, *Polyides*.
6) From 5) landward. — 7 to 11,5 meters. — Stones. — Much the same species as in 5) but scarcer, further *Laminaria hyperborea*.

YU. $^{8}/_{8}$ 02. At Roshage (Hanstholm), near land.

1) Immediately E. of Roshage, on a dry rock near land, the bottom in a depth of 2 meters. — *Polysiphonia Brodiæi* (at the upper level), *Polys. nigrescens*, species of *Ceramium* ....

2) Eastside of Roshage, near land. — About 2 meters. — Stones. — Abundant vegetation: *Spermothamnion Turneri*, (*Chondrus*, *Corallina off.*).

3) Inside the rock [(1)]. — 1,5 meters. — Stones. — Rich vegetation: *Chorda Filum*, *Ceramium rubrum*. ...

4) Off Roshage and from thence along the shore towards the landing-place. — 2 to 2,5 meters. — *Ceramium rubrum*, *Cystoclonium*, *Polysiphonia*; in some places *Laminaria digitata*; on the W. shore *Gracilaria confervoides*.

YM. $^{10}/_{7}$ 02. The W. and S. part of Bragerne (a bank). — 2,5 meters. — Stones. — 1) *Florideæ*, rather scarce (*Rhodomela*, *Polysiphonia violacea* var. *fibrillosa*, *Corallina off.*). — 2) The same Algæ and *Laminaria hyperborea*).

YM^{1}. $^{10}/_{6}$ 02. Bragerne. — 1 to 2 meters. — Stones. — *Mesogloia*, *Ceramium fruticulosum*, *Laminaria digitata* and *saccharina*, *Fucus serratus*, *Cystoclonium*, *Corallina off.* — 1 meter: *Laminaria*, *Punctaria*, *Spongomorpha*.

YN. $^{10}/_{6}$ 02. Immediately inside Bragerne. — 4,5 meters. — Stones. — *Fucus serratus*, *Laminaria digitata*.

YN^{1}. $^{10}/_{6}$ 02. A little nearer to land. — 6,5 meters. — Stones. — *Chorda Filum*, *Brongniartella*.

YN^{2}. $^{10}/_{6}$ 02. S.E. of Bragerne. — 10,5 meters. — Stones. — *Laminaria hyperborea*, *Chorda Filum*, *Phylloph. Brodiæi*, *rubens*, *Spermothamnion*, *Corallina offic.*

YN^{3}. $^{10}/_{6}$ 02. S.E. of Bragerne, near land, towards Sandnæshage. — About 2 meters. — Sand and boulders. — Almost no Algæ (*Polysiphonia elongata*).

SZ. $^{21}/_{8}$ 94. About 2 miles N.W. of Løkken. — Stones. — No vegetation.

SY. $^{19}/_{8}$ 94. About 1 mile N. of Løkken. — ca. 13 meters. — Stones. — Scarce vegetation, mostly *Cystoclonium*, *Rhodomela* and *Spermothamnion*.

ZK$^{0-13}$. $^{2-4}/_{8}$ 04. Off Lønstrup.

0) W. side of Mellemgrund, 1,5 miles from land. — 7,5 to 9,5 meters. — Stones. — *Halidrys*, *Cystoclonium*.

1) N. end of Stenrimmen, 2 miles from land. — ca. 7,5 to 9,5 meters. — *Laminaria digitata*, *saccharina*, *Halidrys*: *Florideæ*, mostly *Corallina offic.*, *Furcellaria*.

2) E. end of Mellemgrund. — 7,5 to 9,5 meters. — Stones. — *Laminaria hyperborea*, *Halidrys*, *Florideæ*.

3) Mellemgrund. — 13 to 15 meters. — Stones. — Some few *Halidrys* and single *Florideæ*.

4) Grønne Grund 1 mile from land. — 9,5 to 11,5 meters. — Stones. — *Halidrys*, *Florideæ*, particularly *Cystoclonium*, *Phyllophora membranifol.*, further *Laminaria hyperborea* and *saccharina*.

5) Palen, abreast of Rubjergknude light-house, 1 mile from land. — ca. 11 meters. — Stones. — Veg. as in 4).

6) Shallow off the landing-place. — 11 to 13 meters. — Firm clay with stones. — *Phyllophora membranif.*, *Furcellaria*, *Laminaria*.

7) E. end of Rimmen, abreast of Rubjergknude light-house, about 4 miles from land. — 17 to 19 meters. — Stones. — *Halidrys*, *Laminaria sacchar.* and *hyperborea*. — Later, clay with pebbles and scarce Algæ, mostly *Heterosiphonia coccinea*.

8) A little more S. — Sand without vegetation.

9) Stenrimmen, about 4 miles from land. — 13 meters. — Stones. — Few Algæ: *Halidrys*, single *Florideæ*.

10) Mellemgrund, something more than 2 miles from land. — 11,5 meters. — Stones. — *Halidrys*, *Laminaria hyperb.*, *Cystoclonium*.

11) Graagrund, off Maarup church, about 1,5 miles from land. — 9,5 meters. — Stones. — Rather scarce vegetation: *Halidrys*, (*Lomentaria clavellosa*, *Cystoclonium*).

12) Kongshøj Grund, off Maarup church, 1 mile from land. — 8,5 meters. — Stones. — *Cystoclonium*, (*Polyides*, *Deless. sangvin.*, *Halidrys*).

13) Near land, immediately N. of the landing-place. — 1 meter. — Stones, clay; *Mytilus*, acorn-shells. — Various *Florideæ*, as species of *Polysiphonia*, *Gracilaria confervoides*.

YL. 1/8 01. Hirshals light-house S.E. 2,5 miles (Pullen). — 13 meters and something more. — Stones. — *Halidrys* with *Florideæ*.

YL[1]. 1/8 01. Hirshals light-house S.E. 1,5 miles. — Stones. — A few specimens of *Brongniartella byss.*

21/5 02. Hirshals light-house S.E., ca. 1 mile (the church between the hills). — Stones. — *Flustra foliacea* with various small Algæ, *Delesseria sangvinea* (scarce *Halidrys*, *Cystoclonium*).

21/5 02. N. and W. end of Bredegrund, N.W. of Hirshals. — ca. 11 meters. — Stones. — Few Algæ (*Halidrys*, *Cystoclonium*, *Laminaria hyperborea*).

21/5 02. Within Bredegrund. — 19 meters. — Stones. — One specimen of *Halidrys*.

21/5 02. The channel within the stony shallows N.W. of Hirshals. — 19 meters. — Clay. — No vegetation.

YK. 1/8 01. Hirshals light-house in S.S.E. 2 miles (the church on the brook). — 14 meters. — Stones. — *Cystoclonium*, *Brongniartella*, *Laminaria digitata*. — 15 meters. — *Flustra foliacea* with few Algæ.

XO. 8/8 99. Møllegrund by Hirshals, ca. 1/2 mile from land. — 11 to 15 meters. — Stones. — *Laminaria hyperborea* and *Halidrys*, (*Laminaria saccharina*).

21/5 02. Off the brick-works at Hirshals, near land. — 6,5 meters. — Sand with stones. — *Rhodomela*, *Polysiphonia nigrescens*.

21/5 02. Off the marine hotel at Hirshals. — 4,5 meters. — Stones. — *Polyides*.

VJ. 12/6 95. Off Hirshals, W. of the mole. — 4,5 meters. — Stones alternating with sand. — On the stones *Polyides* and *Furcellaria*.

bD. 6/7 07. 13 miles N.N.W. 1/2 N. of Hirshals; 57°46′ N., 9°44′ E. — 32 meters. — Soft bottom. — No vegetation.

bC. 6/7 07. Hirshals light-house S. 1/2 W. 12 miles. — 45 meters. — Soft bottom, ooze. — No vegetation.

bE. 6/7 07. 6 miles N.E. by N. of Hirshals. — 23 meters. — Coarse sand. — No vegetation.

bF. 6/7 07. Skagbanken; 9 miles N.E. by E. of Hirshals. — 16,5 meters. — Sand. — No vegetation.

bB. 5/7 07. Skagens light-house E. 10 miles; Lat. N. 57°41′,5, Long. E. 10°20′. — 24 meters. — Stones and sand. — No vegetation.

bG. 9/7 07. Northside of Skagens Gren, N.N.W. of Skagens light-house. — 5,5 to 17 meters. — Sand. — Few loose Algæ.

16/8 03. Between Gammel Skagen and the Siren, within the first shoal. — Small pebbles. — *Chorda Filum*, *Polysiphonia nigrescens*.

bG. $^{15}/_{8}$ 03. Between first and second shoal. — 3,5 to 4,5 meters. — Small pebbles. — *Polysiphonia nigrescens, Ceramium rubrum.*

$^{16}/_{8}$ 03. Between Gammel Skagen and Højens light-house; between first and second shoal. — 3,5 to 5,5 meters. — Small stones. — Few Algæ, mostly species of *Polysiphonia*, (acorn-shells and young *Mytilus*).

Limfjord. (Lf)

ZS. $^{25}/_{7}$ 05. Under the land at Kobberød. — 2 to 4 meters. — Stones. — *Fucus serratus.*

ZV^1. $^{26}/_{7}$ 05. In the middle of Nissum Bredning; the broom for Mullerne E. 2,5 miles. — 5 meters. — Soft bottom. — *Cladophora gracilis.* (*Ciona canina* in abundance).

ZV^2. — A little farther N.; the broom E. by S. $^1/_2$ S. 2,5 miles. — (Small shells, *Ophioglypha albida*, often infested by a *Dactylococcus*).

LY. $^{24}/_{8}$ 93. Between Gellerodde and Inderrøn near Lemvig. — 3 to 3,5 meters. — Sand with spots of loose *Furcellaria*, (*Cladophora, Phyllophora Brodiæi*).

M. $^{9}/_{9}$ 90. Søndre Røn near Lemvig. — 1 meter. — Stones. — *Fucus vesicul.*, here and there *Zostera.*

ZU. $^{26}/_{7}$ 05. W. of the N. end of Rønnen near Lem Vig. — 3 meters. — Stones. — *Fucus vesicul.* — Thereafter (northward) 4 meters — sand with *Ciona canina* and *Fucus serratus.*

LX. $^{24}/_{8}$ 93. Rønnen, a reef near Lem Vig. — Uppermost *Fucus vesicul.*; — 2 to 4 meters *Fucus serratus*; — 4 to 5,5 meters broad-leaved *Zostera.*

ZT. $^{25}/_{7}$ 05. Off Østerbol. — about 4 meters. — *Zostera*, and a little farther out loose *Furcellaria* and *Cladophora gracilis* in great quantities.

XV. $^{19}/_{6}$ 01. N. of Rønnen by Lem Vig. — Oysters, *Furcellaria.*

XX. $^{19}/_{6}$ 01. Midway between XV and Mullerne. — 5,5 meters. — *Furcellaria*, (*Cladophora gracilis*).

LZ. $^{26}/_{8}$ 93. Off Røjens Odde. — 4 meters. — Clay-mud with a few stones. — No vegetation.

ZX. $^{26}/_{7}$ 05. Immediately E. of the broom at Mullerne. — 6,5 meters. — Soft bottom. — *Cladophora gracilis.*

ZY. $^{26}/_{7}$ 05. Nearer to land. — 4,5 meters. — Stones and soft bottom. — *Zostera, Fucus serratus.*

XY. $^{19}/_{6}$ 01. Near Mullerne. — 6,5 meters. — Soft bottom with stones. — *Fucus serratus*, (sparingly *Zostera*).

MA. $^{26}/_{8}$ 93. Off Jestrup. — 5 meters. — Stones. — Scarcely any vegetation, only single specimens of *Fucus serratus, Chorda Filum* and *Desmarestia aculeata.*

LV. $^{24}/_{8}$ 93. Off Nissum Huk. — 5,5 meters. — Clay-mud mixed with sand, with stones and oysters. — No plants.

LU. $^{24}/_{8}$ 93. Off Kamstrup Røn. — Scarcely 7,5 meters. — Clay-mud without plants (a few *Cladophora gracilis*).

XU. $^{19}/_{6}$ 01. Immediately W. of Oddesund-Nord. — 4 meters. — Sand with single stones. — *Fucus serratus*, (*Halidrys*).

MB. $^{26}/_{8}$ 93. S.W. of Oddesund-Nord. — 6,5 meters. — At first bare sand, then clay-mud with single Florideæ and, rather abundantly, loose *Cladophora gracilis.*

MD. $^{26}/_{8}$ 93. Studemilen, right opposite Doverodde. — Thick *Zostera* vegetation everywhere; up on the bank also stones with *Fucus vesiculosus.*

ME. $^{27}/_{8}$ 93. Off Skjoldborg (Thy), near the shoal. — 7,5 meters. — Soft bottom without vegetation.

MF. $^{27}/_{8}$ 93. Sundby Stengrund, at the N. side of Mors. — Stones. — *Chorda Filum.*

MG. $^{27}/_{8}$ 93. Stony reef by Hanklit. — *Fucus vesiculosus*, covered with *Melobesia*, *Lithophyllum pustulatum* and *Laurencia pinnatifida.* — Outside the reef *Zostera.*

MH. $^{28}/_{8}$ 93. Bank off Skrandrup, Thisted Bredning. — Stones. — *Fucus vesiculosus*, (*Chorda Filum*, *Corallina offic.*).

I. $^{8}/_{9}$ 90. Venø Bugt, off Nørskov, Venø. — 3,5 meters. — Stony bottom with *Zostera*, (few Algæ, *Phyllophora membranifol.*).

K. $^{8}/_{9}$ 90. Venø Bugt, off Nørskov, Venø, N. of Venø Tap. — 4,5 to 5,5 meters. — *Furcellaria* and *Phylloph. membranif.*

L. $^{8}/_{9}$ 90. Venø Bugt, Nygaards Hage. — 3,5 meters. — Stones. — *Zostera*, (*Furcellaria*, *Phyllophora membranif.*).

XT. $^{19}/_{6}$ 01. South side of Jegindø Tap. — 4,5 meters. — Clay. — *Zostera*, (loose *Furcellaria*).

MC. $^{26}/_{8}$ 93. Jegindø Tap, immediately W. of the broom. — 6,5 meters. — Clay-mud without veg.

MC¹. $^{26}/_{8}$ 93. East side of Jegindø. — From shallow water to 4 meters depth *Zostera*, farther out clay-mud without vegetation.

H. $^{6}/_{9}$ 90. Kaas Bredning, off Sillerslev, Mors. — 7,5 meters (?). — Clay-mud without vegetation.

XN. $^{14}/_{7}$ 99. Sallingsund, immediately S. of Glyngøre. — 4 to 9 (?) meters. — Stones, oysters. — *Chorda Filum*, *Fucus vesiculosus.*

XM. $^{13}/_{7}$ 99 and $^{21}/_{6}$ 06. Off Snabe. — 4 to 5,5 meters. — *Zostera* and stones with *Fucus vesiculosus*, *Chorda Filum* etc.

XY¹. $^{25}/_{6}$ 01. Vodstrup Hage (Skælholm) near Nykøbing. — Stones. — *Fucus vesic.*, *Rhodomela*, *Furcellaria* (loose).

LT. $^{22}/_{8}$ 93. Immediately outside the broom at Vodstrup Hage. — Ca. 5,5 meters. — Firm bottom with *Zostera*, (*Polysiphonia nigrescens*).

LS. $^{22}/_{8}$ 93. Off Alsted (Arnakke), Mors. — 5 meters. — Clay-mud with dead shells. — *Florideæ*, particularly *Polysiphonia nigrescens.*

LS¹. — Nearer to land. — 1 to 3 meters. — Stones with *Fucus vesiculosus*; in some places also *Zostera*; farther out clay-mud with scarce *Florideæ*.

aT. $^{22}/_{6}$ 06. Outer part of Draaby Vig, off Alsted church. — 4 to 5,5 meters. — Soft bottom with *Zostera* and *Furcellaria*; in other places stones and oysters but few Algæ, farther out, 7,5 meters — soft bottom with shells, without vegetation.

MF. $^{28}/_{8}$ 93. Løgstør Bredning, off Ejerslev. — From land to 4 meters depth clayey sand with *Zostera*; in shallow water stones with *Fucus vesiculosus.*

MK. $^{28}/_{8}$ 93. Holmtunge Hage. — Stony reef with *Fucus vesiculosus*, here and there *Zostera.*

LQ. $^{22}/_{8}$ 93. Lendrup Røn. — Stones. — *Fucus vesiculosus*, (*Fucus serratus*, *Laurencia pinnatifida*).

LR. $^{22}/_{8}$ 93. E. of Livø. — 6,5 meters. — Soft bottom. — *Zostera.*

F. $^{5}/_{9}$ 90. Skive Fjord, North side of Lundø Hage. — Ca. 5,5 meters. — Soft bottom. — No vegetation.

F¹. — On the bank. — 3 meters. — *Zostera*, (a few loose *Furcellaria* and *Phyllophora Brodiæi*).

G. $^{5}/_{9}$ 90. Off Skive. — 3,5 meters. — *Zostera* (a few loose *Furcellaria*). — On bare bottom loose clumps of *Furcellaria*, (*Phyllophora Brodiæi*, *Cladophora gracilis*).

E. $^{4}/_{9}$ 90. Louns Bredning, W. of Trangmanden. — 5,5 meters. — Soft bottom. — Loose Algæ: *Cladophora gracilis*, (*Rhodomela*, *Phyllophora Brodiæi* etc.).

E¹. — A little farther northwards. — Same depth and bottom, similar vegetation.

ML. $^{29}/_{8}$ 93. Outside the broom near Klitgaard in Gjøl Bredning. — Thick broad-leaved *Zostera* vegetation with *Melobesia Lejolisii* and some *Ceramium rubrum*.

Kattegat, Northern part. (Kn)

bH. $^{9}/_{7}$ 07. 8 miles S.E. by E. $^{1}/_{2}$ E. of Skagen. — 30 meters. — Soft bottom. — No vegetation.

FG. $^{13}/_{7}$ 92. Herthas Flak. — 19 to 22,5 meters. — Stones, gravel. — *Laminaria saccharina*, *Desmarestia aculeata*, (*Deless. sangvin.*, *Cystoclonium*).

XI. $^{29}/_{7}$ 96. Herthas Flak. — 20 to 22,5 meters. — Gravel and stones. — *Lamin. sacch.*, *Desmar. acul.*, *Deless. sangv.*, *Ceram. rubrum*, *Callithamnion corymbosum*, *Sporochnus*. (Vegetation spread).

— $^{14}/_{7}$ 05. — 20,5 to 24,5 meters. — The bottom alternately clay-mud and gravel with single stones; on these some few incrusting Algæ, for the rest nearly no vegetation (repeated dredgings).

bI. $^{9}/_{7}$ 07. S.E. of Herthas Flak; 11 miles S.E. $^{1}/_{4}$ S. of Skagen. — 26,5 meters. — Clay-mud. — No plants.

IZ. $^{16}/_{5}$ 93. Skagens light-house N.N.W. $^{4}/_{5}$ W. a good 7 miles. — About 24,5 meters. — No vegetation (seine).

IY. $^{15}/_{5}$ 93. Hirsholm light-house S.W. by S. a good 5 miles. — 22,5 meters. — Clay-mud. — No vegetation.

KA. $^{15}/_{5}$ 93. Hirsholm light-house S. by E. $^{1}/_{2}$ E. a good 5 miles. — 13 meters. — Fine sand. — scarce *Zostera* (seine).

TV. $^{1}/_{10}$ 04. Krageskovs Rev, northern shoal. — Stones and sand. — 5 meters. — Abundant vegetation: *Halidrys*, *Fucus serratus*, *Laminaria sacch.*, *Furcellaria*, (*Corallina off.*).

KC. $^{15}/_{5}$ 93. Krageskovs Rev, southern shoal. — 4 to 5,5 meters. — Stones. — Abundant vegetation: *Halidrys*, *Fucus serratus*, *Laminaria digitata*.

KB. $^{15}/_{5}$ 93. Off Snedkergaarde. — 4,5 meters. — Fine bare sand with only a few spots most probably of *Zostera*.

TX. $^{2}/_{10}$ 94. Inside the broom N. of Græsholm (Hirsholmene). — 7,5 to 9,5 meters. — Stones. — Dense vegetation: *Halidrys*, *Fucus serratus*, *Laminaria hyperborea*.

— $^{5}/_{1}$ 95 and $^{24}/_{7}$ 95. Same vegetation; of predominant species further *Laminaria digitata* and *saccharina*, *Furcellaria*.

YR. $^{31}/_{7}$ 02. Naamands Rev N. of Græsholm. — Stones. — *Halidrys*, *Laminaria digitata*.

XK. $^{4}/_{7}$ 99. N.E. of Græsholm. — 7,5 to 11,5 meters. — Stones. — *Laminaria hyperborea*....

YS¹. $^{31}/_{7}$ 02. E. of the broom N. of Græsholm. — Ca. 9 meters (?). — Soft bottom. — No vegetation.

YS². $^{31}/_{7}$ 02. The broom N. of Græsholm W.S.W. ca. 1 mile. — 15 meters. — Clay-mud with snails etc. — On the snail-shells some Algæ (*Antithamnion*, *Polysiphonia atrorubescens*, *P. elongata* a. o.).

YX. $^{11}/_{7}$ 04. E. of the broom at N.E. reef by Hirsholm. — 22,5 to 28 meters. — Soft bottom. — On mollusc shells: *Polysiphonia atrorubescens*, *P. elongata* a. o. Algæ.

TU. $^{1}/_{10}$ 94 and $^{5}/_{1}$ 95. At the broom at N.E. reef by Hirsholm. — ca. 9,5 meters. — Sand and stones. — *Laminaria saccharina*, (*Desmarestia aculeata*, *Laminaria hyperborea*).

— $^{11}/_{7}$ 04. Same place, but within the broom. — 7,5 to 9,5 meters. — Stones. — *Laminaria hyperborea*, *L. sacchar.*, *Furcellaria* a. o. *Florideæ*.

TU. $^{11}/_{7}$ 04. Outer side of the same reef. — 9,5 to 11,5 meters. — Soft bottom and gravel (?). — *Stictyosiphon*, *Striaria* a. o.

NF. $^{21}/_{9}$ 93. Immediately outside the harbour of Hirsholm. — 4 meters. — Sand. — *Zostera*.

TY. $^{2}/_{10}$ 94.. The bank S. of Hirsholm. — 7,5 meters. — Sand and single stones. — Scattered *Zostera*.

NE. $^{21}/_{9}$ 93. Off Lerbæk. — 5,5 meters. — Gravel. — *Zostera*.

YQ. $^{25}/_{7}$ 02. E. side of Kølpen. — 2 to 5,5 meters. — Stones. — Abundant algal vegetation: *Fucus vesicul.*, *F. serratus*, *Chorda Filum*, *Halidrys*, *Laminaria sacchar.*, *L. digit.* . . .

XG. $^{2}/_{8}$ 95. E. of Deget. — 4 to 5,5 meters. — Stones. — *Halidrys*, *Fucus serr.*, *Florideæ*, (*Laminaria hyperb.*).

GO. $^{23}/_{9}$ 92. Outside Busserev near Frederikshavn. — 3 meters and more. — Stones. — *Fucus serratus*, *Halidrys*, (*Laminaria digitata*).

UD. $^{5}/_{1}$ 95. Marens Rev. — 4,5 to 5,5 meters. — Stones. — *Halidrys*, (*Laminaria digit.*, *sacchar.*, *Fuc. serr.*).

XH. $^{9}/_{7}$ 96. The beacon buoy at Marens Rev W. by S. ca. 1 mile. — 15 meters. — Clay-mud with snails (*Turritella*, *Aporrhais*.). — On the shells *Polysiphonia atrorubescens*.

XL. $^{8}/_{7}$ 99.. The buoy at Marens Rev W. by N. a good 1,5 miles. — 19 to 20,5 meters. — Clay-mud. On *Aporrhais* and *Turritella*: *Polysiphonia atrorubescens*, *Stictyosiphon tortilis*, *Antithamnion*, *Sphacelaria*.

FH. $^{15}/_{7}$ 92. Borrebjergs Rev, near the triple broom. — 4 to 7,5 meters. — Sand. — *Zostera*.

YP¹. $^{25}/_{7}$ 02. Outside Laurs Rev. — Stones. — *Halidrys* (with *Ectocarpus*).

YP². $^{25}/_{7}$ 02. Borrebjergs Rev. — Stones. — *Halidrys*, (*Laminaria digitata* and *sacchar.*).

YP³. $^{25}/_{7}$ 02. Laurs Rev. — Stones. — *Halidrys*, *Lamin. digit.*, *hyperb.* and *sacchar.*

TZ. $^{3}/_{1}$ 95. Between Borrebjergs Rev and Laurs Rev. — No vegetation.

YO. $^{20}/_{7}$ 02. 1 mile S.E. of Laurs Rev. — Soft bottom. — Dead *Zostera*-leaves.

$^{13}/_{7}$ 05. In the deep channel N.W. of Læsø. — Soft bottom. — No Algæ.

BP. $^{24}/_{8}$ 91. Off Sæby. — 7 meters. — Firm clayey sand. — In spots *Zostera*.

TM. $^{27}/_{9}$ 94. Nordre Rønners light-house S.E. by S. 2,6 miles. — 13 meters. — Sand without vegetation.

VT. $^{3}/_{7}$ 95. Nordre Rønners light-house S. scarcely 2,5 miles. — 9,5 meters. — Sand. — *Zostera*, *Fucus serratus*, *Florideæ*, (*Laminaria sacchar.*).

UA. $^{3}/_{1}$ 95. Nordre Rønners light-house S. scarcely 2 miles. — 11,5 meters. — No plants.

TI. $^{26}/_{9}$ 94. Nordre Rønners light-house E.S.E. scarcely 1,5 miles. — 12,5 meters. — Firm clay with stones. — *Laminaria sacchar.*, *Desmarestia acul.* a. o. (vegetation not abundant).

TL. $^{27}/_{9}$ 94. Nordre Rønners light-house E. by N. $^{1}/_{4}$ N. $1^{1}/_{3}$ miles. — 7,5 meters. — Stones. — Rich vegetation: *Fucus serratus* and *Florideæ*.

— — Nearer to the reef. — 4 to 5,5 meters. — Sand with stones. — Alternately sand without vegetation or with scarce *Zostera*, or stony bottom with various Algæ.

TK. $^{26}/_{9}$ 94. Nordre Rønners light-house E. by N. $2^{2}/_{3}$ miles. — 9,5 meters. — Sand. — *Zostera*.

KD. $^{15}/_{5}$ 93. At the beacon-buoy at Nordvestrevet, Læsø. — 11,5 to 22,5 meters. — Sand to sandy clay-mud. — No vegetation.

ZP. $^{15}/_{7}$ 05. The broom N.E. of Nordre Rønner S. $^{1}/_{2}$ E. 1 mile. — 11,5 meters. — Sand with stones. — *Zostera*, *Halidrys*, (scarce *Fucus serratus*).

NG. $^{21}/_{9}$ 93. N. of Nordre Rønner. — 4 meters. — Stones. — Abundant vegetation: *Halidrys*, *Fucus serratus*, (*Laminaria digitata*, *Fucus vesiculosus*).

UC. 5/9 95. At the broom N.E. of Nordre Rønner. — ca. 9.5 meters. — Stones. — ***Halidrys***, *Fucus serratus*, *Florideæ*, *Laminaria digitata*).

VU. 5/7 95. Nordre Rønners light-house S.W. by W. 3/4 W. 2.5 miles. — 15 meters. — Stones. — *Halidrys*, *Cruoria*.

GL. 21/9 92. 1/2 mile E. of the broom at Nordre Rønner. — 9.5 meters. — Sand without vegetation.

GN. 21/9 92. Anchoring ground at the E. side of Nordre Rønner. — Ca. 4 to 5 meters. — Stones. — *Fucus serratus*, (*Halidrys*, *Laminaria digitata* and *sacchar.*).

UB. 3/1 95. Nordre Rønners light-house W.N.W. 2 2/3 to 3 1/2 miles. — Here and there stones. — *Halidrys*, *Fucus serratus*, *Florideæ* mostly *Furcellaria* and *Corallina*, (*Zostera*).

TH. 26/9 94. Nordre Rønners light-house W.N.W. 1/4 N. a good 3 miles. — 10.5 meters. — Sand. — *Fucus serratus*, (*Florideæ*, *Zostera*).

ZL. 5/7 05. 3 miles S.E. by E. of Nordre Rønner. — 6.5 meters. — Sand with stones. — *Fucus serratus*, *Fuc. vesiculosus*, *Halidrys*).

ZL[1]. — Near the preceding. — 9.5 meters. — Similar vegetation but moreover *Zostera* and *Desmarestia acul.*

ZL[2]. — Near the preceding. — 11.5 meters. — Stones. — Similar vegetation, in abundance *Furcellaria* and *Corallina off.*

TN. 27/9 94. Trindelen light-ship E.S.E. 5 1/3 miles. — 12 meters. — Sand. — No vegetation.

NH. 21/9 93. Trindelen light-ship E. 5 1/2 miles. — 15 meters. — Gravel. — Almost no vegetation.

ZM. 5/7 05. Ca. 4 1/2 miles E. 3/4 N. of Nordre Rønner. — 15 meters. — Gravel and small pebbles. — Almost no Algæ.

IX. 12/5 93. Trindelen light-ship N.E. 2/3 E. 4 miles. — ca. 19 meters (in the channel). — *Desmarestia acul.*, *Laminaria sacch.*, *Halidrys*).

GM. 21/9 92. At Engelskmands Banke. — Ca. 5.5 meters. — Stones. — *Fucus serratus*, *Chorda Filum*, *Florideæ* (*Phyllophora*).

— 3/7 95. Stony reef by Jegens Odde. — 2 to 4 meters. — *Fucus serratus* with *Polysiphonia violacea*, *Halidrys*. — On a dry rock particularly *Chordaria flagelliformis*, *Ahnfeltia*, *Spermothamnion*, *Chondrus*.

TG. 26/9 94. Syrodde Pynt (Læsø) S.S.E. 1 1/2 miles. — 9.5 meters. — Sand. — *Halidrys*, *Fucus serratus*, *Florideæ*, mostly *Furcellaria*, *Zostera*).

TO. 27/9 94. Tønneberg Banke: Trindelen light-ship S. 2 1/2 miles. — 18 meters. — Stones. — *Laminaria saccharina* (large specimens) and *Florideæ*.

TP. 27/9 94. Tønneberg Banke: Trindelen light-ship S.S.W. 1/2 W. 2 1/2 miles. — 16 meters. — Sand (?) with stones. — *Florideæ*, *Halidrys*, *Laminaria saccharina*.

ZA. 26/7 04. Tønneberg Banke: Trindelen light-ship S.W. by S. 2 miles. — 12 to 18 meters. — Stones. — *Desmarestia aculeata*, *Halidrys*, *Brongniartella*, *Fucus serratus*, later *Laminaria sacchar.*

YZ. 26/7 04. Kummel Banke: Trindelen light-ship S.W. by W. 3/4 W. 3 3/4 miles. — 38 meters. — Clay. — No Algæ.

NK. 21/9 93. Kummel Banke. — 28 to 30 meters. — Gravel. — No vegetation.

ZB. 26/7 04. Trindelens light-ship W. by S. 3/4 S. 2 1/2 miles. — 28 to 30 meters. — Gravel, shells. — *Lithothamnion calcareum*, *Corallina offic.*, *Furcellaria*, *Rhodomela*.

FF. 15/7 92. Double broom at Trindelen S. by W. 1/2 W. 1/2 mile. — 15 meters. — Stones. — *Halidrys*, *Laminaria sacchar.*, (*Florideæ*).

FE. $^{13}/_{7}$ 92. Trindelen, immediately E. of the double broom. — 9,5 to 11,5 meters. — Stones. — *Fucus serratus*, (*Laminaria*, *Furcellaria*).

NI. $^{21}/_{9}$ 93. Trindelen. — 9,5 to 10,5 meters. — Stones. — *Halidrys*, *Fucus serratus*, *Florideæ*: abundant vegetation.

TQ. $^{27}/_{9}$ 94. At Trindelen light-ship. — Stones, mostly rather small. — Incrusting Algæ, e. gr. *Lithoderma*, *Cruoriella Dubyi*, (other Algæ scarce).

TR. $^{27}/_{9}$ 94. Trindelen light-ship N.W. $1^{1}/_{4}$ miles. — 23,5 meters. — Stones. — Incrusting Algæ e. gr. *Lithoderma*, *Cruoria pellita*, *Aglaozonia* . . ., (*Desmarestia acul.*, *Laminaria sacch.*).

IV. $^{12}/_{5}$ 93. Triple broom S. of Trindelen E. by S. $^{1}/_{2}$ mile. — Ca. 11 meters. — Sand. — No vegetation.

VV. $^{3}/_{7}$ 95. E. of the triple broom S. of Trindelen. — 32 to 36 meters. — Clay-mud (?). — No vegetation.

VX. $^{3}/_{7}$ 95. Bøchers Banke. — 29 meters. — Gravel. — Almost no Algæ (scarce *Laminaria sacch.*, *Desmarestia acul.*, *Odonthalia*).

Kattegat, eastern part. (**Ke**)

FD. $^{13}/_{7}$ 92. E. of Flyndergrund, E. of Læsø, Lat. N. 57°16′25″, Long. E. 11°15″. — 9,5 to 11,5 meters. — Dark sand. — In spots *Zostera*.

FC. $^{13}/_{7}$ 92. E. of Flyndergrund, Lat. N. 57°16′10″, Long. E. 11°16′6″. — 17 to 18 meters. — Soft bottom. — Molluscs with single Algæ.

FB. $^{13}/_{7}$ 92. E. of Flyndergrund, Lat. N. 57°15′45″, Long. E. 11°18′. — 30 to 36 meters. — No vegetation.

EY. $^{12}/_{7}$ 92. Kobbergrundens light-ship E. by S. $^{4}/_{5}$ mile. — 13 meters. — Fine sand. — No plants.

ZH. $^{29}/_{7}$ 04. North end of Groves Flak; Kobbergrundens light-ship W. $^{1}/_{2}$ S. $6^{3}/_{4}$ miles (?). — 32 meters. — Soft bottom, partly firm clay, also pebbles. — Scarce vegetation: *Laminaria sacch.*, single *Delesseria sinuosa*.

ZI. $^{29}/_{7}$ 04. North end of Groves Flak; Kobbergrundens light-ship W. $4^{2}/_{3}$ miles. — 26,5 meters. — Stones and gravel, shells. — Almost no Algæ.

EX. $^{12}/_{7}$ 92. Groves Flak, Lat. N. 57°7′30″, Long. E. 11°31′40″. — 26,5 meters. — Sand. — Scarce algal vegetation.

VZ. $^{5}/_{7}$ 95. Groves Flak, Lat. N. 57°6′18″, Long. E. 11°32′40″. — 24,5 meters. — Gravel and stones. — Incrusting Algæ: *Cruoria pellita*, *Cruoriella Dubyi* (*Lamin. sacch.* overgrown with *Membranipora*, *Desmarestia aculeata*).

IR. $^{12}/_{5}$ 93. Groves Flak; Kobbergrundens light-ship N.W. by W. a good 8 miles. — 24,5 meters. — Stones. — *Cruoria pellita*, (*Desmarestia acul.*).

IS. $^{12}/_{5}$ 93. Groves Flak; Kobbergrundens lightship N.W. a good 7 miles. — 22,5 meters. — Sand — *Desmarestia aculeata*, (*Laminaria sacch.*).

IT. $^{12}/_{5}$ 93. Groves Flak, S.W. border; Kobbergrundens light-ship N.W. $^{1}/_{2}$ N. 7 miles. — 24,5 meters. — *Desmarestia acul.*, *Deless. sangvin.* (trawl).

IU. $^{12}/_{5}$ 93. Same place. — 30 to 38 meters (seine). — *Desmarestia acul.*, (*Delesseria sangvin.*).

EV. $^{12}/_{7}$ 92. South end of Groves Flak, Lat. N. 57°4′50′, Long. E. 11°35′. — 22,5 meters. — Stones. — *Laminaria sacch.*, (*Lamin. digit.*, *Desmarestia acul.* and *viridis*, *Florideæ*.).

IL. $^{12}/_{5}$ 93. Fladen, Nidingen N. E. $^{1}/_{2}$ N. a good 4 miles. — 24,5 meters. — Stones and gravel. — *Lithothamnia*, (*Laminaria sacchar.*, *digit.*, *Desmarestia aculeata*).

IL^{1}. $^{12}/_{5}$ 93. Fladen, Nidingen N.E. $4^{2}/_{3}$ miles. — 28 meters. — Gravel and stones. — *Lithothamnia*, (*Laminariæ*, *Odonthalia*).

IM. $^{12}/_{5}$ 93. Fladen, Lat. N. 57°12′50″, Long. E. 11°47′. — 16 meters. — Gravel. – *Halidrys*, *Desmarestia acul.*, *Laminaria sacch.*

ZG. $^{28}/_{7}$ 04. Fladens light-ship S.E. by S. a good 2 miles. — 18 meters. — Stones. — *Halidrys*, *Florideæ*, *Laminaria hyperb.*, *Desmar. acul.*, *Corallina off.*

VY. $^{5}/_{7}$ 95. Fladen, Lat. N. 57°11′22″, Long. E. 11°44′. — 18 meters. — Sand with stones. — Vegetation not abundant: *Halidrys*, *Desmarestia acul.*, *Polysiphonia elongata.*

IN. $^{12}/_{5}$ 93. Fladen, Lat. N. 57°11′10″, Long. E. 11°45′. — 15 meters. — Gravel, stones, — *Fucus serratus*, *Halidrys*, *Desmar. acul.*

IO. $^{12}/_{5}$ 93. Fladen, Lat. N. 57°10′40″, Long. E. 11°44′40″. — 10,5 to 11,5 meters. — Stones. — *Fucus serratus*, *Halidrys.*

ZF. $^{28}/_{7}$ 04. Fladens light-ship S. by E. a good mile. — 22,5 meters. — Stones. — The three species of *Laminaria*, particularly *L. digitata*, various *Florideæ*.

ZE. $^{28}/_{7}$ 04. Immediately W. of Fladens light-ship. — 26,5 meters. — Stones. — *Laminaria digit.*, *sacch.*, *Fucus serratus*, a few *Florideæ*.

ZE^{1}. $^{28}/_{7}$ 04. Fladens light-ship S.E. by E. $^{1}/_{6}$ mile. — 19 meters. — Stones. — *Laminariæ* 3 species, various *Florideæ* e. gr. *Odonthalia.*

— — Fladens light-ship S.E. by E. $^{1}/_{3}$ mile. — 15 meters. — Stones. — *Florideæ*, mostly *Furcellaria*, *Halidrys*, *Fucus serratus.*

IP. $^{12}/_{5}$ 93. W. side of Fladen, Lat. N. 57°10′, Long. E. 11°41′20″. — Ca. 21 meters. — Stones. — *Desmarestia acul.*, (*Lamin. sacchar.*, *Lithothamnia*, *Halidrys*).

IQ. $^{12}/_{5}$ 93. W. side of Fladen, Lat. N. 57°9′30″, Long. E. 11°41′40″. — 21,5 to 30 meters. — Stones. — *Laminaria sacch.*

— — — 30 to 38 meters. (seine). — Incrusting Algæ, *Desmarestia aculeata.*

XA. $^{5}/_{7}$ 95. Kobbergrundens light-ship N. by W. $^{1}/_{2}$ W. a good $6^{1}/_{2}$ miles. — 13 meters. — Gravel with stones, shells. — Scarce vegetation: *Halidrys*, *Chorda Filum*, various *Florideæ*.

IK. $^{10}/_{5}$ 93. Lille Middelgrund, the beacon S.W. by W. $1^{2}/_{3}$ miles. — 17 to 19 meters. — Gravel. — *Lithothamnia.*

II. $^{10}/_{5}$ 93. Lille Middelgrund, the beacon S.E. by S. $^{1}/_{2}$ S. $^{5}/_{6}$ mile. — 14 meters. — Stones. — *Fucus serratus*, (*Furcellaria*).

EU. $^{12}/_{7}$ 92. Lille Middelgrund, Lat. N. 56°56′28″, Long. E. 11°51′52″. — 14 meters. — Gravel with stones. — *Corallina offic.*, (*Halidrys*, *Chorda Filum*, *Lithothamnion Lenormandi*).

ET. $^{12}/_{7}$ 92. Lille Middelgrund, Lat. N. 56°56′25″, Long. E. 11°52′40″. — 12 meters. — Stones, gravel. — *Fucus serratus.*

ES. $^{12}/_{7}$ 92. S.W. of Lille Middelgrund. — 24,5 meters. — Coarse brown sand. — No vegetation (1 specimen of *Laminaria sacchar.*).

IH. $^{10}/_{5}$ 93. The beacon at Lille Middelgrund N.W. by N. $^{1}/_{2}$ N. a good 4 miles. — 20 to 28 meters. — Stones and gravel. — *Lithothamnia*, (*Laminaria sacchar.*, *Desmarestia acul.*).

IG. $^{10}/_{5}$ 93. The beacon at Lille Middelgrund N.W. $^{4}/_{5}$ N. 6 miles. — 36 meters. — Sand and clay-mud. — No vegetation.

ER. $^{12}/_{7}$ 92. Fyrbanken, the beacon at Anholt Knob S. by W $1^{5}/_{6}$ miles. — 28 meters. — Sand with stones. — Scarce algal vegetation, (mostly *Desmarestia viridis*).

EQ. $^{12}/_{7}$ 92. At the beacon at Anholt Knob. — 9,5 to 16 meters. — Scarce algal vegetation.

IF. $^{10}/_{5}$ 93. Røde Banke, the beacon at Anholt Knob N.W. by W. $^{1}/_{2}$ W. 8 miles. — 31 meters. — Red clayey sand. — No vegetation.

IE. $^{10}/_{5}$ 93. Near Røde Banke, Anholt Knobs light-ship N.W. 7 miles. — 34 to 36 meters. — No vegetation.

RU. $^{1}/_{8}$ 94. Tylø light-house E. S. E. $^{1}/_{2}$ E. scarcely 9 miles. — 26,5 meters. — Clay-mud. — Scarce *Florideæ*.

RV. $^{1}/_{8}$ 94. Tylø light-house S. E. $^{1}/_{2}$ S. $5^{1}/_{2}$ miles. — 20,5 meters. — Stones. — Nearly no Algæ.

RT. $^{1}/_{8}$ 94. Store Middelgrund, Lat. N. 56°37,5′, Long. E. 12°4,5′. — 24,5 meters. — Sand. — No vegetation.

ID. $^{10}/_{5}$ 93. Store Middelgrund, Lat. N. 56°34,5′, Long. E. 12°5,5′. — 19 meters. — Stones. — *Corallina offic.*

IC. $^{10}/_{5}$ 93. Store Middelgrund, Lat. N. 56°33′20″, Long. E. 12°5′10″. — 10,5 meters. — Stones. — *Fucus serratus*, (*Furcellaria*).

IB. $^{10}/_{5}$ 93. Store Middelgrund, Lat. N. 56°33′, Long. E. 12°5′. — 11,5 to 13 meters. — *Fucus serratus*, *Halidrys*, *Furcellaria*, *Laminaria digitata*.

IA. $^{10}/_{5}$ 93. Store Middelgrund, Lat. N. 56°32′50″, Long. E. 12°5′20″. — 11,5 to 13,5 meters (trawl). — *Fucus serratus.*

— $^{12}/_{7}$ 07. Nearly in the same place. — Stones with incrusting Algæ, *Cruoria pellita*, *Lithothamnia*, and *Delesseria sangvinea*, *Desmarestia acul.*, *D. viridis*, *Corallina offic.*

HX. $^{10}/_{5}$ 93. Store Middelgrund, south side, Lat. N. 56°32′30″, Long. E 12°3′40″. — 17 meters. - Stones. — *Fucus serratus*, *Halidrys*, *Corallina offic.*

HY. $^{10}/_{5}$ 93. Store Middelgrund, south side, Lat. N. 56°32′20″, Long. E. 12°5′20″. — 15 meters. — Reddish gravel. — *Fucus serratus.*

HZ. $^{10}/_{5}$ 93. Store Middelgrund, south side, Lat. N. 56°32′, Long. E. 12°5′40″. — 25,5 meters. — Few Algæ.

GI. $^{21}/_{7}$ 92. Ostindiefarer Grund. — 4 to 8,5 meters. — Stones. — 4,5 meters: *Halidrys*, *Laminaria digitata*, *Fucus serratus*, *Florideæ*. — 4 to 7,5 meters: *Florideæ*, mostly *Phyllophora membranifolia*, *Furcellaria*, (*Fucus serratus*).

OO. $^{18}/_{4}$ 94. Søborghoved Grund. — 8,5 meters. — Stones. — *Fucus serratus*, *Halidrys*, *Phylloph. membranif.*, (*Phylloph. Brodiæi*, *Lithothamnia*, *Corallina off.*, *Laminaria digit.*, *sacchar.*).

Kattegat, central Part. (Km)

TT. $^{1}/_{10}$ 94. W. of Dvalegrunde, Læsø Rendes light-ship S. E. $^{1}/_{2}$ E. $2^{2}/_{3}$ miles. — 7,5 meters. — Coarse sand. — *Zostera*.

FI. $^{15}/_{7}$ 92. Dvalegrund, by the double broom. — 4,5 meters. — Sand with shells. — No Algæ.

BO. $^{24}/_{8}$ 91. By the broom at Stensnæs. — 5,5 meters. — Sand. — Narrow-leaved *Zostera*.

BN. $^{24}/_{8}$ 91. Asaa W. by N., the broom at Stensnæs N. N. E. — Ca. 9,5 meters. — Sandy claymud. — Scarce vegetation: *Halidrys*, (*Polysiphonia nigresc.*).

TS. $^{1}/_{10}$ 94. Off Hov, Lat. N. 57°$2^{1}/_{2}$′, Long. E. 10°27′. — 7,5 meters. — Clayey sand with few stones. — *Zostera*, *Halidrys*, *Corallina offic.*

VQ. $^{2}/_{7}$ 95. Svitringen, Lat. N. 57°, Long. E. 10°35′. — 11,5 meters. — Sand. — Scarce *Zostera*.

VS. $^{2}/_{7}$ 95. Læsø Rende, Ryggen, the light-ship S.W. $^{1}/_{2}$ S. $2^{3}/_{4}$ miles. — 18 meters. — Sand. — No vegetation.

KE. $^{15}/_{5}$ 93. By the broom at Søndre Rønners Flak. — 7,5 meters. — Sand without vegetation.

VR. $^{2}/_{7}$ 95. Læsø Rendes light-ship N.W. by N. $^{1}/_{2}$ N. $3^{3}/_{4}$ miles. — 20,5 meters. — Soft bottom without vegetation.

XF. $^{5}/_{7}$ 95. Søndre Rønners beacon E.N.E. 4 miles. — 8,5 meters. — Sand with few stones. — *Zostera* with *Fucus serratus*, (*Ahnfeltia*, *Corallina offic.*, *Cystoclonium*).

KF. $^{15}/_{5}$ 93. Læsø Rendes light-ship N.W. by N. $^{1}/_{5}$ N. a good 14 miles. — 6,5 meters. — Sand with pebbles. — *Fucus serratus*, very broad, (*Fuc. vesiculosus*, *Zostera*).

XE. $^{5}/_{7}$ 95. Near the broom at Silderøn. — Mostly 2 to 4 meters. — Sand. — *Zostera*, (*Fucus serratus*).

FA. $^{12}/_{7}$ 92. E.S.E. of Hornfiskerøn, S. side of Læsø. — Within $^{1}/_{2}$ meter line bare sand, outside this line *Zostera*-vegetation.

EZ. $^{12}/_{7}$ 92. W. of Mellemflak, S. of Læsø. — 4 meters. — Sand. — *Zostera*.

YY. $^{23}/_{7}$ 04. From the broom at the N. end of Kobbergrund northwards. — 4,5 meters. — First bare sand, later single stones with *Fucus serratus*.

ZC. $^{27}/_{7}$ 04. The broom at the N. end of Kobbergrund N.E. 1,5 miles. — 4 to 4,5 meters. — Sand. — *Zostera* in spots, with various Algæ, *Fucus serratus*.

ZC¹. $^{27}/_{7}$ 04. Inside Kobbergrund. — 5 meters. — Sand. — *Chorda Filum*, *Spermatochnus*.

ZD. $^{27}/_{7}$ 04. Kobbergrundens light-ship E.S.E. 4 miles. — 7,5 meters. — Sand. — *Zostera* with *Fucus serratus*, large, broad plants.

XD. $^{5}/_{7}$ 95. The broom at Silderøn, N. $^{3}/_{4}$ W. nearly 8 miles. — 9,5 meters. — Sand. — *Zostera* (with *Fucus serratus*).

XB. $^{5}/_{7}$ 95. Kobbergrundens light-ship N. $^{3}/_{4}$ E. $8^{3}/_{4}$ miles. — 12 meters. — Stones. — *Fucus serratus*, *Furcellaria* a. o. *Florideæ*.

BM. $^{23}/_{8}$ 91. The broom at Muldbjerg Grund W. $^{2}/_{3}$ N. a good 2 miles. — 8,5 meters. — Sand (?) with stones. — *Zostera* and *Halidrys*.

VP. $^{2}/_{7}$ 95. The broom at Muldbjerg Grund N.N.W. $^{1}/_{3}$ N. $5^{1}/_{2}$ miles. — 7,5 meters. — Fine sand. — Scarce *Zostera*.

BL. $^{23}/_{8}$ 91. Mariager Fjord S.W. by W. $^{3}/_{4}$ W., Muldbjergene N.W. $^{3}/_{4}$ N. — 9,5 meters. — Sand. — *Zostera*.

VO. $^{2}/_{7}$ 95. Off Stevn in Mariager Fjord. — Mud with *Mytilus*, scarce *Ceramium rubrum*.

VN. $^{1}/_{7}$ 95. The buoy at the mouth of Randers Fjord N.W. $3^{1}/_{3}$ miles. — 8,5 meters. — Sand. — Loose *Furcellaria* in abundance, very scarce *Zostera*.

VM. $^{1}/_{7}$ 95. The buoy at Tangen N.E. $^{2}/_{3}$ E. $4^{1}/_{4}$ miles. — 8 meters. — Sand. — Loose *Furcellaria* in abundance.

BK. $^{23}/_{8}$ 91. By the buoy at Tangen. — 7 meters. — Coarse sand with stones. — *Zostera*, rather narrow-leaved with broad *Fucus serratus*, (*Furcellaria*).

VL. $^{1}/_{7}$ 95. The buoy at Tangen N.N.W. $5^{1}/_{2}$ miles. — 10,5 meters. — Sand. — Dead *Zostera*-leaves, loose *Furcellaria*.

NC. $^{19}/_{9}$ 93. E. of Tangen, Fornæs light-house S. $^{1}/_{4}$ W. 7 miles. — 8,5 meters. — Sand with stones. — *Fucus serratus*, *Laminaria digitata*, *Furcellaria*, *Corallina offic.*

BI. $^{23}/_{8}$ 91. Gjerrild Flak; Fornæs light-house S. by E. $^{1}/_{3}$ E. a good 6 miles. — 7,5 meters. — Sand with sparse spots of *Zostera*, (*Furcellaria*).

BH. $^{23}/_{8}$ 91. Off Gjerrild Klint, $^{1}/_{2}$ mile from land. — 7,5 meters. — Bare sand with spots of vegetation: *Zostera* and *Furcellaria*, (*Fucus serratus.*)

VK. $^{1}/_{7}$ 95. Fornæs light-house S. $^{1}/_{2}$ W. $2^{2}/_{3}$ miles. — 12 meters. — Pebbles. — A clump of *Halidrys*.

VK[1]. $^{1}/_{7}$ 95. $^{2}/_{8}$ mile W. by N. of VK. — 10,5 meters. — Sand and pebbles. — No vegetation.

FK. $^{15}/_{7}$ 92. Aalborg Bugt, Lat. N. 56°56,5′, Long. E. 10°45,5′. — 12 to 13 meters. — Sand. — No vegetation.

FL. $^{15}/_{7}$ 92. Lat. N. 56°56,5′, Long. E. 10°46,8′. — 9,5 meters. — Sand, alternately bare and covered with *Zostera*.

FM. $^{15}/_{7}$ 92. The buoy at Tangen W. by S. $^{1}/_{2}$ S. a good 8 miles. — 13 meters. — Sand, shells. — No vegetation, only single specimens of *Corallina offic.*

FN. $^{15}/_{7}$ 92. Fornæs light-house S. $^{1}/_{2}$ W. nearly 14 miles. — 12 meters. — Sand with stones. — *Halidrys.*

ND. $^{19}/_{9}$ 93. Fornæs light-house S. by W. $^{1}/_{2}$ W. $11^{3}/_{4}$ miles. — 11,5 to 13 meters. — Sand with single stones. — Very scarce vegetation: *Lithothamnion*, *Halidrys.*

HT. $^{9}/_{5}$ 93. Fornæs light-house S.W. $^{5}/_{8}$ W. 7 miles. — 16 meters. — Sand and pebbles. — No vegetation.

HU. $^{9}/_{5}$ 93. Fornæs light-house S.W. by W. $^{1}/_{4}$ W. nearly 13 miles. — 17 meters. — Sand with stones. — No vegetation.

XC. $^{5}/_{7}$ 95. The double broom at the end of Anholt Nordvest Rev S.S.E. $^{1}/_{2}$ E. 11 miles. — 11,5 meters. — Gravel with stones. — *Halidrys.*

bK. $^{12}/_{7}$ 07. 15 miles N.W. by W. $^{1}/_{2}$ W. of Anholt light-house. — 15 meters. — Stones. — Very few Algæ (*Polysiphonia elong.*, *Desmarestia viridis.*).

bL. $^{12}/_{7}$ 07. 13 miles W. by N. $^{1}/_{4}$ N. of Anholt light-house. — 19 meters. — Sand. — No vegetation.

KF[1]. $^{16}/_{5}$ 93. Anholt Nordvest Rev, 2 miles of the broom. On the reef and on both sides of it bare sand.

KF[2]. $^{16}/_{5}$ 93. N. of Anholt, E. of Nordvest Rev. — Ca. 8 to 13 meters. — Bare sand, here and there spots of loose *Furcellaria* partly mixed with *Polyides.*

KG. $^{16}/_{5}$ 93. W. of the double broom by Rønneløbet by Anholt. — 4,5 meters. — Sand with stones. — *Fucus serratus.*

HV. $^{9}/_{5}$ 93. Anholt light-house N.E. by E. $^{1}/_{6}$ E. $7^{1}/_{2}$ miles. — 5,5 to 7,5 meters. — Sand. — No vegetation.

Kattegat, southern part. (Ks)

RQ. $^{31}/_{7}$ 94. Fornæs light-house W. $^{1}/_{4}$ S. 1 mile. — 17 meters. — Coarse sand. — Almost no vegetation.

FO. $^{15}/_{7}$ 92. Off Havknude. — 5,5 to 6,5 meters. — Sand. — Very scarce vegetation (*Fucus serratus*, *Florideæ*).

NB. $^{18}/_{9}$ 93. Havknudeflak. — 7,5 to 8,5 meters. — Sand with stones. — Vegetation in spots: *Furcellaria*, (*Fucus serratus*, *Brongniartella*, *Zostera*).

FP. $^{15}/_{7}$ 92. Jessens Grund, by the buoy. — 4 meters. — Stones. — *Fucus serratus*, (*Laminaria digitata*, *Florideæ*, *Halidrys*).

NA. $^{18}/_{9}$ 93. Hjelm light-house S.W. by S. $^{1}/_{4}$ S. $5^{1}/_{4}$ miles. — 17 to 18 meters. — Fine gravel. — No plants.

KH. $^{17}/_{5}$ 93. The broom at Jessens Grund N.N.W. $^{1}/_{4}$ W. $3^{1}/_{2}$ miles. — 18 meters. — Stones. — No vegetation.

MZ. $^{18}/_{9}$ 93. Hjelm light-house S. by E. 2 miles. — 10,5 to 13 meters. — Gravel (?) with stones. — *Chorda Filum*, (*Corallina offic.*).

BG. 21/8 91. 1 1/3 miles N. by E. 1/2 E. (?) of Hjelm light-house. — 38 meters. — No vegetation.

EP. 12/7 92. Pakhusbugt by Anholt. — 19 meters. — Sand. — Loose *Furcellaria*.

ZN. 10/7 05. Anholt light-house N.E. 1/2 N. 12 miles. — Gravel and sand. — No vegetation.

RS. 1/8 94. Fornæs light-house W. 1/2 S. 15 miles. — 20,5 meters (?). — No vegetation.

RR. 1/8 94. Fornæs light-house W. 1/2 S. 7 miles. — 17 meters (?). — No vegetation.

ZO. 10/7 05. Lat. N. 56°28′15″, Long. E. 11°23 1/2′. — 15 meters. — No vegetation.

EO. 11/7 92. The light-house S. by E. 9,1 miles. — 26,5 meters. — Clay-mud with shells. — No vegetation, on *Modiola* some few *Lithothamnia* and *Antithamnion plumula*.

HS. 9/5 93. Briseis Grund. — 7,5 to 13 meters. — Stones. — *Fucus serratus*, *Furcellaria*, (*Halidrys, Laminaria digitata*).

RP. 31/7 94. Near Briseis Grund, Lat. N. 56°18,5′, Long. E. 11°17,7′. — 20,5 meters. — Stones (gravel?). — No vegetation.

OS. 18/4 94. Hastens Grund, the buoy S.W. by W. 1 5/6 miles. — 13 to 14 meters. — Gravel and stones. — *Fucus serratus*.

OS[1]. 18/4 94. Hastens Grund, the buoy S.W. 1/2 S. 1 mile. — 16 meters. — Gravel. — *Fucus serratus*, (*Halidrys*).

OT. 18/4 94. Hastens Grund, the buoy N.W. by W. 1/2 mile. — 9,5 meters. — Stones. — *Laminaria digitata*, *Halidrys*.

OU. 18/4 94. Schultz's Grund, the buoy S.W. 1/2 mile. — Sand with stones. — 9,5 meters. — Abundant vegetation: *Halidrys*, *Laminaria digitata*, (*Fucus serratus*, *Furcellaria*, scarce *Zostera*).

OV. 18/4 94. The beacon on Sjællands Rev S.E. 1/2 E. 1 2/3 miles. — 17 to 19 meters. — Sand. — No vegetation.

OX. 19/4 94. W. of the beacon on Sjællands Rev. — 9,5 meters. — Stones. — No vegetation.

OY. 19/4 94. Nearer land. — ca. 4 meters. — Stones. — *Fucus serratus*.

GG. 21/7 92. Sjællands Rev, E. side of Mellemrevet. — A good 4 meters. — Stones. — *Fucus serratus*, (*Furcellaria* a. o. *Florideæ*).

GF. 21/7 92. Sjællands Rev, in the Snekkeløb. — 8 meters. — Stones. — *Fucus serratus*, (*Florideæ*.)

OQ. 17/4 94. E. of Lille Lysegrund, Hesselø light-house S.E. by S. 1/3 S. 8 1/3 miles. — 20,5 meters. — Sand. — No vegetation.

OR. 18/4 94. S.W. side of Lille Lysegrund. — 17 to 18 meters. — Brown Sand. — No vegetation.

EL. 11/7 92. N. of Lysegrund, 2 2/3 miles N.W. 1/2 W. of the buoy. — 20,5 meters. — Clayey sand. — No vegetation.

EN. 11/7 92. Lysegrund, 1/2 mile N. of the 2 meters shallow. — 14 meters. — Stones. — Scarce *Lithoderma*, otherwise no Algæ. — 17 meters: *Polysiphonia violacea*, *Ectocarpus*.

EM. 11/7 92. Lysegrund, 1/3 mile N. of the 2 feet shallow. — Ca. 9,5 meters. — Stones. — *Fucus serratus*, (*F. vesiculosus*, *Furcellaria*).

OP. 18/4 94. Lysegrund, near the 2 meters shallow. — 6 meters. — Stones and gravel. — *Fucus serratus*, *Halidrys*, *Laminaria digitata*.

EK. 11/7 92. W. side of Lysegrund. — 14 meters. — Sand. — No vegetation.

EJ. 11/7 92. Lysegrund, near the triple broom. — 4 to 5,5 meters. — Stones. — *Fucus serratus*, (*Fucus vesiculosus*, *Florideæ*).

HQ. 8/5 93. E. side of Lysegrund. — Ca. 9,5 meters. — Sand. — Single clumps of *Fucus serratus* (and *F. vesiculosus*).

HP. $^{8}/_{5}$ 93. S. E. of Lysegrund, $4^{1}/_{2}$ miles N.W. by W. $^{1}/_{6}$ W. of Hesselø light-house. — 25,5 meters. — *Furcellaria*, (*Fucus serratus*).

RO. $^{31}/_{7}$ 94. W. of Hesselø. — 20,5 meters. — Sandy clay-mud. — *Desmarestia viridis*, otherwise no plants.

HR. $^{8}/_{5}$ 93. S. of Hesselø. — 19 meters. — Soft bottom. — No vegetation.

RN. $^{31}/_{7}$ 94. By the Sydostrev by Hesselø. — 21,5 meters. — Gravel. — *Desmarestia viridis*, otherwise no plants.

B. $^{17}/_{7}$ 90. Hesselø light-house N.W. $^{1}/_{3}$ N. a good 3 miles. — 24,5 to 32 meters. — Soft bottom. — No vegetation.

A. $^{17}/_{7}$ 90. Hesselø light-house N.W. $^{3}/_{4}$ N. nearly 4 miles. — 28 meters. — Soft bottom. — Loose *Dilsea edulis*, shells of *Cyprina*, *Aporrhais* a. o. with *Lithothamnia* and boring Algæ.

C. $^{17}/_{7}$ 90. 5 miles N. of the buoy at Grønne Revle. — Ca. 19 to 22,5 meters (?). — No vegetation (only some few *Desmarestia viridis* on *Buccinum* and loose *Dilsea edulis*).

GH. $^{21}/_{7}$ 92. Lat. N. 56°1′40″, Long. E. $11°30^{1}/_{2}$′. — 19 meters. — Clay-mud. — No vegetation.

aU. $^{6}/_{8}$ 06. Lumbsaas mill S. 32° W. 2 miles. — 13 meters. — Sand with few stones. — *Furcellaria*, (*Zostera*, *Fuc. serratus*, *Polyides*, *Ectocarpus*). — Another dredging: Larger stones with *Furcellaria*, *Fuc. serratus*, *Laminaria digitata*.

D. $^{17}/_{7}$ 90. 1 mile N. of the buoy at Grønne Revle. — 11,5 meters. — Stones. — Abundant vegetation: *Fucus serratus*, *Furcellaria*, (*Zostera*, *Phylloph. Brodiæi*, *Laminaria digit.*, *Polyides*, *Ahnfeltia* ...).

HO. $^{8}/_{5}$ 93. Hesselø light-house W. by N. $^{1}/_{4}$ N. 12 miles. — 22,5 meters. — Clay-mud with stones. — *Lithothamnia*.

RM. $^{31}/_{7}$ 94. Off Raageleje, Lat. N. 56°10′10″, Long. E. $12°5^{1}/_{2}$′. — 19 meters. — Sand. — No vegetation.

RL. $^{30}/_{7}$ 94. The buoy at Ostindiefarer Grund S.E. by E. $2^{1}/_{2}$ miles. — 15 meters. — *Florideæ*, particularly *Cystoclonium*, *Furcellaria*, *Phyllophora*, *Chondrus*, (*Laminaria digitata*, *L. saccharina*, *Fucus serratus*).

EJ. $^{11}/_{7}$ 92. Isefjord, midway between Korshage and Spodsbjerg. — Ca. 4,5 meters. — Sand almost without vegetation.

EH. $^{11}/_{7}$ 92. Off Lynæs, $^{1}/_{8}$ mile W. of the broom. — 4,5 meters. — Sand with pebbles. — *Chorda Filum*, (*Zostera*, *Rhodomela*, *Polysiphonia elongata* and *nigresc.*).

NL. $^{23}/_{9}$ 93. $1^{5}/_{6}$ miles W. $^{1}/_{2}$ S. of Lynæs. — 4 meters. — Sand with *Zostera*.

NM. $^{25}/_{9}$ 93. Roskilde Fjord off Nordskov, Kulhus mill W. $^{1}/_{3}$ N. $1^{3}/_{4}$ miles. — 7,5 meters. — Mud with broad-leaved *Zostera*.

PQ. $^{3}/_{5}$ 94. E. of Bogenæs in Roskilde Fjord. — 3 meters. — Stones. — *Zostera*, *Mytilus*, *Polysiph. nigresc.*, *Phylloph. Brodiæi*.

PQ^{1}. $^{3}/_{5}$ 94. Between Bogenæs and Boserup. — Stones. — *Zostera*, *Potamogeton pectinatus*, *Polysiphonia*, *Ceramium*, *Spirulina versicolor*.

Samsø area. (Sa)

KK. $^{17}/_{5}$ 93. Klørgrund, S. of Hjelm. — 6,5 to 8,5 meters. — Stones. — *Fucus serratus*, *Halidrys*, (*Fucus vesic.*).

KI. $^{17}/_{5}$ 93. Hjelm light-house N. $^{1}/_{2}$ W. $2^{1}/_{2}$ miles. — 13 meters. — Stones. — *Lithothamnion norvegicum*, *Corallina offic.*

KL. 17/5 93. Bjarkes Grund, S.W. of Hjelm. — 5,5 to 7,5 meters. — Stones. — *Halidrys*, *Laminaria digitata*, *Fucus serratus*.

KM. 17/5 93. Hjelm light-house E. by N. 3/8 N. a good 3 1/2 miles. — 9,5 to 17 meters. — Stones. — *Halidrys*, *Fucus serratus*, (*Laminariæ* . . . .

PJ. 21/4 94. Ebeltoft Vig, Ellemands Bjerg S.W. 3 5/6 miles. — 13 meters. — Clay-mud with stones. — Scarce *Florideæ*.

FR. 16/7 92. Near Pikkelgrund in Ebeltoft Vig. — 5,5 meters. — Soft bottom. — Dead *Zostera*-leaves, loose Algæ.

FQ. 16/7 92. E. side of Ebeltoft Vig. — 8 meters. — Soft bottom. — Broad-leaved *Zostera* and *Chorda Filum*, (loose Algæ).

MY. 18/9 93. Sletterhage light-house N.W. by N. 3 3/4 miles. — 9,5 to 14 meters. — Sand with stones. — *Halidrys*, (*Laminaria sacch.*, *L. digit.*, *Fuc. serratus*, *Corallina off.*).

FT. 16/7 92. Klepperne, at the N. end of Samsø, inside the double broom. — 5,5 meters. — *Halidrys*, (*Laminaria digitata*, *Florideæ*, in particular *Cystoclonium*).

PH. 21/4 94. Lindholms Dyb W. of Vejrø, 1/4 mile S. of the double broom. — 20,5 meters. — Mud with stones. — *Lithothamnion norvegicum* and *Cruoria pellita*.

FS. 16/7 92. Vejrø Sund, N. of Bosserne. — 4 to 19 meters, (dredging up the slope). — Stones. — Abundant vegetation: *Fuc. serratus*, (*Fuc. vesic.*, *Lamin. digit.*, *L. sacch.*, *Chorda Filum*, *Halidrys*, *Florideæ*).

PG. 21/4 94. The beacon on Hatter Rev E. by S. 3/4 S. 1 2/3 miles. — 7,5 to 8,5 meters. — Stones. — *Laminaria digitata*, (*Lam. sacch.*, *Florideæ*, *Zostera*).

OZ. 19/4 94. W. of Gniben, Sjællands Odde point in E. 2/3 S. 1 2/3 miles. — 14 meters. — Sand without vegetation.

PA. 19/4 94. Near Albatros, on the W. side of Sjællands Odde. — Ca. 7,5 meters. — Stones. — *Furcellaria*, (*Laminaria*, *Fucus serratus*).

GD. 21/7 92. 1 1/2 miles N.E. by N. of Sejerø light-house. — 11,5 to 14 meters. — Stones. — *Fucus serratus*, (*Laminaria digit.*, *Florideæ* in particular *Furcellaria*, *Delesseria sangvin.*, *sinuosa*, scarce *Zostera*.

GE. 21/7 92. Sejerø light-house S.W. by S. 1 mile. — 7,5 to 9,5 meters. — Stones. — *Halidrys*, (*Zostera*, *Fuc. serratus*, *Lamin. digit.*, *Florideæ*, in particular *Furcellaria*).

PB. 19/4 94. Sejerø Bugt, Sejerø light-house N.W. by W. 2/3 W. nearly 7 miles. — 14 meters. — Clay-mud without plants.

PC. 19/4 94. Between Sejerø and Ordrups Næs, the point of Ordrups Næs E.S.E. nearly 2 miles. — 4 meters. — Stones. — *Fucus serratus*, *Laminaria digitata*, *Florideæ*.

YV. 3/6 04. The light-buoy at Hatterbarn N. 2 1/2 miles. — 15 meters. — Stones. — *Florideæ*, in particular *Furcellaria*, *Delesseria sinuosa*, *sangvin.*, *Polysiph. elongata*, and *Laminaria digit.* and *sacchar.*

PD. 19/4 94. S. of Sejerø, Lat. N. 55°48′, Long. E. 11°5′. — Ca. 13 meters (?). — Sand without vegetation.

PE. 19/4 94. Refsnæs light-house S. by E. 1/2 E. 1 1/4 miles. — 23,5 meters. — Clay-mud, gravel and pebbles. — *Laminaria digitata*, *Desmarestia acul.*

PF. 21/4 94. The light-buoy at Refsnæs S.E. by E. a good half mile. — 18 to 20,5 meters. — ? with stones. — Scarce vegetation: *Florideæ*, in particular *Delesseria sinuosa*, and *Desmarestia acul.*

MP. $^{16}/_{9}$ 93. Falske Bolsax. — 11,5 to 13 (to 19) meters. — Stones. — *Laminaria sacchar.*, *Florideæ*, (*Laminaria digit.*, *Fucus serratus*).

DK. $^{12}/_{5}$ 92. Bolsaxen, N.E. of the broom. — 13 to 15 meters. — Stones. — *Halidrys*, *Laminaria digit.*, (*Desmar. acul.*, *Florideæ*).

AH¹. $^{12}/_{8}$ 91. Lillegrund by Fyens Hoved, by the northernmost broom. — 9,5 meters. — Stones. Abundant algal vegetation: *Furcellaria*, *Fuc. serratus*, *Lamin. sacchar.*

AH. $^{12}/_{8}$ 91. Same reef, by the middelmost buoy. — 7,5 meters. — Stones. — *Fucus*, (*Laminaria digitata*, *Furcellaria*).

BF. $^{21}/_{8}$ 91. Off Sletterhage, ca. $^{1}/_{2}$ mile. — 14 meters. — Stones. — *Lithothamnion norvegicum*, (*Corallina offic.*, *Cruoria*, *Brongniartella*).

BE. $^{21}/_{8}$ 91. Off Sletterhage, ca. $^{2}/_{3}$ mile. — 10 meters. — Stones. — *Halidrys*, (*Corallina off.*, *Lithothamnion spp.*, *Chorda Filum*).

FU. $^{18}/_{7}$ 92. S. side of Begtrup Vig. — 5,5 meters. — Dead *Zostera*-leaves, living *Zostera*, *Chorda Filum*.

KN. $^{17}/_{5}$ 93. Sletterhage light-house S.E. $^{3}/_{4}$ S. 5 miles. — 15 meters. — Sandy clay-mud with small pebbles. — No vegetation.

AR. $^{18}/_{8}$ 91. S.W. of Skødshoved, nearly 1 mile. — 4 meters. — Sand. — *Fucus serratus* and *vesiculosus*, (*Halidrys*, *Zostera*).

PP. $^{23}/_{4}$ 94. Aarhus Bugt, Ryes Flak. — 4,5 meters. — Small pebbles and gravel. — Spots of *Zostera*, *Fucus vesiculosus*, *Fuc. serratus*, *Halidrys*.

AP. $^{18}/_{8}$ 91. W.N.W. of Skødshoved, $^{2}/_{3}$ mile of land. — 17 meters. — Clay-mud without veg.

PM. $^{23}/_{4}$ 94. Kalø Vig, Skødshoved S. by E. 1 mile. — 5,5 to 11,5 meters. — No vegetation.

AQ. $^{18}/_{8}$ 91. Off the entrance to Knebelvig. — 9,5 meters. — Mud. — *Zostera* in spots.

PN. $^{23}/_{4}$ 94. Kalø Vig, Skødshoved point S.W. $2^{2}/_{3}$ miles. — 5,5 to 11,5 miles (?) — *Zostera*.

PO. $^{23}/_{4}$ 94. Kalø Vig, by Kalø. — 9,5 meters. — Mud without vegetation.

PL, $^{23}/_{4}$ 94. E. side of Wulffs Flak. — 9,5 to 13 meters. — Clayey sand. — *Fucus serr.*, *Desmarestia acul.*, *Lithothamnion glaciale*, *Corallina off.* a. o. *Florideæ*.

FV. $^{18}/_{7}$ 92. E. side of Hesbjerg Grund. — 6,5 meters. — Sand with small pebbles. — *Zostera*, (*Fucus vesic.*, *Halidrys*, *Furcellaria*).

PK. $^{21}/_{4}$ 94. E. side of Norsminde Flak, the broom in S. $^{1}/_{2}$ mile. — 5,5 meters and some more. — Sand with stones. — *Zostera* with *Chætopteris* a. o., *Rhodomela*, *Fucus vesic.* and *serr.*, (*Halidrys*, *Corallina off.*).

AS. $^{18}/_{8}$ 91. W. side of Meilgrund. — 4 to 5,5 meters. — *Zostera* with *Fuc. serratus*, (*Halidrys*, *Ahnfeltia*).

BD. $^{21}/_{8}$ 91. Tunø light-house S. $^{3}/_{8}$ E. 3 miles. — 15 meters. — Sandy clay-mud. — Scarce vegetation, mostly *Polysiphonia elongata forma*.

MX. $^{18}/_{9}$ 93. N. side of Tunø Rev. — 7,5 to 11,5 meters. — Sand. — *Zostera*.

FX. $^{18}/_{7}$ 92. Off Dyngby Hage, Tunø light-house E.S.E. $5^{1}/_{2}$ miles. — 6 meters. — Sand. — *Florideæ*, in particular *Furcellaria*, (*Zostera*, loose *Halidrys*).

MV. $^{18}/_{9}$ 93. Kirkegrund S.W. of Tunø. — 7,5 to 9,5 meters. — *Zostera* with scarce *Florideæ*, mostly *Furcellaria*.

BC. $^{21}/_{8}$ 91. Abreast of Hov Røn, the broom N.E. $^{1}/_{2}$ E. $^{4}/_{5}$ mile. — 5,5 meters. — Sand and mud with stones. — Dense *Zostera*-vegetation (with *Fuc. vesic.* and *Furcellaria*).

MU. $^{18}/_{9}$ 93. Abreast of Søby Rev, Kolse Nak point S.W. by W. $^{1}/_{8}$ W. $3^{1}/_{2}$ miles. — 6,5 to 7,5 meters. — Dense broad-leaved *Zostera*.

BB. 21/8 91. By the buoy at Søgrund. — 3 to 4 meters. — Sandy mud with single stones. — Dense broad-leaved *Zostera*. (*Fucus vesiculosus*).

AT. 19/8 91. Svanegrund. $^{1}/_{2}$ mile E.S.E. of the broom at its S.E. side. — 4,5 meters. — Gravel and sand. — *Fucus serratus*, (*Furcellaria*, *Halidrys*).

BA. 21/8 91. Skomagergrund, near the double broom. — 8,5 meters. — Soft bottom. — Dense broad-leaved *Zostera*-vegetation.

MT. 16/9 93. Horsens Fjord, by the broom W. of Alderø. — 4 to 11,5 meters. — Broad-leaved *Zostera* with *Laminaria saccharina* and *Chorda Filum*.

AZ. 20/8 91. S. side of Søndergrund S. of Hjarnø. — 9,5 to 11,5 meters. — Mud. — Pure *Zostera*-vegetation.

aV. 7/8 06. Vestborg light-house E. by S. $5^{1}/_{2}$ miles. — 8,5 to 9,5 meters. — Sand. — 1) Broad-leaved *Zostera*, *Halidrys*, *Lamin. sacchar.*, *Fucus vesic.* — 2) *Zostera* and dead *Zostera*-leaves, with many loose Algæ, in particular *Ahnfeltia*.

AO. 15/8 91. $1^{1}/_{2}$ miles S.E. by E. of the S. point of Endelave. — 7,5 meters. — *Zostera* (*Fucus serratus*).

MR. 16/9 93. Æbelø light-house W. by S. $^{1}/_{2}$ S. nearly 8 miles. — Ca. 26 meters. — Soft bottom. — No vegetation.

MQ. 16/9 93. S. of Paludans Flak, Vestborg light-house N. $^{1}/_{2}$ E. 4 miles. — 11,5 meters. — Sand with stones. — *Fucus serratus*, *Furcellaria*, (*Laminaria digit.*, *Corallina off.*, *Halidrys*, scarce *Zostera*).

aX. 8/8 06. At the south side of Endelave. — 4,5 meters. — Sand. — *Zostera*, in spots, with single *Fucus vesic.* and *F. serratus*; numerous loose Algæ between the *Zostera*, on the sand bottom.

MS. 16/9 93. S. of Klophagen, Æbelø light-house S.S.W. $^{1}/_{6}$ W. $5^{2}/_{3}$ miles. — 15 meters. — Sandy mud with stones. — *Florideæ*, mostly *Polys. nigresc.*, and *Desmarestia acul.*, *Chorda Filum*.

AY. 20/8 91. By the broom at Ashoved. — 9,5 to 11,5 meters. — Sand with stones. — *Zostera*, *Fucus vesic.*, *F. serrat.*, *Furcellaria*.

FY. 19/7 92. 1 mile N.E. by E. of the point of Bjørnsknude. — 5,5 meters. — Sand with stones. — *Fucus vesiculosus*, (*F. serratus*, *Lamin. digit.*, *Zostera*, *Halidrys*).

OA. 20/8 94. E. of the buoy N. of Æbelø. — 7,5 meters. — *Zostera*, (*Fucus vesicul.*).

AJ¹. 12/8 91. By the N. side of Æbelø. — 4 meters. — Stones. — *Fucus serrat.*, *Furcellaria*, *Ahnfeltia*, *Lamin. digit.*

GB. 20/7 92. Æbelø light-house W. $3^{4}/_{5}$ miles. — 17 to 18 meters. — Soft bottom. — No vegetation.

DJ. 11/5 95. E. of Æbelø. — 7,5 meters. — Sand with stones. — *Fuc. serratus*, *Furcellaria*, (*Fuc. vesicul.*).

GC. 20/7 92. Æbelø light-house W. by N. $^{1}/_{3}$ N. $6^{1}/_{4}$ miles. — 13 meters. — Sand with stones. — *Desmar. aculeata*, *Florideæ*, dead leaves of *Zostera*).

NZ. 20/8 94. Off Tørresø, Fyns Hoved E. $^{1}/_{6}$ S. $5^{3}/_{4}$ miles. — 4,5 meters. — *Fucus serratus*, *F. vesic.*, *Furcellaria*.

aY. 8/8 06. Fyns Hoved E. $^{3}/_{4}$ N. $4^{3}/_{4}$ miles. — 8,5 to 9,5 meters. — Sand with stones. — *Zostera*, *Fucus vesicul.*, *F. serratus*.

aZ. 8/8 06. Fyns Hoved E. $^{3}/_{4}$ N. $5^{1}/_{2}$ miles. — 4 to 5,5 meters. — Sand with stones. — *Fucus vesic.* and *serratus*, *Zostera* with loose Algæ).

NY. 20/8 94. Off the entrance to Odense Fjord. — 6,5 meters. — *Fucus serratus* and *vesicul.* (*Florideæ*, in particular *Furcellaria*, and *Zostera*).

Little Belt. (Lb)

AX. 20/8 91. Near the double broom at Bjørnsknude. — 9,5 meters. — Clayey sand. — *Zostera*, (*Fuc. serratus*, *Furcellaria*).

GA. 20/7 92. W.N.W. of Æbelø, 2 1/3 miles. — 18 meters. — Clay-mud. — No vegetation.

AU. 19/8 91. Vejle Fjord, off Barritskov, 1 mile off land. — 17 meters. — No vegetation.

AV. 19/8 91. Vejle Fjord, off Rosenvold. — 19 meters. — Mud. — No vegetation.

FZ. 20/7 92. Near the triple broom at Kasser Odde. — 6,5 meters. — Sand with stones. — *Fucus vesicul.* and *serratus*, *Halidrys*, *Furcellaria*, *Laminaria digit.*

AJ. 14/8 91. Trelde Næs N.W. by W. 4 miles. — 13 meters. — Sandy mud. — No vegetation.

AK. 14/8 91. Stavrshoved W. by S. 1 mile. — 17 meters. — Soft bottom. — No vegetation.

AL. 14/8 91. W. side of Baaring Vig. — 7,5 meters. — Sand (?). — *Furcellaria*, *Zostera*.

DJ. 11/5 92. Trelde Næs N.N.W. 3 miles. — 13 meters. — Mud with dead *Zostera*-leaves. — Few *Florideæ*.

OB. 20/3 94. Off Stavrshoved, 1/3 mile off land. — 9,5 to 11,5 meters. — Stones. — *Laminaria saccharina* a. o.

AM. 14/8 91. Sand bank N.E. of Fredericia. — 5,5 to 6,5 meters. — Bare sand.

AN. 14/8 91. Off the N. end of the wall at Fredericia. — 4 to 5,5 meters. — Stones. — *Fucus vesiculosus*, (*Fuc. serrat.*, *Chorda Fil.*, *Zostera*).

XQ. 12/7 00. Lyngsodde S. by W. 3/4 W. 1 mile. — Ca. 19 meters. — Stones. — *Delesseria sangvinea*, *Phylloph. membranifolia.*

NX. 20/3 94. E.N.E. of Middelfart. — 15 meters. — Clay with stones. — *Laminaria digit.*, *sacchar.*, (*Florideæ*, in particular *Phylloph. membranif.* and *Deless. sinuosa*).

XP. 10/7 00. Nearly the same place. — Ca. 19 meters. — Stones. — *Laminaria sacch.*, *Deless. sangv.*, *Desmar. viridis*, *Phylloph. membranif.*

NV. 19/3 94. Between Middelfart and Kongebroen. — 15 to 19 meters. — Stones, and clay with pebbles. — *Laminaria digit.* and *sacchar.*, *Desmarestia acul.*

EG. 26/6 92. By the N.E. side of Fænø Kalv. — Stones. — *Laminariæ* and *Florideæ*.

OC. 23/3 94. S. of Fænø Kalv. — 14 meters. — Soft bottom. — No vegetation.

EF. 18/6 92. Fænø Sund, S.E. of Hindsgavl. — Below the *Zostera*-zone stones with *Florideæ* and *Laminariæ*.

EF[1]. 21/6 92. S. of Hindsgavl. — 9,5 to 11,5 meters. — Stones. — *Laminariæ* and *Florideæ*.

ED. 10/6 92. S. end of Fænø Sund. — 13 meters. — *Desmarestia acul.*, *Ectocarp. silicul.*, *Laminariæ*, *Florideæ*.

EE. 11/6 92. Between Midskov and Fænø.

1) and 2). In the middle of the Belt. — 54,5 to 56 meters. — Stones. — No attached Algæ, but loose fresh *Florideæ*.

3) More westerly. — 34 meters. — Stones. — Fresh Algæ, uncertain whether attached.

4) More westerly. — 13 meters. — Stones. — *Laminariæ*, *Florideæ*, *Desmarestia acul.*

5) E. of 1). — 28 to 36 meters. — Clayey sand with dead shells.

6 and 7). More easterly. — 24,5 and 13 meters. — Sand with stones. — *Desmarestia aculeata.*

8) More easterly. — 11,5 meters. — *Zostera*, (*Florideæ*).

EC. 10/6 92. S. of Fænø. — Ca. 5,5 meters. — *Zostera* with single *Fucus vesiculosus* and *Laminaria digitata.*

OD. 23/3 94. S. of the broom at Stenderup Hage. — 17 meters. — Gravel. — Scarce vegetation (*Phylloph. Brodiæi*, *Furcellaria*).

DH. 11/5 92. Near Flækøjet, the broom at Stenderup Hage N.N.E. 1 mile. — 11,5 to 15 meters. — Stones (?). — Scarce Algæ (*Desmarestia aculeata*, *Florideæ*).

OE. 23/3 94. At the N. side of Brandsø. — 8,5 meters. — *Zostera*, (*Furcellaria*).

DG. 11/5 92. Off Ivernæs. — 5,5 meters. — Sand with stones. — *Zostera*, (*Fucus vesic.*, *Florideæ*).

OF. 23/3 94. Fyrrenden, Baagø church E. by N. 5/8 N. 1 1/4 miles. — 13 meters. — Mud with dead *Zostera*-leaves, scarce *Florideæ*.

DF. 11/5 92. Remmen, E. of Baagø. — 5,5 meters. — Sand (?) with a few stones. — *Zostera*. (*Fucus vesic.*).

DE. 10/5 92. By the broom at Thorø. — 5,5 meters. — Sand. — *Zostera*, (*Ceramium Rosenvingii*, *Rhodomela*).

DD. 10/5 92. N. side of Thorø Banke. — 7,5 meters. — Sand. — *Fucus vesic.*, *Zostera*.

DC. 10/5 92. Aakrog Bugt, off Brunshus. — 5,5 meters. — Sand (?) with stones. — *Fucus vesicul.*, (*F. serratus*, *Furcellaria*).

DB. 10/5 92. Lillegrund, W. of Helnæs, near the buoy. — 7,5 meters. — Stones. — *Furcellaria*, (*Fuc. serratus* . . .).

CD. 21/9 91. Helnæs Hoved Flak. — 4 meters. — Sand with stones. — *Zostera*, (*Fuc. vesiculosus*).

CE. 21/9 91. S. of Helnæs Hoved Flak. — 26,5 meters. — Mud. — No vegetation.

DA. 10/5 92. Off Bøjgden. — 5,5 meters. — Stones. — *Fucus vesiculosus* and *serratus*.

CF. 22/9 91. Near the broom W. of Lyø. — 15 meters and some less. — *Florideæ*, (scarce *Zostera*).

DY. 14/5 92. W. side of Skjoldnæs, Ærø. — 7,5 to 9,5 meters. — Bare sand with spots of *Zostera* (rather small and narrow-leaved).

LG. 4/7 93. Off Vidsø, Ærø, 1/4 mile of land. — 8 to 10,5 meters. — Sand with a few stones. — *Zostera*, (*Fucus vesiculosus*).

DX. 14/5 92. Vodrups Flak. — 13 meters. — Sand with stones. — *Florideæ*, in particular *Furcellaria*, *Deless. sinuosa*, (*Fucus serratus*, *Laminaria digit.*).

LF. 4/7 93. Vodrups Flak. — 9,5 meters. — Sand. — *Zostera*, *Fucus serratus*, (*Furcellaria*).

The South Fyen Waters (Sydfyenske Øgaard). (Sf)

CC. 21/9 91. S. side of Hornenæs. — 7,5 meters. — Sand with stones. — *Zostera*, *Furcellaria*, *Fucus vesiculosus* and *serratus*.

CZ. 10/5 92. E. of CC. — 9,5 to 15 meters. — Soft bottom. — Few Algæ (*Phyllophora Brodiæi*).

CB. 21/9 91. Near the N. side of Lyø Rev. — Ca. 21 meters (?). — Mud. — No vegetation.

CX. 10/5 92. Between the N. end of Lyø and Knollen. — 19 meters. — Mud. — No vegetation.

CY. 10/5 92. Near CX. but nearer to Lyø. — 20 meters. — Mud with dead leaves of *Zostera*. — No vegetation.

CA. 21/9 91. Faaborg Fjord, W. of the broom at Højen. — Dense vegetation of broad-leaved *Zostera*.

CG. 22/9 91. S. end of Skrams Flak. — 6,5 meters. — Sand with stones. — *Zostera* with *Fucus serratus* and *vesiculosus*, (*Polys. nigrescens*, *Furcellaria*).

BZ. 19/9 91. W. of Svelmø. — 15 meters. — Mud, dead *Zostera*-leaves. — No vegetation.

CU. 9/5 92. Near the buoy at Flæskholms Flak, N. of Drejø. — 5,5 meters. — *Zostera*.

CV. 9/5 92. Billes Grunde, N. of Ærø, the most eastern bank. — 5,5 meters. — Sand with stones. — *Fucus vesic.* and *serratus*, *Florideæ*: *Phyllophora Brodiæi*, *Ceramium Rosenvingii*.

UX. $^{25}/_{5}$ 95. Skjoldnæs light-house S. $^{3}/_{4}$ W. $^{3}/_{4}$ mile. — 9,5 meters. — First sand with *Zostera*, farther out stones with *Laminaria digit.*, *Furcellaria* a. o. *Florideæ*.

UV. $^{25}/_{5}$ 95. Skjoldnæs light-house N.W. $^{2}/_{3}$ W. nearly 5 miles. — 13 meters. — Stones. — *Florideæ*: *Furcellaria*, *Deless. sangvinea* . . ., (*Fucus serratus*).

DZ. $^{14}/_{5}$ 92. Egholms Flak, near the buoy at the N. end of Mørke Dyb. — 5,5 meters. — *Zostera*.

V. $^{18}/_{9}$ 90. At the W. side of Birkholm. — 4 to 7,5 meters. — *Zostera* with *Fucus vesic.*, *F. serratus*, *Chorda Filum*.

U. $^{18}/_{9}$ 90. Same place, nearer to land. — 1 to 2 meters. — *Fucus vesic.*, *Chorda Filum*.

CT. $^{9}/_{5}$ 92. The bank W. of Knudedyb W. of Taasinge. — 2 meters. — Stones. — *Fucus vesicul.* and *serratus*. Outside the stones: *Zostera*.

BY. $^{18}/_{9}$ 91. Svendborgsund, W. of the pier at Taasinge. — 7,5 meters. — Stones. — *Florideæ*, (*Laminaria sacchar.*).

BX. $^{17}/_{9}$ 91. E. of Svendborg, near Taasinge. — 5,5 meters. — Sandy mud, dead *Zostera*-leaves, with scarce *Florideæ*.

EB. $^{15}/_{5}$ 92. Near the broom at Stenodde, E. side of Taasinge. — 7,5 meters. — Mud. — *Zostera*.

EA. $^{15}/_{5}$ 92. Near the buoy on Middelgrund at the N. end of the Rudkøbing channel. — 5,5 meters. — *Zostera*.

Great Belt. (**Sb**)

MO. $^{16}/_{9}$ 93. Refsnæs light-house N.W. $^{1}/_{3}$ W. 3 miles. — 19 meters. — Clay-mud with stones. — No vegetation.

DL. $^{12}/_{5}$ 92. S. side of Refsnæs, $1^{1}/_{2}$ miles from the light-house. — 6,5 to 7,5 meters. — Bare sand with patches of *Fucus serratus*.

MN. $^{16}/_{9}$ 93. The broom at Asnæs S.W. $^{3}/_{5}$ W. a good 3 miles. — 10,5 to 11,5 meters. — Fine sand with stones. — *Zostera*, *Fuc. serratus*, *Laminaria digit.*

GT. $^{9}/_{11}$ 92. $^{1}/_{3}$ mile N. of the broom at Asnæs. — 7,5 meters and probably more. — Stones. — *Florideæ*, in particular *Furcellaria*, (*Deless. sangv.*, *Del. sinuosa*).

DM. $^{12}/_{5}$ 92. Asnæs Rev, inside the broom. — 6,5 meters. — Shells. — Scarce Algæ (*Desmar. aculeata*, *Chorda tomentosa*).

GU. $^{9}/_{11}$ 92. The broom at Asnæs N.W. $^{3}/_{4}$ N. 2 miles. — 19 meters. — Stones. — *Laminaria sacch.*, *Desmar. acul.*, *Deless. sangv.*

GS. $^{9}/_{11}$ 92. N. side of Lysegrunde S. of Asnæs. — 9 meters (?). — Sand with stones. — *Zostera*, *Fucus serratus*.

LK. $^{6}/_{7}$ 93. Elefantgrund. — 6,5 to 11,5 meters. — Stones. — *Fucus serratus*, *Laminaria digitata*, *Florideæ*, in particular *Furcellaria*.

AG. $^{12}/_{8}$ 91. By the broom at Klæpen W. of Romsø. — 4 meters. — Sand with vegetation in spots of *Furcellaria*, (*Fuc. vesicul.*, *F. serratus*).

LM. $^{6}/_{8}$ 93. By the S. side of Romsø. — 4 to 5,5 meters. — Sand with stones. — *Fucus vesic.*, *F. serratus*, *Halidrys*, (*Lamin. digit.*, *Furcellaria*).

GV. $^{9}/_{11}$ 92. By the buoy S.E. of Romsø. — Stones. — *Furcellaria*, (*Halidrys*, *Laminaria sacch.*, *Fuc. vesic.*).

LN. $^{6}/_{8}$ 93. Off the E. side of Stavreshoved. — 5,5 meters. — Stones. — *Fucus vesicul.*, *F. serrat.*, *Halidrys*, *Lamin. digit.* — Also sand with *Zostera*.

LP. $^{17}/_{8}$ 93. Off the S.E. side of Stavreshoved. — 2 to 4 meters. — Stones. — *Fucus vesicul.*, (*F. serratus*).

AF. 12/8 91. Møllegrund S. of Stavreshoved. — 8 meters. — Sandy mud with dead *Zostera*-leaves. — *Furcellaria. Phylloph. Brodiæi. Polys. nigresc.*

LL. 2/8 93. Rønnen off Broløkke by Kerteminde. — 4 to 5,5 meters. — Stones. — *Fucus vesicul.*, (*Halidrys, Furcellaria*).

AE. 10/8 91. Off the slope at Lundsgaard. — 7,5 to 9,5 meters. — Clayey sand. — *Zostera*, (*Furcellaria*).

LO. 14/8 91. Off the valley S. of Lundsgaard. — Ca. 5,5 meters. — Sand with stones. — *Fucus vesicul.*, (*Halidrys, Furcellaria. Spermatochnus*).

AD. 10/8 91. Off Risingehoved, ca. 3/4 mile off land. — 13 meters. — Clay-mud with dead shells. — Very sparse vegetation on tubes of Annelids a. o.

MM. 15/9 93. The buoy at Elefantgrund N. by W. 3/8 W. 3 miles. — 19 to 20,5 meters. — Soft bottom. — No vegetation.

GR. 9/11 92. Musholm Havn. — 4 meters. — *Zostera.*

GQ. 9/11 92. W. side of Slettings Grund. — 7 meters. — *Zostera*, (*Fucus vesic., F. serratus*).

NU. 25/1 94. Off the Strandskov by Bogense, 1/2 mile of land. — 11,5 meters. — Sand (?) with a few stones. — *Furcellaria.*

AA. 9/8 91. Sprogø light-house S.E. 5 1/6 miles. — Ca. 26,5 meters. — Clay-mud. — Nearly no vegetation (*Brongniartella, Polys. nigrescens, Ectocarpus*).

Z. 5/8 91. Off Skagbo Huse. Sprogø light-house S.E. by E. 1/8 E. 5 miles. — 19 meters. — Sandy mud. — Scarce veg.: *Desmar. acul., Polys. nigr.*

GX. 10/11 92. Sprogø light-house S.E. 3 miles. — More than 21 meters. — Clay-mud. — No veg.

AB. 9/8 91. Off the S. end of Teglgaardsskov by Nyborg, 1/2 mile of land. — 7,5 meters. — Sand with stones. — *Fucus vesicul., F. serr., Zostera*, scarce *Florideæ.*

AC. 10/8 91. Knudshoved light-house S.W. 1/2 S. 3/4 mile. — 17 meters. — ? with small pebbles. — Scarce veg. of *Florideæ* (*Polys. nigresc.* and *Brongniartella*) and *Desmarestia acul.*

GY. 10/11 92. W. side of Gjellegrund S. of Sprogø. — 5,5 meters. — Sand with stones. — *Zostera*, (*Fuc. serratus*).

NO. 22/1 94. E. of Gjellegrund, Sprogø light-house N.W. by N. 1/4 N. 1 2/5 miles. — 13 meters. — Sand (?) with stones. — *Florideæ* and *Chætomorpha Melagonium*, (*Zostera*).

GP. 9/11 92. Near the light-buoy at Halskov Rev. — 9,5 to 11,5 meters. — Stones. — *Laminaria digitata, Delesseria* three species.

NR. 23/1 94. Immediately N.W. of the entrance to Korsør harbour, between the double broom and the buoy. — Stones. — *Fucus vesiculosus.*

NP. 22/1 94. 2/5 mile W. 1/2 S. of the broom at Badstue Rev. — 9,5 meters. — Sand with stones and *Mytilus*. — *Polysiph. elong.* a. o.

NQ. 23/1 94. Badstue Rev. — 4 to 5,5 meters. — Sand with stones. — *Zostera*, *Mytilus* with a few *Florideæ*, in particular *Rhodomela.*

NX. 22/1 94. Sprogø light-house N.E. 3/4 E. 3 1/3 miles. — 19 meters. — *Florideæ* (*Delesseria sangv., D. sinuosa, Rhodomela*).

NT. 25/1 94. Knudshoved light-house W. by N. 6/7 mile. — 19 meters. — Clay-mud or sand. — No vegetation.

NS. 24/1 94. Between Slipshavn and Knudshoved, 2/3 mile of land. — 5,5 meters. — Sand with stones. — *Fucus vesicul., F. serrat., Florideæ, Zostera.*

BS. 15/9 91. W. side of Palegrund. — 7,5 meters. — Mud. — *Zostera*, (*Furcellaria*).

LJ. 5/7 93. E. of Palegrund. — 16 meters. — Soft bottom with dead *Zostera*-leaves and some loose *Florideæ*.

XS. 27/10 00. By Kløverhage, Knudshoved light-house N.E. 2/3 N. 2 3/4 miles, and a little more north. — 5,5 to 7,5 meters. — Mostly *Zostera*, here and there stones with *Furcellaria, Phylloph. Brod., Polys. nigresc.*

BT. 15/9 91. S. of Kløverhage. — 7,5 meters. — Sandy mud. — Dense *Zostera*-vegetation.

Y. 19/9 90. By the broom at Stokkebæk Flak. — 4,5 meters. — Sand with stones. — *Fucus vesicul., F. serratus.* — 1/4 mile S. of the broom. — 7,5 meters. — *Zostera.*

BU. 15/9 91. Off Lundeborg. — 5,5 meters. — Mud. — Dense broad-leaved *Zostera*-vegetation.

CJ. 23/9 91. 1/3 mile S.S.W. of the entrance to the Stoense channel. — 5,5 meters. — *Zostera.*

BV. 15/9 91. Off the S. side of Elsehoved. — 6 meters. — Dense, pure *Zostera*-vegetation.

UU. 24/5 95. Snøde Rev. — 4 to 4,5 meters. — Dense *Zostera*-vegetation.

X. 19/9 90. 2 miles N.E. of the broom at Turø Rev. — 11 meters. — Clay-mud. — Broad-leaved *Zostera*, no Algæ.

LH. 5/7 93. S. of Egeløkke Rev, off Bøstrup. — 8,5 to 10,5 meters. — Soft bottom with stones. — *Zostera*, (*Furcellaria*).

CH. 23/9 91. 1 1/3 miles E.N.E. 1/3 E. of the broom at Turø Rev. — 11,5 meters. — Mud with dead *Zostera*-leaves. — No vegetation.

bA. 10/8 06. Sprogø light-house N.N.W. 4 miles. — 22,5 to 23,5 meters. — Sand. — No vegetation.

UE. 20/5 95. By the buoy at Vresens Puller. — 6,5 to 7,5 meters. — *Zostera* (with stones on which *Fuc. vesic., F. serratus, Lamin. digit., Furcellaria* a. o. *Florideæ*).

UF. 20/5 95. N. point of Langeland S.W. by W. 2/3 W. 2 1/2 miles. — 8,5 meters. — Sand and stones. — *Zostera, Fucus serratus, Florideæ*, (*Laminaria digitata*).

DN. 13/5 92. Vengeance Grund. — 11,5 to 12 meters. — Stones. — *Florideæ* with *Laminaria digitata, Fucus serratus* and *Halidrys.*

DO. 13/5 92. Langelandsøre, W. side of Omø. — 4 to 5,5 meters. — *Zostera*-vegetation and stones with *Fucus vesiculosus.*

UG. 20/5 95. Langelandsbelt, abreast of Østerhuse, the point by Hov N. by W. 1/4 W. 2 1/2 miles. — 33 meters. — ? with stones. — Some few loose Algæ.

UH. 20/5 95. Tranekær light-house S.W. by W. 4 1/2 miles. — 19 to 21,5 meters. — Stones. — *Lamin. digit., Delesseria sangvin.*

T. 17/9 90. 1/2 mile N.W. of the buoy at Staalgrunden. — 4 to 5,5 meters. — Sand with stones. — *Zostera* with a few *Fucus vesicul., Chorda Filum* a. o.

UT. 22/5 95. Tranekær light-house E. by N. 1/3 N. 2 2/3 miles. — 19 meters. — Coarse sand with stones. — *Delesseria sangvin.* a. o. *Florideæ, Laminaria sacch.* and *digit.*

UK. 21/5 95. Abreast of Tranekær light-house, 1 1/2 miles. — 12 meters. — Gravel (?) with some stones. — *Desmarestia acul.*, (*Phylloph. Brodiæi*).

DP. 13/5 92. The broom at Onsevig S.W. 1/2 W. a good 1 mile. — 6,5 meters. — Sand with some stones. — *Zostera* with some *Fucus vesic.*

UI. 20/5 95. The broom at Onsevig S. a good 1/2 mile. — 7,5 meters. — *Zostera*, (*Florideæ* in particular *Furcellaria, Rhodomela*).

DQ. 13/5 92. N.W. of Nakskov Fjord, Taars ferry outer light-house S.E. 1/2 E. 2 1/4 miles. — 5,5 meters. — Sandy clay-mud. — *Zostera*, (with *Florideæ*; numerous shells).

US. 22/5 95. Gillebjerg N.W. 1/4 W., Taars light-house E. — Ca. 45 meters. — Stones. — Scarce *Delesseria sinuosa* and *sangvinea.*

US[1]. $^{22}/_{5}$ 95. Gillebjerg N.W. $^{1}/_{2}$ W., Taars light-house E. — 20 meters. — Stones. — *Laminaria digitata* and *sacch.*, *Deless. sangvinea.*

DR. $^{14}/_{5}$ 92. Near the buoy at Albu Triller. — 8,5 meters. — *Zostera*, (with *Florideæ*).

DS. $^{14}/_{5}$ 92. The buoy at Albu Triller N.E. by E. $^{1}/_{4}$ E. 2 miles. — 11,5 meters. — Sand (?). — No vegetation.

DT. $^{14}/_{5}$ 92. Off Magleby on Langeland, $^{2}/_{5}$ mile of land. — 7,5 to 9,5 meters. — Sand. — *Zostera.*

LB. $^{4}/_{7}$ 93. Kjelsnor light-house W. nearly 4 miles. — 17 meters. — Mud with stones. — *Florideæ*, mostly *Delesseria sangvin.*, (*Laminaria digitata*).

UR. $^{22}/_{5}$ 95. S. of Albuen, Kappel church E. $^{1}/_{4}$ N., Fakkebjerg light-house W. $^{1}/_{2}$ N. — 7,5 meters. — ? with stones. — Rather dense *Zostera*-vegetation, (*Mytilus*, various *Florideæ*, some *Fucus serratus*).

Smaaland Sea. (Sm)

GZ. $^{10}/_{11}$ 92. 1$^{1}/_{2}$ miles N. of the N. end of Egholm. — 6,5 meters. — Sand with stones. — *Zostera*, (*Fucus serratus*, *F. vesicul.*).

HA. $^{10}/_{11}$ 92. Agersø Sund, the broom off the channel to Skelskør Nor S. E. $^{1}/_{4}$ E. a good 1 mile. — 11,5 meters. — Stones. — *Florideæ*, (*Polysiphonia*, *Delesseria*).

VB. $^{27}/_{5}$ 95. E. side of Omø Tofte. — 5,5 meters. — Sand with *Mytilus*, among which various Algæ, mostly *Furcellaria* and *Ceram. rubrum.*

HB. $^{11}/_{11}$ 92. S. end of Agersø Sund, Helleholm light-house N.W. by W. $^{3}/_{8}$ W. 3 miles. — 8,5 meters. — Stones and *Mytilus*. — *Rhodomela* and *Polysiph. nigresc.*, (*Zostera*).

VC. $^{27}/_{5}$ 95. Venegrund, inside the buoy. — 4 to 5,5 meters. — Sand with stones. — *Zostera*, not dense, various Algæ, *Mytilus.*

HC. $^{11}/_{11}$ 92. By the broom at Knudshoved Odde. — 11,5 meters. — *Zostera*. — *Florideæ* (*Polys. nigrescens*).

CK. $^{23}/_{9}$ 91. 2 miles S. by E. $^{3}/_{4}$ E. of the buoy at Staalgrund. — 9,5 meters. — Sand (?) with stones. — *Furcellaria*, (*Phyllophora membranif.*, *Ph. Brodiæi*, *Polys. nigresc.*).

CL. $^{23}/_{9}$ 91. In the middle of Raagø Sund. — 5,5 meters. — Dense veg. of broad-leaved *Zostera.*

CM. $^{23}/_{9}$ 91. By the broom at Kragenæs. — 4,5 meters. — Dense broad-leaved *Zostera.*

S. $^{16}/_{9}$ 90. By the W. side of Fejø. — 5,5 meters. — *Zostera.*

CN. $^{23}/_{9}$ 91. N.E. of Middelgrund at the E. end of Fejø. — 4,5 meters. — *Zostera*, (*Fuc. serratus*, *Furcellaria*).

HD. $^{11}/_{11}$ 92. Knudskov Rev. — 4,5 meters. — *Fucus vesicul.*, (*Zostera*).

CQ. $^{25}/_{9}$ 91. 1$^{3}/_{4}$ miles N.E. by E. $^{1}/_{5}$ E. of the broom at Kogrund. — 4,5 meters. — Sand with a few stones. — *Zostera*, (*Fucus vesicul.*).

Q. $^{15}/_{9}$ 90. N. of Vesterskovsflak. — 7,5 meters. — Sand. — *Zostera.*

P. $^{15}/_{9}$ 90. Between Kogrund and Suderø, $^{1}/_{4}$ mile S.E. by E. of the broom inside of Kogrund. — 3 meters. — Dense *Zostera*-vegetation with scarce *Fucus.*

CO. $^{23}/_{9}$ 91. By the broom at Vigsø Skal. — Ca. 6 meters. — *Zostera.*

CP. $^{25}/_{9}$ 91. By the broom at Guldborg. — 4 meters. — *Zostera.*

O. $^{15}/_{9}$ 90. Off Guldborg. — 5,5 meters. — Mud without vegetation.

N. $^{14}/_{9}$ 90. Guldborgsund, off Vennerslund. — 1 to 2 feet: *Polysiphonia violacea* f. *aculeata* a. o. scattered. — 2 feet: *Potamogeton pectinatus* and *Zannichellia pedicellata*. — 3 feet: *Spermatochnus paradoxus*, *Fucus serratus* a. o. — 3 to 4 feet and outwards: *Zostera.*

CR. 25/9 91. By the beacon at the W. end of Stor Strøm. — 4,5 meters. — Broad-leaved *Zostera*.

HE. 11/11 92. W. end of Masnedsund, near the beacon. — 4 to 5,5 meters (?). — Sand. — Pure *Zostera*-vegetation.

KP. 2/7 93. S. E. of Masnedø, between Kalvestrøm and Færgestrøm. — Ca. 3 meters. — *Zostera*, with scattered *Fucus vesic.*

HF. 12/11 92. W. of Farø, about 2/3 mile of land. — 12 meters. — Mud with stones and dead *Zostera*-leaves. — Very scarce *Florideæ*.

R. 16/9 90. Off Petersværft, near land. — Ca. 2 meters. — *Zostera*.

R1. 16/9 90. Off Sprove, Møen, right opposite Langø. — From 1,3 meters outwards *Zostera*. — In the channel mud without vegetation.

HJ. 12/11 92. Bredemands Hage by the S. side of Bogø. — 6,5 meters. — *Zostera*, dead and probably also growing, (scarce *Florideæ*).

KQ. 2/7 93. Grønsund, off the N. end of Østerskov. — 4 meters. — Bare sand. — 3,5 meters: *Zostera*.

The Sound. (Su)

RX. 1/8 94. Outside of Møllegrund off Höganäs. — 15 meters. — Clay-mud with stones. — No vegetation.

BQ. 12/9 91. Off Ellekilde. — 5,5 meters. — Stones. — *Fucus vesic.*, *Fuc. serratus*, (*Furcellaria* a. o. *Florideæ*).

BR. 12/9 91. Off Odinshøj. — 9,5 to 11,5 meters. — *Zostera*-vegetation.

CS. 1/5 92. Off Aalsgaarde. — 4 to 5,5 meters. — Stones. — (*Fucus vesiculosus*, *F. serratus*, and *Florideæ*.

GK. 4/8 92. Off Hellebæk. — Between first and second shoal. — Stones. — *Fucus serratus*. (*F. vesicul.*, *Furcellaria*).

ON. 17/4 94. E. side of Lappegrund. — 6,5 to 9,5 meters. — Coarse sand with pebbles. — No vegetation.

HN. 8/5 93. Øretvisten, E. side, Kronborg light-house S.W. 3/5 S. 2 miles. — 17 to 19 meters. — No vegetation.

HM. 8/5 93. Øretvisten, Kronborg S.W. 3/5 S. 1 3/5 miles. — 24,5 to 28 meters. — Clay-mud. — (A stone with a young *Lithothamnion*, one spec. of *Delesseria sangvinea*).

HL. 8/5 93. Øretvisten, Kronborg S.W. 1/4 S. 1 1/4 mile. — 41,5 meters. — Soft bottom (?). — No vegetation.

OK. 17/4 94. Disken, Lat. N. 56°0,3', Long. E. 12°38,5'. — 7,5 meters. — Bare sand.

OM. 17/4 94. W. side of Disken, Lat. N. 56°0,2', Long. E. 12°38'. — Sand. — No vegetation (*Mytilus*).

OL. 17/4 94. E. side of Disken, Lat. N. 56°0', Long. E. 12°37,7'. — 14 to 16 meters. — Sand. — No vegetation.

PX. 23/7 94. Off Tibberup. — 8,5 meters. — Sandy mud with a few small pebbles. — Dense vegetation of *Zostera*, (with *Fucus vesiculosus*, *Rhodomela*, *Polysiph. nigrescens*).

TD. 10/9 94. Hveens revolving light S. 1/2 W. 2 1/2 miles. — 20,5 meters. — No vegetation (seine).

OI. 17/4 94. Nivaa Flak, off Nivaa. — 6,5 meters. — *Rhodomela* (seine).

HK. 8/5 93. Off the N.W. end of Hveen. — 17 meters. — Clay-mud. — No vegetation. — 9,5 to 21,5 meters: In part clay-mud. — A few Algæ (*Polysiph. nigresc.*, *Ceramium rubrum*, *Delesseria sinuosa*).

TC. $^{10}/_{9}$ 94. Hveens revolving light N. $^{1}/_{2}$ W. $^{1}/_{2}$ mile. — 17 meters. – Clay-mud (?). — No vegetation (seine).

PV. $^{23}/_{9}$ 94. N. end of Lous's Flak, Hveens revolving light E. by N. $^{1}/_{2}$ N. 3 miles. — 10 meters. — Fine sand. — *Zostera.*

OH. $^{17}/_{9}$ 94. Vedbæk W.S.W. $^{1}/_{4}$ S. 1 mile. — 9,5 to 10,5 meters. — Sandy clay-mud with a few stones. — *Florideæ*, in particular *Furcellaria* and *Rhodomela*, (*Laminaria sacchar.*).

PY. $^{23}/_{7}$ 94. E. of Hveen, Haken light-house S. $^{1}/_{2}$ W. 1 mile. — 40,5 meters. — Clay-mud. — No vegetation.

PZ. $^{23}/_{7}$ 94. Near the E. side of Hveen, Haken light-house S. by E. $^{1}/_{4}$ E. 1 mile. — 10,5 to 19 meters. — Stones, from 12 meters upwards. — *Florideæ*, *Laminaria sacchar.*

TE. $^{25}/_{9}$ 94. W. of Staffans Flak, Haken light-house N.N.W. $^{1}/_{4}$ N. a good 1,5 mile. — 22,5 to 30 meters. — Clay-mud with stones. — No plants.

— The channel between Hveen and Landskrona. — 45 meters. — Clay-mud. — No plants.

TF¹. $^{25}/_{9}$ 94. Staffans Flak. — 12 to 13 meters. — Stones. — *Laminaria sacch.*, *Florideæ*, in particular *Furcellaria*, (*Chorda Filum*).

TF². $^{25}/_{9}$ 94. Immediately S. of Staffans Flak. — 28 to 32 meters. — Clay-mud and stones. — No plants.

TF³. $^{25}/_{9}$ 94. S.W. border of Staffans Flak. — 14 to 18 meters. — *Laminaria digitata*, *Florideæ*, *Phymatolithon polymorphum.*

QA. $^{23}/_{7}$ 94. By the buoy at Pilhaken, off Landskrona. — 24,5 to 39,5 meters. — No vegetation.

QB. $^{23}/_{7}$ 94. S. of the same buoy. — 16 meters. — Coarse sand, almost without vegetation, (a few *Desmarestia viridis* and *Ectocarpus*).

bM. $^{14}/_{7}$ 07. S. of Hveen, 1 mile W.S.W. $^{1}/_{4}$ S. of the whistle buoy at Pilhaken. — 22,5 meters. — Stones. — Abundant vegetation: *Laminaria digitata*, *L. sacchar.*, *Florideæ*, in particular *Delesseria sinuosa* and *sangvinea.*

RZ. E. of Lous Flak, Lat. N. 55°51,6′, Long. E. 12°41,5′. — 13 meters. — Clay-mud. — A few Algæ.

RY. Lous Flak, Lat. N. 55°51,5′, Long. E. 12°38′. — 12 meters. — Sandy clay-mud. — *Cladophora gracilis.*

bN. $^{14}/_{7}$ 07. — Off Vedbæk, Lat. N. 55°51′, Long. E. 12°36,5′. — 13 meters. — Abundant vegetation of Algæ and *Zostera*; of Algæ mostly *Ectocarpus*, *Furcellaria*, *Polysiphonia elong.* and *nigrescens*, *Rhodomela.*

RK. $^{30}/_{7}$ 94. Off Eremitagen, $^{3}/_{4}$ mile of land. — 7,5 meters. — Sand and mud. — *Zostera* and *Furcellaria* (probably loose).

PT. $^{21}/_{7}$ 94. By the broom at Taarbæk Rev. — Stones. — Abundant vegetation: *Fucus serratus*, *Furcellaria*, *Polysiph. nigrescens*, *Chorda Filum*, *Zostera.*

OG. $^{17}/_{4}$ 94. Taarbæk Rev, nearly 1 mile W. of the broom. — 6 meters. — Sand with stones. — *Florideæ*, in particular *Furcellaria* and *Rhodomela*, *Fuc. serratus.*

PU. $^{21}/_{7}$ 94. The broom at Taarbæk Rev N.W. by W. $^{1}/_{3}$ W. $2^{1}/_{6}$ miles. — 12 meters. — No vegetation.

TB. $^{10}/_{9}$ 94. The harbour of Skovshoved W.S.W. $^{1}/_{2}$ mile. — 5,5 meters. — Sand (?) with stones. — *Furcellaria*, *Zostera*, (*Chorda Filum*).

TA. $^{10}/_{9}$ 94. Near the harbour of Skovshoved. — 4,5 meters. — Sand. — *Zostera.*

PS. $^{21}/_{7}$ 94. Off Charlottenlund, the broom at Taarbæk Rev N.E. $^{1}/_{2}$ N. $2^{1}/_{3}$ miles. — 5,5 meters. — Sand with stones. — Abundant vegetation: *Zostera*, *Ectocarpus*, *Chorda Filum*, *Furcellaria.*

KO[1]. 18/6 93. Off the fort of Charlottenlund. — 3 meters. — Stones. — *Chorda Filum*, *Cladophora*.

KO[2]. 18/6 93. A little farther out. — 7 meters. — Stones. — *Fucus serratus*, *Laminaria sacch.*, *Furcellaria*, *Zostera*.

OG[1]. 16/4 94. Between Trekroner and Middelgrund. — Ca. 9,5 meters (?). — *Desmarestia acul.*, *Delesseria sinuosa* and *alata*, *Chætopteris*....

RI. 30/7 94. S. end of Middelgrund, between the beacon and the triple broom. — 5 meters. — Gravel with stones. — *Chorda Filum*, (scarce *Zostera*).

QE. 23/7 94. Nordre Røse. — 10,5 meters. — Gravel and stones. — No plants. — 5 to ca. 10 meters: Stones. — *Zostera*, *Chorda Filum*, (*Mytilus*).

RH. 30/7 94. S. end of Knollen. — 9,5 meters. — Stones. — *Laminaria sacchar.*, *Florideæ*, mostly *Polysiphonia violacea*, broad-leaved *Zostera*.

QC. 23/7 94. E. side of Saltholms Flak, 2/3 mile E. 5/6 S. of the broom. — 6 meters. — Sand (?) with stones. — Dense vegetation of *Fucus vesiculosus*, *F. serratus*, *Furcellaria* a. o. *Florideæ*, *Chorda Filum*.

QD. 23/7 94. E. of the N. end of Saltholm, 1 mile S.S.W. 1/2 S. of the beacon. — 5,5 meters. — Sand (?) with stones. — Dense vegetation of *Fucus serratus*, *Furcellaria*, *Polysiph. nigrescens*, *Zostera*.

SA. 2/8 94. Flinterenden; 1/4 mile S. of the buoy at N. Flint. — 10,5 meters. — Stones and black mud. — Broad-leaved *Zostera*, *Laminaria sacchar.*, (*Dictyosiphon*, *Laminaria digit.*).

SB. 2/8 94. Flinterenden; 3/8 mile S.W. of Oscargrund light-ship. — 8,5 meters. — Stones. — *Fucus serratus*, (*Florideæ*, *Dictyosiphon foeniculaceus*).

PR. 24/5 94. Off Dragør. — 7,5 to 9,5 meters. — Hard bottom with stones. — *Florideæ*: *Rhodomela*, *Polysiph. nigrescens*, *Furcellaria* and *Zostera*.

PR[1]. 24/5 94. About the same place but farther out. — Ca. 7,5 meters. — *Zostera* and the same Algæ as in PR.

Baltic, Western Part. (**Bw**)

VA. 25/5 95. Vejsnæs Nakke E. 1/3 N. — 26,5 meters. — Sand and pebbles. — No vegetation.

DV. 14/5 92. S. of Marstal, Fakkebjerg light-house S. E. 3/4 E. nearly 7 miles. — 9,5 to 11,5 meters. — Sand with pebbles. — *Zostera*, *Fucus serratus*, *Furcellaria*.

LE. 4/7 93. N. side of Vejsnæs Flak. — 9,5 meters. — Sand. — *Zostera*, (*Fucus serratus*, *Florideæ*).

UY. 25/5 95. Vejsnæs Flak. — 9,5 meters. — Bare sand with a few stones, on which *Fucus vesiculosus* and *F. serratus*, (and some *Florideæ*).

UY[1]. 25/5 95. S. side of Vejsnæs Flak. — 18 meters. — Sandy clay-mud. — Loose *Furcellaria*, *Laminaria digitata*.

UZ. 25/5 95. In the channel E. of Vejsnæs Flak. — 34 meters. — Clayey sand with small stones. — No vegetation.

LD. 4/7 93. Fakkebjerg light-house E.S.E. 1/4 E. 6 3/4 miles. — 20,5 to 22,5 meters. — Clay-mud without vegetation (*Ophiuræ*).

DU. 14/5 92. Off Dimesodde S. of Bagnkop, 1/3 mile of land. — 11 meters. — Stones. — *Furcellaria*, (*Fucus serratus*, *Laminaria digitata*....

LC. 4/7 93. S. of the buoy at Gulstav. — 11,5 meters. — Stones. — *Florideæ*, mostly *Furcellaria*, *Fucus serratus*, *Halidrys*, *Laminaria digit.*).

UL. $^{21}/_{5}$ 95. Femerbelt; Øjet, Markelsdorf Huk S. $^{5}/_{8}$ E. 7 miles. — 20 meters. — Gravel with stones. — Abundant vegetation: *Laminaria digitata*, *L. saccharina*, *Florideæ*.

LA. $^{3}/_{7}$ 93. Kappel church N. by W. $^{3}/_{4}$ W., W. end of Vesterskov N. $^{1}/_{4}$ W. — 7,5 meters. — Sand with some stones. — *Zostera*, *Florideæ*, (*Fucus vesiculosus*).

UQ. $^{22}/_{5}$ 95. Tillitse church N.E., Kappel church N. by W. $^{1}/_{2}$ W. — 12 meters. — Gravel and stones. — *Mytilus* with *Polysiphonia nigrescens* and a few other *Florideæ*.

UP. $^{22}/_{5}$ 95. Off Kramnisse Gab, $1^{1}/_{4}$ miles of land. — 8,5 meters. — Sand with stones. — Some *Zostera*, scarce *Furcellaria* and *Fucus serratus*, (*Mytilus*).

KZ. $^{3}/_{7}$ 93. Immediately outside Kramnisse Gab. — 7,5 meters. — *Zostera*, *Fucus serratus*, *Furcellaria*.

KY. $^{3}/_{7}$ 93. Ølstrup church E.N.E. 6 miles. — 12,5 meters. — Gravel and stones, *Mytilus*. — *Florideæ*, in particular *Ceramium* and *Polysiph. nigrescens*, (dead *Zostera*-leaves).

KX. $^{3}/_{7}$ 93. Olenburg Huk S.W. by W. $^{3}/_{4}$ W. a good 6 miles. — 26,5 meters (?). — Mud. — A few *Florideæ* on stones.

KV. $^{3}/_{7}$ 93. S. of Nysted, the buoy N.E. by N. $^{1}/_{2}$ mile. — 5,5 meters. — Sand. — *Zostera* in large patches, *Florideæ*.

KU. $^{3}/_{7}$ 93. Schønheyders Pulle. — 6,5 meters. — Stones. — *Fucus serratus*, *Florideæ*, (*Laminaria digitata*).

— $^{21}/_{5}$ 95. — 7 meters. — Small pebbles or coarse gravel, in great measure without vegetation, with however patches of *Fucus serratus* and a few *Florideæ* and some *Zostera*, (*Mytilus*).

KT. $^{2}/_{7}$ 93. Gjedser Rev, near the inmost broom. — 8,5 meters. — Stones. — *Fucus serratus*, *Florideæ*, in particular *Ceramium Rosenvingii*.

UO. $^{21}/_{5}$ 95. Gjedser Rev, Trindelen. — 5,5 to 7 meters. — Sand, gravel. — No vegetation.

UN^{1}. $^{21}/_{5}$ 95. Gjedser Rev, Yderknoben. — 5,5 to 9,5 meters. — Sand and coarse gravel without vegetation.

UN. $^{21}/_{5}$ 95. Gjedser Rev, by "Varsko". — 9,5 meters. — Sand without vegetation.

UM^{1}. $^{21}/_{5}$ 95. Near Gjedser Revs light-ship. — 19 meters. — Sand without vegetation.

UM. $^{21}/_{5}$ 95. Kadetrenden; Gjedser Revs light-ship N.W. $1^{1}/_{6}$ miles. — 24,5 to 25,5 meters. — Small pebbles. — No vegetation, (a few *Hildenbrandtia* a. o.).

Baltic, Part around Møen. (**Bm**)

QF. $^{23}/_{7}$ 94. W. of Lille Grund by Flinterenden, Drogdens light-ship N. by W. $^{1}/_{4}$ W. nearly 3 miles. — 9,5 meters (?). — Stones. — *Zostera*, *Fucus serratus*, broad, *Ectocarpus*, (*Mytilus*).

RG. $^{30}/_{7}$ 94. Falsterbo light-house S.S.E. 6 miles. — Sand, stones. — *Fucus serratus*, *Florideæ*, (the Algæ probably in part loose).

QG. $^{24}/_{7}$ 94. Abreast of Bredgrund, $^{1}/_{2}$ mile N.E. $^{1}/_{2}$ E. of the broom at Virago Grund. — 7,5 meters. — Stones. — *Fucus serratus*, *F. vesiculosus*.

QM. $^{24}/_{7}$ 94. N. of Juels Grund, harbour of Køge W. $5^{1}/_{2}$ miles. — 6,5 to 7,5 meters. — Sand with stones. — Abundant vegetation of *Fucus vesiculosus*, *Polysiph. nigrescens* a o. *Florideæ*, *Zostera*.

QL. $^{24}/_{7}$ 94. S. of Juels Grund. — 11,5 meters. — No vegetation.

QK. $^{24}/_{7}$ 94. Off Køge Søhuse. — 9,5 meters. — Fine sand. — *Zostera*.

QN. $^{24}/_{7}$ 94. Off Køge Søhuse, $^{3}/_{4}$ mile of land. — 6,5 meters. — Stones. — *Fucus serratus*, (with *Florideæ*).

QI^1. 24/7 94. Køge Bugt, 7 miles due N. of Stevns light-house. — 16 meters (seine). — *Florideæ*, *Laminariæ*.

QO. 24/7 94. Køge Sønakke N.W. 1/4 W. 1,3 miles. — 4,5 to 5,5 meters. — Stones. — *Fucus vesiculosus*, *Florideæ*.

QP. 24/7 94. Kalkgrund, at the N. end of Stevns Klint. — 3 to 4 meters. — Limestones. — *Fucus vesiculosus* and *F. serratus*, (*Ceram. rubrum*, *Chorda Filum*).

VF. 28/5 95. Off Mandehoved, Stevns. — 4 to 9,5 meters. — Limestones. — Rather abundant vegetation: *Fucus vesiculosus* and *F. serratus*, (*Polys. nigrescens*).

QJ. 24/7 94. 6 miles due W. of Falsterbo light-house. — 16 meters. — Fine sand. — No vegetation.

QH. 24/7 94. Falsterbo light-house N.E. 1/2 E. 2 1/2 miles. — Ca. 7,5 meters. — Sand. — *Zostera*, *Fucus vesiculosus* a. o.

SC. 2/8 94. Falsterbo light-ship S.E. 1/2 S. 2 1/2 miles. — 9,5 meters. — Fine Sand. — No vegetation.

VE. 28/5 95. Stevns light-house N.E. 1/2 E. 1 1/3 miles. — 15 meters. — Gravel, small pebbles. — No vegetation.

QQ. 24/7 94. Off Rødvig. — 6,5 to 7,5 meters. — Stones. — *Fucus vesiculosus*, (*F. serratus*).

VD. 27/5 95. Near the whistle buoy at the entrance to Bøgestrømmen. — 7,5 meters. — Sand with stones. — *Fucus vesiculosus*, *F. serratus*....

RA. 25/7 94. Hollænder Grund. — 5,5 meters. — Stones. — *Fucus vesiculosus*, *Spermatochnus*.

RB. 25/7 94. Inside Hollænder Grund. — 4,5 meters. — Sand and gravel with stones. — *Fucus vesiculosus*, *Zostera*; the vegetation here and there wanting.

QR. 25/7 94. Gyldenløves Flak. — 7,5 meters. — Gravel with stones. — *Fucus vesiculosus*.

SD. 2/8 94. Stevns light-house N. by W. 1/4 W. nearly 13 miles. — 23,5 meters. — Sand. — Loose *Florideæ* in abundance, in particular *Furcellaria*, *Delesseria sangvinea*, *D. alata*, *Rhodomela*, *Polysiphonia nigrescens*.

QS. 25/7 94. The Møen cliff S.S.W. 7 miles. — 20,5 meters. — Gravel and small stones. — *Florideæ*, in particular *Rhodomela*, *Delesseria sangvinea*, *D. alata*, for the most part loose, (many *Mytilus*).

VG. 28/5 95. N. of the Møen cliff, abreast of Hellehavns Nakke, 3/4 mile of land. — 17 meters. — Gravel and stones. — *Mytilus* with various *Florideæ*.

RC. 26/7 94. Inside "Danneskiold" near the Møen cliff. — 7,5 meters. — Stones. — *Fucus vesiculosus*.

QZ. 25/7 94. Abreast of Møen light-house. — Ca. 7,5 meters. — Stones. — *Fucus vesiculosus*, *F. serratus*, a great many loose *Rhodymenia palmata*.

QY. 25/7 94. S. side of Bjelkes Flak. — 10,5 meters. — Stones. — *Fucus serratus*.

VH. 28/5 95. S. side of Böchers Grund. — 8,5 to 10,5 meters. — Sand and stones. — *Fucus serratus* and *F. vesiculosus*.

VI. 28/5 95. Off Hjelm, Møen, near land. — 5,5 to 6,5 meters. — Gravel with stones. — *Fucus serratus* and *vesiculosus*, (*Rhodomela*, *Polysiph. nigrescens*).

HG. 12/11 92. Præstebjergs Rev, N. of the broom. — 7 meters. — Stones. — *Fucus vesiculosus* and *serratus*.

HH. 12/11 92. The broom at Præstebjergs Rev N.W. by W. a good 2 miles. — 17 meters. — Clay-mud. — No vegetation.

KR. 2/7 93. By Korselitze Grund. — 7,5 meters. — Sand with stones. — *Fucus vesiculosus*, *F. serratus*, *Florideæ*.

KS. $^{2}/_{7}$ 93. E. of Falster, off Ulfslev; Gjedser light-ship S.S.W. $^{3}/_{4}$ W. $11^{1}/_{2}$ miles. — 9,5 to 11,5 meters. — Gravel and stones. *Fucus vesicul.* and *serratus*, *Florideæ*, in particular *Rhodomela* and *Polys. nigrescens.*

bO. $^{17}/_{7}$ 07. Lat. N. 54°37′, Long. E. 12°25′ (Mag. O. PAULSEN). — 15 meters (trawl). — *Laminaria sacchar.*, *Desmarestia acul.*, various *Florideæ.*

QV. $^{25}/_{7}$ 94. Lat. N. 54°43,6′, Long. E. 12°28,5′. — 17 meters. — Sand. — No vegetation.

QX. $^{25}/_{7}$ 94. Lat. N. 54°49,7′, Long. E. 12°28,4′. — 20,5 meters. — Fine sand. — No vegetation.

QU. $^{25}/_{7}$ 94. Lat. N. 54°46,6′, Long. E. $12°34^{2}/_{5}$′. — 16 meters. — Fine sand. — No vegetation.

SE. $^{2}/_{8}$ 94. Lat. N. 55°4′, Long. E. 12°47′. — 28 meters. — Clay-mud without vegetation.

QT. $^{25}/_{7}$ 94. Møen light-house W. by N. $10^{2}/_{3}$ miles. — 34 meters. — Clay-mud with fine sand. — No vegetation.

bP. $^{18}/_{7}$ 07. E. side of Kriegers Flak, Lat. N. 55°3′, Long. E. 13°5′ (? (Mag. O. PAULSEN). — Ca. 15 (18?) meters. — *Rhodomela. Ceramium strictum. Desmarestia viridis* a. o.

RF. $^{30}/_{7}$ 94. Lat. N. 55°10′, Long. E. 13°15′. — 37,5 meters. — Sand and clay-mud, a few small stones. — No vegetation.

Baltic, Part around Bornholm. (**Bb**)

RE. $^{30}/_{7}$ 94. Lat. N. 55°10′, Long. E. 14°. — Ca. 40 meters. — No vegetation.

SF. $^{3}/_{8}$ 94. Adler Grund. $^{1}/_{2}$ mile S. of the light-ship. — Ca. 10,5 meters. — Sand with stones. — *Furcellaria, Ceramium vertebrale.*

SG. $^{3}/_{8}$ 94. Adler Grund. $1^{3}/_{4}$ miles S. by E. $^{1}/_{4}$ E. of the light-ship. — Stones. — 10,5 meters. — *Furcellaria. Ceramium vertebrale.*

SU. $^{7}/_{8}$ 94. Rønne Banke, Lat. N. 54°54′, Long. E. 14°33′. — 24,5 meters. — Hard sand with stones. — Scarce vegetation, in particular *Rhodomela* and *Ectocarpus littoralis.*

ST. $^{7}/_{8}$ 94. W. side of Rønne Banke, Lat. N. $54°55^{3}/_{4}$′, Long. E. 14°33′. — 18 meters. — Stones. — *Mytilus*; a few *Florideæ* and *Ectocarpus littoralis.*

SS. $^{7}/_{8}$ 94. W. side of Rønne Banke. Lat. N. $54°58^{1}/_{4}$′, Long. E. $14°32^{1}/_{2}$′. — 19 meters. — Stones, gravel. — *Sphacelaria racemosa.*

SH. $^{3}/_{8}$ 94. Rønne Banke. Lat. N. $54°59^{1}/_{3}$′, Long. E. $14°45^{1}/_{3}$′. — Stones. — *Stictyosiphon, Ceramium.*

SR. $^{7}/_{8}$ 94. Rønne Banke, Lat. N. $55°1^{3}/_{4}$′, Long. E. $14°41^{1}/_{3}$′. — 15 to 16 meters. — Gravel and stones. — *Florideæ*, in particular *Rhodomela* and *Ectocarpus.*

YI. $^{11}/_{7}$ 01. Port of Rønne E. by N. $2^{3}/_{4}$ miles. — 33 meters. — No vegetation.

YH. $^{11}/_{7}$ 01. Port of Rønne E.N.E. $1^{1}/_{2}$ miles. — 24,5 meters. — Stones. — Incrusting Algæ (*Hildenbrandtia. Lithoderma*), a few arbuscular *Florideæ.*

RD. $^{27}/_{7}$ 94. Hvidmæhrn, S. of Rønne. — 9,5 meters. — Stones. — *Fucus vesiculosus. F. serratus*.

SK. $^{3}/_{8}$ 94. Rønne Banke: Højbratterne, $^{1}/_{6}$ mile S. of the broom. — 11,5 meters. — Gravel and stones. — *Fucus serratus*, *F. vesicul.*, (*Furcellaria* with *Ceramium*).

SI. $^{3}/_{8}$ 94. Rønne Banke. Lat. N. $55°0^{1}/_{2}$′, Long. E. $14°47^{3}/_{4}$′. — 13 meters. — Gravel. — No vegetation.

YF. $^{11}/_{7}$ 01. Inside Arnager Rev. — 5,5 meters. — *Fucus serratus* and *vesiculosus*, (scarce *Zostera*).

YG. $^{11}/_{7}$ 01. Arnager Rev, a good mile of the port. — 7 meters. — Limestone. — *Fucus vesiculosus* a. o.

YE. $^{10}/_{7}$ 01. Off Ølenaa, $^{1}/_{3}$ mile of land. — 10,5 meters. — Stones or rock. — *Polysiph. nigrescens. Furcellaria.* (*Fucus serratus*).

SN. 6/8 94. Davids Banke. — 15 to 17 meters. — *Fucus serratus*, (*Ectocarpus*).
— — — — 24,5 to 28 meters. — Stones. — *Laminaria saccharina*.
XZ^1. 5/7 01. — — N.W. side of the bank. — 29 meters. — Stones. — Red and brown Algæ, no *Laminariæ*.
XZ^2. — Davids Banke — 12 to 22,5 meters. — Stones. — *Fucus serratus* (and some *Florideæ*).
XZ^3. — — — 15 meters. — Stones. — *Fucus serratus* with red and brown Algæ.
XZ^4. — — — 19 to 20,5 meters. — *Laminaria saccharina* in abundance, *Fucus serratus*.
XZ^5. 5/7 01. Hammer Odde S.E. by E. 7 miles. — 41 to 43 meters. — Firm clay with a few small stones. — No plants.
SM. 6/8 94. N. of Hammeren, Lat. N. 55°18,8′, Long. E. 14°46′. — 24,5 meters. — Sand. — No vegetation.
SL. 5/8 94. Off Allinge. — Ca. 5,5 to 11,5 meters. — Rock and stones. — *Fucus vesiculosus*, *Ceramium rubrum*, *C. vertebrale*, *Sphacelaria racemosa*.
SO. 6/8 94. Off Gudhjem. — 5,5 to 11,5 meters. — Rocky ground. — *Florideæ*, in particular *Ceramium rubrum* f. *baltica*, *C. vertebrale*, *Phyllophora membranifol.*, *Ph. Brodiæi*, *Furcellaria*, *Dictyosiphon*, *Fucus serratus*.
SP. 6/8 94. 1/4 mile N. by W. 1/2 W. of Møllenakke by Svaneke. — 28 meters. — Gravel. — No vegetation.
SQ. 6/8 94. Close S. of Broens Rev. — 9 meters. — Rocky ground. — *Fucus serratus*, (very few *Florideæ*).
YD. 6/7 01. The double broom at Salthammer Rev W. 1/4 S. 1 mile. — 19 meters. — Stones. — Abundant vegetation of red and brown Algæ: *Ectocarpus littoralis*, *Delesseria sangvinea*, *Rhodomela*, *Polysiphonia elongata var.* a. o.
YC. 6/7 01. The double broom at Salthammer Rev N.W. 3/4 N. 1 1/2 miles. — 24,5 meters. — Rather rich vegetation of *Ectocarpus littor.*, *Rhodomela*, *Polysiph. elongata var.* a. o.
YA. 6/7 01. Dueodde light-house W. 5 3/4 miles. — 37,5 meters. — *Rhodomela*, *Sphacelaria racemosa*, *Furcellaria*, *Deless. sinuosa*.
YB. 6/7 01. Dueodde light-house W. 6 miles. — 43,5 to 45 meters. — Stones. — No plants.
SV. 8/8 94. Nordvestgrund by Christiansø. — 30 to 32 meters. — Rocky ground. — No vegetation.
SX. 8/8 94. That by Christiansø. — 0 to ca. 15 meters. — Abundant vegetation.

List of stations arranged chronologically, with indication of the waters where they are situated.

July 1890.	A—D	Ks.	Aug. 1891.	AI—AN	Lb.	Sept. 1891.	BS—BV	Sb.
Sept. —	E—M	Lf.	— —	AO—AT	Sa.	— —	BX—CC	Sf.
— —	N—S	Sm.	— —	AU—AX	Lb.	— —	CD—CF	Sb.
— —	T	Sb.	— —	AY—BF	Sa.	— —	CG	Sf.
— —	U—V	Sf.	— —	BG	Ks.	— —	CH—CI	Sb.
— —	X—Y	Sb.	— —	BH—BO	Km.	— —	CK—CR	Sm.
Aug. 1891.	Z—AG	Sb.	— —	BP	Kn.	May 1892.	CS	Su.
— —	AH—AI^1	Sa.	Sept. —	BQ—BR	Su.	— —	CT—CZ	Sf.

May	1892.	DA—DI	Lb.	Sept.	1893.	MM—MN	Sb.	July	1895.	VL—VS	Km.
—	—	DJ—DK	Sa.	—	—	MO—MY	Sa.	—	—	VT—VX	Kn.
—	—	DL—DT	Sb.	—	—	MZ—NB	Ks.		—	VY—XA	Ke.
—	—	DU—DV	Bw.	—	—	NC—ND	Km.	—		XB—XF	Km.
—	—	DX—DY	Lb.	—	—	NE—NK	Kn.	Aug.	—	XG	Kn.
—	—	DZ—EB	Sf.			NL—NM	Ks.	July	1896	XH—XI	Kn.
June	—	EC—EG	Lb.	Jan.	1894.	NN—NU	Sb.	July	1899	XK—XL	Kn.
July	—	EH—EP	Ks.	March	—	NV—NX	Lb.	—	—	XM—XN	Lf.
—	—	EQ—EY	Ke.	—	—	NY—OA	Sa.	Aug.	—	XO	Sk.
—	—	EZ—FA	Km.	—	—	OB—OF	Lb.	July	1900.	XP—XQ	Lb.
—	—	FB—FD	Ke.	Apr.	—	OG—ON	Su.	Aug.	—	XR	Ns.
—	—	FE—FH	Kn.	—	—	OO—OY	Ks.	Oct.	—	XS	Sb.
—	—	FJ—FN	Km.	—	—	OZ—PP	Sa.	June	1901.	XT—XY	Lf.
—	—	FO—FP	Ks.	May	—	PQ—PQ[1]	Ks.	July	—	XZ—YI	Bb.
—	—	FQ—FY	Sa.	—	—	PR—PR[2]	Su.	Aug.	—	YK—YL	Sk.
—	—	FZ—GA	Lb.	July	—	PS—QE	Su.	July	1902.	YM—YN	Sk.
—	—	GB—GE	Sa.	—	—	QF—RC	Bm.	—	—	YO—YS	Kn.
—	—	GF—GH	Ks.	—	—	RD—RF	Bb.	Aug.	—	YT	Ns.
—	—	GI	Ke.	—	—	RG	Bm.	—	—	YU	Sk.
Aug.	—	GK	Su.	—	—	RH—RK	Su.	June	1904.	YV	Sa.
Sept.	—	GL—GO	Kn.	—	—	RL—RQ	Ks.	July	—	YX	Kn.
Nov.	—	GP—GY	Sb.	Aug.	—	RR—RS	Ks.	—	—	YY	Km.
—	—	GZ—HF	Sm.	—	—	RT—RV	Ke.	—	—	YZ—ZB	Kn.
—	—	HG—HH	Bm.	—	—	RX—SB	Su.	—	—	ZC—ZD	Km.
—	—	HI	Sm.	—	—	SC—SE	Bm.	—	—	ZE—ZI	Ke.
May	1893.	HK—HN	Su.	—	—	SF—SX	Bb.	Aug.	—	ZK	Sk.
—	—	HO—HS	Ks	—	—	SY—SZ	Sk.	July	1905.	ZL—ZM	Kn.
—	—	HT—HV	Km.	Sept.	—	TA—TF	Su.		—	ZN—ZO	Ks.
—	—	HX—IU	Ke.	—		TG—TR	Kn.		—	ZP	Kn.
—	—	IV—KD	Kn.	Oct.	—	TS—TT	Km.	—	—	ZQ—ZR	Ns.
—	—	KE—KG	Km.	—	—	TU—TY	Kn.	—	—	ZS—ZY	Lf.
—	—	KH	Ks.	Jan.	1895.	TZ—UD	Kn.	—	—	ZZ—aE	Ns.
—	—	KI—KN	Sa.	May	—	UE—UK	Sb.	Aug.	—	aF—aS	Ns.
June	—	KO	Su.	—	—	UL—UQ	Bw.	June	1906.	aT	Lf.
July	—	KP—KQ	Sm.	—	—	UR—UU	Sb.	Aug.	—	aU	Ks.
—	—	KR—KS	Bm.	—	—	UV—UX	Sf.	—	—	aV—aZ	Sa.
—	—	KT—LA	Bw.	—	—	UY—VA	Bw.		—	bA	Sb.
—	—	LB	Sb.	—	—	VB—VC	Sm.	July	1907.	bB—bG	Sk.
—	—	LC—LE	Bw.	—		VD—VF	Bm.		—	bH—bI	Kn.
—	—	LF—LG	Lb.	—	—	VG—VI	Bm.	—	—	bK—bL	Km.
—	—	LH—LK	Sb.	June	—	VJ	Sk.	—	—	bM—bN	Su.
Aug.	—	LL—LP	Sb.	July	—	VK—VK[2]	Km.		—	bO—bP	Bm.
—	—	LQ—ML	Lf.								

Rhodophyceæ.

A. *Protoflorideæ.*

I. Bangiales.

Fam. 1. Bangiaceæ.

J. Agardh (1883), Till Algernes Systematik. Tredje afd. VI. Ulvaceæ. Lunds Univ. Årsskrift Tom. XIX.
G. Berthold (1881), Zur Kenntniss der Siphoneen und Bangiaceen. Mittheil d. zoolog. Station zu Neapel, II.
— (1882), Die Bangiaceen des Golfes von Neapel. Leipzig.
H. Hus (1902), An Account of the species of Porphyra found on the Pacific coast of North America. Proc. Calif. Acad. sc. 3. ser. vol. II No. 6, San Francisco.
H. Kylin (1907), Studien über die Algenflora der schwedischen Westküste. Upsala.
Fr. Oltmanns (1904), Morphologie und Biologie der Algen, I, p. 529—534.
Fr. Schmitz (1894), Kleinere Beiträge zur Kentniss der Florideen. V. La Nuova Notarisia, Ser. V, p. 717.
— (1896), Bangiaceen. Engler-Prantl, Natürl. Pflanzenfam. I, 2, p. 307—316.

With regard to the natural history of the *Bangiaceæ* reference may be made to the above-quoted works of Berthold, Schmitz and Oltmanns; I wish only to make some remarks on the spores produced asexually. Berthold named them "neutral spores", a name in my opinion but little applicable, as these spores cannot be said to be more neutral than the carpospores. Schmitz named them monospores as they are produced by the whole contents of a cell, but the carpospores were given by him the same name, and consequently this was not a name peculiar to the spores produced asexually. Besides, it seems to me more reasonable to compare the cell, which after division produces a number of spores, with the tetrasporangium in the *Florideæ*, than to compare the daughter-cell the contents of which become a spore with the monosporangium of *Chantransia*, for the fact is that the spores in the tetrasporangium are also separated by cell-walls. If the term monospore might be used within this family, it must be for the cases where one spore only is produced by each originally vegetative mother-cell (e. g. *Goniotrichum*, *Erythrotrichia*). When more than one spore are produced by a mother-cell, it might be desirable to give them the same designation as the tetraspores of the *Florideæ*, but against that we have the fact that the number of spores is not fixed and may be reduced to one. In order to avoid a long designation the spores produced without sexual process may be named gonidia. According to their mode of development the family may be divided into the following sections.

1. *Bangieæ.* Gonidia arising by division (or also without division) from an originally vegetative mother-cell.
   Frond filiform .... *Bangia.*
   Frond flat .... *Porphyra.*
2. *Erythrotrichieæ.* Gonidia arising in special monosporangia, cut off by a curved wall in a vegetative cell.
   Frond erect, filiform .... *Erythrotrichia.*
   Frond first cushon-like, thereafter vesicular, ruptured and expanded in a monostromatic plane .... *Porphyropsis.*
   Frond consisting of creeping branched filaments, more or less confluent to a monostromatic disc........................ *Erythrocladia.*
   (Frond a monostromatic parenchymatous disc............... *Erythropeltis*).
3. *Goniotrichieæ.* Gonidia arising without cell-division.
   Gonidia naked.. *Goniotrichum.*
   Gonidia provided with cell-wall .... *Asterocytis.*

Bangia Lyngb. emend.

1. **Bangia fusco-purpurea** (Dillw.) Lyngb.

LYNGBYE Hydr. p. 83, tab. 24 C; HARVEY Phyc. Brit. pl. 96; REINKE in Pringsh. Jahrb. 9. Bd. p. 274 tab. 12; BERTHOLD (1882) fig. 12—14; KYLIN (1907) p. 107.

Conferva fusco-purpurea Dillw. Brit. Conf. pl. 92.

Bangia atro-purpurea (Roth) β, *fusco-purpurea* (Dillw.) Ag. Syst. p. 76; Fl. Dan. tab. 1841; J. Agardh (1883) p. 36.

In 1806 ROTH described (Catal. bot. III p. 208), under the name of *Conferva atro-purpurea*, a filamentous Alga found in a water-mill at Bremen; it was referred to the genus *Bangia* by LYNGBYE and was found in similar localities at many other places in Europe. Three years later, DILLWYN described a somewhat similar species, *B. fusco-purpurea*, first found on the British shores, and largely distributed on the Atlantic and Mediterranean shores. The resemblance between the two species, however, was so great, that LYNGBYE referred ROTH's species as a variety to *B. fusco-purpurea*, while C. AGARDH conversely regarded *B. atro-purpurea* as the main species and *B. fusco-purpurea* as variety. The latter view was also maintained by J. AGARDH, who, however, expressly distinguished the freshwater form from the marine form while the older AGARDH only took the colour into consideration. I shall not enter on the question of the relation of these species, but like most of the marine phycologists record the marine species under DILLWYN's name. The distribution of the species on the Danish shores does not favour the supposition of a gradual transition to the freshwater form, as it does not occur in water of low salinity.

The plant is at first a filament consisting of a single row of cells, and fixed at the base by rhizines, which grow downwards from the lower cells in the common outer-wall (REINKE l. c. fig. 1). In this form the plant can attain a considerable size, but sooner or later longitudinal walls occur, which have a more or less radial position and which divide the articles into wedge-shaped cells.

According to Berthold (l. c. p. 9), the first stage in the formation of the "neutral spores" or gonidia begins with the protoplasmic body increasing in mass, while at the same time shining globules occur, which are soluble in water and are stained brown by iodine, more rarely minute starch-grains, and the pyrenoid occupies the centre of the cell. During the first stages of these changes one or two divisions take place and then the cell-bodies are set free as spores. Berthold does not indicate, if these divisions are only anticline or if they can also be pericline. According to Schmitz (1896 p. 311), these spores can also arise without division from the whole of the contents of a vegetative cell. The first dividing wall of the fertilized carpogonium is, according to Berthold (l. c. p. 16), parallel with the surface of the thread, while the following are radial, and we thus have as result eight carpospores in vigorous threads. These though of very variable size are smaller than the gonidia, and differ from the latter, according to Berthold, by containing minute granules of starch and a smaller and less lobed chromatophore; they show amoeboid movements though slower than those of the other spores.

It will be understood from the above, that it is not always easy to decide if we have to do with gonidia or with carpospores, especially in examining dried specimens, and when the direct traces (e. g. canal) of the fecundation process have disappeared. — Male filaments I have met with rather seldom, though at different seasons, but most frequently and best developed in spring. While the formation of spermatia ordinarily takes place very uniformly, all cells in the same part of the thread being in the same stage of development, some threads collected in July at Frederikshavn showed a more irregular disposition, the antheridia being intermingled with cells which were little or not at all divided, and which undoubtedly would not reach to the production of spermatia. They could not be supposed to be carpogonia as there were no spermatia attached outside them and they showed no periclinal walls. Berthold states also, that the species is dioecious "mit wenigen Ausnahmen".

Female filaments with attached spermatia I have met with in February, April and May, and I have also several times been able to see the fine fertilization tube, though it seems to disappear rapidly along with the spermatia. In fig. 1 some fertilization tubes are still visible after the disappearance of the spermatia. The carpogonia may appear in thin threads, which are only divided by a few longitudinal walls, as well as in thicker filaments the articles of which consist of several cells (fig. 1). Fig. 2 *A* and *B* show transverse sections of female filaments which, seen from the side, showed spermatia attached to the surface. The cells, which have been divided by periclinal walls, must be supposed to be fertilized carpogonia. How many cells belong to the individual cystocarps in fig. 3 *B* is difficult to decide; it seems that vegetative periclinal divisions have also taken place, either before or after fertilization. I have only seldom seen carpospores containing starch-grains, e. g. in specimens collected at Hirshals in April, showing distinctly the process of fertilization (fig. 1). In dried specimens I could not see distinct starch-grains, but only indistinctly limited spots giving blue-violet colour with iodine.

Gonidia seem to occur much more frequently than the carpospores on our coasts, as I have met with the species at all seasons and most frequently with spores, which must be regarded as gonidia. These spores may arise in very thin threads whose articles show only one longitudinal wall, but their origin can also take place in thick threads with numerous longitudinal walls. As a rule two or four spores are produced by each mother-cell; most frequently I found no starch in these spores, but in a few cases I observed numerous very small starch-grains in spores which were undoubtedly gonidia (Thyborøn and Skagen, July). In May I saw the spores escape from threads recently collected at Hirshals, a process that took place very rapidly; amoeboid movements I did not observe, but the chromatophore showed alterations of form. In one spore it had taken a globular form and was sharply defined; shortly afterwards it became angular and seemed about to take the ordinary stellate shape, but it soon took again the rounded form. In other cases these spores showed the amoeboid movements.

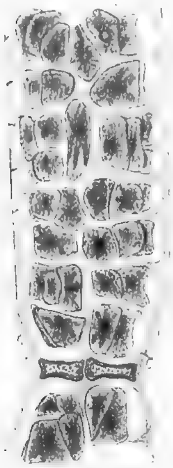


Fig. 1.
Bangia fusco-purpurea. Fragment of female filament with fertilization tubes and a few spermatia still adhering. 390 : 1.

This species occurs at ordinary high-water mark and higher, so that it is frequently out of the water and even dried up and in great measure only wetted by the spray of the waves. It is therefore easy to understand why it is not commoner than it is at the Danish shores, where the tide is mostly insignificant; in unfavourable periods with continual low water and calm, dry weather it would be in danger and would be killed at all the places, where it is not protected by special conditions against desiccation of long duration. At Frederikshavn it grows chiefly on the outer sides of the moles, where with a westerly wind the level of the sea is proportionally high, while with an easterly wind the level is low but the mole ordinarily washed by the waves. The most dangerous condition for the *Bangia* vegetation is a fairly long period of easterly winds with the wind so light, that this vegetation is not reached by the waves, especially when the weather at the same time is bright and dry. Its occurrence is therefore very different, not only at various seasons, but also in different years. In winter it is very abundant, but the critical period of the spring will every year kill a greater or smaller part of it and on the duration and intensity of this period depends to what degree that will take place. In summer for example it occurs at

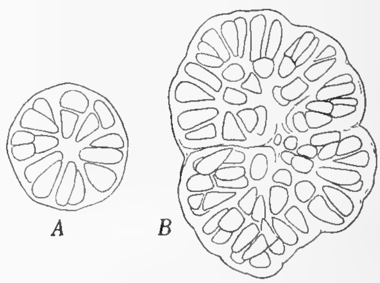


Fig. 2.
Bangia fusco-purpurea. Transverse sections of female threads with cystocarpia. 200 : 1.

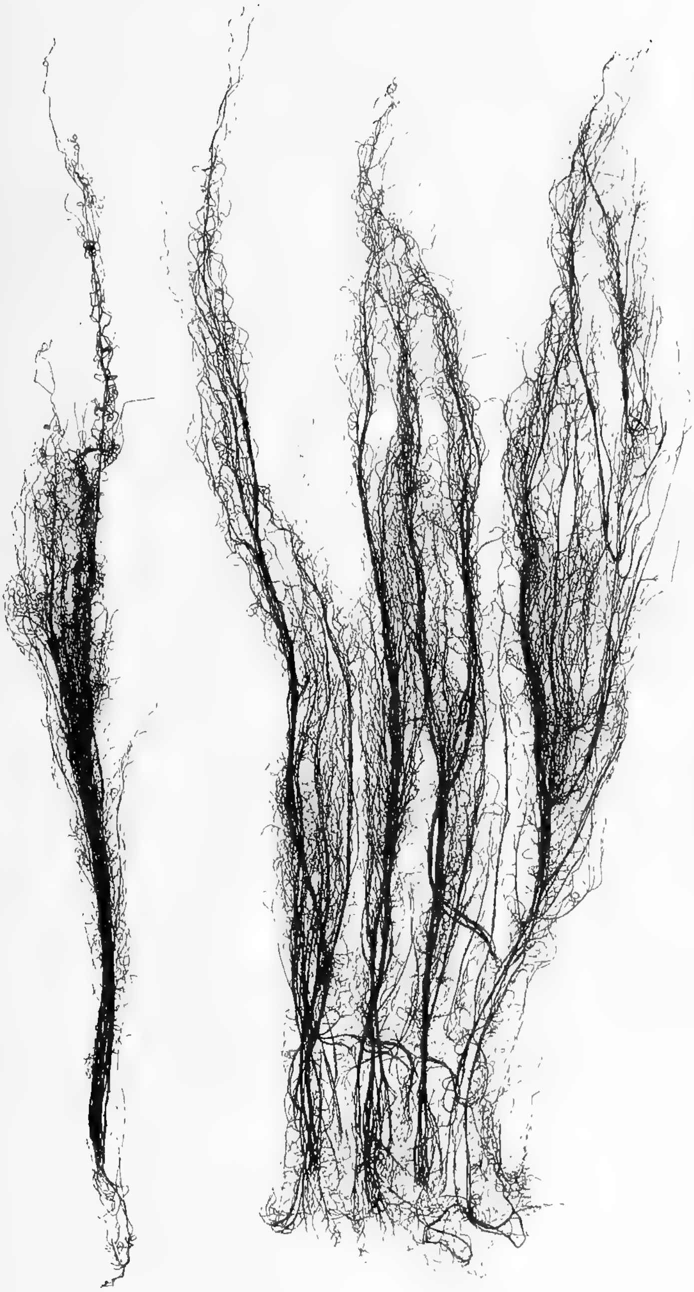


Fig. 3.
Bangia fusco-purpurea. Specimens collected at Middelfart (Kongebro) March 1894. After photograph, natural size.

Fig. 4.
Bangia fusco-purpurea, growing on Phyllitis zosterifolia, mole at Hirshals. Aug. Phot., nat. size.

Frederikshavn in some years only in small quantities, while in others it forms extensive growths especially on the outer side of the south mole, as in the beginning of August 1902. In the Little Belt it completely disappears in summer, at all events in certain years (e. g. 1901), while in spring it is often abundant and luxuriant. In March 1894 it was so well developed there, that I have never found it better developed on the Danish shores: the threads attained a length of 14—15 cm and were above thick and curled (fig. 3). In April 1904 I searched for it in vain at the same place. This is the most southern locality known on the Danish shores.

Localities. Ns: Thyborøn, groin No. 58. — Sk: Hirshals, on the mole and on a boulder on the shore, observed in the months April to August, may occur abundantly still in July. Has also been found growing on *Phyllitis zosterifolia* (fig. 4). Greatest length of the threads observed here ca. 7 cm. — Lf: Harbour of Lemvig (?): Thisted: Glyngøre. — Kn: Harbour of Skagen: Busserev by Frederikshavn (April and July): harbour of Frederikshavn. — Ke: Harbour of Gilleleje, Febr. and May, ca. 1 cm long. — Lb: Harbour of Fredericia (Hofm. Bang. !); harbour of Middelfart, stone-slope west of the harbour, March and April. Kongebro.

Bangia pumila Aresch. (DARBISHIRE. Ueber Bangia pumila Aresch., eine endemische Alge der östlichen Ostsee. Wiss. Meeresuntersuchungen, N. F. 3. Bd., Abt. Kiel 1898, S. 25) which according to DARBISHIRE is readily distinguished from *B. fusco-purpurea* as well as from the fresh-water *B. atro-purpurea*, and which, as far as known, is endemic in the Baltic, has not been met with hitherto in the Danish shores, though I have sought for it, particularly on the shores of Bornholm. It differs from *B. fusco-purpurea* in particular in that the articulation of the frond is still distinct in the older frond, which is divided by longitudinal walls, and through smaller cystocarps. As it has been found at Swinemünde and at Dantzig, there is reason to believe that it may also be found on the Danish Baltic coasts.

According to KYLIN (1907 p. 109), however, this species has been found by ARESCHOUG not in the Baltic but "in den innersten Buchten von Göteborg". This author regards it as being not a distinct species but probably only feebly developed specimens of *B. fusco-purpurea*.

Porphyra Agardh.

1. **Porphyra umbilicalis** (L.) J. Ag. (Plate I and II fig. 1—3.)

J. Agardh (1883) p. 66.

P. laciniata (Lightf.) Ag.: Thuret in Le Jolis Liste des Alg. mar. de Cherbourg 1864, p. 99, Janczewski, Études anat. sur les Porphyra. Ann. sc. nat. V^{e} sér., t. 17 1873, p. 241, pl. 19 fig. 25—26; Thuret et Bornet, Études phycologiques, 1878, pl. 31, p. 58.

f. *linearis* (Grev.) Harv.

P. linearis Greville, Algæ britannicæ 1830 p. 170 tab. 18; Kützing Tabulæ phycologicæ XIX tab. 79; J. Agardh, l. c. p. 71; Le Jolis Algues marines de Cherbourg No. 96; Kylin (1907) p. 111.

Ulva purpurea β. *elongata* Lyngb. Hydr. p. 29.

P. vulgaris forma, Harvey Phycologia Britannica pl. 211, fig. 2—3; Thuret in Le Jolis Liste p. 99.

P. hiemalis Kylin. (1907) p. 112 Taf. 3 fig. 2.

f. *vulgaris* (Ag.) Thur. in Le Jol. Liste p. 99.

Ulva purpurea Roth Catalecta I p. 209, Lyngb. Hydr. p. 29.

Porphyra vulgaris Agardh, Flora 1827 II p. 642, Icones Algar. tab. 28; Harv. Phyc. brit. pl. 211; Aresch. Alg. Scand. exs. No. 261.

f. *laciniata* (Lightf.) Thur. in Le Jolis Liste p. 99.

Ulva umbilicalis Lyngb. Hydr. p. 28; Flor. Dan. tab. 1663.

P. laciniata Ag. Syst. Algar. p. 191, Icones Algar. pl. 27; Harv. Phyc. Brit. pl. 92; Areschoug Alg. scand. exs. No. 116 and No. 260.

P. laciniata var. *umbilicalis* Ag. Ic. Algar. tab. 26.

With regard to the limitation of the species I agree with Thuret (in Le Jolis Liste), but I follow J. Agardh in adopting the specific name of Linné, as it is the oldest and besides not less significant than Lightfoot's name *laciniata*.

As to the f. *linearis*, the views of authors have been divergent. It was Harvey (Phyc. Brit. pl. 211) who first showed, from observations in nature, that it is only a juvenile winter-form, which later passes over into the broader form, and this has been confirmed later by Thuret and others. J. Agardh regards it however as a distinct species, emphasizing that it occurs not only in winter but also in spring. Kylin follows this author but without discussion of his view. Having observed this form in nature in winter and spring, I cannot but come to the same result as Harvey and Thuret. In winter this species is abundant on the moles at Frederikshavn, on the inner as well as the outer side, and it occurs then mainly in rather narrow forms, which pass gradually and evenly into specimens which correspond exactly with *P. linearis* Grev. While the latter is said to attain only a length of a few inches, specimens more than 20 cm. long but less than 1 cm. broad, for the rest fully typical, were commonly found. The largest specimen I have collected is without the basal portion but is notwithstanding 43 cm. long with a breadth of only 0,8 cm. The typical specimens of f. *linearis* have a well developed stipe, rounded base and the margin a little or not undulated. In some broader specimens the margin becomes more undulated, the base broader and cordate (Plate II fig. 1—3). Such specimens agree with Kylin's *P. hiemalis*; the only difference between this and *P. linearis* seems to me to be, after Kylin's description, besides the somewhat greater dimensions, the fact, that the sporocarps form long narrow sori. This I have also observed in some of the specimens mentioned here (Plate II fig. 1), but by no means in all, and on the other hand it occurs also in broad specimens of *P. umbilicalis* (Plate I fig. 3), and therefore it cannot be used as a distinguishing character between the forms of this species.

These narrow forms occur in great quantity in winter on the moles of Frederikshavn, particularly on the outer side of the outer moles, at high level, and also on moles and groins on the west coast of Jutland. In spring, when easterly winds occasion low water, this fact in connection with the increasing dryness of the air and the strong sun will cause these *Porphyra* plants to a great extent to die. The individuals surviving this critical season are those growing at a rather low level or in places which are protected by particular conditions against drying up during low water. In growing older the frond of these individuals increases more in breadth than in length, and the same frond may then pass in development from f. *linearis* through f. *vulgaris* to f. *laciniata* (comp. THURET in LE JOLIS Liste p. 100). In f. *vulgaris* the longitudinal axis of the frond is much longer than the radii going outwards or downwards, but under the continued growth of the frond in transverse direction this difference diminishes and at last entirely disappears, the frond obtaining an approximately orbicular outline, at the same time becoming more or less laciniated and, on account of the continuous transverse growth, much radially folded (Plate I fig. 2). The point of attachment in this stage is only apparently, not really central and umbilicate, as supposed in the older descriptions and drawings (LINNÉ, Spec. plant. II 1763, and DILLENIUS, Hist. muscor. 1741, tab. 8).

Though the f. *linearis* normally disappears in spring on the Danish shores, it can however be found much later in the year if rarely. Thus I have met with it on the outer side of the northern mole of Frederikshavn, near the entrance of the harbour, at a place where the sea is as a rule agitated, in July 1895 and September 1892. The specimens found in September were very well developed, up to 30 cm. long, 0,5 to 1,3 cm. broad, fully typical, only of a lighter colour than the specimens occurring in winter. These discoveries, however, may be very rare exceptions, for I have otherwise never found this form in summer at Frederikshavn, one of the best investigated localities in Denmark, as little as in any other locality. ARESCHOUG has also found it in August on the shore of Bohuslän (Phyc. scand. mar. p. 180).

This species has been met with in all the months of the year, and it occurs at all seasons in fully developed specimens. It can probably attain an age of more than one year, but most of the specimens die, as said above, at a rather young age. It has been found fertile at all seasons, and then nearly always with sexual organs (or carpospores). While several authors state that the species is as a rule dioecious (THURET, BERTHOLD, KYLIN), I have found it most frequently monoecious on the Danish shores, at all events in summer. In winter only have I found the specimens generally dioecious, particularly f. *linearis* (Plate II fig. 2—3). In the specimens met with in summer the frond is generally divided by a longitudinal limiting line into a male and a female portion, distinguishable thereby that the margin of the first is yellowish white, that of the second purple. The limiting line is most often remarkably straight; it is very distinct towards the margin, while downwards it becomes indistinct and finally vanishes on reaching the sterile portion of the frond (Plate I fig. 1). The male and female parts of the frond are in some cases of equal size, in others the male or the female is broadest. Even the narrow winter forms can be monoecious and show a well marked limiting line (Plate II fig. 1). According to HUS (1902, p. 197), the sporocarpia and antheridia in *Porphyra laciniata* (*umbilicalis*), when they are developed in the same frond, "occur in patches very much as in *P. perforata*". If that is really normal to the species of the Pacific coast, it must be supposed that it is a different species from the European *P. umbilicalis*.

The decoloration of the developing antheridia generally takes place gradually from the margin inwards. Some few specimens from Helsingør showed however, at some distance from the margin, some lighter spots, reminding one of the antheridial spots in *P. leucosticta.* They were found to consist of antheridia earlier in their development than the surrounding antheridia, which were still in division.

As first shown by Berthold (1880 and 1882), the spermatia attach themselves to the female portions of the frond, and a fine fertilization canal is formed through the wall of the carpogonium-cell. These fertilization canals contain a thin strand of protoplasm, which is still to be seen a long time after the fertilization, while the exhausted spermatium quickly disappears. Their number is often remarkably great, much greater than that of the carpogonia (fig. 5 *A—C*). It is evidently a very common case that several fertilization tubes are introduced to one carpogonium.

The fertilised carpogonium divides, as is well known, by a transverse wall; thereafter follow often one or two further transverse walls, whereupon arises a 3- or 4-celled prismatic body wich thereafter may be further divided by differently orientated walls (fig. 5 *D*, *F*). Such divisions result no doubt in cystocarps with numerous carpospores, while the typical case is regarded to be eight carpospores in two layers. Extraordinarily large cystocarps, containing a great number of spores, were found in specimens collected in the harbour of Skagen in April, the frond of which was unusually thick, 90 to 115 μ (fig. 5 *D—E*). Comp. Berthold (1882) fig. 10.

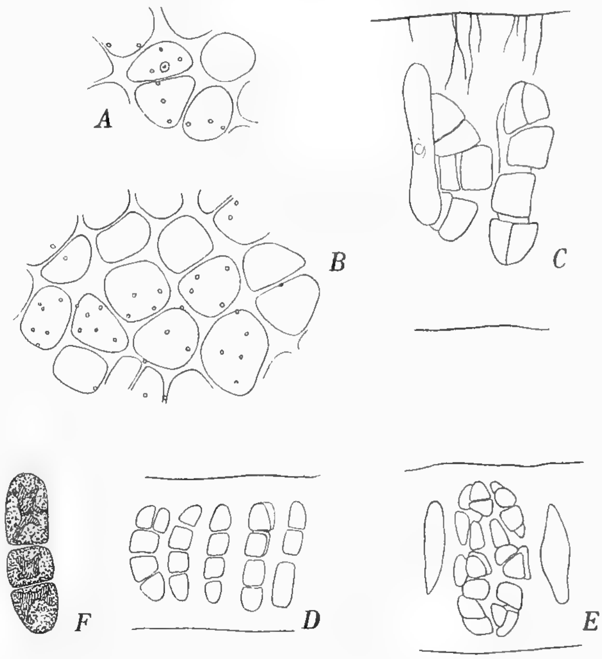


Fig. 5.

Porphyra umbilicalis. *A—E*, specimens from the harbour of Skagen, July. *A* and *B*, parts of frond seen from the surface; the cell-walls and, at a higher level, the fertilization tubes and in *A* a spermatium are shown. *C*, part of frond with fertilization-tubes and cystocarps in transverse section. *A—C* 390 : 1. *D* and *E*, transverse sections of frond with cystocarps from the same locality, April. 230 : 1. *F*, incompletely divided cystocarp, Frederikshavn December. 500 : 1.

In a number of specimens (52) collected in March on groins near Thyborøn, nearly all belonging to f. *linearis*, a few to f. *laciniata*, I found only cystocarps containing about 8 carpospores arranged in two layers, but in no case could spermatia or fertilization tubes be observed, and none of the plants contained antheridia. As the spores in all cases examined resulted from a division parallel to the frond, it may be supposed that we have here a case of apogamy, if it should not be found that the monospores can result also from such divisions.

The development of the cystocarps is as a rule uniformly progressive from the margin of the frond inward. Sometimes, however, the maturation takes place more rapidly in some irregularly ramified spots than in the surrounding parts, and these spots appear therefore with a deeper red colour, as observed earlier by Berthold (1882 p. 16). As mentioned above, this is to be found in broad as well as in narrow forms, and it cannot be used as distinctive character between them.

The carpospores contain as a rule numerous minute starch-grains which are stained brown-violet with iodine. I have also found fertilised carpogonia containing starch before dividing, but on the other hand I have also seen carpospores without starch.

The gonidia result, according to Berthold, from one or two divisions perpendicular to the plane of the frond, and the frond after these divisions is consequently one-layered as in the vegetative state. These spores seem to occur much rarer on the Danish shores than the carpospores. I have not had occasion to observe this kind of fructification in fresh specimens or in specimens preserved in alcohol; I have only met with a few herbarium specimens which seemed to contain gonidia. Thus, a specimen collected in the harbour of Sæby in September was without sexual organs, rather uniformily rose-coloured, and consisted merely of a single layer of cells of the same size as the vegetative cells, but with richer, more granular plasmatic contents, which stained brown-violet to nearly dark with iodine, without however showing distinct starch-grains. Further, the cell-bodies were much disposed to leave the cell under the softening.

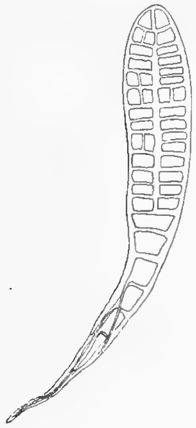


Fig. 6.
Porphyra umbilicalis. Germinating plant, growing on Nemalion multifidum. 240 : 1.

The germinating plants are, as shown by Thuret and Bornet (1878 p. 58), at first filiform, but at an early period longitudinal divisions and rhizines arise. The apical cell is early divided by a longitudinal wall, while the inferior part of the thallus is still filiform (fig. 6).

The species grows, on the Danish shores, about at ordinary water level, or at some distance above it, especially in winter, or a little under it, but hardly under the lower water-level. When occurring in the *Fucus*-zone, it grows only in the upper part of it. At Esbjerg it occurs only in the upper part of the littoral region. It thrives best where the salinity of the water is comparatively high and the locality tolerably protected. It attains therefore its greatest size at Esbjerg and in the Limfjord, where it becomes more than 40 cm. long, while it is smaller on the more exposed groins and moles at Thyborøn and Hirshals. In the most southern localities in the seas within Skagen I found the following maximal sizes of the frond: in Little Belt (Middelfart) 24 cm., in Great Belt (Smørstakken) 29 cm., in the Sound (Helsingør) 12 cm. Most of the Danish places for this species are moles; the natural habitats are emerging reefs and boulders near land. It grows also on wood, more seldom on *Fucus*; young specimens have been found growing on *Nemalion multifidum.*

Localities. **Ns:** Nordby, Fanø (C. Rasch, abundantly in the *Fucus*-zone!); Esbjerg (Børgesen, on moles and embankments in the upper half of the littoral region!); groins by Thyborøn (in spring chiefly f. *linearis*, in summer only broader forms. — **Sk:** Hirshals (on the mole and on boulders on the shore, in spring f. *linearis* abundantly above high-water mark, in summer the species disappears entirely or almost entirely). — **Lf:** Harbours of Lemvig, Struer and Thisted; Aalborg, harbour and piers of bridge (!, Th. Mortensen and unknown collector in herb. C. Rosenberg); Nørre Sundby; Hals. — **Kn:** Harbour of Skagen; Busserev (with *Bangia* near high-water level, small specimens in April; harbour of Frederikshavn (in winter f. *linearis* abundantly, mainly at high-water level, in summer only broader forms, as a rule in small quantity); harbour of Sæby. — **Ks:** Harbour of Grenaa. — **Sa:** Kyholm (upper *Fucus*-zone, with *Ralfsia*); Aarhus, harbour, and on boulders on the shore by Riis Skov. — **Lb:** Harbour of Bogense (!, Børgs.); Fredericia (Hofm. Bg., Joh. Lange,!); Strib; harbour of Middelfart (Hofm. Bg., C. Rosenb.,!), Kongebro. — **Sb:** Harbour of Lohals; Smørstakken. — **Su:** Harbour of Helsingør.

2. **Porphyra leucosticta** Thuret. (Plate II fig. 4—13.)

Thuret in Le Jolis, Alg. mar. de Cherb. 1864, p. 100. Janczewski, Ann. sc. nat. Ve sér. t. 17, 1873, p. 241 pl. 19 fig. 1—14. Berthold (1881) p. 79. Id. (1882) Taf. 1 Fig. 1—6.

Porphyra atropurpurea Olivi in Saggi Accad. di Padova III. 1. 1791, teste De-Toni, Syll. Alg. IV. Sect. 1, p. 17.

Exsicc.: Crouan Alg. mar. du Finistère No. 397. Le Jolis Alg. mar. de Cherbourg No. 156.

This species which has only been met with on our most northern shores, occurs there in its typical shape but does not attain a considerable size. The largest observed specimens are (in a dried state) 10—11 cm. long, only one specimen was 16 cm. long. The longest fronds are lingulate, about 2—4 cm. broad, with rounded or more frequently cordate base, but very often the margins of the frond overlap each other below the base, particularly in the broadest specimens, in which the attachment may then become apparently umbilicate. The frond is generally entire, rarely a little lobed, the margin more or less undulated. The colour is as a rule a little more reddish than in *P. umbilicalis*, but the difference is not absolute; the two species can occur with exactly the same colour. The thickness of the frond I found to vary between 28 and 44 μ.

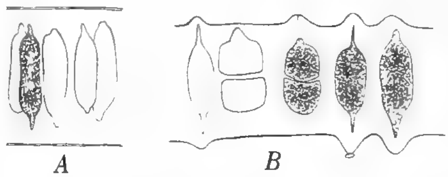


Fig. 7.
Porphyra leucosticta. Transverse sections of frond with carpogonia; in *A* these are not fertilized, while in *B* three of them are fertilized and two divided by a cross-wall. 390 : 1.

The specimens met with in April were all provided with sexual organs, in so far as they had attained a tolerable size. The antheridia formed the well known patches, running longitudinally in the upper part of the frond, 5—10 mm. long, 1—1,5 mm. broad. There are, however, also very small antheridial patches, originating in a group of very few mother-cells. The number of spermatia arising from each mother-cell is fairly often smaller than 64. As shown by Janczewski (l. c. p. 247), isolated cystocarps are often scattered among the antheridia. The carpogonia had very often produced a hyaline protuberance at each extremity, a state which, according to Berthold, is due to the fact that the carpogonia have been obliged to wait a long time for fecundation. When all the carpogonia assume this form, the frond becomes papillose on both sides. Fig. 7 *B* shows a spermatium attached to the top of a papilla, while the adjacent carpogonium has divided by a transverse wall after fecundation; the fertilization-canal of this carpogonium is yet to be seen below. The carpogonia produce 4 or 8 spores in two layers.

This species seems to disappear during the summer. On July 2nd 1905 on the moles of the harbour of Skagen I only found some very small specimens 1—1,5 cm. high, being evidently the under part of specimens which had exhausted their spermatia and carpospores; there were namely still to be seen remnants of emptied antheridial sori and some few cystocarps containing 8 spores, while the upper border of the frond consisted of emptied cell-walls (Plate II fig. 9—13). In 1907 the species remained longer, perhaps in connection with the fact, that the summer was unusually cold with predominant westerly winds. On July 11th 1907 I found in the same locality rather large specimens, some of which showed antheridia, in part not emptied, and cystocarps. Other specimens did not show these organs and did not seem to have produced them earlier. In such a specimen the cells in the upper part of the frond had more granular contents than the vegetative cells, for which reason I am inclined to believe, that they were producing gonidia (Plate II fig. 8). These cells had a sharply limited lateral vacuole; they were not divided by walls parallel to the frond.

Kylin (1907 p. 110 Taf. 3 Fig. 1) has established a species nearly related to *P. leucosticta* under the name *P. elongata* (Aresch.) Kylin (*P. laciniata* var. Areschoug Alg. Scand. exsicc. No. 117), which is distinguished by its elongated form of frond with uniform breadth, its thinner frond (25—33 μ while it is said to be 33—40 μ in *P. leucosticta*), and the smaller antheridial sori; it may be added that the author found it epiphytic and fructiferous in August. It appears to me, however, to be rather doubtful if it can really be regarded as a species distinct from *P. leucosticta*; at all events, the alleged characters are hardly conclusive. As said above *P. leucosticta* has often a lingulate form (comp. Pl. II fig. 4—8), and that is so also in specimens from the coasts of France. The thickness of the frond was found, in the Danish specimens of this species, to vary on both sides of the limit given by Kylin (se above). That the sori of antheridia in the specimens of Kylin reached only a size of 2 mm., while they attained a length of 10 mm. in the Danish specimens, is scarcely sufficient for specific distinction. I have found no specimen on the Danish coasts fully agreeing with *P. elongata* Kylin, the specimen most similar to it was 16 cm. long, 2 cm. broad, on the one side with a small lobe; it had a thickness of 28 μ, but the antheridial sori were long.

The plant grows on stones at the mean level of the sea.

Localities. Sk: Hirshals, on the mole and on a large boulder on the shore, April 1906. — Kn: Harbour of Skagen; it appeared contemporaneously with the construction of the harbour; it was detected by Mag. M. L. Mortensen, 9/4 1905, on the moles commenced the preceding year and constructed, as far as known, exclusively of stones taken on land. Later, I have found it, on several visits in April and July, on the outer and inner sides of the moles, but only or principally near land.

Erythrotrichia Areschoug.

Phyceae Scandinavicae marinae 1850 p. 209.

1. **Erythrotrichia carnea** (Dillw.) J. Ag.

J. Agardh (1883) p. 15.
Conferva carnea Dillwyn, Brit. Conf. 1809 pl. 84.
Conferva ceramicola Lyngb. Hydr. 1819 p. 144 tab. 48 D (teste specim.)
Bangia ceramicola Chauvin. Rech. sur l'org. de plus. genr. d'Algues, Caen 1842, p. 33; Harvey, Phyc. Brit. pl. 317: Hauck, Meeresalg. p. 22.
Erythrotrichia ceramicola Aresch. l. c. p. 210; Le Jolis (Thuret), Alg. mar. Cherb. p. 103 pl. III fig. 1—2!; Berthold (1882).

This species is attached to the substratum not by means of a basal layer of cells, but only by the basal cell which gives off short ramified rhizines radiating in all directions on the surface of the substratum, while the other cells of the filament produce no rhizines. In fig. 8 C the rhizines are rather irregular as the plant was attached to the border of a *Porphyra* thallus. At the base the filaments are a little thinner than higher up, but the outer cell-wall becomes by and by incrassated. The filaments often attain only a length of 0,5 cm., but where the plant thrives well it becomes at least 3 cm. long. The thickness of the filaments is 16—24 μ, a little less at the base.

The cells contain a star-shaped chromatophore with numerous narrow branches radiating in all directions, in particular downwards and upwards, and with a central pyrenoid. The nucleus is small and not always visible as it is often hidden behind the chromatophore or between its branches (fig. 8 *D—F*). The vegetative cells contain in general no starch; some specimens collected in Sallingsund, Limfjord, in July were however the exception in this respect, all cells containing numerous small starch grains staining blue-violet with iodine; yet the sterile cells showed not so many starch grains as the sporangia. The length of the cells in proportion to the breadth is rather variable. In specimens collected in January the cells were very short and their contents very dense; their length was always shorter than the breadth, often only a third, while in summer filaments are often met with, the cells of which are 3—4 times as long as broad and then with rather poor contents. Plants collected on Herthas Flak (Kn) in 19 meters depth in September consisted of cells of about equal height and breadth. I have only seldom met with a few cells divided by longitudinal walls and they gave one rather the impression of being somewhat abnormal. Berthold (l. c. p. 25) also found longitudinal divisions very seldom, while J. Agardh (l. c. p. 14—15) thought that they were common in this species[1].

This species has only non-sexual reproduction. The spore-mother cell is, as well known, cut off by an oblique wall at the upper end of a cell which is not different in form from the vegetative cells. Its formation begins with the nucleus

[1] It may be doubtful, whether all that is referred to this species by this author, belongs really to it, as for inst. his Tab. I fig. 8, which represents a polysiphonous proliferous filament.

dividing into two, the one lying over the other at the one side of the cell. Then the chromatophore divides after a longitudinal plan into two of unequal size lying side by side (Fig. 8 *D*); the larger later moves upwards and is taken up in the spore together with the upper nucleus (Fig. 8 *E*, *F*). In the lower chromatophore the pyrenoid is very small and indistinct shortly after the division, while the upper contains a large and distinct pyrenoid; it is therefore probable that the original pyrenoid passes undivided over into the larger chromatophore, while a new pyrenoid is formed in the smaller. The fructiferous cells contain many small starch-grains which stain dark-violet with iodine; they are to be found in the sporangia as well as in their sister-cells. The sporangium is in general smaller than its sister-cell; when the mother-cell is very short, however, they can be of equal size or even larger. As shown by THURET and BERTHOLD, the under-lying cell, after the evacuation of the spore, expands and occupies the place of the original mother-cell, and the process of spore-formation may be repeated.

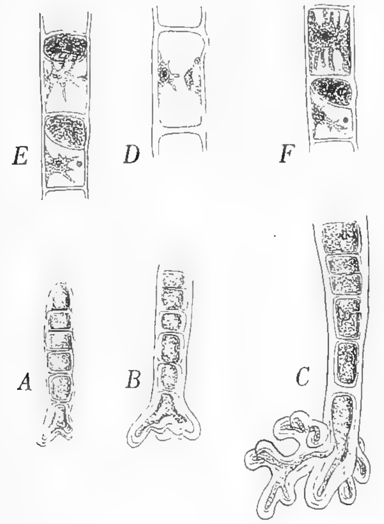


Fig. 8.
Erythrotrichia carnea. *A*—*C*, young plant and bases of plants attached to Porphyra. 380:1. *D*—*F*, fructiferous cells; in *D* the chromatophore and the nucleus have recently divided, in *E* and *F* the sporangial cell has been cut off. 412:1.

The plant has been found in almost all Danish waters excepted the Baltic, as a rule, however, only in small quantities and therefore not conspicuous. In greater quantity only found at Struer, in the Limfjord, (Sept. 1890) and in the harbour of Frederikshavn (particularly in August 1891 and July 1896). It is a summer Alga, nearly exclusively met with in the months July to September; it has however also been collected in winter (Nov. and Jan.). It has been found fructiferous in all the months named. It does not like much agitated water; it has been found most frequently and in greatest quantity in harbours, on piers and the like, in small depths, but it has been found down to 19 meters. It is always epiphytic and has been found growing on a number of different Algæ, e. gr. *Polysiphonia nigrescens* and *violacea*, *Ceramium rubrum*, *Brongniartella*, *Bryopsis*, *Porphyra umbilicalis* and many others.

Localities. **Sk:** SY, off Løkken, 13 meters. — **Lf:** Harbour of Struer; Sallingsund, at Glyngøre and off Snabe, 4—6 meters: LS, off Arnakke, 7 meters; MI, off Ejerslev, 4 meters. — **Kn:** Herthas Flak, 19 meters, (Børgs.); harbour of Frederikshavn; Borrebjergs Rev; Nordre Rønner; GM, 6 meters. — **Km:** BL, 9,5 meters; BH, off Gjerrild Klint, 4 meters. — **Ks:** Holbæk Fjord. — **Sa:** Kalø Rev; Hofmansgave (Lyngbye, Hofm. Bg.). — **Lb:** Harbour of Middelfart. — **Su:** BQ, off Ellekilde, 5,5 meters; PZ, E. of Hveen.

Porphyropsis gen. nov.

Frons initio pulvinata parenchymatica, dein vesiculosa et rupturâ in membranam monostromaticam expansa. Sporæ (gonidia), ut in *Erythrotrichia*, divisione obliqua in cellulis frondis gignuntur. Reproductio sexualis ignota.

1. **Porphyropsis coccinea** (J. Ag.).

Porphyra coccinea J. Agardh, Novitiæ fl. Svec. 1836 p. 6 (without description); J. Areschoug, Phyc. Scand. mar. 1850 p. 181 tab. I D; J. Agardh (1883) p. 56; P. Kuckuck, Bemerk. z. mar. Algenveg. Helgoland II, 1897, p. 390 fig. 13, 14.

This pretty little Alga, which has been referred till now to the genus *Porphyra*, I have met with only at three places in the eastern Kattegat, at the two only in extremely small quantity. As its mode of fructification has been hitherto unknown, its systematic position has remained uncertain, as pointed out by Kuckuck, who showed that the chromatophore has no central pyrenoid as in the other species of *Porphyra* but that it forms a much divided parietal plate. It will be seen from the following that this plant also in other respects differs so much from the typical species of *Porphyra*, that it must be removed from this genus. Thus the development of the frond is quite different; whereas in *P. umbilicalis* this begins as a filament which early becomes leaf-like, being divided by longitudinal walls, in *Porphyropsis coccinea* the frond is at first cushion-like, parenchymatous and composed of more than one layer of cells. The frond increases in height and becomes globular and vesicular. Such a condition is to be seen in Fig. 9 *A*. As this and other similar plants were growing together with more advanced stages of this species and as they much resembled the lower, basal portions of the latter, I conclude that they belong really to the same species. The plant figured is nearly hemispherical with a lobed plane of attachment, in the margin of which the cells are somewhat elongated. The upper part of the frond consists of a layer of cells which are actively dividing by anticlinal walls; the growth caused by these divisions has caused a separation of this cell-layer from the cells lying within, and the continued growth must necessarily cause the plant to become more and more vesicular. A rupture of the vesicle must, however, take place at an early period, for small individuals occur with an irregularly lobed monostromatic frond tapering downwards and ending in a cushion-like, basal disc resembling the under part of fig. 9 *A*. In consequence of this development the young frond is usually more or less cup-shaped; in particular, the margins immediately above the basal cushion are most frequently bent inwards to the same side. The expanded frond projects from the one side of the basal cushion, the greater part of which is situated at the hollow side of the young frond. On the side of the cushion opposite to the frond are often to be seen irregular projections representing the lower border of the split by which the monostromatic frond has arisen. The lap visible below on the left in fig. 9 *C* belongs undoubtedly to this category. The formation of the split itself I have unfortunately not observed; probably a transverse split is formed on the one side of the vesicular frond. The development here described is not entirely unknown; J. Agardh (1883 p. 56) describes the young plants thus: "Hoc modo plantam nondum lineam altam fere hemisphæricam vidi, nempe lamina marginibus ita involuta ut media pars sursum spectaret, apice marginibusque ad ambitum hemisphærii decumbentibus (Tab. II fig. 41); dum dein circumcirca increscit, sensim magis erigitur et fit fere cucullatim involuta, marginibus sursum hiantibus (l. c. fig. 42)". The celebrated author has not perceived that the leaf-like frond arises by splitting of a globular vesicle, but his fig. 41 seems to represent just the state where the split is formed. When the frond grows older, numerous rhizines are formed from the cells in the lowest part of the frond, which may result in the original basal cushion becoming less distinct; it is however always evident that the cells in the basal portion of the frond are situated in more than one plane.

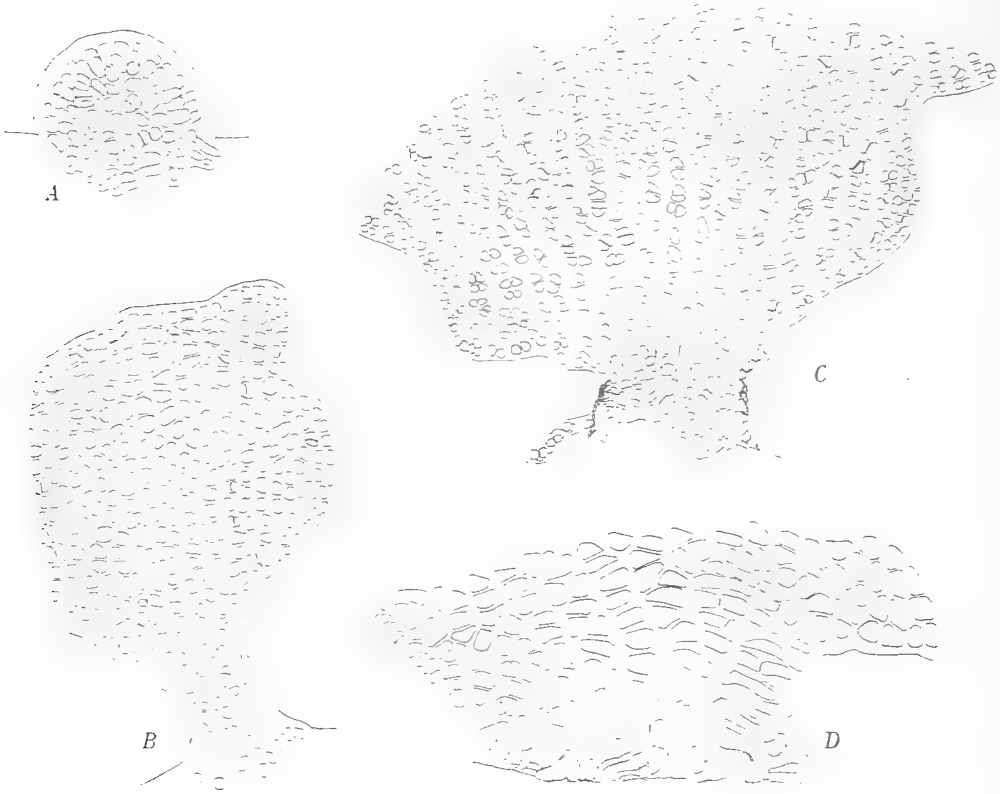


Fig. 9.

Porphyropsis coccinea. *A*. young plant, still hemispherical. 550 : 1. *B*. more developed plant with expanded lamina and spore-mother cells scattered over the frond. 340 : 1. *C*. lower part of older plant: it was not plane, but the borders were curved somewhat backwards. 340 : 1. *D*. basal portion of frond showing the rhizines. 550 : 1.

This plant offers an interesting analogy to the genus *Monostroma* among the *Chlorophyceæ* and the genus *Omphalophyllum* among the *Phæophyceæ*. In *Porphyra naiadum* Anderson the frond also begins according to Hus (1902, p. 212) as a parenchymatous cushion, but the later development is quite different from the above described, the cushion producing from its surface hair-like projections which, dividing in two directions, give rise to a monostromatic frond.

The cell-divisions take place in some measure uniformly over the whole monostromatic frond, more frequently however at the border, where the cells are therefore a little smaller and closer together. The intensive marginal growth results in the margin becoming much undulated. In fig. 9 *C*, which was drawn after a dried specimen, the cells are seen to be arranged in groups of two or four or a little more, rather distant from each other.

As said above, the reproduction has hitherto been unknown in this species, and I have also searched in vain for any indication of a fructification in several fully developed specimens. In other cases, however, I succeeded in finding a formation of spores corresponding to that in *Erythrotrichia*; even in very small specimens it could be observed. Thus in fig. 9 *B* several cells are divided by an inclined curved wall into a roundish cell filled with protoplasmic contents, the spore-mother cell, and a crescent-shaped sterile cell. The spore-mother cells are scattered without order over the whole frond; even marginal cells may produce them (fig. 9 *B*, at the summit). In fig. 10 is shown a small fragment of another, larger plant where most of the cells have produced spores. As I have only examined the plant in preserved condition I cannot give any information of the behaviour of the sterile cell on the escape of the spore.

The described fructification along with the peculiar development of the frond justify the establishment of this plant as the representative of a new genus. On account of the resemblance in appearance to the genus *Porphyra* I have named it *Porphyropsis*; a diagnosis is given above.

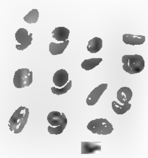


Fig. 10.
Porphyropsis coccinea. Part of frond with sporangia. 630 : 1.

Only found in the eastern Kattegat in 20 to 25,5 meters depth, epiphytic on various Algæ. The largest specimens, 5 mm. high, with much undulated margin, were met with at the end of July; young plants were collected in May and July.

Localities. Ke: Fladen, ZF, on stalks of *Laminaria digitata*, on *Dilsea edulis* and *Rhodymenia palmata* a. o.; Groves Flak, VZ, on *Desmarestia aculeata*; Lille Middelgrund, IK, on *Odonthalia dentata.*

Erythrocladia gen. nov.

Thallus horizontaliter expansus, e filis ramosis, aliis algis adfixis, radiatim egredientibus, initio inter se discretis, dein in discum tenuem unistratosum confluentibus, constans. Crescentia filorum apicalis. Sporangia eodem modo ac in genere *Erythrotrichia* in cellulis intercalaribus vel rarius terminalibus gignuntur. Generatio sexualis adhuc ignota[1].

[1] Batters has in 1896 (Journ. of Botany Vol. 34) established a genus *Colaconema*, characterized by branched filaments living in the cell-walls of various Algæ and by monosporangia "formed from portions either of the terminal cells of the principal axes, or of short swollen 1- or few-celled lateral branches, or even from a portion of a cell in the continuity of the filament. The undifferentiated portions of the cells forming cup-like bases for the sporangia". This genus was later placed by Batters (Journ. of Bot. Vol. 40, 1902, Supplement p. 57) near to the genus *Acrochætium* (*Chantransia*) and one species was removed to this genus. The indicated mode of formation of the monosporangia suggests however that the genus may include forms belonging to the *Erythrotrichieæ*, and the sporangia arising

1. **Erythrocladia irregularis** sp. nov.

Thallus minutus, ambitu irregulari. Fila lateraliter ramosa, irregulariter radiantia, sæpe maxima pro parte inter se discreta. Rami plerumque in cellula subterminali nascuntur. Cellulæ plerumque oblongæ, long. 7—11 μ, lat. 3,5—5 μ, chromatophorum unicum parietale, ut videtur pyrenoide instructum, continentes. Sporangia diametro c. 4 μ.

Schmitz has established a genus *Erythropeltis* (1896 p. 313), which in its reproduction agrees with the genus *Erythrotrichia* but differs from it by the frond consisting only of a monostromatic disc with continuous border and with marginal growth. To this genus is only referred one species, *E. discigera* (Berth.) Schmitz[1], and to the same species Batters has later referred a new variety, var. *Flustræ*, (Journ. of Botany, Vol. 38, 1900 p. 376). The thallus is described in this as "orbicular, becoming confluent and irregular in outline", and it must therefore be supposed that the irregularity only appears by the fusion of originally separate discs. In our plant, on the contrary, the frond consists of mutually separate filaments which only at a later stage are partly confluent, and it must therefore be referred to a new genus.

The plant of which a diagnosis is given above was found in rather great numbers on some specimens of *Polysiphonia urceolata* dredged off Hirshals in the Skagerak. It forms irregular spots of up to 100 μ in diameter on the surface of the host-plant. It consists at first of branched filaments whose branches are mutually entirely separate. As shown in fig. 11 *A* the primary filament grows out in two opposite directions and gives off branches at both sides. These branches grow out and branch further, and in the more developed plant the filaments are therefore radiating in all directions in the horizontal plane, and the filaments are then more or less fused together in the central part of the frond. The filaments show apical growth, and transverse walls appear only in the terminal cells, a natural consequence of the filaments being fixed to the substratum. The branches usually arise in the subterminal cell, sometimes also in cells nearer the centre of the frond, but the terminal cell is only very seldom ramified. The ramification is thus strongly monopodial. Not seldom a number of consecutive cells each give off a branch, now alternating, now secund. The outline of the plant is always more or less irregular, some filaments growing longer than others.

The cells contain a single chromatophore, the form and structure of which I have not been able to determine with certainty, as I have only had dried specimens at my disposal. In several cases however it appeared to be undoubtedly parietal, and I often saw a body which I took to be a pyrenoid, though it was not very distinct (fig. 12).

from a cell in the continuity of the branched filaments recall the genus *Erythrocladia*, but the plants need further examination. None of the described species can apparently be referred to the genus *Erythrocladia*.

[1] The genus is founded on *Erythrotrichia discigera* Berth.; but, according to Berthold (1882 p. 25), the disc in this species sometimes produces erect filaments, and it must therefore be supposed that Schmitz has taken the species in a more restricted sense than Berthold.

The sporangia are cut off in the ordinary vegetative cells, in a similar manner as in the genus *Erythrotrichia*, by a more or less oblique curved wall. The formation of sporangia takes place usually in the inner, intercalary cells, more rarely in the terminal cells. The orientation of the wall is not always the same; usually the sporangium is cut out at the proximal end of the cell, apparently very seldom at the distal end; but the wall is not seldom longitudinal, particularly in short cells from which a branch is given off (fig. 12). The spores are in the fully developed state nearly globular, about 4 μ in diameter; they have more granular contents than the vegetative cells and often show a distinct parietal chromatophore (fig. 11 *C, D,* fig. 12).

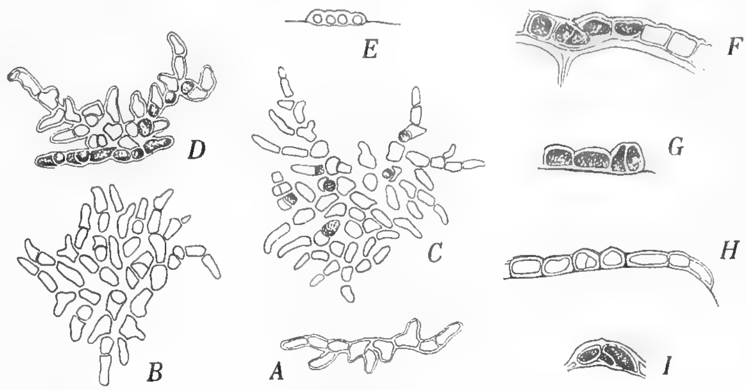


Fig. 11.
Erythrocladia irregularis. *A*, young plant seen from above. *B–D*, more developed plants with sporangia seen from above. *E–I*, plants in vertical section. *F–I*, with sporangia. *A–E* 390 : 1. *F–I* 620 : 1.

It is evident that the above described plant cannot be referred to the genus *Erythropeltis* on account of the structure of the frond. It differs further from *E. discigera* var. *Flustræ* Batters by its much smaller spores, while the spores in Batters' plant are about 9 μ in diameter.

Fig. 12.
Erythrocladia irregularis. Plant with sporangia seen from above. 730 : 1.

Localities. **Sk**: Møllegrund off Hirshals, 11,5 to 15 meters, on *Polysiphonia urceolata*, August.

2. Erythrocladia subintegra sp. nov.

Thallus minutus suborbicularis. Fila sat regulariter radiantia, plerumque fere ad apices lateraliter connata, cellulis terminalibus tamen inter se plus minus discretis. Ramificatio fit in cellulis terminalibus, sæpe dichotoma. Cellulæ plerumque cylindricæ, lat. 3—4 (—5) μ, long. 8—10,5 μ. Sporangia in parte proximali aut distali cellularum orta diametro c. 4 (—5) μ.

In company with the foregoing species I found some individuals of a species evidently nearly related to it, but showing however such differences that I think it best to consider it as a distinct species. It is more regular, more or less approaching to the orbicular form, and consists of more regularly radiating, closer together and a little thinner threads (3—4 μ), which are most often united almost to the extremity, the terminal cells, however, being usually more or less free, and the same being also sometimes the case with the cell next to the end-cell. The ramification takes place exclusively or principally in the end-cells, and it has usually the character of a dichotomy, the cell bifurcating with two equally developed branches; the one branch, however, may sometimes be stronger than the other. The cell-walls of the filaments are thin and often not easily distinguishable. In the inner part of the cell-disc a granular substance is often to be seen in the middle of the walls; perhaps interstices between the filaments. The chromatophore seems to be of the same shape as in the foregoing species, it is parietal, apparently mantle-shaped, and seems to contain a pyrenoid; at all events a body of greater density is often visible in the middle of the cell. The cells are cylindrical or oblong or more irregular, usually 2—3 times as long as broad, in the inner part of the frond generally a little broader than at the margin.

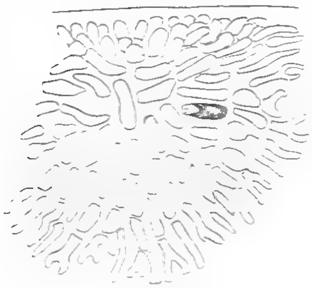


Fig. 13.
Erythrocladia subintegra. Frond growing on the rounded surface of Polysiphonia urceolata. In one cell a sporangium is cut off. 660:1.

The sporangia are, as in *E. irregularis*, cut off in the ordinary cells through a faintly curved wall, sometimes at the proximal, sometimes at the distal end of the cell; they have a parietal, cupshaped chromatophore and measure 4 μ in diameter.

This species shows more resemblance than the preceding to the genus *Erythropeltis*, from which it differs, however, by the margin of the frond consisting of separate filaments. If we supposed, that the distinction established between these two genera might prove not to be constant, there would be reason to compare *Erythrocladia subintegra* with *Erythropeltis discigera* Schmitz. Such a comparison, however, is difficult to undertake, as the last-named species is imperfectly known, in particular on account of what is alluded to above (p. 72) with regard to the limitation of the species. Using the magnification indicated by Berthold I have calculated that the cells of his species are 5,5 to 7 μ broad, thus considerably broader than in *E. subintegra*, and in *Erythropeltis discigera* var. *Flustræ* Batt., where the spores are much larger than in our species, namely 9 μ in diameter; the cells are also larger than in *E. subintegra*. It must therefore be supposed, that the species described here has not hitherto been observed, but I admit that it needs further investigation as well as the species of *Erythropeltis* and the relation between this genus and the genus *Erythrocladia*, and the relation between the genera *Erythropeltis* and *Erythrotrichia*.

Fig. 14.
Erythrocladia subintegra. Frond seen from above. A few sporangia are visible. 630:1.

The description given above refers only to the specimens mentioned as found on *Polysiphonia urceolata*. Later I have found, on *Flustra foliacea*, some discs which I think must be referred to the same species; they differed in their slightly larger dimensions and in the margin being partly continuous, the filaments being united to the extremities. These discs were thus still more similar to *Erythropeltis*, but the filaments had always partly free endings. The filaments were 3,5—5 μ thick, narrowest at the border, broadest in the middle of the frond. The spores were 4—5 μ in diameter.

Localities, Sk: Off Hirshals (XO and YK), 11,5 to 15 meters, August.

Goniotrichum Kütz.

1. **Goniotrichum elegans** (Chauv.) Le Jolis.

Le Jolis, Alg. mar. Cherb. p. 103; J. Agardh (1883) p. 13; Berthold (1882) p. 26; Hauck, Meeresalg. p. 518.
Bangia elegans Chauvin, Mém. Soc. Linn. Norm. t. 6 (not seen); Rech. sur l'org. d. plus. genr. d'Algues, Caen 1842 p. 33; Harvey Phyc. Brit. pl. 246.
Ceramium ceramicola Fl. Dan. tab. 2207 fig. 2 (? not the description).

This plant attains a length of at least 5 mm. in the Danish waters. The filaments are below up to 50 μ thick, above they become gradually thinner and are at the summit only 15 μ thick. The increase in thickness below is usually due only to the thickening of the gelatinous outer wall, the diameter of the cells not increasing, and the cells forming usually a single row. There may be, however, more than one cell at the same level. This was caused, in the cases examined by me, not by longitudinal division of the cells but by displacement of the cells, so that the growing axes became inclined, the cells dividing then as usually by walls perpendicular to the growing axis and becoming arranged in two irregular longitudinal rows, or even more than two cells may occur at the same level (fig. 15 *E*). The outer wall is usually uniform, limited outwards by a fine line. Sometimes, however, the cells are provided with a denser, special membrane. In the plant represented in fig. 15 *E* a rather thick, dense cuticular-like outer-wall was visible in the lower part of the plant; the cells were here also provided with dense special membranes, and between these and the outer membrane a stratification was often visible.

The ramification takes place in a manner reminding one of the so-called false branching of the *Scytonemataceæ*. The branches rise at a great distance from the end of the filament, a cell growing outward through the gelatinous wall, dividing by a wall perpendicular to the new direction of growth (fig. 15 *B*, *C*). The further growth results in the branch coming to form a direct continuation of the principal filament and often takes nearly the same direction as this, the upper part of the principal filament being more or less pushed aside and taking the appearance of a branch (fig. 16). The cell lying at the origin of the branches is divided by a transverse wall as well as all the other cells. New branches very often arise below the older; even in old filaments new branches may arise (fig. 15 *A*).

The cells are of rather variable length, usually about as long as broad or somewhat longer, up to 3 times as long, in the last case usually barrel-shaped. On the other hand they may be sometimes much shorter than broad, up to 3 to 4 times as broad as long (fig. 15 *B*); they are then proportionally broad, 9—12,5 μ, being otherwise 6,5—10 μ broad. The cells contain, as is well known, a star-shaped chromatophore with a central pyrenoid. The colour is lilac; in very light localities, however, it is faded, feebly yellowish or grayish. Such a pale yellowish specimen was placed in a glass-vessel filled with sea-water in a room with subdued light for some days. After 24 hours the colour was already somewhat reddish, and after

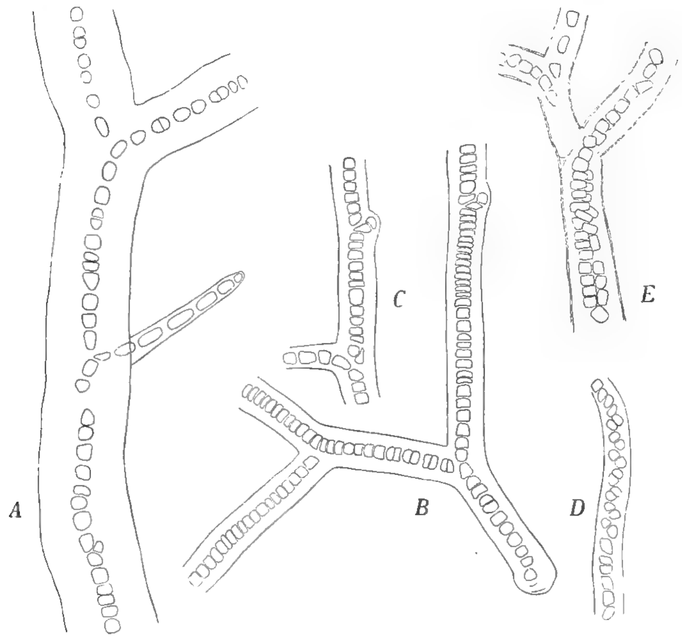


Fig. 15.

Goniotrichum elegans. *A*, portion of the older part of a frond with young branch below the older. — *B* and *C* show the normal ramification; the cells partly very short. — *D* and *E*, the cells displaced, giving up the uniserial arrangement; the cuticle in *E* very thick. — *B* and *C* from the Skagerak, the others from Sallingsund. — All figures 190 : 1.

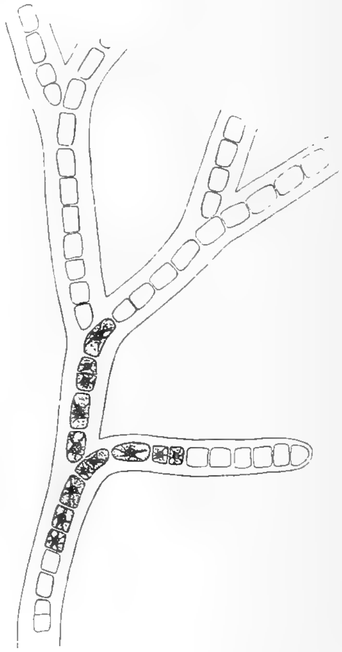


Fig. 16.

Goniotrichum elegans. After a living plant from Sallingsund. 290 : 1.

3 days the plant had a decided lilac colour. When dying the cells assume a light blue-green colour.

Concerning the reproduction I have made no observations. According to Schmitz (1894 p. 718 (14) and 1896 p. 314), monospores are produced by the ordinary cells, the cell-content being condensed and liberated as a naked spore. I have not seen this spore-formation, but I have sometimes remarked, that single cells were wanting in the filaments, probably because they had been set free in the form of spores.

The species has hitherto been found in the Skagerak, Limfjord and Kattegat, but it is not improbable that it may have a somewhat larger distribution. The plant represented in Flora Danica tab. 2207 fig. 2, which is said to have been found by LYNGBYE in Odense Fjord, seems to judge from the figure to belong to this species; the description, however, belongs not to it but to *Erythrotrichia carnea.* In LYNGBYE's herbarium I have, from the locality in question, seen only the last-named species, not *Goniotrichum*, and it must therefore remain doubtful, if *Goniotrichum elegans* really occurs in Odense Fjord. — It has been found growing on various species of *Polysiphonia*, on *Rhodomela*, *Gloiosiphonia*, *Zostera* and *Flustra foliacea* in depths of 2 to 15 meters; it has only been observed in summer (June to August).

Localities. **Sk:** YK, N.W. of Hirshals, 15 m. — **Lf:** MH in Thisted Bredning; at several places in Sallingsund; LS, N. of Nykøbing. — **Kn:** Busserev at Frederikshavn; VT, N. of Læsø. — **Km:** BL, 9,5 m. — **Sa:** (Odense Fjord, Lyngbye?).

Asterocytis Gobi.

1. Asterocytis ramosa (Thwaites) Gobi.

C. Gobi in Arbeiten St. Petersb. Naturf. Gesellsch. Bd. X 1877 p. 85; Fr. Schmitz 1894 p. 717; id. 1896 p. 314; N. Wille, Algolog. Notizen, I—IV. Nyt Mag. f. Naturvid. Bd. 38, 1900 p. 7 Taf. I fig. 8—14.
Hormospora ramosa Thwaites in Harv. Phyc. Brit. pl. 213.
Goniotrichum ramosum Hauck, Meeresalg. p. 517, Batters, Mar. Alg. Berw. p. 13; Lakowitz, Algenfl. Danziger Bucht 1907 p. 79.
Goniotrichum simplex Lakowitz l. c. p. 80.

The genus *Asterocytis* has been established by GOBI in his "Bericht über die im Sommer 1877 ausgeführte algologische Excursion" published in 1879 in "Arb. St. Petersb. Nat. Ges." Bd. X. As this report has only been published in the Russian language, I give in the note below a translation in German of that part of the report which treats of this genus, and which Professor GOBI has kindly communicated to me[1]. Later the genus and the species on which it was founded, *A. ramosa* (Thwaites) Gobi, has been mentioned by SCHMITZ (1894) who examined specimens of it from water of very low salinity at Greifswald and found that it had nearly the same mode of reproduction as the genus *Goniotrichum*, only with this difference that the monospores in the last-named are set free by the sporangial wall becoming mucilaginous, while in *Asterocytis* they escape through an opening in the

[1] "Die sogenannte *Hormospora ramosa* Thwaites (Vid. Harvey, Phyc. Brit. Tab. 213; auch Rabenhorst Fl. Eur. Alg. etc. Bd. III, p. 49) welche bis jetzt (als Pseudoparasit) nur an den Küsten Englands im Meerwasser angetroffen wurde, habe ich schon mehrere Male auf meinen früheren Excursionen im Finnischen Meerbusen (1872 u. 1873) gefunden und zwar auch immer nur auf anderen Meeresalgen aufsitzend in Form einzelner einfacher oder schwach verzweigter Fäden. — THWAITES, welcher zuerst diese Form beschrieb, (die im lebenden Zustande bis jetzt nur von SMITH beobachtet wurde), sah sie als zur Gattung *Hormospora* Brébisson gehörend an, mit welcher Gattung jedoch sie nichts Gemeinschaftliches hat sowohl in structureller Hinsicht, als auch in der Färbung ihres Zellinhaltes. Meiner Ansicht nach muss diese Alge als eine neue Gattung angesehen werden, für die ich provisorish den Namen *Asterocytis* (strahlende Zelle) vorschlage, mit dem einzigen bis jetzt bekannten Repräsentanten *Asterocytis ramosa* (Thwaites) mihi." (l. c. p. 85—86).

unaltered sporangial membrane. In the treatise on the *Bangiaceæ* by the same author (1896), however, these characters are not mentioned; the author states only some less essential differences and declares that at least *A. ramosa* might possibly be referred to the genus *Goniotrichum*. In 1900 Wille has given a more detailed description of an Alga which he had found at Mandal on the South coast of Norway, and which he refers to the same species. He gives a description of the setting free of the spores which is in accordance with that of Schmitz in 1894, but apparently without knowing the treatise of Schmitz, and he recommends that the genus *Asterocytis* should be kept distinct from *Goniotrichum*, primarily on account of the blue-green colour, but also because the author supposes that it produces resting cells, akinetes. It seems further that we may add as a distinctive character, that *Asterocytis ramosa* grows in brackish water, as stated by several authors (Harvey, Hauck, Schmitz, Batters), while *Goniotrichum elegans* needs water of higher salinity.

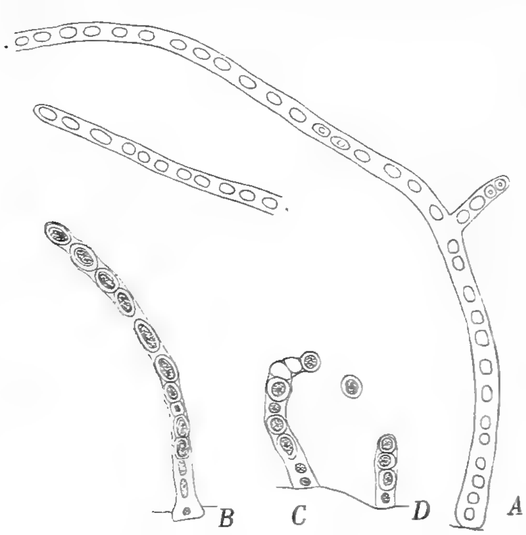


Fig. 17.
Asterocytis ramosa (from Guldborgsund). *A*, filament with branch; in some cells the pyrenoid is shown. *B—D*, small unbranched filaments with akinetes. 220:1.

I have found in several localities in the inner Danish waters a small Alga with blue-green cells, undoubtedly belonging to this species. It occurred, however, as a rule in small individuals, most frequently even unbranched, and in such cases agreeing with *Goniotrichum simplex* Lakowitz. Some of these specimens were short and only 9—11 μ thick, with vegetative cells 3—6 μ broad. Others were longer and somewhat thicker below, and the most vigorous provided with one or a few branches. Such specimens had often a thickness of 16 μ near the base, in a single case of 25 μ; the vegetative cells were about of the same size as in the smaller specimens, or they might be up to 7,5 μ broad. In the plants examined by Wille the cells were, to judge from his figures and the magnification indicated, not a little greater (8—11,5 μ broad), and the plants were as a whole more vigorously developed. In the Danish specimens the cells are usually oblong or ellipsoidal, often ca. 2 times as long as broad, sometimes shorter, nearly globular. The chromatophore, as is well known, is star-shaped with a distinct pyrenoid; this, however, is not always central in the cell, the chromatophore being often nearer to the one side of the cell (fig. 17 *B*).

The occurrence of akinetes supposed by Wille I have been fortunate enough to confirm with certainty. In nearly all my gatherings of this species there was found a number of filaments, the cells of which were for the most part transformed into spores, being provided with a thick firm wall, of a much denser consistency than the gelatinous wall of the vegetative filaments. The akinetes are only surrounded by a thin common membrane, much thinner than the wall of the vegetative cells, and it is thus beyond doubt that the walls of the akinetes have risen by transformation of the innermost layers of the original gelatinous wall, and these cells thus agree completely with the conception of akinetes by WILLE. In some cases the akinetes are close together, in others they are separated. They are partly ellipsoidal or oblong, partly globular, measuring 8,5 to 10,5 μ in transverse diameter, up to 15 μ in length. In fig. 17 *C* a free akinete is to be seen and two emptied cells which have contained an akinete. As shown in fig. 17 *C* and *D*, the formation of akinetes may take place in very small plants.

As mentioned above, I have no doubt but that the specimens from the Danish waters really belong to *Asterocytis ramosa*, though it seems that the species does not attain in these waters the same dimensions as e. g. on the Norwegian coasts. The frequently occurring unbranched individuals do not represent a distinct species but only a reduced form, f. *simplex* (Lak.).

The species has been found with certainty in some places in the Smaaland Waters and in the Baltic, but is probably widely distributed in brackish water. I have formerly noted it from Holbæk Fjord and from Kertinge Vig, but omitted to keep the specimens. It has been found in shallow water near land, fixed on *Polysiphonia violacea* and *nigrescens* and *Ceramium*, only in summer (July to September).

Localities. **Ks**: (Holbæk Fjord). — **Sb**: Kertinge Vig by Kerteminde. — **Sm**: Kragevig; off Petersværft; Guldborgsund, near Vennerslund. — **Bb**: Rønne, the reef S. of the town.

B. *Florideæ.*

II. Nemalionales.

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C. NÄGELI, Beiträge zur Morphologie und Systematik der Ceramiaceae. Sitzungsber. d. Akad. d. Wiss. München 1861. p. 401—415.

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G. THURET in LE JOLIS, Liste des Algues marines de Cherbourg. Cherbourg 1864, p. 104.

Fam. Helminthocladiaceæ.

Tribe Chantransieæ.

Chantransia (D. C.).

As shown by THURET (1864 p. 104), ELIAS FRIES was the first to define the genus *Chantransia* in such a manner that it had a natural limitation, and one could clearly see what plants it comprised. It was better characterized in 1864 by THURET who emphasized the fact that it has no tetrasporangia but only monosporangia. He mentioned at the same time the antheridia of *Ch. corymbifera*, and in 1876 (Notes alg. I p. 16) he described in conjunction with Bornet the sexual reproduction in this species, and the genus came thus to comprise species with and without sexual reproduction (comp. MURRAY and BARTON (1891)). In 1904, however, BORNET has proposed to separate the species with sexual reproduction from those bearing only sporangia, the first being kept in the genus *Chantransia*, while the others are referred to the genus *Acrochætium* Nægeli (1861), which might otherwise be regarded as synonymous with *Chantransia*. I do not make this distinction in what follows, as I have arrived at the view that it would not lead to a natural classification of the species. In several cases there is great resemblance and probably also relationship between species with and without sexual reproduction, as e. g. between *Chantransia hallandica* and *baltica*, *Ch. efflorescens* and *Ch. pectinata*, *Ch. Thuretii* and *Ch. Daviesii*, and on the other hand the sexual species are mutually very different. That is also evident from BORNET's paper (1904) in which the species are divided after the differences in the basal portion of the frond, while in every group distinction is made between the asexual species, referred to *Acrochætium*, and the sexual ones, referred to *Chantransia*. There is in reality no other difference whatever between the two genera than that of the presence or absence of sexual reproduction. It would, in my opinion, be equally justifiable to remove from other genera of Florideæ all the species in which only tetrasporangia are known. Undoubtedly, sexual organs will later be found in some of the species hitherto known as only asexual, as I have succeeded in detecting them in *Ch. hallandica*, where KYLIN had only described monosporangia, but on the other hand there is no doubt that many species are really devoid of sexual organs.

The great number of species described below will certainly appear surprising to many phycologists: it is the result of a careful search through a large material of Algæ. Many of them are very small and inconspicuous and need careful examination for determination. It is therefore not to be wondered at that they have been overlooked or perhaps so incompletely described that it is impossible to recognize them.

As two-thirds of the species described below are new, and as I have several new observations on most of the formerly described species, it might be useful to make here some general remarks on the genus *Chantransia*, based on the observations communicated below.

As shown by BORNET (1904), the structure and development of the basal portion of the frond within the genus *Chantransia* offers considerable differences which can be used in subdividing the genus. I fully agree with this excellent phycologist who by his small but important paper has largely contributed to the classification of this genus. If my classification does not always coincide with that of Dr. BORNET, it depends on the fact that I have not found representatives for all the subdivisions of Bornet in the Danish waters, and that I have found new species which do not fall under these groups. I may now give an account of the types found by me.

In some species the germinating spore is a globular or hemispherical basal cell which keeps its form and divides only on branching. This cell is fastened to the substratum by a cementing substance staining intensely blue by MAYER's Hæmalum[1]. In some cases it gives off only free filaments (first group), in others it also produces endophytic filaments from its under side (BORNET's second group, of which no representative is mentioned below). In *Ch. efflorescens* (fig. 61) and *Ch. Thuretii* (figs. 30, 31) the hemispherical basal cell gives off an erect filament and several radiating, creeping, epiphytic filaments which later unite to a pseudoparenchymatous disc giving off a number of erect filaments. During this development the original basal cell becomes indistinguishable amongst the other cells of the basal disc. I believe that the basal part of the frond probably develops in a similar manner in some other species, the germination of which has not been observed (*Ch. attenuata, stricta, Daviesii*). In a small group of species (*Ch. polyblasta* (fig. 43) and *Ch. humilis* (fig. 44)), to which may be added the partly endophytic species *Ch. Dumontiæ* (fig. 52) and *Ch. cytophaga* (fig. 50), the germinating spore is divided before ramification by a vertical wall into two cells of equal size each growing out in a creeping filament, which branches and forms a filamentous basal structure; in the central part of this the filaments may later fuse together, while a large number of relatively short erect filaments are given off from their upper side. In *Ch. virgatula* (incl. *secundata*) the germinating spore is usually divided by 3 excentric walls into 4 cells forming a parenchymatous disc, which for some time keeps this character during continued divisions of the cells, while later on some of the marginal cells may grow out into creeping filaments (figs. 37—41). In *Ch. leptonema* the development begins in the same manner, but the parenchymatous stage is very short, the disc at an early stage growing out into long creeping filaments (fig. 48). In *Ch. Macula* the basal disc behaves in a somewhat similar manner as in *Ch. virgatula*, but the erect filaments are much reduced or wanting, the sporangia being

[1] This substance attains an extraordinarily great development in *Ch. microscopica* var. *collopoda* Rosenv. (Deux. Mém. Alg. mar. Groenl., Medd. om Grønl. XX, 1898, p. 11), which, however, does not belong to *Ch. miscroscopica* Næg. but ought to be regarded as a distinct species, *Ch. collopoda* Rosenv.

situated directly on the basal disc or at the end of short unbranched erect filaments (fig. 42). An equally extreme reduction occurs in *Ch. reducta*, the frond of which consists of creeping filaments bearing sessile or short-stalked sporangia (fig. 49).

In certain species the thallus is partly endophytic. In *Ch. cytophaga* the development begins as in *Ch. polyblasta*, and it is only when the plant has become multicellular that some of the cells in the creeping filaments produce short filaments from their underside, which penetrate into the cells of the host plant (*Porphyra umbilicalis*), pushing aside the protoplasm and taking without doubt nutriment from it. This plant is thus a true parasite. The intracellular filaments or haustoria do not seem to penetrate from one cell into another but they may make their way again to the surface of the host plant (figs. 50, 51). In *Ch. Dumontiæ* the development begins in the same way but the endophytic filaments are intercellular and become much longer (fig. 52). These intercellular filaments are still more developed in *Ch. Nemalionis*, where they form a widely extended system of branched threads, giving off free filaments at many points through the surface of the host (*Nemalion*), while creeping epiphytic filaments are wanting (figs. 53, 54). The germination has not been observed in this species. Finally, there is a group of species the filaments of which are entirely endophytic. *Ch. endozoica* Darb. forms a transition to this group, the (endozoic) filaments sending out through the surface of the *Alcyonidium* it inhabits numerous short slightly branched sporangia-bearing filaments. In *Ch. emergens* only the solitary short-stalked sporangia are free (fig. 55), and in *Ch. immersa* and *Ch. Polyidis* the solitary sporangia are even more or less sunk in the host plant (figs. 56, 58, 60)[1].

Most of the *Chantransia* are usually epiphytic and then not bound to particular host plants; several species also occur on Hydroids and Bryozoa, further on Mollusc-shells, *Ch. efflorescens* even on stones. Probably other species may also sometimes grow on stones but have not been detected there on account of their small size. On the other hand, the endophytic species appear to occur only in one particular species of Algæ, or several nearly related. Thus, *Ch. Dumontiæ* has been found growing only in *Dumontia filiformis*, *Ch. cytophaga* only in *Porphyra umbilicalis*, *Ch. corymbifera* only in *Helminthocladia*, *Ch. Nemalionis* in *Nemalion lubricum* and *multifidum*, *Ch. immersa* in *Polysiphonia nigrescens* and *violacea* and in *Rhodomela subfusca*. The endozoic *Ch. endozoica* occurs only in *Alcyonidium gelatinosum*.

The form of the chromatophore is of great systematic value as pointed out by Kylin (1906, p. 122). In the vast majority of Danish species the cells contain only one chromatophore, but these may again be divided into two groups. In a fairly large number of species the chromatophore has a central body lying in the

[1] *Rhodochorton Brebneri* Batters (Journ. of Botany 1897 p. 437 and 1900 Tab. 414 fig. 17), which is endophytic in *Gloiosiphonia capillaris*, is evidently a *Chantransia* belonging to this group, to judge from the mode of growth, the hairs and the chromatophore; its name must therefore be *Chantransia Brebneri* (Batt.) Rosenv. The genus *Colaconema* Batters (see page 71 note) seems also to comprise species referable to the group of the endophytic *Chantransiæ*.

axis of the cell, usually in its upper part, and giving off a number of lobes in several directions towards the periphery of the cell. These lobes proceed further along the periphery of the cell and may together form a more or less interrupted cylindrical parietal layer. In the middle of the central body lies a pyrenoid, which is thus situated in the axis of the cell. This form of chromatophore shows a particularly fine development in *Ch. immersa*, where the lobes are very long and distinct (fig. 57); but it must be confessed that in this species the pyrenoid is not always central (fig. 57 *B*, *C*). In two species, *Ch. Dumontiæ* (fig. 52) and *Ch. cytophaga* (fig. 50), which also have stellate chromatophores, I have not been able to see any pyrenoid and must therefore suppose that it is wanting. In other species the chromatophore is an entire or somewhat lobed parietal plate containing a pyrenoid which is thus excentric in the cell. The pyrenoid is always prominent in the interior of the cell, and it is sometimes so large that it reaches almost to the opposite part of the chromatophore; when seen in profile, however, it is always easy to determine that it is parietal (figs. 30, 34, 54). Only in some species with very thin filaments it may be difficult to decide if the pyrenoid is axile or parietal, and transitions may perhaps occur. In *Ch. Polyidis* the chromatophore has a very peculiar structure, which I have unfortunately not been able to fully elucidate; it seems to be single but becoming very much branched (fig. 60). A third (or fourth) type of chromatophore occurs in *Ch. efflorescens* and *pectinata*, where each cell contains usually more than one spiral-shaped or more irregular band-like chromatophores (figs. 64, 66). — In pyrenoids of *Ch. immersa* treated with picric acid an angular body, probably a crystalloid, was observed (fig. 57).

The cells always contain a single nucleus lying almost in the central part of the cell, thus at a lower level than the pyrenoid. In some cases it is easily visible, even in the living state (fig. 30 *C*), in other it is concealed by the chromatophore; in *Ch. immersa* it is even sometimes found in a hollow in the mass of the chromatophore (fig. 57).

In nearly all the species hyaline, unicellular hairs occur at the ends of the filaments, which, when the filaments develop farther, are pushed aside, while the filament continues its way in the same direction as before, but really sympodially. This development has been pointed out by Kylin (1906 and 1907) in some species, and I have found the same in all the species with hyaline hairs examined by me. The hair arises as the terminal cell of the filament, being however much narrower than the usual cells and containing no chromatophore but protoplasm and a nucleus. In the out-growing hair the protoplasm is collected towards the upper end of the cell and decreases in bulk on the lengthening of the hair. In some cases, however, e. gr. *Ch. rhipidandra*, the hair is not pushed aside but retains its terminal position, and the filament then makes a bend for each hair it produces, with the result that the sympodial nature of the filament becomes very evident (figs. 20, 21). But even in the cases where the hair is early shed, this process often causes a more or less pronounced obliquity of the upper end of the cell (fig. 18). The duration of the hairs is very different in the different species; thus they are vigorous and very persistent in *Ch. virgatula*, while in other species they only appear in the young plants or parts of the plant but soon fall off. They occur in the endophytic *Ch. immersa* (fig. 57) and *Ch. Polyidis* (fig. 60 *B*), while they are wanting in the equally endophytic *Ch. emergens* (fig. 55). The hairs appear very early in the young plants: it may even happen that the germinating spore produces a hair before giving off any other organ (*Ch. gynandra*). In *Ch. Thuretii* the above-mentioned hairs seem to be wanting, but on the other hand the branches often taper into hair-like threads, the cells of which become long and discoloured and finally die, as in the hair-like organs of the Phæophyceæ (fig. 32 *B*). Similar hair-like organs occur in *Ch. Daviesii* (fig. 34 *C*).

Sexual organs have been observed in 5 of the species mentioned below. Four of these are monoecious, *Ch. rhipidandra* only is dioecious.

The carpogonium has nearly the same form in all species, being bottle-shaped with a trichogyne of about the same length as the ventral part. It is never borne at the end of a special carpogonic branch as in most other Florideæ even the Nemalieæ. In *Ch. gynandra* (fig 18) and *rhipidandra* (fig. 20) the carpogonia are sessile and lateral on the main filaments. In the other species they are situated, usually laterally, on branched or unbranched branchlets, bearing often also antheridia or even sporangia (*Ch. hallandica*, figs. 21 *A*, *E*, 22 *B*; *Ch. Thuretii*, figs. 30, 31). In *Ch. efflorescens* their position is very remarkable, intercalary carpogonia very often occurring besides others which are lateral (fig. 62). In such cases the lowest cell in the short fertile branchlet develops into a carpogonium, sending out at its upper end a trichogyne upwards along the cell situated above the carpogonium. When the branchlet is two-celled, the upper cell is usually sterile and bears antheridia, but it may happen, though rarely, that two carpogonia are situated the one above the other (fig. 62 *B*). Intercalary carpogonia were hitherto unknown among the Florideæ; they were, however, also found in the here described *Ch. gynandra* where an antheridium is very often seated on the top of the carpogonium (fig. 18 *H—K*).

The antheridia[1] are small roundish cells usually placed two or more together on the fertile branchlets. Only in extremely dwarfish plants of *Ch. gynandra* and *Ch. hallandica* they were found sitting directly on the main filaments, which consist indeed of only very few cells (figs. 18 *D*, 24 *C*). In the monoecious species antheridia usually occur in the neighbourhood of the carpogonia, often very near, and in *Ch. gynandra* an antheridium is often, as already mentioned, placed directly on the carpogonium.

After fertilization the ventral part of the carpogonium grows out and divides by a transverse wall, the trichogyne being pushed aside and later thrown off, and

[1] The mother-cells of the spermatia, the spermatangia of SCHMITZ, may here in agreement with OLTMANNS (1904 p. 669) be named antheridia. Quite recently N. SVEDELIUS has entered a plea for the term spermatangium (Bau und Entwicklung der Florideengattung Martensia. K. Svenska Vetenskapsakad. Handlingar. Band 43 No. 7. Uppsala 1908).

after further transverse divisions it becomes a 3- to 5-celled filament giving rise to a number of branches. The trichogyne or a small remnant of it may often be seen some time afterwards on the convex side of the second cell in the main filament of the gonimoblast (figs. 18 *C*; 20 *E*, *H*; 62 *E*, *F*, *H*). Unfortunately, I have not been able to follow the development of the cystocarp in *Ch. hallandica*, where it seems to be somewhat different (figs. 21, 22). In four of the five sexual species mentioned the carpospores arise only in the terminal cells of the branched gonimoblast. In *Ch. gynandra, rhipidandra* and *Thuretii* the branches are numerous, the cystocarp capituliform; in *Ch. hallandica* the number of the branches and the carpospores is very low. *Ch. efflorescens* is also in this respect different from the other species, the carpospores arising not only in the terminal cell but also in one or two of the cells lying behind in the filaments of the cystocarp, thus seriately (fig. 63).

Sporangia occur in all known species of *Chantransia*. For some time it was generally accepted that monosporangia only occur in this genus, the older statements of tetrasporangia by Harvey being supposed to be due to some error. In later years, however, tetrasporangia have been pointed out with certainty in some species by Schmitz and Hauptfleisch (1896), Børgesen (1903) and Kylin (1906 and 1907), and I have been able not only to confirm these statements but also to find tetrasporangia in five other species, so that the occurrence of tetrasporangia is now established in eight of the species mentioned below (*Ch. Thuretii, Daviesii, virgatula, polyblasta, cytophaga, Dumontiæ, efflorescens, pectinata*). In *Ch. Dumontiæ* and *polyblasta* tetrasporangia only have been met with, in the others also monosporangia. The division of the tetrasporangia is always cruciate, the first division being horizontal. Amoeboid movements of the monospores immediately after the liberation, similar to those described formerly for *Helminthora divaricata*, were observed in *Ch. Thuretii* (fig. 30).

In most of the species provided with sex-organs sporangia occur in the sexual plants, in the monoecious species as well as in the dioecious *Ch. rhipidandra*. On the other hand, as the sex-organs are not present in all the plants, individuals bearing only sporangia will always be met with. In *Ch. efflorescens* only there is a sharp distinction between sexual plants and sporangia-bearing plants. This is perhaps connected with the fact that tetrasporangia occur in this species. As shown by Yamanouchi[1] the tetrasporic plants of *Polysiphonia violacea* show double the number of chromosomes to that of the sexual plants, and a reduction in the number of chromosomes takes place by the formation of the tetraspores. If that is general for the Florideæ, a similar alternation of tetrasporic plants with sexual plants must be supposed to exist in *Ch. efflorescens*, and that is supported by the fact that the sporangia-bearing plants occur in the Danish waters chiefly in spring, the cystocarp-bearing plants in summer. In the sexual species with monosporangia such alternation of generations does not occur, and the reduction of chromosomes must be supposed to take place not in the sporangia but probably in the cystocarps, as in

[1] S. Yamanouchi, The life-history of Polysiphonia violacea. Botanical Gazette Vol. XLII. 1906.

Nemalion[1]. Several questions connected with that just mentioned deserve a closer examination, thus, the cytological behaviour of the monosporangia of *Ch. efflorescens* in comparison with that of the tetrasporangia of the same species, further the nuclear division of the tetrasporangia in the non-sexual species.

The following classification of the species is based in particular on the characters of the basal part and of the chromatophore. *Ch. efflorescens*, however, which differs from the others in several characters, as mentioned above, is first separated as representing a particular sub-genus, *Grania*, named after the Norwegian investigator who first described its sex-organs, and to the same sub-genus is referred *Ch. pectinata*, with similar chromatophores and probably related to it.

Key to the Danish species of Chantransia.

I. Subg. *Euchantransia*. One chromatophore, carpospores only in the last cell of the sporogenous filaments.

1. Frond epiphytic.
  2. A single basal cell. Group I.
    3. With sex-organs.
      4. Antheridia situated on the carpogonia or on unicellular branchlets . . . . 1. *Ch. gynandra.*
      4. Antheridia never situated on the carpogonia.
        5. Antheridia singly or two together, cystocarps with few carpospores; monoecious . . . . 3. *Ch. hallandica.*
        5. Antheridia usually in flat triangular clusters, cystocarps nearly globular with numerous carpospores; dioecious . . . . 2. *Ch. rhipidandra.*
    3. Without sex-organs.
      4. Pyrenoid parietal . . . . 1. *Ch. gynandra.*
      4. Pyrenoid axile.
        5. Cells nearly cylindrical.
          6. Filaments 9—11 μ thick, spor. 14—15 × 9—10 μ 2. *Ch. rhipidandra.*
          6. Filaments at most 7 μ thick.
            7. Filaments 5—6 μ thick, sporangia 10 × 6—7 μ 3. *Ch. hallandica.*
            7. Filaments 6—7 μ thick, sporangia 12—16 × 8—10 μ . . . . 4. *Ch. baltica.*
        5. Cells roundish, frequently barrel-shaped . . . . . . 5. *Ch. moniliformis.*
  2. Basal layer multicellular. Group II.
    3. Basal layer composed of filaments more or less fusing together into a pseudoparenchymatous disc.
      4. Erect filaments well developed; pyrenoid parietal.
        5. Erect filaments branched.
          6. Branches scattered; monospores, rarely tetraspores.

[1] Comp. J. J. Wolfe, Cytolog. Stud. on Nemalion, Ann. of Botany Vol. 18 Oct. 1904.

7. Sex-organs may occur; thickness of filaments usually less than 10 μ, cells usually 5—8 diam. long, sporangia sessile or on unicellular branchlets on the inner side of the branches ...... 6. *Ch. Thuretii.*
7. Without sex-organs; filaments 9—12 μ thick, cells 2—4 diam. long; sporangia-bearing branchlets repeatedly branched, often in the axils ...... 7. *Ch. Daviesii.*
6. Branches partly opposite .... 8. *Ch. attenuata.*
5. Erect filaments unbranched, bearing only numerous sporangia-bearing branchlets, nearly from the base to the top .... 9. *Ch. stricta.*
4. Erect filaments numerous, rather short (up to 300 μ) to very short or wanting; pyrenoid axile.
5. Erect filaments up to ca. 300 μ long, branched.
6. Filaments 7—10 μ thick, sporangia tetrasporous 12. *Ch. polyblasta.*
6. Filaments 3—4 μ thick, sporangia monosporous 14. *Ch. leptonema.*
5. Erect filaments up to ca. 60 μ long, usually unbranched, sporangia monosporous.
6. The cells of the creeping filaments give off 2—3 erect filaments bearing terminal and lateral sporangia .... 13. *Ch. humilis.*
6. The cells of the creeping filaments bear one sessile or stalked sporangium .... 15. *Ch. reducta.*
3. Basal layer first a parenchymatous disc, later growing out into radiating filaments; pyrenoid axile (*Ch. leptonema*).
4. Erect filaments 1—2 mm. long .... 10. *Ch. virgatula.*
4. Erect filaments very short or wanting; sporangia sessile on the basal disc or terminal on the erect filaments .. 11. *Ch. Macula.*
1. Frond partly or entirely endophytic or endozoic. Group III.
2. Vegetative part partly endophytic.
3. Epiphytic creeping filaments present.
4. Endophytic filaments intracellular .... 16. *Ch. cytophaga.*
4. Endophytic filaments intercellular .... 17. *Ch. Dumontiæ.*
3. Epiphytic creeping filaments wanting .... 18. *Ch. Nemalionis.*
2. Vegetative part entirely endophytic or endozoic.
3. Vegetative filaments endozoic, giving off short free, sporangia-bearing filaments .... 19. *Ch. endozoica.*
3. Filaments entirely endophytic.
4. Filaments creeping in the outer cell-wall of *Polysiphonia*; sporangia entirely free, short-stalked, single .... 20. *Ch. emergens.*
4. Filaments intercellular; sporangia partly or entirely immersed in the host.

5. Chromatophore stellate .... 21. *Ch. immersa.*
5. Chromatophore much divided .... 22. *Ch. Polyidis.*

II. Subg. *Grania.* Chromatophores ribbon-like, spiral-shaped, usually more than one; carpogonia often intercalary; carpospores seriate. Group IV.

1. Filaments usually 5—6 μ thick; free descending filaments usually present; sporangia tetrasporous or monosporous, on alternate or opposite branchlets; sex-organs present .... 23. *Ch. efflorescens.*
1. Filaments near the base 6—9 μ (or thicker); free descending filaments usually wanting; sporangia or sporangia-bearing branchlets seriate on the inner side of the branches; sex-organs wanting 24. *Ch. pectinata.*

Subgenus Euchantransia.

Group I. Frond epiphytic with a single basal cell.

1. **Chantransia gynandra** sp. nov.

Thallus minutus. E cellula basali subglobosa, diametro 7,5—9 μ, egrediunt fila 2—4 simplicia, ad circ. 200 μ alta, e cellulis diametro plerumque 2—3-plo longioribus, crassitudine 5—6 μ, superne nonnunquam leniter (ad 7 μ) incrassatis, constantes. Ramuli nulli vel pauci, minuti, unicellulares. Chromatophorum parietale zonale, pyrenoide instructum, mediam partem cellulæ occupans. Pili hyalini terminales et laterales adsunt. Sporangia, antheridia et carpogonia in uno eodemque individuo occurrunt. Sporangia in filis lateralia sessilia solitaria vel in uno articulo duo approximata vel opposita, vel in ramulis terminalia monospora, ovata, long. 9,5—10 μ, lat. 5—6 μ. Carpogonia in filis lateralia. Antheridia ad apicem ramulorum solitaria vel sæpius gregaria vel carpogonio juxta trichogynum solitaria imposita, hemisphærica, oblique breviter ovata vel subconica, long. c. 2,5 μ. Cystocarpia capitula irregularia e filis radiantibus longitudine vario constantia, carposporis in cellulis ultimis, sporangiis similibus, formatis.

This interesting species was found in abundance growing on some specimens of *Ectocarpus confervoides* dredged in the Northern Kattegat. The nearly globular basal-cell, which is fixed to the host by a very thin layer of a cementing substance, gives off a filament upward and usually two similar, though often shorter, filaments out to the sides. The filaments are either absolutely unbranched or bear, besides reproductive organs, only a few one-celled or rarely two-celled branchlets. The cells which are usually a little constricted at the transverse walls, contain a belt-shaped, rather narrow chromatophore containing a pyrenoid projecting inward. Hyaline hairs always occur; they are either terminal on the filaments and the branchlets or lateral. The hair situated at the top of the terminal cell is later pushed to the side, the terminal cell growing out beyond the insertion of the hair (fig. 18 *K*) which, after the next cell-division, comes to be situated at the upper end of the subterminal cell. Nearly all the lateral hairs have developed in this manner;

it seems however that really lateral hairs may also sometimes occur. At all events two hairs may be found on one cell (fig. 18 *G*). Most of the hairs are early thrown off, leaving however a vestige in the outline of the cell, this being a little enlarged at the upper end. I have once seen a hair given off from a basal cell which had not yet produced any filament.

Most of the plants bear at the same time sporangia and both kinds of sexual organs, some plants, however, bear only sexual organs. The sporangia are sessile on the sides of the filaments or sometimes borne by the unicellular branchlets (fig. 18 *A*); they open by a split at the top (fig. 18 *A*, *G*).

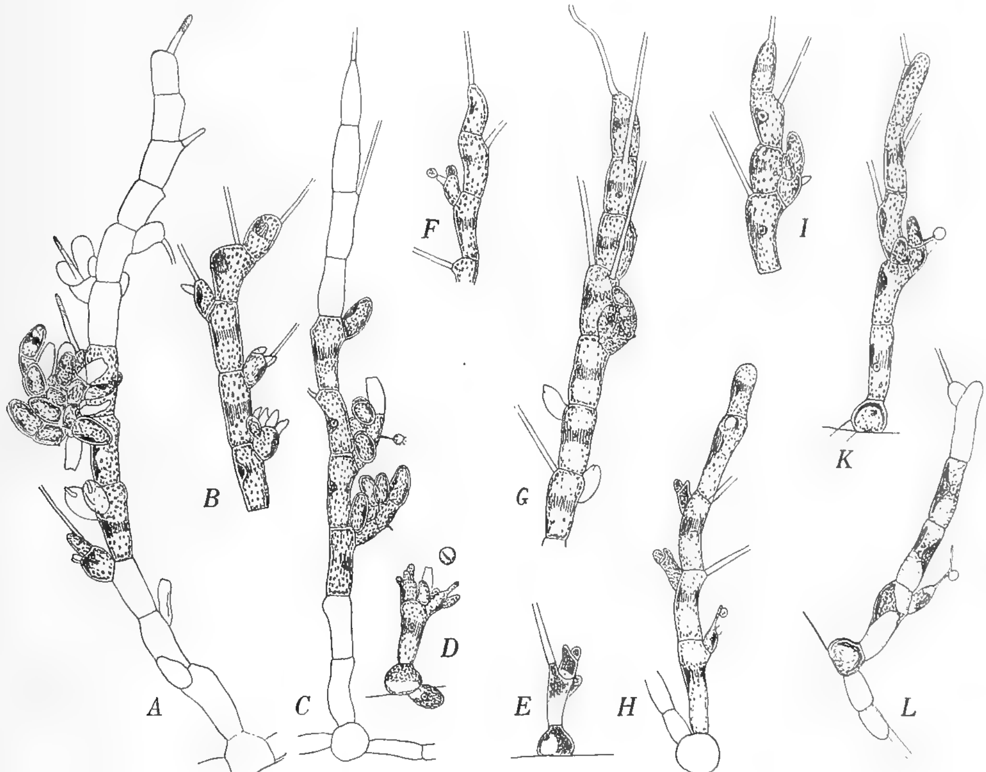


Fig. 18.

Chantransia gynandra. *A*, plant with 3 branchlets, a cystocarp and sporangia. *B*, upper end of filament with branchlets bearing antheridia. *C*, plant with two cystocarps and one sporangium. *D*, dwarfed plant with antheridia and one carpogonium; a spermatium is lying above. *E*, dwarfed plant (comp. text). *F*, two antheridia on a branchlet; a spermatium is situated immediately outside one of the antheridia. *G*, part of filament with a young cystocarp and two empty sporangia. *H*, plant with three carpogonia with epigynous antheridia, two young, the third in the fertilization stage. *I* and *K*, plants with young cystocarps and epigynous antheridia. *L*, plant with carpogonium in fertilization stage. 630 : 1.

The carpogonia are situated on the sides of the filaments at various distances from the base; they are bottle-shaped, the trichogyne being of almost the same length as the ventral part. The antheridia are situated either on the carpogonia or on the ramuli; in the first case they are always solitary, in the latter there are usually two or more crowded together. Only in the dwarfed plant represented in fig. 18 *D* have I seen the antheridia situated directly on the filament, but in this case the filament was only two-celled. The juvenile stages of the epigynous antheridia show that these antheridia are really terminal, while the trichogyne rises as a lateral outgrowth from the subterminal carpogonium (fig. 18 *E*, *H*), a case hitherto unknown among the Florideæ. I have repeatedly, in material preserved in alcohol, observed a little globular body lying immediately outside an empty antheridium or at a slight distance from it (fig. 18 *F*, *D*); as it agreed in size with the spermatia adhering to the trichogynes (fig. *C*, *K*, *L*), I have no doubt that they were really spermatia. Probably a spermatium is often transferred from an epigynous antheridium to the trichogyne of the supporting carpogonium. After fertilization the ventral part of the carpogonium grows out into a slightly inwards curved filament which becomes 3-celled. The trichogyne is pushed outward so that it becomes situated on the convex side, on the second cell of the filament (fig. *C*). The two lowest cells give off several branches, while the uppermost cell produces a carpospore (fig. *C*). Possibly the primary filament of the gonimoblast may sometimes consist of more than three cells. The lateral branches obtain a different length, some becoming relatively long, articulated, curved and branched, others remaining short and in part apparently unicellular, producing a carpospore without division. The mother-cells of the carpospores have about the same form and size as the sporangia. The trichogyne or the lowest part of it can be seen long after fertilization on the second cell of the main filament; even in mature cystocarps a slight remnant of it is sometimes to be seen, (fig. *A*). The emptied epigynous antheridium is also often to be found some time after fertilization; it is then situated on the first cell of the main filament (fig. *I*, *K*).

While the plants often attain a length of 200 μ, very reduced plants also occur, consisting of very few cells (fig. *D*, *E*). In the plant shown in fig. *E* there was only developed one filament consisting of one cell only, bearing a hair, a carpogonium with epigynous antheridium and a lateral outgrowth the character of which could not be determined.

The species differs from all more exactly described species of this group through the position of the sexual organs, the form of the cystocarps and the belt-shaped chromatophore. It may have been observed earlier, however, and possibly some of the plants mentioned under the name of *Callithamnion minutissimum* have belonged to this species. Zanardini's species of this name (Synops. Alg. mar. Adr. 1841 p. 176; Hauck, Oesterr. bot. Zeitschr. 1878 Taf. II fig. 7—8), however, belongs not to this group; and as to Suhr's species (Kützing Spec. alg. 1849 p. 640, Tab. phyc. XI tab. 57), it is impossible to identify it from the description and figures. On the other hand, the specimens referred to that species by Crouan (Alg mar. du Finistère No. 114, Florule du Finistère p. 134) show so much resemblance with the species here described, that they might probably be identical. This, however, cannot yet be decided with certainty as the specimens of Crouan bear no sexual organs (Comp. BORNET 1904 p. XIX). On the contrary, they bear abundant sporangia, in much greater number than in the Danish plants, very often two on each cell, 10—11 μ long, 6—7 μ broad, consequently nearly as in our plants, and of the same shape. The thickness of the filaments is the same (5,5—6 μ), the basal cell is ca. 10 μ in diameter and the chromatophore is parietal, and finally CROUAN's plant grows on an *Ectocarpus* like the Danish plant. All these agreements suggest that CROUAN's plants are asexual individuals of *Ch. gynandra*.

Locality. **Kn**: Tønneberg Banke, ZA, 12 to 18 meters, July.

2. **Chantransia rhipidandra** sp. nov.

E cellula basali globosa vel rarius leviter depressa, diametro c. 14 (13—15) μ, 2—3 fila erecta parce ramosa usque ad 350 μ saltem alta, egrediunt. Rami sparsi simplices vel parce ramosi. Cellulæ (7,5—) 9—11 μ latæ, diametro 2—3 (—4)-plo longiores, chromatophorum stelliforme, pyrenoide centrali, in parte superiore cellulæ sito, instructum, continentes. Fila primaria ramique apice plerumque pilo hyalino instructi. Sporangia in filis lateralia sessilia aut stipitata, stipite unicellulari, sparsa vel (rarius) opposita, sæpe seriata, monospora, ovata vel obovata, long. 14—18,5 μ, lat. 9—10 μ. Antheridia in ramulis, in una fere planitie ramosis, semiflabelliformibus terminalia, 6—6,5 μ longa, 4—5 μ crassa. Carpogonia in filis primariis vel in infima parte ramorum sessilia; cystocarpia subglobosa; carposporæ in cellulis ultimis cystocarpii formatæ, eadem fere forma et magnitudine ac monosporæ. Antheridia et carpogonia in plantis distinctis, sporangia in plantis distinctis aut in plantis sexualibus.

This species is distinct from all well-defined species with one basal cell. Thus, it differs from *Ch. microscopica* (Nægeli) (1861, p. 407 figs. 24, 25) by its globular basal cell[1] being much broader than the filaments and giving off 2 or 3 filaments, and by having longer cells. From *Ch. hallandica* it differs by its larger proportions, the position of the antheridia and the form of the cystocarpia etc., from *Ch. microscopica* var. *pygmæa* KUCKUCK (Bemerk. Helg. II, p. 392 fig. 15) in the dimensions, the absence of endophytic filaments etc. *Ch. unilateralis* KJELLMAN (Algenfl. Jan Mayen, Arkiv f. Bot. Bd. 5 No. 14, 1906 p. 11) differs by having much thicker and more branched filaments and almost globular sporangia, and *Ch. Alariæ* JÓNSSON (Mar. Alg. Iceland. Bot. Tidsskr. vol. 24 p. 132) differs also by having much thicker and more branched filaments, and further by the branches being often opposite; both these species are devoid of sexual organs. From the short description given of *Ch. microscopica* BATTERS (Journ. of Bot. 1896 p. 9) it appears that this species can scarcely be identified with our species, for according to BATTERS the antheridia form "very compact clusters at short intervals along the axes and branches", and

[1] NÆGELI mentions and figures in *Acrochætium microscopicum* a basal disc, "von welcher es (nach Untersuchung an getrockneten Exemplaren) zweifelhaft bleibt, ob es eine niedergedrückte scheibenförmige Zelle oder nur Verdickung der Membran ist (Fig. 24, 25)". On examining the specimens of this species in RABENHORST's Die Algen Europas No. 1650, I have found that this basal disc is a cementing substance, occurring in all the species of this section.

the cystocarpia are "clustered near the basal disc", and according to KUCKUCK (l. c.) the filaments are narrower (4,5—7 μ) in BATTERS' species than in *Ch. rhipidandra.*

To the description given above the following remarks may be added. The basal cell is fastened to the surface of the host plant by a very distinct disc consisting of a cementing substance staining intensely blue in MAYER's hæmalum. The sporangia are usually alternate or more or less regularly secund (fig. 19 on the left), seriate, as the plant generally has a tendency to unilateral ramification. When each cell bears two sporangia, they are usually, but not always, opposite, and several pairs of sporangia are then often superposed (fig. 19 to the right). When the sporangium is placed on a unicellular branchlet, this often bears also a hair; the hair being terminal, the sporangium is then lateral on the branchlet (fig. 19).

Fig. 19.
Chantransia rhipidandra. Two spore-bearing plants. 300:1.

The antheridia are placed in characteristic, flat, usually triangular clusters consisting of 2- to 5-celled branchlets branched only on the upper side; they are produced in a number of one to three on all the terminal cells of the cluster, and also singly by some of the other cells (fig. 20 *A*, *B*).

The carpogonia are sessile on the upper part of the main filaments or on the lower part of the branches; they are bottle-shaped, with a trichogyne of about the same length as the ventral part (fig. 20 *D*, *c*). After fertilization the carpogonium grows out in a three-celled filament which still bears the trichogyne or a remnant of it on the second cell (fig. 20 *E*, *H*, *t*). A branch is now given off from the lowest cell, the primary filament is further divided so that it becomes 4- or 5-celled, and it gives off more branches from the lower cells. In fig. 20 *F*, the primary filament is seen to be 5-celled; the uppermost cell produces a carpospore, the others, with exception of the subterminal cell, each bear two branches which are either unicellular and produce directly a carpospore or become 2- or 3-celled and produce a carpospore in the end-cell. The ripe cystocarpium is of somewhat irregular, nearly globular shape; its peripheral cells are swollen and each produce a carpospore (fig. 20 *D*).

This species has only been found at Frederikshavn, where it was collected in August 1891 growing on *Porphyra umbilicalis* on the outer and the inner side of the moles. It grew on the flat side of the fronds, in some cases so abundantly that the frond of *Porphyra* had become dull and purplish.

Locality. **Kn:** Frederikshavn.

3. **Chantransia hallandica** Kylin.

H. Kylin (1906) p. 123.
Ch. parvula Kylin (1906) p. 124.

Kylin in 1906 described two allied species, *Ch. hallandica* and *Ch. parvula*, differing from each other by the filaments being a little thinner, giving branches off at all sides and consisting of longer cells, further by the sporangia being often stalked and then usually placed two or three together in *Ch. hallandica*, while *Ch. parvula* is smaller, has shorter, a little thicker filaments with branches placed in one or two rows and usually sessile sporangia. In several places in the Danish waters I have met with *Chantransiæ* agreeing exactly with these two species, but I have also found specimens which were intermediate in regard to one or more of the characters mentioned. As I have also found sexual organs, besides the sporangia described by Kylin, it will be necessary to mention these plants more closely.

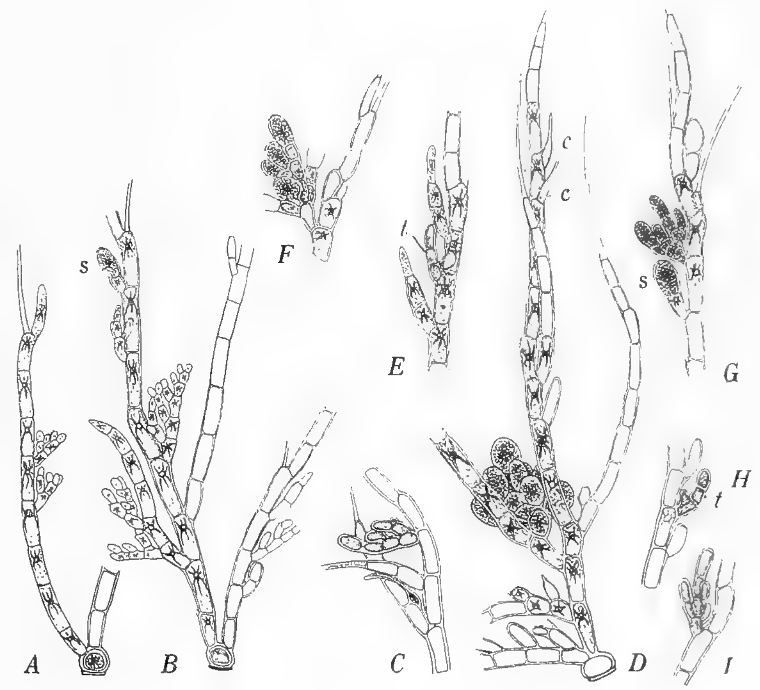


Fig. 20.
Chantransia rhipidandra. *A* and *B* male plants, *B* also with sporangia, *s*. — *C—I* portions of female plants. The carpogonia and the young cystocarpia made more easily recognizable by shading; in *C* an unfertilized carpogonium and a young cystocarp; in *D* carpogonia, *c*, and a ripe cystocarp; in *E* a fertilized carpogonium, 3-celled, still with trichogyne, *t*; in *F* a nearly ripe cystocarp after having been subjected to pressure; in *G* an unripe cystocarp and two sporangia; in *H* a young cystocarp and an empty sporangium; in *I* a young cystocarp. 300 : 1.

In the plants corresponding to Kylin's *Ch. hallandica*, the basal cell is (7,5—) 9—11 (—14) μ in diameter, thick-walled; it gives off usually 3, at the most 4 erect filaments, (4—) 5—6 μ thick and consisting of cells usually 3—4 (—5) times as long as broad. Hyaline hairs are usually present. The originally terminal hair is often pushed aside by the cell bearing it growing out sympodially in the same direction as before, and the hair leaves then only a faint mark at the upper end of the cell which has produced it; but in other cases the hair retains it terminal position, and the filament, i. e. the branch, grows out in another direction (fig. 21 *E*). Transitional cases are also found. The cells contain a stellate chromatophore with central pyrenoid lying in the upper part of the cell, the strands radiating from the central body forming a more or less continuous peripheral layer. As Kylin (1906 fig. 8 *G*) represents the pyrenoid as being sometimes lateral, it may be remarked that I have always found it central.

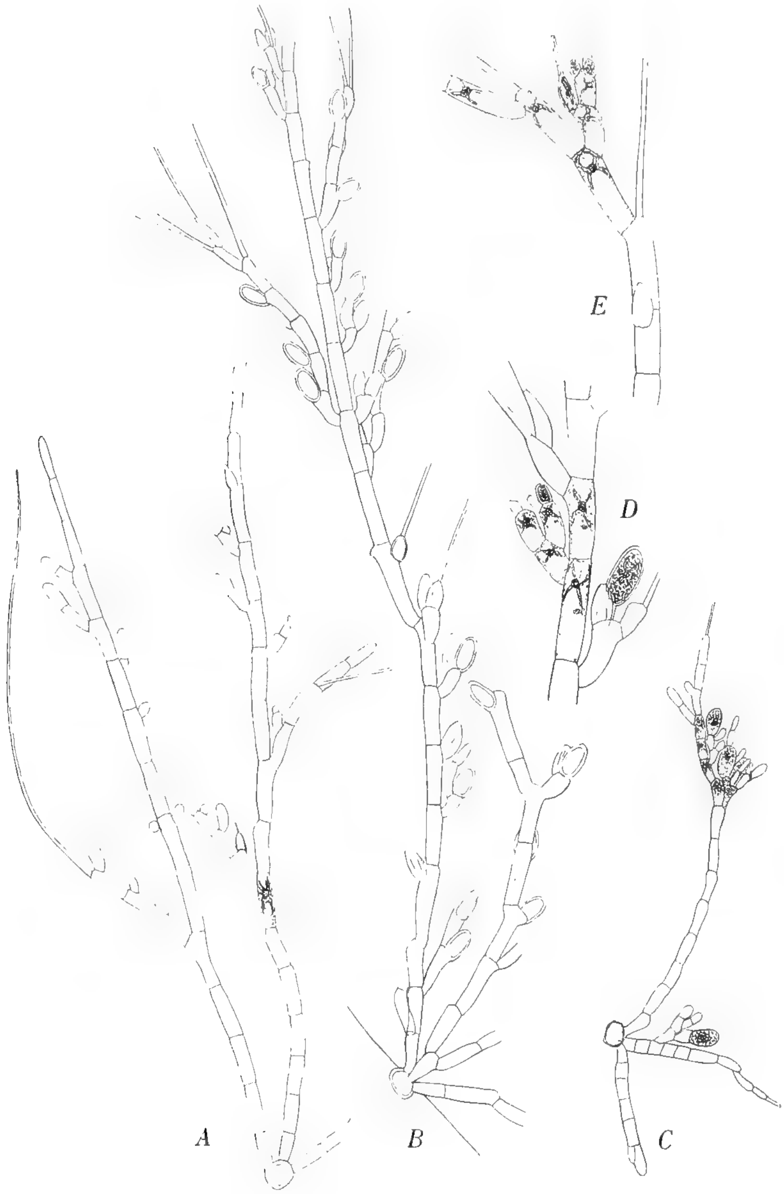


Fig. 21.

Chantransia hallandia α, typica. A, with sexual organs and sporangia, 385 : 1. *B*, with sporangia, 385 : 1. *C*, with cystocarps, 300 : 1. *D*, fragment of plant bearing branchlets with antheridia and sporangia, 620 : 1. *E*, fragment of plant bearing a branchlet with carpogonium and antheridia, and an emptied sporangium, 620 : 1. *A* and *C* from AH[1], *B*, *D*, *E* from LC.

The sporangia are lateral on the filaments, sessile or stalked, i. e. situated on one-celled branchlets and then usually two on each stalk-cell. The branchlet may also be two-celled, the primary stalk-cell bearing, besides a terminal sporangium, a lateral stalk-cell with a sporangium. Usually only one sporangium or sporangium-bearing branchlet is situated on each cell in the filaments. The sporangia are ovate to oblong, (8,5 –) 9,5—10,5 (—13) μ long, (4—) 6—7 (—9) μ broad.

Many plants bear exclusively sporangia, but by searching, specimens bearing also or exclusively sex-organs are easily found, at all events in the Danish waters. In describing the sexual organs I refer also to the plants belonging to the var. *brevior*. The antheridia are placed singly or in small groups of two or three at the end of shorter branches; they are round, 3 μ long, 2,5 μ broad. The carpogonia are situated on similar, rather short, usually 1- to 5-celled, branches as those bearing the antheridia, and they are often placed in the immediate vicinity of the antheridia (figs. 21 *E*, 22 *B*). I have not succeeded in following the development of the cystocarpia, especially the first stages. It seems that the trichogyne disappears very soon after fertilization. In fig. 21 *E* is shown a carpogonium immediately before fertilization, in fig. 23 another with adhering spermatia, and in fig. 22 *A* and *C* abortive carpogonia are shown, but I have never seen a trichogyne on a carpogonium after the commencement of the divisions; it might perhaps have been on the place marked with * in fig. 22 *D*; the two spores situated on each side of this must then be carpospores and the whole cell-complex a cystocarpium. A very similar case is shown in fig. 23 *B*, and the plant shown in fig. 21 *C* bears undoubtedly also two or three cystocarps. The cystocarps are thus corymbiform and produce only a very small number of carpospores. Usually only two carpospores are present at the same time, but it is probable that others may develop after the first have been exhausted. The carpospores are somewhat larger than the sporangia, viz. 14—18 μ long, 7—9 μ broad.

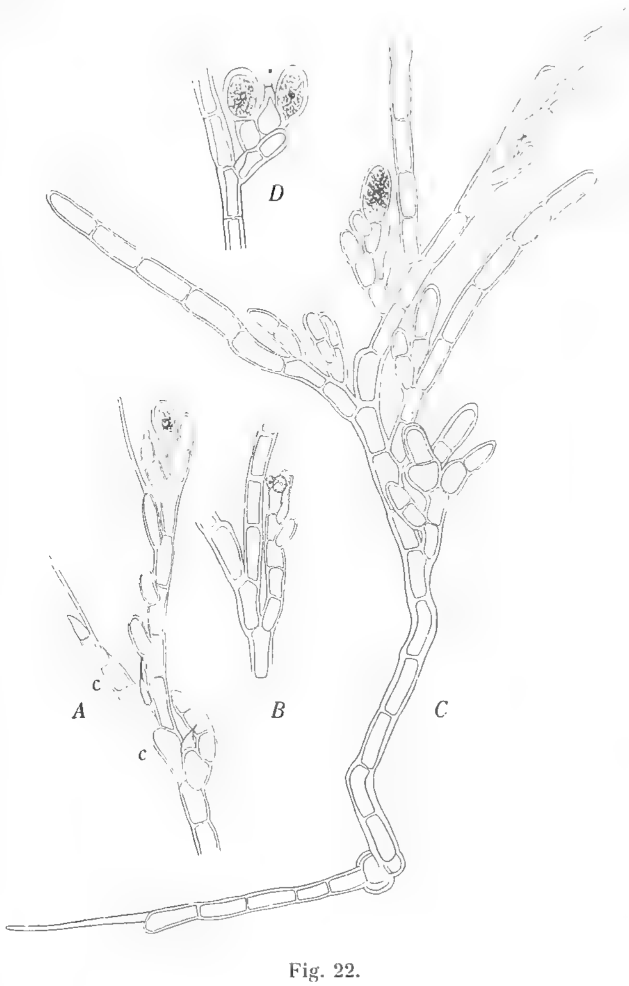


Fig. 22.
Chantransia hallandica α, *typica*. *A*, fragment of plant with abortive carpogonia and sporangia. *B*, branchlet with antheridia and carpogonium. *C*, plant with abortive carpogonia and probably unripe cystocarps. *D*, cystocarp, at * perhaps the place of the trichogyne. 550 : 1. All plants from AH[1].

At some places, mostly in the northern Kattegat, specimens were met with which agreed in all essentials with those described above but differed in having shorter cells, about twice ($1^1/_2$—3 times) as long as broad. The cells being, as in the main form, often a little enlarged at the upper end, they may differ somewhat from the cylindric form (fig. 23 *C*). These plants are lower than the main form and usually branched from the base, while the main form is most often without branches below. In the specimens from VT the sporangia were almost always sessile, alternate, secund or opposite (fig. 23 *A*), while in the specimens from KC they were often stalked (fig. 23 *C*). This form may be named f. *brevior*.

Fig. 23.
Chantransia hallandica β. brevior. *A* and *B* from VT. *A* with sporangia. *B* with sexual organs and a cystocarp. — *C* and *D* from KC. *C* with sporangia, partly stalked. *D* with sporangia and antheridia. 390 : 1.

The specimens just described are only slightly different from others agreeing with KYLIN's *Ch. parvula.* Fig. 25 shows such a specimen, the filaments of which are 5—7 μ thick and the cells about twice as long as broad; the sporangia, however, were somewhat larger than indicated by KYLIN, namely (10—) 12—13 (—14) μ long, 6—8 (—9) μ broad. The basal cell was (10—) 12—13 (—15) μ in diameter. Some specimens growing on the frond of *Porphyra umbilicalis* on the mole of Frederikshavn (fig. 26) may also be referred here, though they were not strongly ramified in one plane; they bore numerous sporangia, most often opposite, sometimes even three in one article. The axile chromatophore is very distinct in the figures which have been drawn after specimens preserved in alcohol. The last-named specimens as well as those from EM (fig. 25) were only provided with sporangia; on the other hand, specimens from BH (fig. 24) had also sexual organs. Fig. 24 *B* fully agrees otherwise with KYLIN's figures, while fig. 24 *A* might perhaps be better referred to f. *brevior*, but these plants grew side by side and were connected by transitional forms. A very reduced plant provided with all kinds of organs of reproduction is shown in fig. 24 *C*. It seems not improbable that the small cells shown in KYLIN's fig. 9 *h*, *i* (1906) may have been antheridia.

Fig. 24.
Chantransia hallandica γ. parvula. From BH. *A* with longer cells and alternate sporangia. *B* with sporangia and antheridia. *C*. dwarfed plant with sporangium and sexual organs. 390 : 1.

From what has been explained above it may be concluded that all the specimens mentioned must be referred to one species, *Ch. hallandica*, which may be divided into three forms not separable by distinct limits.

α, typica. From the basal cell are given off usually three upright filaments which are branched on all sides, usually without branches below, 5—6 μ thick. Cells ca. 4 times as long as broad. Sexual organs and sporangia present, often in the same plant, the sporangia usually alternate, often stalked.

β, brevior. Cells ca. 2 ($1^{1}/_{2}$—3) times as long as broad, primary filaments often branched from the base. For the rest as *α*.

γ, parvula (Kylin). (Syn. *Ch. parvula* Kylin l. c.). From the basal cell are given off up to 6 filaments which are (5—) 6—7 μ thick. Cells ca. 2 times as long as broad. Sporangia almost always sessile, most frequently opposite. Sexual organs often wanting.

Fig. 25.
Chantransia hallandica γ, parvula. From EM. Plant with sporangia only. 390 : 1.

The species has almost always been found epiphytic on *Polysiphonia nigrescens* and *Pol. violacea*. F. *parvula* has also been found on *Porphyra umbilicalis*. It has only been met with in the summer months (May—August), in all cases with sporangia and usually also with sexual organs; ripe cystocarps have been met with in July and August. *α* and *β* have been found in depths of 4 to 15 meters, *γ* in depths of 0 to 9,5 meters.

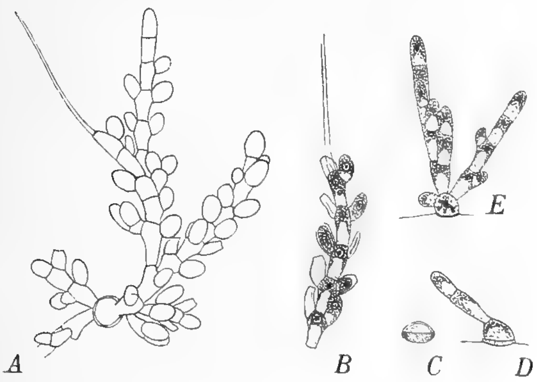


Fig. 26.
Chantransia hallandica γ, parvula. From Frederikshavn, growing on *Porphyra umbilicalis*. *A*, plant with sporangia. — *B*, filament with partly emptied sporangia. — *C*, germinating spore. — *D* and *E*, young plants, still sterile. 300 : 1.

Localities. **Kn:** Krageskovs Rev, KC, (*β*); Hirsholm, (*β*); Frederikshavn, (*γ*); VT, N. of Nordre Rønner, (*α* and *β*); Trindelen, FF, 15 meters. — **Ke:** XA, 13 meters, (*α*). — **Km:** VQ, Svitringen, (*α*); BH, off Gjerrild Klint, (*γ*). **Ks:** EM, Lysegrund, (*γ*). — **Sa:** BD, N. of Tunø; MQ, (*β*); AH[1], N. of Fyens Hoved, (*α*). **Lb:** At Fænø, (*α*). — **Sb:** AB, W. of Sprogø, 7,5 meters (*α*). — **Bw:** LC, S. of Langeland, 11,5 meters, (*α*).

4. **Chantransia baltica** sp. nov.

E cellula basali globosa, diametro 10,5—14 μ, fila usque 6 subsimplicia, longitudine 400 μ vel ultra, egrediunt. Cellulæ (5—) 6—7 (—9) μ crassæ, in filis bene evolutis diametro 4—6 (—7)-plo longiores, chromatophorum axile, pyrenoide centrali instructum, in parte superiore cellulæ situm, continentes. Sporangia monospora ovata, 12—16 μ longa, 8—10 μ lata, vulgo c. 14 μ longa, 10 μ lata, in filis primariis lateralia vel terminalia, sessilia vel stipitata, in stipite unicellulari singula, in articulis filorum sæpe bina, opposita.

superne nonnunquam subsecunda. Organa sexualia desunt. Pili hyalini crebri, in ramulis sporangiferis terminales.

This species which has been found only in two localities in the Baltic is certainly nearly related to *Ch. hallandica*, but however so different from it, that I do not hesitate to set it up as a distinct species. It differs by the primary filaments being more numerous, less branched, somewhat thicker and consisting of somewhat longer cells, by the sporangia being larger, by the sporangial stalks bearing only one sporangium, and by the want of sexual organs. In some of the characters mentioned, the more numerous and thicker filaments, and the sporangia often opposite, it resembles *Ch. hallandica* f. *parvula*, but it is very different from this by the long cells and the sporangia being often stalked.

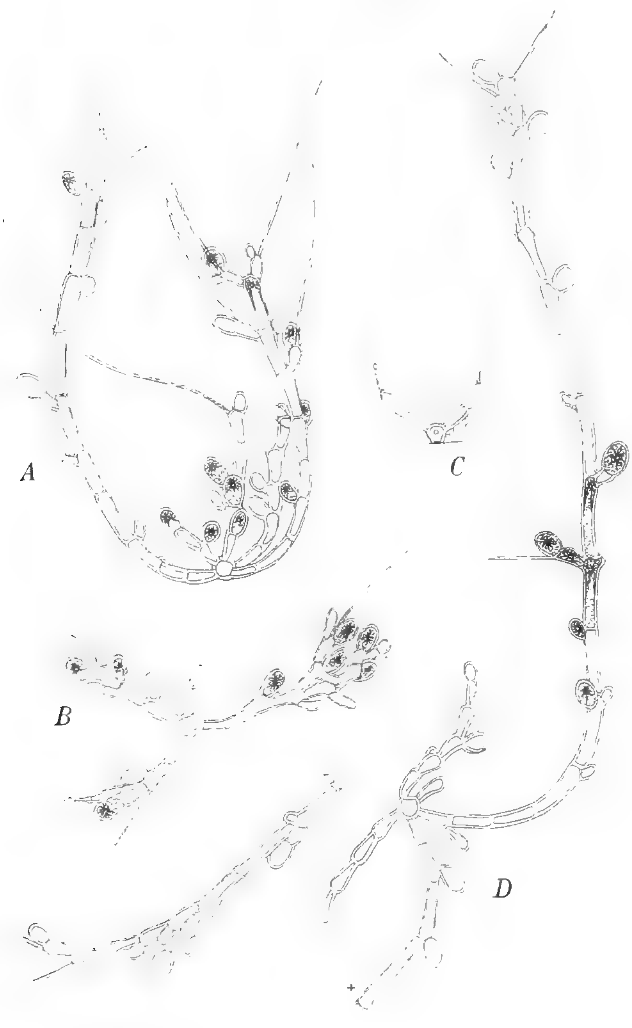


Fig. 27.
Chantransia baltica. (From QR). *A*, *B* and *D*, fully developed plants with sporangia, *C* young plant, seen from the side. 300 : 1.

To complete the description given above, the following remarks may be added. The basal cell is nearly globular, its plane of attachment being often smaller than its transverse section; it is rather thick-walled. The primary filaments bear usually no long branches but only sporangia-bearing branchlets. The most developed primary filaments recall somewhat those of *Ch. virgatula*, but they are thinner and the branchlets bear only one sporangium. The shorter filaments consist of shorter cells, 2—3 times as long as broad and often somewhat enlarged above. In some specimens from SQ the longer filaments were up to 9 μ thick below, upward thinner, ca. 5 μ in diameter, the cells being up to 7 times as long as broad. The chromatophore reaches in the longer cells often only to the middle of the cell, the pyrenoid lies near the upper end of the cell. The spores contain a very distinct stellate chromatophore. I have never seen a sporangial stalk bearing more than one sporangium, and a renewal of an emptied sporangium within the sporangial-wall from the stalk-cell has not been observed, but a new sporangium may sometimes be developed beside an emptied. Colourless hairs are always present; they are terminal or lateral, in the latter case, however, certainly always originally terminal.

Localities. **Bm:** Gyldenløves Flak, QR, 7,5 meters, on *Polysiphonia violacea*, July. — **Bb:** SQ, S. of Broens Rev, 8,5 meters, on *Polysiphonia elongata*, August.

5. **Chantransia moniliformis** sp. nov.

Thallus minutus cæspitulosus, 50—150 μ altus vel parum ultra (sine pilis). Cellula basalis singula subglobosa, fila 2—3 (vel plura?) erecta vel decumbentia et adscendentia, a basi ramosa, e cellulis plus minus inflatis constituta, emittens. Cellulæ diametro æquilongæ ad duplo longiores, plerumque fere sesquilongæ, subglobosæ aut doliiformes vel in parte superiori incrassatæ, 7—10 μ latæ, 7—14 μ longæ. Chromatophorum stelliforme, pyrenoide centrali instructum, in parte superiori cellulæ situm. Fila ramique, præcipue in statu juvenili, sæpe piligeri, pilis initio terminalibus, dein evolutione sympodiali (pseudo-)lateralibus. Sporangia monospora sessilia, rarius pedicellata, lateralia, secundata vel opposita, ovata, 13,5—15 μ longa, 7 μ lata, post evacuationem sæpe sporangio novo, e cellula subjacenti orta, repleta. Organa sexualia ignota.

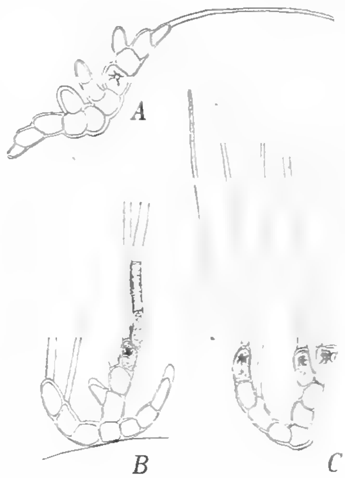


Fig. 28.
Chantransia moniliformis. Young plants with hairs. *A* from Helsingør, *B* and *C* from D. 390 : 1.

This small species is easily distinguishable from the other species of this group by its short, more or less swollen cells, which in juvenile plants approach to the globular form, while in older plants they are almost barrel-shaped. The basal cell which is fixed to the host plant by a thin layer of cementing substance is scarcely different from the other cells in form. The displacement of the originally terminal hairs is easily to be seen in the young plants (fig. 28 *C*); in older plants no hairs are to be found. In the plant represented in fig. 28 *B* the cell situated beneath the upper terminal hair-cell had lengthened and become almost colourless, approaching thus to the character of a hair-cell; but this case appears to be very rare. The branches are mainly given off at the upper side of the decumbent or ascending principal filaments, and this holds good also of the sporangia which are often seriate on the upper side of the filaments. After the evacuation the sporangial wall is seen to be lamellate, but the acroscopic part of it is often dissolved (fig. 29 *B*). — On dried material I once saw a specimen with a blue-green colour; unfortunately I have not examined the species in the living state.

This inconspicuous species has been found epiphytic on *Polysiphonia violacea* and *nigrescens*, in company with other species of *Chantransia* (*virgatula, hallandica* etc.), at several places but in small quantities. It has been met with in May to September, in depths from 1 to 11,5 meters, and was collected with sporangia in the same months.

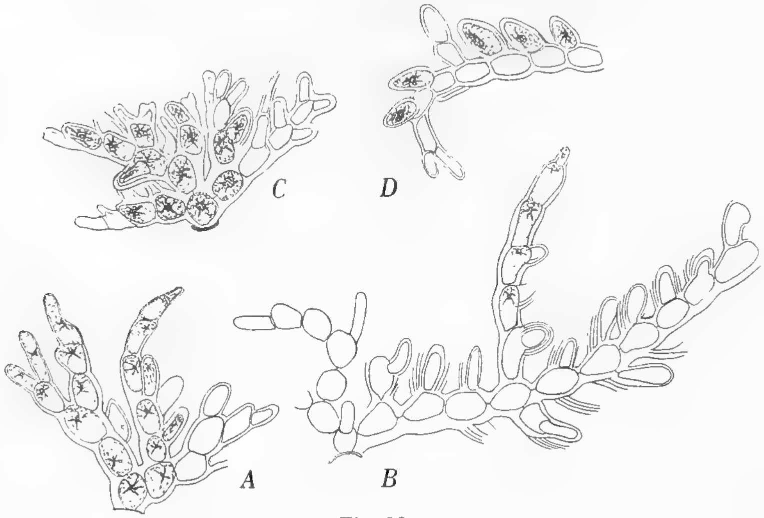


Fig. 29.
Chantransia moniliformis. Adult plants with sporangia. *A—C* from Helsingør, September, *D* from AH¹. In *D* full-grown sporangia, in *B* the sporangia have been emptied and new sporangia are developing within their membranes. 390 : 1.

Localities. **Kn:** Krageskovs Rev, KC. — **Ks:** D, N. of Isefjord, 11,5 meters. — **Sa:** AH¹, N. of Fyens Hoved; MQ, S. of Samsø, 11,5 meters. — **Sn:** Stone-slope at Helsingør (Kronborg). — **Bw:** LC, S. of Langeland, 11,5 meters. — **Bm:** QR, Gyldenløves Flak.

Group II. Frond epiphytic with a pluricellular basal layer.

6. **Chantransia Thuretii** (Born.) Kylin.

Kylin (1907) p. 119.
Chantransia efflorescens var. *Thuretii* Bornet (1904) p. XVI pl. I.

α, amphicarpa nob.

Of this species, which is quite distinct from *Ch. efflorescens* (J. Ag.), as shown by Kylin, I have found specimens fully agreeing with Kylin's description and drawings. Such specimens, provided with monosporangia and sexual organs, were met with repeatedly in July near Frederikshavn. In some cases the sporangia and the sexual organs occur on different branches of the same plant, but as shown by Kylin, the sporangia are often situated near the sexual organs, and all the three kinds of organs of reproduction may then occur very close together, as is seen in fig. 30 *B*, where the same cell bears a carpogonium and a sporangium, while a cluster of antheridia is situated on the next branchlet. Also in fig. 31 *B*, the sporangium is situated close to the carpogonium and in fig. 31 *A* a two-celled branchlet is seen to bear a carpogonium, an antheridium and a sporangium.

When not occurring together with the sexual organs the sporangia are situated on the inner side of the branches near the base, usually 2 or 3 together on one-celled branchlets, or they are sessile at the same place; more rarely the branchlets are 2- or 3-celled. It may sometimes happen, that two sporangiferous branchlets are seated on the same cell, the one over the other (fig. 30 *A*). On maturation the spore leaves the sporangium through a narrow opening at its upper end. After liberation, which was observed in July, the spores took an ovoid form, thereafter they became globular and then showed amoeboid movements.

The germinating spore forms an orbicular basal cell which gives off one upright filament but for the rest remains unaltered for some time (fig. 30 *D*); later on it forms cells in the periphery which grow out in creeping filaments fusing together to a rather large-celled basal disc, which produces more upright filaments (fig. 31 *C*). The original basal cell is for some time distinguishable in the centre of the disc. As shown by KYLIN, no downwards growing filaments occur at the base of the upright filaments. However, I have once observed two short vigorous descending filaments given off very near the base of an upright filament, and each producing an upright filament on its convex side (fig. 31 *D*).

The chromatophore, the form of which KYLIN was not able to determine, is shown in fig. 30 which was drawn after living plants; it is a parietal plate, often with a lobed margin and with a large pyrenoid which is also parietal but much projecting inward in the cell. The nucleus often lies at the opposite side of the cell from the pyrenoid (fig. 30 *B*, *C*).

Plants similar to those mentioned above were found at a locality in the Samsø Waters in September. They were, however, only provided with ripe cystocarpia and bore no sporangia, perhaps to be explained by the sporangia accomplishing their development faster than the cystocarps.

Referring for the rest to KYLIN's description, I may remark finally, that the filaments in my plants were 7,5—9,5 μ thick, that I have once observed a pair of opposite branches, that the sporangia were 14—16 (—17) μ long, 9—11 μ broad, and that the carpospores were 19—21 μ long, 11—12,5 (—14) μ broad.

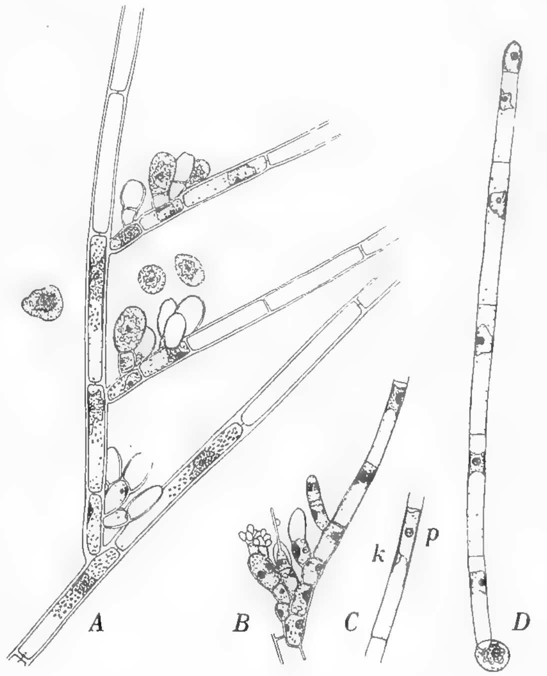


Fig. 30.
Chantransia Thuretii α, amphicarpa. Drawn after living plants from Busserev by Frederikshavn. *A*, plant with sporangia and liberated spores. *B*, branch with branchlets bearing antheridia, a carpogonium and sporangia; behind the carpogonium an emptied sporangium is visible. *C*, cell with chromatophore, pyrenoid *p* and nucleus, *k*. *D*, young plant. 320 : 1.

The main form has been found growing on *Polysiphonia violacea*, *Ceramium rubrum*, *Cystoclonium* and *Dictyosiphon*, with sexual organs and ripe carpospores and monospores in July, with ripe carpospores in September.

Localities. **Kn:** Busserev by Frederikshavn, July. — **Sa:** MP, Falske Bolsax, 11—13 meters.

β. agama var. nov.

In the Danish waters plants only provided with sporangia are much more frequent than the above described sexual plants. As they greatly resemble these, I conclude that they belong to the same species; as they are different, however, not only by the want of sexual organs but also by somewhat larger sporangia they may be mentioned separately: and this will appear all the more legitimate when we remember the great likeness between the sporangia-bearing filaments of *Ch. Thuretii* and those of *Ch. corymbifera* Thur. (Bornet et Thuret 1876 pl. V), so that it is not excluded that the specimens mentioned here might represent a separate species.

As to the vegetative organs this form agrees with the sexual plants; the principal filaments, however, are as a rule a little thicker, namely 8—11 μ in diameter. In some cases the thickness reached 12 μ, and in some specimens from the North Sea (aF, fig. 32 *F*) it attained even 13 μ. On the other hand principal filaments only 7 μ thick may also occur. The cells are, as in the sexual plants, rather thick-walled; in the lower part of the filaments they are proportionally short (seldom however so short as in fig. 32 *A*), upward longer.

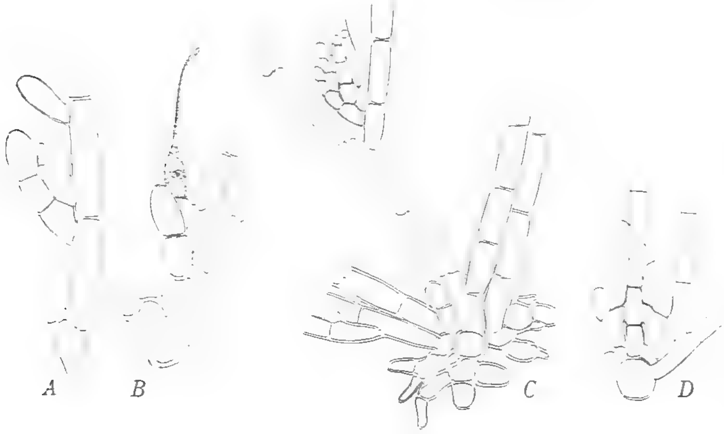


Fig. 31.
Chantransia Thuretii α. amphicarpa. From Busserev by Frederikshavn. *A*. the branchlet bears a carpogonium, an antheridium and a sporangium. *B*. the branchlet bears a terminal carpogonium and a lateral emptied sporangium. *C*. lower part of a plant: above a branchlet with antheridia and a carpogonium. *D*. lower part of a plant with two short descending filaments. *A*, *B* 560 : 1, *C*. *D* 350 : 1.

The branches are somewhat thinner than the principal filaments and become thinner towards the apex. Sometimes they taper into very thin hair-like threads consisting of long, thin cells, the contents of which become colourless (fig. 32 *B*); this may also occur in *α*. Descending filaments at the base of the plants were not observed in typical specimens of this form. The chromatophores have the same shape as in the sexual plants.

The sporangia have the same position and shape as in the sexual form but are somewhat larger. The length is usually 19—22 μ, but it may attain 24 μ and may sometimes be only 17,5 μ; the breadth varies between 8 and 12 μ (7—13 μ). Only once have I seen a sporangium or a sporangium-bearing branchlet situated beneath another sporangium on the same cell (fig. 32 *C*, comp. fig. 30 *A*). In specimens collected towards the end of September in the Northern Kattegat (TP), some peculiar crooked branchlets were observed, mostly rising from the sporangia-bearing branchlets, more rarely independently of these, and then usually given off from the lower end of the cells (fig. 33); in some cases they bear sporangia (fig. 33 *A*). Sometimes they occur in great number on a branchlet, forming a short-stalked capitulum (fig. 33 *B*). These crooked filaments showed rich, coloured contents; they must without doubt be regarded as abnormal formations.

Besides the monosporangia tetrasporangia have also been met with, but only in one locality in the North Sea (aF, 31 meters) in August. The specimens bore numerous, typical monosporangia and in smaller number tetrasporangia, having a similar position to the former. The number of tetrasporangia on one branchlet was frequently greater than usual, but that was also the fact for the monosporangia in these specimens. The tetrasporangia were almost globular, a little longer however than broad, 25—26 μ long, 21—22 μ broad (fig. 32 *D*). In one branchlet only one sort of sporangia occurred, but branchlets with monosporangia were found at a little distance from those with tetrasporangia on the same plant. Some plants bore only monosporous sporangia.

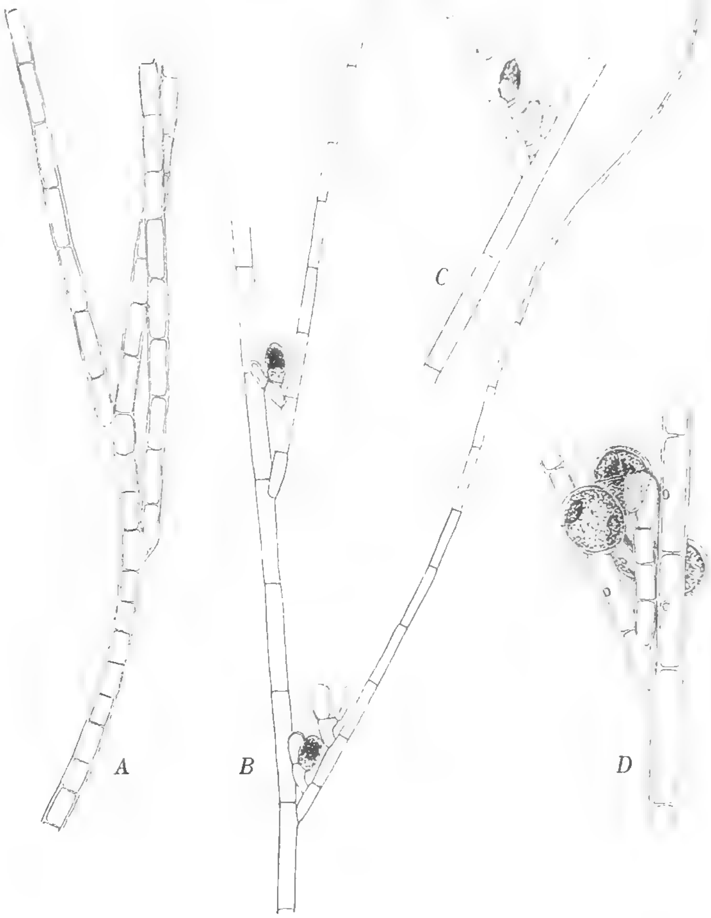


Fig. 32.
Chantransia Thuretii β, *agama*. *A—C* from ZL^1. 265 : 1, *A* from the lower, *B* from the upper part of the plant. *C*, branch with sporangia, partly 2 on each cell. *D*, from aF. 345 : 1, branchlet with tetrasporangia. The pyrenoids have been drawn in some of the cells.

Some specimens growing on *Flustra foliacea* dredged in the Skagerak N.W. of Hirshals in May (no. 7109) may be mentioned here, as they are somewhat different in the smaller size of the sporangia and the more irregular position of the sporangia-bearing branchlets. These were namely not restricted to the inner side of the branches but occurred on all sides of the filaments and at various distances from the base, and the sporangia were usually only 11—14 μ long, 7,5—8 μ broad; one, however, was found to be 16 μ long, 9,5 μ broad. The sporangia were for a great part emptied, and new were formed within the sporangial wall from the underlying cell. As these specimens agreed otherwise with the f. *agama*, and as they were found only in very small number, I may content myself with just naming them here; it need only be pointed out that they showed short descending filaments near the base.

Ch. Thuretii β, agama occurs in depths of 2—31 meters. In the Limfjord it has been observed in depths of 2—7 meters, in the other waters only in depths greater than 9,5 meters. It has been found growing on 14 different species of Algæ, as species of *Polysiphonia*, stipes of *Laminaria*, *Delesseria sangvinea*, *Gloiosiphonia*, *Desmarestia aculeata*, *Fucus serratus*, further on *Zostera*-leaves and on *Flustra foliacea*. It has only been found in the months June to September, except the above named, somewhat aberrant specimens collected in May. Ripe sporangia have been met with in all the months named.

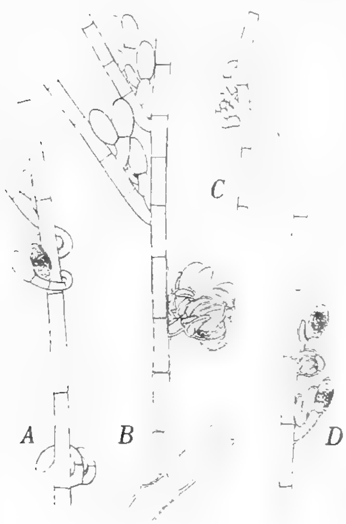


Fig. 33.
Chantransia Thuretii β, agama. From TP. Parts of filaments with crooked branchlets rising mostly from the sporangiferous branchlets. 300 : 1.

Localities. **Ns:** aF, 31 meters. — **Sk:** ZK^{6} off Lønstrup, 11—13 met.; (? N.W. of Hirshals, 13—15 met., May, no. 7109). — **Lf:** ZU, 3 met., and XU, 4 met., in Nissum Bredning; MH in Thisted Bredning; off Grønnerup in Sallingsund, ca. 2 met.; LS and MI East of Mors. — **Kn:** Herthas Flak, 20—22,5 met. (!, Børgs.); Frederikshavn; ZL^{1} N. of Læsø, 9,5 met.; FF and TP, Trindelen, ca. 15 met. — **Ke:** Fladen, 22,5 met. — **Ks:** EM, Lysegrund. — **Sa:** MQ, S. of Samsø, 11,5 met. — **Lb:** N. of Fænø Kalv, 13 met.

7. **Chantransia Daviesii** (Dillw.) Thur.

Thuret in Le Jolis Liste p. 106; Kylin (1907) p. 117 fig. 27.
Conferva Daviesii Dillwyn, Brit. Conf. 1809 p. 73, pl. F (teste specim.).
Callithamnion Daviesii Harvey, Phyc. Brit. pl. 314; J. Agardh Sp. III p. 8.
Acrochætium Daviesii Nægeli (1861) p. 405; Bornet (1904) p. XXII.

This species is as a rule easily recognizable by its fairly thick, thick-walled and short-celled filaments and by its fasciculated sporangia-bearing branchlets. It is undoubtedly nearest related to *Ch. Thuretii* which it may sometimes very closely resemble, while it is very different from *Ch. virgatula* with which it was formerly often confused. Although it was the first described of all the marine species of the genus, it is imperfectly known in some respects, for which reason a short description of the Danish specimens may be given here.

The basal part consists of branched creeping filaments which may become so densely interwoven that they form a continuous basal disc. When the plant is growing on an irregular surface, as e. g. the stalk of *Laminaria hyperborea*, the filaments are very irregularly curved and may grow over one another, and the basal part may thus become two or even three cells thick, as stated by HARVEY GIBSON (Journ. of Bot. 1892 p. 104), but a real parenchymatous disc I have never seen. From the basal layer numerous erect filaments appear, forming 6 mm. high clusters. The filaments are usually 9—12 μ thick, but the thickness may vary from 8 to 13 μ. The cells are usually 2—4 times as long as broad (more rarely 1—5 times). The cells contain a parietal chromatophore with a well developed pyrenoid, very prominent in the interior of the cell; sometimes the pyrenoid is so large that the part of the chromatophore in which it lies reaches nearly to the part of the same chromatophore on the opposite side of the cell (fig. 34 *F*). According to KYLIN (1907 p. 118) hairs rarely occur, a sporangia-bearing branchlet terminating in a hair instead of a sporangium. I have never seen unicellular hyaline hairs; on the other hand the fertile branchlets were often found tapering into very thin hair-like filaments, the cells of which become longer and thinner and decoloured upwards (fig. 34 *C*), as in *Ch. Thuretii*.

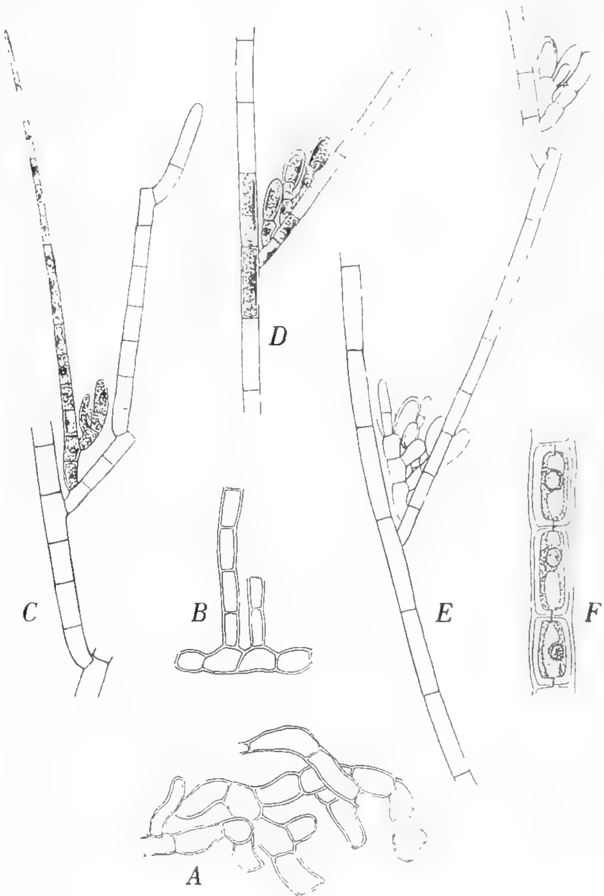


Fig. 34.
Chantransia Daviesii. *A* and *B*, basal parts of plants growing on the stalk of *Laminaria digitata* seen from above and from the side. *C—E*, erect filaments with sporangia-bearing branchlets. *F*, three cells showing the chromatophore (December). *A—E* 300 : 1, *F* 390 : 1.

The sporangia are always situated on branchlets which are more or less branched; the most vigorous are repeatedly branched and consist of at least 3 generations of branches, the youngest of which is situated on the inner side of the foregoing, so that the branchlet gets the form of a fan-shaped fascicle. These branchlets are mainly placed in the axils of the branches, on the inner side of their undermost cell, but they may also occur scattered on the sides of the principal filaments. In the first case one fascicle only is placed in each axil, especially when the branchlet is well developed, but not rarely two less branched branchlets are placed the one over the other (fig. 34 *D*), and there is then a resemblance with *Ch. Thuretii*; typical sporangia-bearing fascicles are, however, always to be found on the same plants. I found always only monosporangia, but KYLIN states (1907 p. 118) that tetrasporangia may occur together with the monosporangia. The size of the sporangia was found to be somewhat different, the length varying from 11 to 19 μ, the breadth from 8 to 10 μ. It seems however that two groups of sporangia are distinguishable with regard to the size, the one being 11—14 μ long, 8—9 μ broad, the other 15—19 μ long, 9—10 μ broad, and one kind of sporangia is always only to be found on the same plant. As I have not found these differences of size connected with other differences, I have not thought it necessary to distinguish the two kinds of individuals.

It will be seen from the above that this species must be considered related to *Ch. Thuretii*; it differs from the asexual form of this particularly by somewhat thicker filaments, shorter cells and smaller sporangia being placed, at any rate in part, on repeatedly branched branchlets situated in the axils of the branches.

The species occurs epiphytically on various Algæ, especially *Laminariæ*, on the stalks as well as on the blade, in particular on the borders of the segments of the digitate species; further it has been met with on *Flustra foliacea* and once on *Littorina littorea*. It has been collected in 1 to 23,5 meters depth. It is certainly perennial or may be so. It has been found, in all cases with sporangia, in the months of May to December, in November and December in a great measure with empty sporangia.

Localities. **Ns:** aD, 23,5 met. — **Sk:** N.W. of Hirshals, 11 to 15 met. — **Kn:** XK, TX and TU near Hirsholmene; Krageskovs Rev, 5 met.; port of Frederikshavn; Busserev; Borrebjergs Rev; TP, Tønneberg Banke, 16 met. — **Ke:** Lille Middelgrund, on *Odonthalia*, 17 to 19 met. — **Sb:** Kerteminde, 9,5 to 11,5 met., on *Littorina littorea*.

8. **Chantransia attenuata** sp. nov.

Discus basalis bene evolutus, unistratosus, e filis repentibus confluentibus, cellulis fere isodiametricis, constructus. Fila erecta sat numerosa, parce ramosa, apicem versus sensim attenuata, usque ad 550 μ longa, basi 6,5—7 μ, superne c. 5 μ crassa, cellulis inferioribus diametro c. duplo, superioribus 3—4-plo longioribus. Chromatophorum ut videtur unicum parietale, pyrenoide laterali instructum. Rami sparsi vel oppositi. Crescentia apicalis sæpe sistitur, formatione pili vel sporangii (?), et rami oppositi infra apicem extinctum egrediuntur. Monosporangia 7,5—9 μ longa, 4,5—6 μ lata, in ramulis unicellularibus solitaria vel bina, vel in ramulis majoribus plura sessilia, pedicellata et terminalia conferta.

This species has only been met with once, growing on *Desmarestia aculeata* dredged in the Limfjord in August, and was then in a rather advanced stage of development. As moreover I have had only rather few dried specimens for examination, my description is in some respects incomplete; the species seems, however, to be distinct from all known species.

The well developed basal layer resembles that of *Ch. Thuretii*. As the most striking character may be mentioned the frequent occurrence of opposite branches, which, however, were only found when the growth of the filament was stopped seemingly by the formation of a terminal hyaline hair. The hair had usually disappeared, leaving only a faint scar, in some few cases it was still visible (fig. 35 B). The principal filaments consist in their lower part of short cells, about twice as long as broad; upwards the filaments become gradually somewhat thinner, and the cells at the same time longer. On the whole, the filaments are not much branched. Owing to the defective state of preservation of the material I have not been able to determine with certainty the form of the chromatophore. In some cases, however, I have seen that it is parietal, and I suppose it to be single and to have one parietal pyrenoid.

Fig. 35.
Chantransia attenuata. *A*, plant the basal layer of which is seen from the under face. 350 : 1. *B* and *C*, upper ends of filaments with sporangia. 560 : 1.

The position of the sporangia is somewhat variable; they occur mostly in the upper part of the plant and are relatively often placed singly, more rarely two together on unicellular branchlets, or they are, though rarely, sessile on the filaments. Sometimes a greater number is placed on somewhat larger, often branched branchlets, but such branchlets grade evenly to the long filaments. The sporangia-bearing branchlets show usually no distinct arrangement on the filaments.

The species is perhaps related to *Ch. Thuretii*; it differs from it by the opposite branches and the small sporangia.

Locality. **Lf:** MA in Nissum Bredning, 5 meters, on *Desmarestia aculeata*.

9. **Chantransia stricta** sp. nov.

Discus basalis unistratosus e filis lateraliter confluentibus compositus. Fila erecta pauca e centro disci egredientia simplicia vel subsimplicia, stricta, usque ad 1 mm. et ultra longa, 6—7 μ crassa, ramulos sporangiferos per totam fere longitudinem gerentia; cellulæ 3—4.5 diametra longæ, chromatophorum parietale, pyrenoide instructum continentes. Ramuli sparsi, nonnunquam secundati, erecti, uni—bicellulares, monosporangia 2—3 gerentes, nonnunquam piliferi. Sporangia anguste ovata, (12—) 13—14 μ longa, (5—) 6—7 μ lata.

Fig. 36.
Chantransia stricta. *A*, lower part of a plant. *B*, fragment of the middlemost part, and *C*, the upper part of the same plant. 350:1.

This species is characterized by its straight erect filaments which are unbranched or bearing at most a single branch of the same kind as the principal filament. The direction of this is usually not at all influenced by the numerous lateral fertile branchlets, one of which is usually placed on nearly every one of the cells from the base to the top. The branchlets are situated on all sides of the filament, but not infrequently a number of consecutive branchlets are placed on the same side (fig. 36 *C*). Most of the branchlets are unicellular and bear 2 sporangia, but two-celled branchlets are also frequent, while such consisting of more than two cells are rare. In well developed filaments sessile sporangia do not usually occur, but they may be found in feebly developed filaments (fig. 36 *A* at left). Hairs are often met with at the end of the branchlets and marks of decayed hairs are frequently visible. The sporangia are relatively narrow, twice as long as broad. As I have only had occasion to examine a small number of dried specimens, I cannot give any information on the development of the basal layer.

As far as I can see, this species cannot be identified with any of the more exactly described species. The nameless species described by Reinsch (Contrib. ad Alg. et Fung. 1877 p. 38 pl. XII fig. 1—2) which also has unbranched filaments, (setting aside the branchlets) differs among other things by its much smaller dimensions, shorter cells, less erect branchlets and more roundish sporangia.

Only found in small quantity together with other species of *Chantransia* on *Polysiphonia nigrescens* in depths of 7,5 to 11,5 meters, in July and August.

Localities. **Km**: BH off Gjerrild Klint. — **Ks**: D, N. of Isefjord. — **Sa**: AH[1] off Fyens Hoved.

10. **Chantransia virgatula** (Harv.) Thur. emend.

I have for a long time been in doubt whether the forms mentioned under this species ought to be regarded as distinct species or as forms of one species. It is easy to point out within this group of forms some fairly different types, and I tried at first to carry out the first alternative, but I then repeatedly met individuals which might apparently with equal right be referred to one or other of the presumed species. As the delimitation of the species seemed not to be facilitated by the establishment of new species embracing the intermediate forms nor by division otherwise of the forms, I have ended by referring them all to one species. My observations have led me to the view, that this species is able to take various forms under different conditions. I dare not deny that any form referred to it may possibly prove on closer examination to be a distinct species, but as I have not been able to draw the limits, I have judged it best to keep them together.

The species was first described by Harvey in 1833 and figured by the same author in Phyc. Brit. pl. 313 (1851), where it was represented with tetrasporangia, showing even partly tetrahedral division. The last must at all events be wrong, and it has also been supposed by Thuret (Le Jolis Liste p. 104) and later authors that the statement of tetrasporangia was founded on some mistake. It was then generally accepted, that this species, as well as all other species of *Chantransia*, had only monosporangia, until Schmitz and Hauptfleisch briefly mentioned (1896 p. 331) that tetrasporangia may occur together with the monosporangia in *Ch. secundata*. Later the same was observed in *Ch. virgatula* by Børgesen and Kuckuck (Børgesen 1902 p. 351), and the observation of Schmitz was confirmed by Børgesen (l. c. p. 350) and Kylin (1907) for *Ch. secundata*. I have also found tetrasporangia in the latter but in particular in a form coming near to the typical *Ch. virgatula* (f. *tetrica*).

As will be shown below, the forms referred to this species differ principally in the nature and intensity of the ramification, the length of the cells and the number of spores in the sporangia; in other respects they are quite alike. Thus, the structure of the cells is the same. The chromatophore contains an axile pyrenoid situated in the upper part of the cell and gives off a number of branches downwards and upwards; under the chromatophore a nucleus is visible. The germination takes place in the same manner in all the forms, the germinating spore dividing by excentric walls into an inner triangular and three peripheral cells, without changing the orbicular outline (figs. 37 *C*, 38 *A*—*C*, 39 *C*—*D*, 40 *E*, 41 *A*), (comp. Murray and Barton (1891) p. 212 pl. 37 fig. 5; Kylin (1907) fig. 24). Some small differences may sometimes occur (fig. 40 *F*), but the greater part of the spores germinate as described. The orbicular outline of the basal disc may sometimes hold out for a long time, in other cases some of the peripheral cells grow out to creeping filaments at an early period (figs. 39, 40). The number of erect filaments given off from the basal disc is usually low; the first is produced by the central triangular cell, the following from the neighbouring cells.

a, luxurians (J. Ag.).

Callithamnion luxurians J. AGARDH Sp. II p. 14.
Chantransia luxurians KYLIN l. c. p. 117 fig. 26.
Callithamnion virgatulum CROUAN Alg. mar. Finist. p. 116.
Chantransia virgatula THURET in Le Jol. Liste p. 106; KYLIN (1907) p. 116 fig. 25; BØRGESEN, M. A. Fær. p. 351 fig. 52.
Trentepohlia virgatula FARLOW Mar. Alg. New Engl. p. 109 pl. X fig. 3.

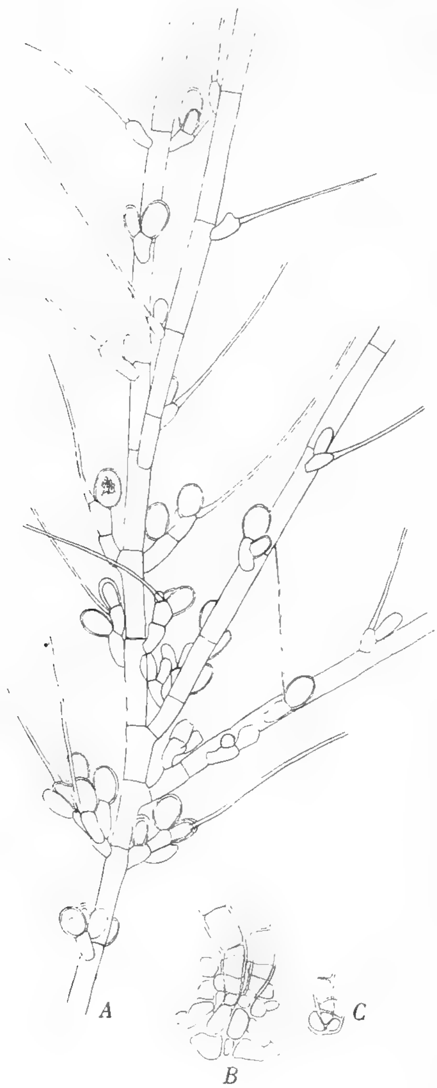


Fig. 37.
Chantransia virgatula a. luxurians. *A*, part of plant with sporangia. *B*, basal part. *C*, basal part of young plant. 260 : 1.

This form which corresponds to the *Ch. virgatula* in the common restriction of the authors is the commonest form in the Danish waters. It has two or three generations of long filaments, which are straight, up to 2 mm. long, 10 to 14 μ thick, more rarely up to 16 μ thick or even thicker, consisting of cells 3 to 5 times as long as broad. There is a distinct contrast between the long filaments and the branchlets which occur in great number, one or two on each cell of the filaments, in the first case often secund, in the latter usually opposite; they are usually 1 to 3 cells high, unbranched or branched and bear generally two or more sporangia and most frequently also one or more vigorous hairs. The sporangia are monosporous, ovate or broadly ellipsoidal 17—21 (—26) μ long, 13—16 (—19) μ broad.

Under this species I have included two forms regarded by KYLIN as distinct species, namely *Ch. virgatula* and *Ch. luxurians*, because I have not been able to distinguish them after the alleged characters. In most of the Danish specimens the thickness of the filaments varies between 11 and 13 μ, thus within the limits indicated for *Ch. luxurians* by KYLIN, and the dimensions of the sporangia also agree with the measurements indicated for this species. On the other hand, the specimens with thicker filaments, thus agreeing better with *Ch. virgatula* KYLIN, had not shorter, approximately globular sporangia as indicated by KYLIN, but were of the same dimensions. The thickest filaments were found in some specimens from Lysegrund in Ks (9,5 meters); they varied from 13 to 20 μ in thickness, the cells were thick-walled, 3 to 4 times as long as broad, the sporangia 17,5—19 μ long, 14—15 (16) μ broad. As a contrast to these some specimens may be mentioned which were found growing on *Porphyra umbilicalis* in Thyborøn Channel (Lf); they agreed on the whole fairly well with this form, but the filaments were only 7—8 μ thick. Such a small thickness I have otherwise never observed in the specimens referred to this form, though certainly in f. *secundata* which occurs along the west coast of Jutland; I imagine that these specimens may have originated from f. *secundata* but have developed in a more sheltered locality. It deserves notice that groin no. 63 is more sheltered than no. 62 where f. *secundata* was found growing, and that the species has otherwise not been found in the Limfjord with the exception of at Hals at the eastern entrance of the fjord where f. *secundata* has been met with. — For the rest the specimens referred to this form are on the whole homogenous.

This form has been found in all the Danish waters within Skagen, from low-water mark to 11,5 meters depth. The specimens found at Bornholm are typical but not very vigorous and with little branched filaments. It was mostly met with in the summer months and is undoubtedly mainly a summer Alga; for the rest it has been met with in the months April to November, in all cases with sporangia. It was most frequently found growing on *Polysiphonia violacea* and *nigrescens*, further on *Ceramium rubrum* a. o. species, *Cystoclonium*, *Zostera*-leaves, *Porphyra umbilicalis* and *Sertularia pumila*.

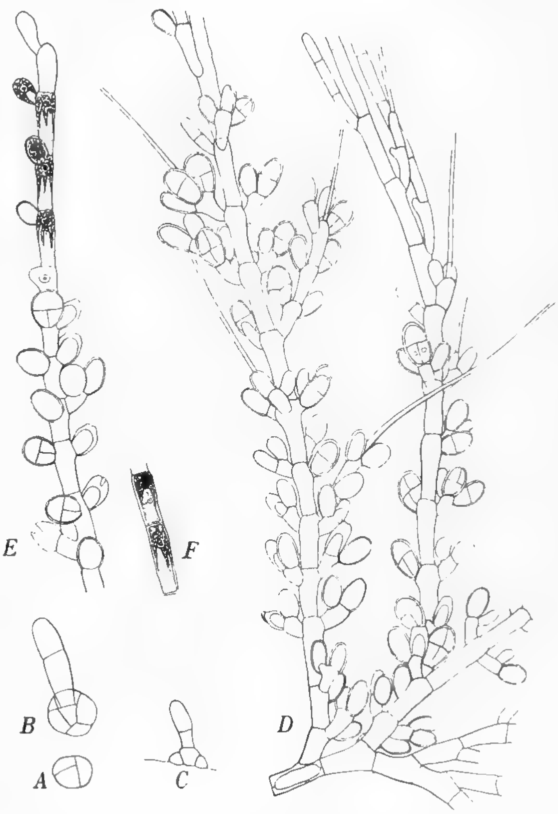


Fig. 38.
Chantransia virgatula β, *tetrica*. *A*, *B* and *C*, young plants seen from above and from the side. *D*, branched filament with tetrasporangia mostly on opposite branchlets. *E*, filament with sessile tetrasporangia. *F*, two cells showing the chromatophore. 265 : 1.

Localities. **Lf**: Thyborøn Channel, groin no. 63, otherwise not found in the Limfjord. — **Kn**: Harbour of Skagen; Hirsholm; Frederikshavn (Th. Mortensen, !); Nordre Rønner; stony reef by Jegens Odde (GM). — **Ks**: Lysegrund; D, 11,5 meters. — **Sa**: Rønnen in Begtrup Vig; Kalø Rev; AS, Mejlgrund. — **Lb**: Fænø. — **Sb**: Kertinge Vig. — **Sm**: Petersværft; Guldborgsund. — **Su**: BQ, off Ellekilde; Helsingør; Copenhagen. — **Bm**: QP, Kalkgrund; QR, Gyldenløves Flak. — **Bb**: Rønne; off Allinge.

β, *tetrica* nob.

Filaments (8—) 9—12 μ thick, cells 2—4 diameters long, sporangia on opposite branchlets or sessile on the long filaments, all or partly tetrasporous and then 19—22 μ long, 13—17 μ broad.

The above diagnosis is made after specimens growing on *Porphyra umbilicalis* in the harbours of Skagen and Frederikshavn. They are somewhat more branched than f. *luxurians* and have a little thinner filaments and shorter cells. The sporangia are very numerous and, at least in many specimens, all tetrasporous. They are in a great measure placed on branchlets which are usually opposite, partly also sessile on the sides of the filaments. From the characters mentioned this form is, in spite of its great resemblance, so different from the main form, that I was for some time inclined to regard it as a distinct species, but some other less pronounced specimens have led me to the result that it is closely related to the f. *luxurians* and still more to the f. *secundata*. Thus I found at Middelfart some specimens having chiefly monosporangia, 16—20 μ long, 11—13 μ broad, but also some tetrasporangia, and the sporangia were placed on the filaments as well as on the branchlets. These specimens might be regarded as intermediate between f. *luxurians* and f. *tetrica*, but they were also related to f. *secundata*, differing however by longer cells (3—5 diameters long). The resemblance between the f. *tetrica* and f. *secundata* will be seen on comparing fig. 38 with fig. 39. To this form at least some of the Færoese specimens mentioned by Børgesen (l. c. fig. 53) may be referred.

Only found in summer, the typical specimens growing on *Porphyra umbilicalis*.

Localities. **Kn**: Harbours of Skagen and Frederikshavn. — **Sa**: Middelfart, on *Cladophora*.

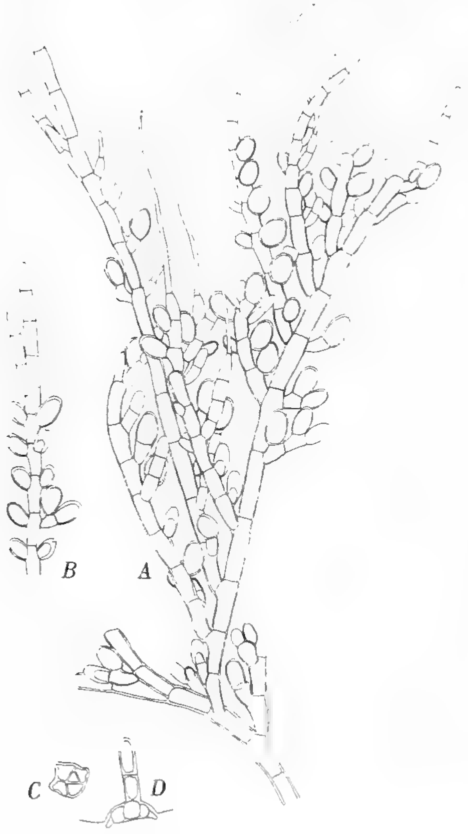


Fig. 39.
Chantransia virgatula γ, *secundata*. Plants growing on *Porphyra umbilicalis* at Esbjerg. *A* and *B*, branched filaments with monosporangia. *C* and *D*, young plants. 260 : 1.

γ, **secundata** (Lyngb.).

Callithamnion Dawiesii β, *secundatum* Lyngb. Hydr. p. 129 tab. 41.
Acrochætium secundatum Næg. Beitr. Ceram. p. 405.
Chantransia secundata Thur. in Le Jol. Liste p. 106; Børgesen, M. A. Fær. p. 350; Kuckuck in Oltmanns, Morph. Alg. I p. 650; Kylin (1907) p. 115.

That *Ch. virgatula* and *Ch. secundata* are nearly related and often difficult to distinguish from each other has often been admitted, also by Børgesen and Kuckuck, who think however that for the present they ought be kept distinct (Børgesen l. c. p. 354). I have also wished to regard *Ch. secundata* as a distinct species, but I have ended by referring it as a form to *Ch. virgatula*, as the limit between them, according to my experience, cannot be drawn without arbitrariness. As mentioned above, tetrasporangia have been found together with monosporangia by earlier authors in this form; I have found the same in Danish specimens in some few cases, but I was then usually in doubt whether the specimens ought to be referred to this or to the foregoing form. They pass really, in my experience, gradually into each other.

The filaments are much branched, more than in f. *luxurians*, often very much branched, and the branches are then usually lying in one plane, being secund or opposite. There is no distinction between branches and branchlets. The filaments are 7—12 (—14) μ thick, the cells 1—3 times as long as broad. The sporangia are nearly always

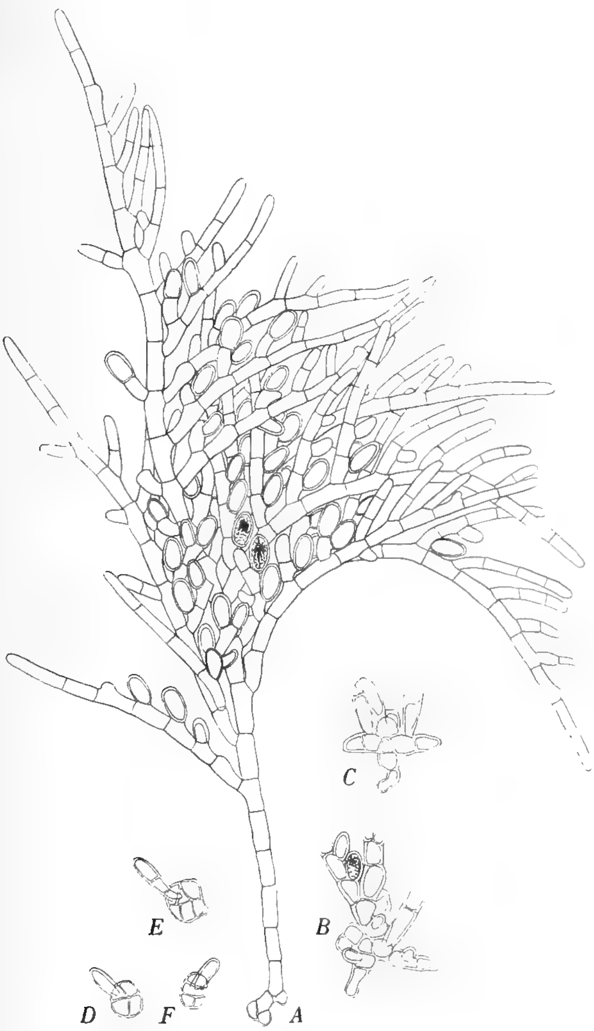


Fig. 40.
Chantransia virgatula γ, ***secundata.*** Plants growing on *Porphyra umbilicalis* at Thyboron. *A*, much branched plant with monosporangia. *B* and *C*, basal portions of plants. *D—F*, young plants seen from above. 260 : 1.

Fig. 41.
Chantransia virgatula γ, *secundata.* Plants growing on *Porphyra umbilicalis* at Thyboron. *A*, young plant. *B*, plant with monosporangia. 260 : 1.

monosporous, (13—) 15—20 (—21) μ long, (9—) 10—14 (—15) μ broad. They are sessile on the sides of the filaments or terminal and lateral on the branchlets. The sporangia as well as the sporangia-bearing branches are often secund, and then situated on the upper, inner side of the branches (fig. 40 *A*), but they may also be opposite or at least situated two on the same cell (figs. 39, 41). The basal layer is sometimes proportionally much developed (fig. 41), but like KYLIN I found it always consisting of one layer of cells, while PRINGSHEIM (Beitr. Morph. Meeresalg. p. 26 Taf. VII fig. 2), BØRGESEN and COLLINS (1906 p. 194) found it consisting of two or several layers.

While this form in its typical shape is quite distinct from the typical f. *luxurians*, intermediate specimens may sometimes occur. In my opinion it is a reduced form of the species produced by growing near the low-water mark, where it may sometimes be exposed to the air. On the Danish shores it has only been found at the low-water mark, on the west coast of Jutland even at a higher level. It has been found growing on *Porphyra umbilicalis*, *Sertularia pumila*, *Chætomorpha Melagonium* and *Polysiphonia nigrescens*, in the months January to August.

Localities. **Ns:** Esbjerg; groin no. 62 by Thyborøn. — **Sk:** Hirshals mole. — **Lf:** Hals. — **Kn:** Frederikshavn, harbour (!, TH. MORTENSEN, C. H. OSTENFELD).

11. **Chantransia Macula** sp. nov.

Thallus minutus membranaceus monostromaticus fere orbicularis, diametro usque c. 70 μ, substrato adhaerens, initio parenchymaticus; dissepimentum primum medianum, sequentia obliqua; postea cellulæ marginales in fila repentia plus minus radiantia excrescunt. Cellulæ c. 4 μ crassæ, diametro sesqui- ad duplo longiores, chromatophorum stellare pyrenoide centrali instructum continent. Fila erecta sparsa brevissima paucicellularia simplicia plerumque e disco egrediuntur. Pili hyalini in filis radiantibus erectisque terminales hinc illinc occurrunt. Sporangia monospora in disco sessilia vel in filis erectis terminalia, ovata, long. 10—11,5 μ, lat. 6,5—7 μ.

This very small species has been found growing on *Polysiphonia violacea* together with several other species of *Chantransia*. It is very characteristic from its thin disc-shaped frond of an irregular outline, approaching however the circular, and corresponding to the basal layer of the more developed species, while the erect filaments are wanting or much reduced. The germinating spore divides always by a median vertical wall, and oblique walls then appear in the two daughter-cells, frequently resulting in the formation of two inner, triangular and four outer cells (fig. 42 *A*, *B*, *F*). The orientation of the walls may be somewhat variable, but in the central part of the more developed discs one or two triangular cells are usually recognizable, thus indicating the place of the first division wall. In some cases one of the primary daughter-cells only is divided by oblique walls (fig. 42 *D*), and more rarely both cells are divided by a wall parallel to the first. The plant keeps for some time its parenchymatous character and a fairly regular outline, often up to the eight-celled stage, but then the marginal cells begin to grow out into creeping filaments which from the first may be rather irregular but later by the increasing number become more regularly radiating, forming a pseudoparenchymatous disc with irregular border formed by the separate ends of the filaments. The filaments branch laterally from the subterminal cells or by subdichotomous division of the terminal cell (fig. 42 *H*). The cells are somewhat various in shape, usually longer than broad, and contain a stellate chromatophore with central pyrenoid which is usually situated in the median line of the cell, sometimes however nearer to the one side of the cell. The hairs appear in various quantity, sometimes already in the parenchymatous stage (fig. 42 *A*). The erect filaments, if they are not entirely wanting, appear in rather small number spread on the disc; I have found them one to three cells long, scarcely 4 μ thick. The sporangia are placed directly on the basal disc or terminal on the erect filaments; they were not very numerous in the specimens examined.

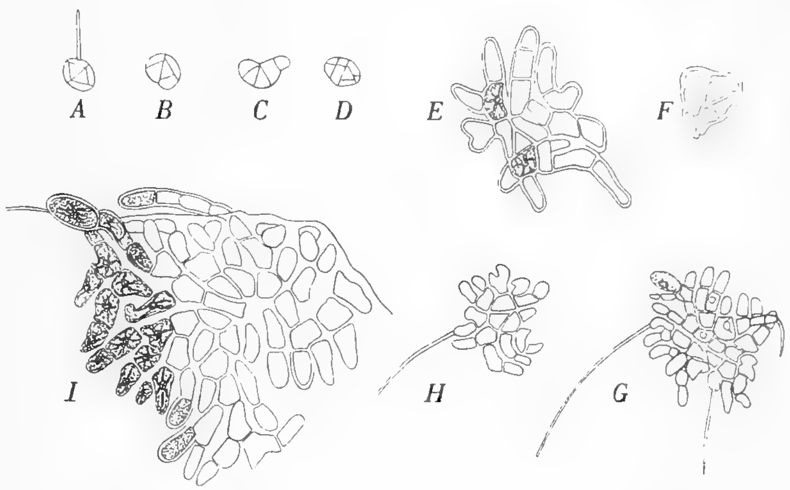


Fig. 42.
Chantransia Macula. *A—D*, young plants in the parenchymatous stage. *E*, older plant, with marginal cells growing out into filaments. *F*, parenchymatous disc. *G—I*, more developed discs, partly with erect filaments and sporangia. *A—E* from BH, *F—I* from AH[1]. *A—D*, *G—H* 390 : 1; *E*, *F*, *I* 630 : 1.

The species is easily distinguishable from all other species by the characteristic disc and the position of the sporangia. It has been found in August and September in depths of 7,5 to 11,5 meters.

Localities. **Km:** BH off Gjerrild Klint. — **Sa:** AH[1] by Fyens Hoved; MQ, S. of Samsø.

12. **Chantransia polyblasta** sp. nov.

Thallus cæspitulosus. Pars basalis e filis repentibus, ramosis, initio saltem inter se discretis, constructa. Spora germinans dissepimento verticali diametrali in duas cellulas aequales dividitur, quarum utraque filum repens procreat. E filo primario lateraliter fila repentia et sursum fila erecta numerosa per totam longitudinem egrediuntur. Fila erecta usque ad c. 270 μ longa, maxima ex parte brevia, longiora ramosa, ramis ramulisque numerosis in quoque articulo singula vel bina, ramis majoribus eodem modo ramosis. Pili hyalini apicibus filorum et ramulorum impositi occurrunt. Cellulæ 7—10 μ crassæ, diametro 2—3 (—4)-plo longiores, chromatophorum stelliforme, pyrenoide centrali instructum, continentes. Sporangia tetraspora, ovata, (16—) 18—21 μ longa, 10—12 μ lata, in filis erectis primariis vel in ramis lateralia vel terminalia, lateralia sessilia vel in ramulis unicellularibus vulgo singula.

In its mode of growth this species resembles the species *Ch. Dumontiæ* and *Ch. cytophaga* described below. The germinating spore divides, as in these, into two equal cells giving rise to two creeping filaments growing out in opposite directions and giving off new creeping filaments which appear to be later confluent into a pseudoparenchymatous disc in the central part of the basal layer. Usually one erect filament is given off from each of the cells of the basal layer, the outer as well as the inner, and not rarely the same cell gives off two filaments, the one behind the other (fig. 43 *E, F*). Most of the filaments attain only a small size and remain unbranched, but some of them grow out and become much branched. The most vigorous filaments are much and repeatedly branched; usually each cell bears one or two branches, long filaments or branchlets, but there is no distinction between these two kinds of branches, as transitions between them frequently occur. When two branches are borne by the same cell, they are very often not opposite but placed near each other on the same side of the cell. In fig. 43 *E, F* the last cell of the creeping filament is seen to be somewhat raised above the substratum and ends in a hair. Transitions between creeping and erect filaments thus appear to occur; however, I have never seen the transformation of a creeping filament into a true erect one. The cells are cylindrical, by ramification frequently a little broader at the upper end. The stellate chromatophore contains a distinct central pyrenoid.

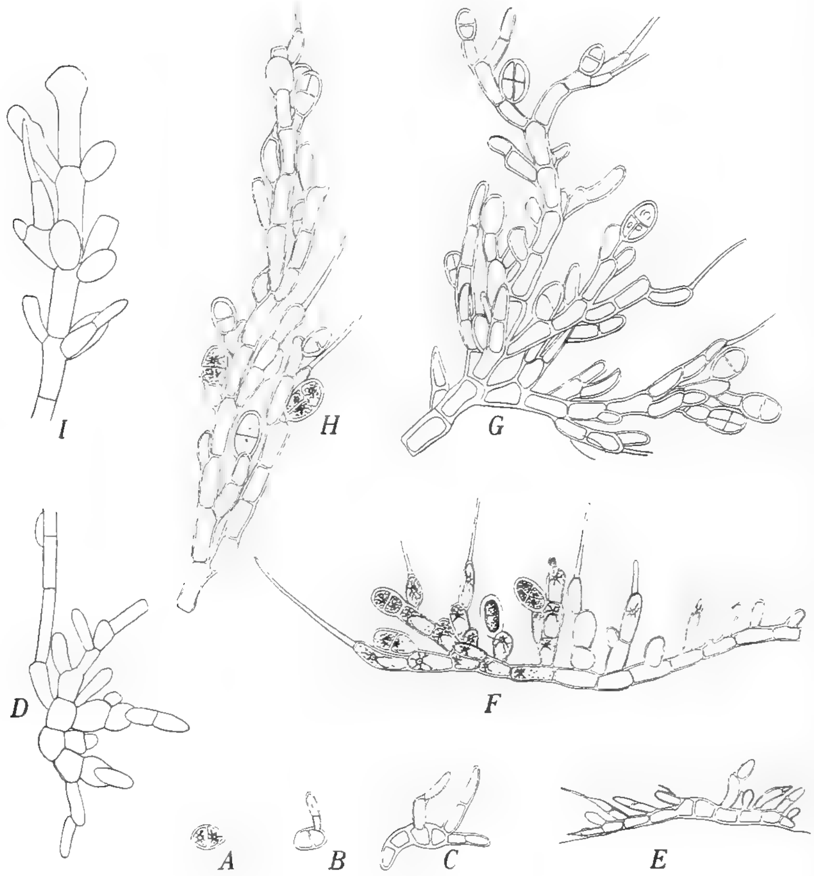


Fig. 43.
Chantransia polyblasta. (From Hals). *A—C*, young plants seen from above. *D*, more developed plant seen from above. *E, F*, plants seen from the side with short erect filaments. *G, H*, more developed, branched erect filaments, *I*, end of erect filament. *A—C, E—H* 300:1, *D, I* 390:1.

The sporangia are very often sessile on the sides of the filaments; the same cell then also bears frequently a branch or a branchlet, or it may bear up to four lateral organs (fig. 43 *I*). But the sporangia may also be terminal on the filaments or on one-celled branchlets. It also sometimes happens that the sporangia are produced directly by the creeping filaments. The sporangia are always tetrasporous; monosporangia were never observed.

As mentioned above, the mode of growth somewhat resembles that of *Ch. Dumontiæ*; it differs mainly by being throughout epiphytic. In examining numerous sections of *Cystoclonium* covered with *Ch. polyblasta*, I have once only seen a creeping filament penetrating through the surface of the host, but the surface was there evidently injured. As another difference may be named that the chromatophores have a distinct pyrenoid in *Ch. polyblasta* while such a body is not to be found in *Ch. Dumontiæ*. As to its relation to *Ch. humilis* see this species.

The species has been found in spring (April, May) in two localities in the northern Kattegat and at Hals at the eastern entrance to the Limfjord. It occurred in greatest quantity in the last named locality, where it was found growing on *Cystoclonium purpurascens,* collected by Dr. Børgesen; in the other localities it was growing on *Polysiphonia nigrescens.*

Localities. **Lf:** Harbour of Hals (Børgesen). — **Kn:** Krageskovs Rev, 4—5,5 meters; harbour of Frederikshavn (Børgesen).

13. **Chantransia humilis** sp. nov.

Thallus pulvinatus. Pars basalis e filis repentibus ramosis breviarticulatis in parte centrali demum confluentibus, constructa. Spora germinans in duas cellulas æquales divisa est, quarum utraque filum repens procreat. E filis primariis lateraliter fila repentia et superne fila erecta numerosa per totam longitudinem, e quaque cellula 2—3, egrediuntur. Fila erecta brevia, 2—4-cellularia, c. 60 μ alta, simplicia; cellulæ apicem versus sensim incrassatæ, superne 5,5—7 μ crassæ, diametro 2—3-plo longiores, chromatophorum axile, pyrenoide centrali instructum continentes. Pili hyalini apicales crebri. Sporangia monospora ovata vel oblonga, long. 11—14 μ, lat. 7 μ, in filis erectis terminalia vel lateralia.

In its mode of growth and the structure of the cells this species somewhat resembles *Ch. polyblasta*, from which it differs however by its short, unbranched, erect filaments and by the smaller, monosporous sporangia. The basal layer develops as in the species named; as shown in fig. 44 *D*, the germinating spore is nearly globular, much higher than the primary creeping filaments, and the two primary cells are for a long time recognizable from the other cells in the basal layer. In fully developed plants the creeping filaments are more or less confluent in the inner part of the plant; the cells are there usually short, roundish, 7—9 μ broad. The formation of the erect filaments begins as a rule when the basal layer is two-celled (fig. 45) but I have in some cases seen an erect filament given off from a basal cell still undivided. Hyaline hairs frequently occur at the end of the erect filaments, more rarely at the sides of them. It appears that the usual displacement of the originally terminal hairs occurs also in this species, but that the hairs soon disappear; the fact that the upper end of the cells is usually prominent at one side is in accordance with this supposition. The hairs may appear already in the two-celled stage of the plants (fig. 44 *C*). The erect filaments seem to be always unbranched; their great number in conjunction with their small size give the plant a pulvinate appearance. The cells of the erect and creeping filaments, as well as the sporangia, contain a stellate chromatophore giving off a number of branches towards the periphery. The species has hitherto only been found in one locality, growing on *Polysiphonia nigrescens* in May.

Locality. **Sb:** pier at Spodsbjerg, Langeland.

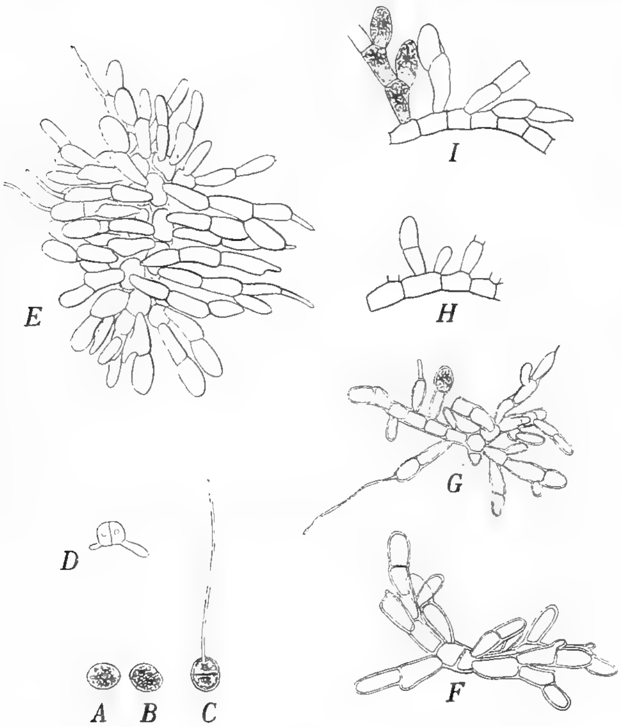


Fig. 44.
Chantransia humilis. *A—C*, germinating plants, *C* with a hair. *D*, the two first creeping filaments are given off; the pyrenoids are shown. *E*, adult plant seen from above. *F*, *G*, plants seen from above, *G* with sporangium. *H*, *I*, plants seen in vertical section, *I* with lateral sporangia. *A—F*, *H*, *I* 390:1. *G* 300:1.

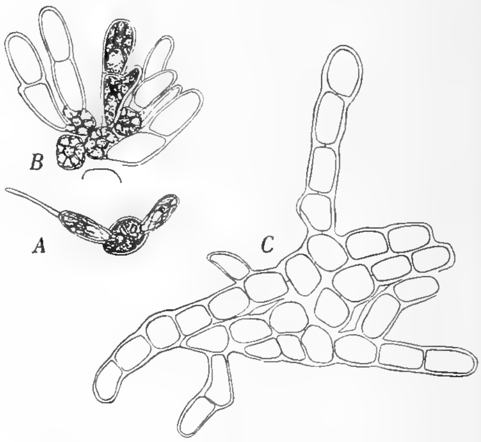


Fig. 45.
Chantransia humilis. *A*, young plant, seen from above. *B*, part of a plant showing the basal layer and erect filaments with terminal sporangia. *C*, basal layer seen from below. 560:1.

14. **Chantransia leptonema** sp. nov.

Thallus minutus e filis repentibus et filis erectis numerosis constructus. Fila repentia irregularia, lateraliter ramosa, plerumque ut videtur inter se libera, cellulis plus minus tumidis, lat. 3—4 μ, diametro sesqui- ad triplo longioribus. Spora germinans discum parenchymaticum serius in fila repentia excrescentem gignit. Fila erecta simplicia vel parce ramosa, usque ad 300 μ longa, 3—4 μ lata, cellulis diametro duplo ad 5-plo longioribus, cylindraceis vel, in cellulis brevibus, leviter tumidis, chromatophorum cylindraceum pyrenoide centrali munitum continentibus.

Pili hyalini terminales occurrunt. Sporangia monospora (et tetraspora?) in filis primi et secundi ordinis lateralia vel terminalia, plerumque sparsa, unilateraliter seriata, rarius opposita, nonnunquam in ramulis unicellularibus bina vel solitaria, etiam in filis repentibus sessilia, ovata, long. 10—12,5 μ, lat. 5,5—6,5 μ.

The above diagnosis is essentially made after specimens growing on *Chondrus crispus* found at Hanstholm, on which it formed a fine felted covering. One erect filament is usually given off from each cell in the creeping filaments, except the outermost ones. In the most developed erect filaments the cells are cylindrical, usually 3—4 diameters long (up to 17 μ long), while in shorter filaments and in the fructiferous parts of the longer the cells are shorter and often somewhat swollen. The shape of the chromatophore was not easily discernible, as I had only dried material at my disposal; in some cases, however, a chromatophore was visible, consisting of a cylindrical parietal plate and an axile part containing a central pyrenoid lying in the upper part of the cell (fig. 47 *A*). Most of the erect filaments attain only a small size and remain unbranched, but some grow longer and may then bear one or some few vegetative branches. Terminal hairs frequently occur and may give rise to sympodial branching. The sporangia are in great measure lateral on the erect filaments and then as a rule seriate, a position which often causes a recurvation of the filament (fig. 46 *A*, *G*). The sporangia are more rarely opposite, but they are frequently terminal, in the long filaments as well as in the very short (figs. 46, 47); in the specimens from Hanstholm sporangia sitting directly on the creeping filaments were not observed. Sporangia borne on unicellular branchlets also occur, one sporangium being terminal, the other lateral (fig. 46 *B*, *C*). The long filaments are only sporangia-bearing in their upper part. The sporangia are only a little varying in shape and size, nearly twice as long as broad. They appear to be

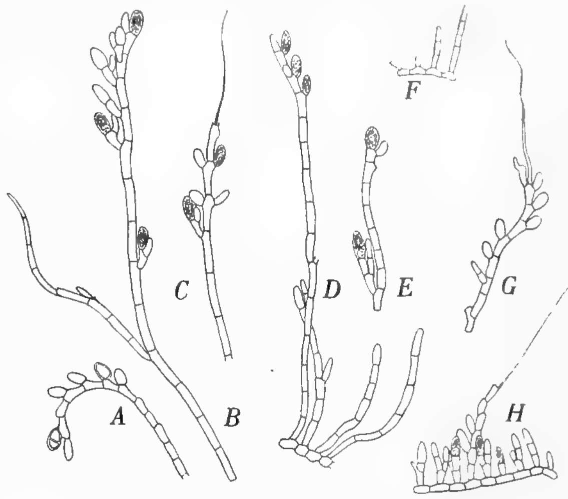


Fig. 46.
Chantransia leptonema (Hanstholm). *A—C*, *E*, *G*, erect filaments with sporangia. *D*, *F*, *H*, creeping filaments with erect filaments. 300 : 1.

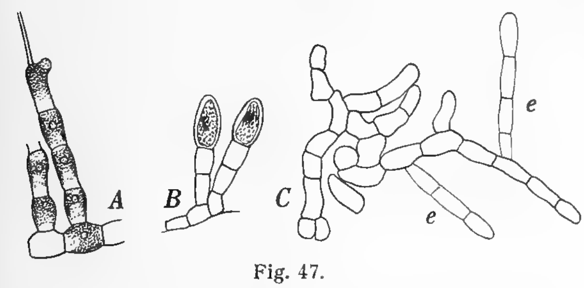


Fig. 47.
Chantransia leptonema (Hanstholm). *A* and *B*, fragments of creeping filaments with short erect filaments. *C*, creeping filaments seen from below and two erect filaments, *e*. 620 : 1.

usually monosporous; in some cases, however, the contents seemed to be divided into two or four parts (fig. 46 *A*), but conclusive observations were not arrived at.

On *Polysiphonia urceolata* dredged near Hirshals I have found, growing in company with other interesting Algæ (*Erythrocladia irregularis* and *subcontinua*, *Chantransia emergens*), a small *Chantransia* which I believed at first to be a different species, most of the rather few specimens consisting only of creeping filaments, bearing sporangia either directly or on unicellular stalks (fig. 48). Later however I found other specimens with numerous erect, partly sporangia-bearing filaments fully agreeing with the above described specimens growing on *Chondrus*, and I therefore have no doubt that they belong to the same species. The dimensions were the same; I found however that the sporangia borne directly on the basal layer were somewhat shorter, 8—9 μ long, 6 μ broad, perhaps only because they were not fully ripe. The chromatophore showed the same appearance as in the specimens from Hanstholm, but the pyrenoid appeared not to be central; as the material from both localities was only dried, the question must however be left open. In some fairly juvenile plants I succeeded in finding that the first divisions of the germinating spore take place in a similar manner as in *Ch. virgatula*, three peripheral cells being cut off round an inner triangular cell (fig. 48 *B*).

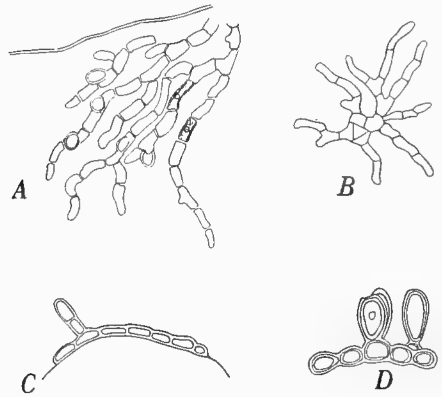


Fig. 48.
Chantransia leptonema. (From XO). *A*, creeping filaments on the surface of *Polysiphonia urceolata*, bearing sporangia. *B*, fairly young plant seen from above. *C* and *D*, plants seen in vertical section, *D* with sporangia. *A*—*C* 390 : 1. *D*, 730 : 1.

This species appears to be distinct from all hitherto described species especially by its mode of growth and its slight thickness. *Ch. chiloensis* Reinsch (Contrib. ad Alg. et Fung. Vol. I 1877 p. 37 Taf. XI fig. 1) which was found at St. Thomas, West Indies, growing on *Acanthophora Thierii*, differs according to Reinsch by the greater length and thickness of the filaments, by the short creeping filaments consisting of shorter cells and by broader sporangia.

Localities. **Sk**: Hanstholm, Roshage, on *Chondrus crispus* in 2 m. depth, YU[4], August; XO, Møllegrund off Hirshals, on *Polysiphonia urceolata*, 11,5 to 15 m., August.

15. **Chantransia reducta** sp. nov.

Thallus filiformis ramosus repens substrato affixus. Spora germinans in cellulas duas divisa est quarum utraque filum repens procreat. Cellulæ filorum repentium leviter tumidæ, c. 4 μ crassæ, longitudine diametro fere æquali vel sæpius duplo longiores, chromatophorum parietale, pyrenoide fere axili munitum, continentes; utraque cellula demum superne sporangium aut filum brevissimum gerens. Fila erecta 1—3-cellularia simplicia, rarissime ramosa, 4,5—6 μ lata, cellulis diametro fere æquilongis vel paullo longioribus, nonnunquam pilum hyalinum apicalem brevem gerentia. Sporangia monospora in filis repentibus sessilia aut in filis erectis terminalia, ovata vel subsphærica, long. 7—9,5 μ, lat. 5,5—7,5 μ.

The erect filaments are extremely reduced in this species; only in *Ch. Macula* among the epiphytic species here mentioned are they as much reduced. In most cases the reduction process is carried so far that the erect filament has completely disappeared, and the sporangium is situated directly on the creeping filament, or it is represented by a single stalk-cell. The erect filaments, however, may be sometimes two- or three-celled, and I have, though very rarely, seen such filaments bearing a unicellular branch (fig. 49 *C*). In hardened material a parietal chromatophore with a large pyrenoid was easily visible; the latter were apparently lying in the median line of the cell, but were, in some cases at least, certainly excentric (fig. 49 *A*, *B*). The two cells resulting from the division of the germinating spore remain easily recognizable by their greater breadth and rounded outline (fig. 49 *A*, *G*, *H*, *I*). In this mode of germination the species recalls *Ch. humilis* (p. 117) which has also little developed erect filaments, but this species differs by its greater dimensions, by two or three erect filaments given off from each cell in the basal layer, and by stellate chromatophores. The *Ch. leptonema* just described may also occur in a much reduced form resembling *Ch. reducta*; but that form differs by a different mode of division of the germinating spore (fig. 48).

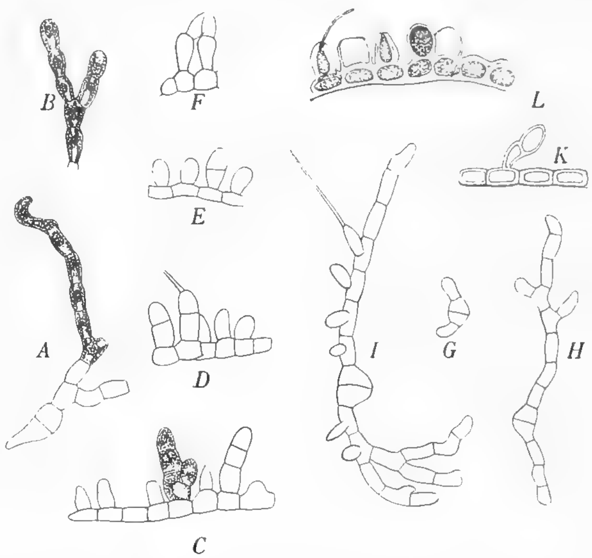


Fig. 49.
Chantransia reducta. *A* and *B* (Frederikshavn), creeping filaments showing the chromatophores. *C—F*, plants in vertical section with sporangia. *G*, young plant seen from above. *H*, more developed plant seen from the under side. *I*, plant seen from above. *K*, fragment of plant in vertical section, with a stalked sporangium. *L*, fragment of plant with sessile sporangia, in vertical section. *C—L* from GM. 560 : 1.

The species has been found growing on *Polysiphonia nigrescens* and *Rhodomela subfusca* collected near the low-water mark in the northern Kattegat, in July and September.

Localities. **Kn:** Hirsholm; harbour of Frederikshavn; dry rock near Jegens Odde (GM).

Group III. Frond partly or entirely endophytic.

16. **Chantransia cytophaga** sp. nov.

Thallus cæspitosus, ad 0,2 mm. altus, e filis 1° repentibus plantæ hospiti affixis, 2° erectis sporangiferis et 3° endophyticis constructus. Spora germinans dissepimento verticali in duas cellulas divisa est quarum utraque filum horizontale procreat. E filis primariis lateraliter fila repentia, subtus fila endophytica et superne fila erecta numerosa egrediuntur. Fila endophytica brevia ramosa, in cellulas hospitis penetrantes. Fila erecta simplicia vel parce ramosa, 7—10 μ lata, apicem versus paullo attenuata. Cellulæ diametro fere duplo longiores, superne vel medio tumidæ, chromatophorum stelliforme, ut videtur sine pyrenoide, in parte superiori cellulæ situm continentes. Pili hyalini adsunt. Sporangia in filis lateralia, sessilia, in utroque articulo plerumque 2—3, monospora aut tetraspora, ovata vel ellipsoidea, latitudine fere duplo longiora, monospora (11—) 13—17 μ longa, 7,5—8 μ lata, tetraspora c. 19 μ longa, 10 μ lata.

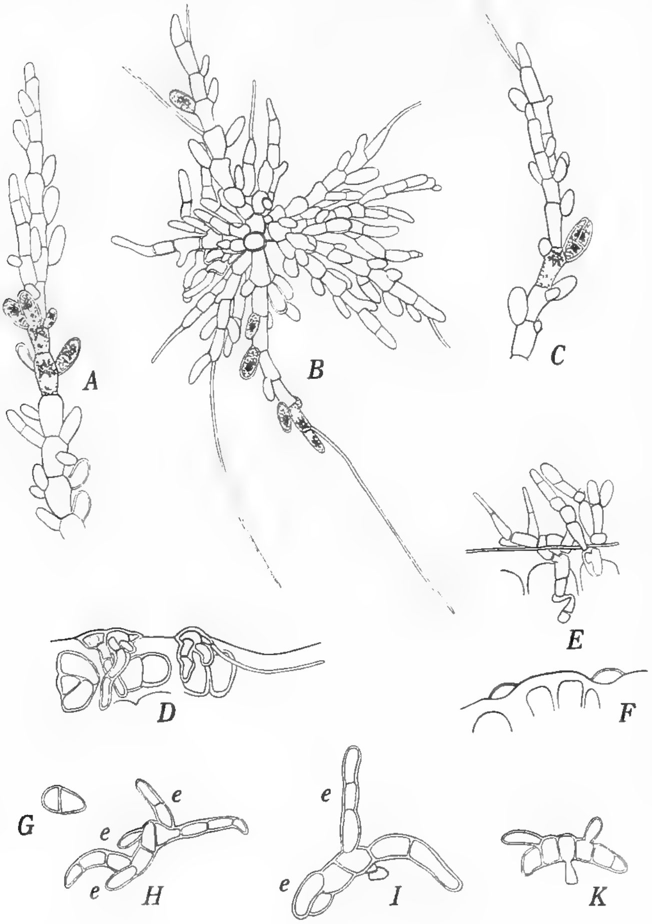


Fig. 50.

Chantransia cytophaga. *A*, Filament with monosporangia. *B*, plant seen from above. *C*, filament with tetrasporangium. *D*, young plants fastened to the margin of the frond of Porphyra. *E*, transverse section of Porphyra with the parasite. *F*, two spores on the point of germinating on the margin of the Porphyra. *G*, two-celled plant. *H*, more developed plant with three erect filaments, *e*. *I* and *K*, plants with two erect filaments and haustorium. *A—G* 300 : 1. *H—K* 400 : 1.

This species forms small cushions on the margin and at a small distance from the margin of the frond of *Porphyra umbilicalis.* It reminds one in its mode of growth as well as in other respects of *Ch. Dumontiæ* but is smaller. The basal layer develops as in *Ch. polyblasta* and *Ch. humilis* and finally consists of filaments radiating on all sides though often rather irregularly, and it sometimes happens that one filament is growing over another (fig. 50 *D*). When the *Chantransia* is situated on the margin of the *Porphyra*, the filaments make their way on both sides of the flat frond. From some of the cells in these filaments are given off haustorial filaments penetrating into the host. The place of the endophytic filaments is indistinct, but they appear to be mainly given off from the central part of the basal layer. They make their way through the outer wall of the host and penetrate into the nearest cell, the protoplasm of which is more or less displaced by the intruding haustorium (fig. 51). As shown in fig. 51 *A* two haustoria may sometimes penetrate into one cell. The filaments often branch within the host cell, and some of the branches may again become free, growing outwards through the wall of the host, and the same occurs with endophytic filaments without branching (in fig. 51 the free endings of the haustorial filaments are not shaded). As far as I have observed, these filaments do not penetrate from one cell into another, and therefore do not serve as propagating organs. The protoplasm of the host cell is more or less shrunk and evidently yields nourishment to the *Chantransia* which is thus a veritable parasite.

A great number of erect filaments are given off from the creeping filaments, from the peripheral part as well as the central. As new erect filaments are constantly produced, a fully developed plant shows numerous erect filaments of different sizes, giving the plant a cushion-shaped appearance. Most of these filaments attain only an inconsiderable length, the greatest are about 200 μ long; they are either unbranched or bear one or a few branches which are much shorter than the main filament. Hyaline hairs frequently occur at the ends of the filaments, becoming lateral by the continued growth of these. In the lower part of the filaments the cells are more or less swollen at their upper ends or in the middle. The structure of the cell is the same as in *Ch. Dumontiæ* (see p. 124), the chromatophore being stellate without pyrenoid, while a body staining intensely by hæmalum and undoubtedly a nucleus is to be seen under the chromatophore.

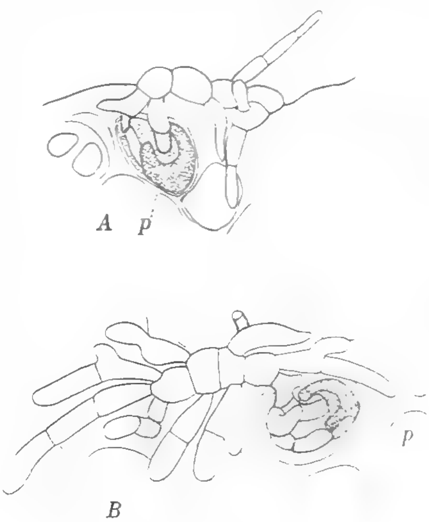


Fig. 51.
Chantransia cytophaga. *A*, plant growing on the margin of the frond of Porphyra umbilicalis, to the left two haustoria penetrating into the same cell. *B*, plant growing on the flat side of the frond seen from above, showing three haustorial filaments. The endophytic filaments are shaded, their free emerging ends are white; *p*, protoplasm of the host cell. 550 : 1.

The sporangia are always sessile on the sides of the erect filaments, in their whole length. From the first each cell bears one sporangium, but very soon one or two others appear, and each cell bears thus usually two or three sporangia, the two being as a rule opposite. The latest formed sporangium is sometimes seated at a lower level than the other, near the middle of the cell. Terminal sporangia were not observed. Nearly all the sporangia were monosporous, very few tetrasporous; the latter were somewhat larger than the other. Possibly some of the undivided sporangia were unripe tetrasporangia; I imagine, however, that most of them were really monosporangia.

The structure of the cell and the mode of growth bring this species near to *Ch. Dumontiæ*; it differs from it in particular by the intracellular haustoria, by shorter, less branched erect filaments, by shorter cells and by the want of terminal sporangia. *Ch. polyblasta* and *Ch. humilis* differ by the want of endophytic filaments and by the presence of a distinct pyrenoid.

Locality. **Su:** Only found at Helsingør, growing on *Porphyra umbilicalis* on the outer side of the southern mole in September.

17. **Chantransia Dumontiæ** sp. nov.

Thallus cæspitulosus ad 0,5 mm. altus, e filis 1^{o} horizontalibus epiphyticis 2^{o} erectis ramosis sporangiferis et 3^{o} endophyticis constructus. Spora germinans dissepimento verticali diametrali in duas cellulas æquales divisa est quarum utraque filum horizontale procreat. E filis primariis lateraliter fila repentia et superne fila erecta egrediuntur. Fila endophytica intercellularia ex parte saltem e filis erectis egrediuntur. Fila erecta a basi ramosa, ramis numerosis sparsis plus minus ramosis; cellulæ diametro fere triplo longiores, superne 6,5—9 μ crassæ, inferne tenuiores, chromatophorum stellare, ut videtur sine pyrenoide, in parte superiori cellulæ situm continentes. Pili hyalini terminales vel pseudolaterales adsunt. Sporangia tetraspora oblonga—ovata, latitudine fere duplo longiora, 15—19 μ longa, 8—11 μ lata, in filis lateralia et terminalia, plerumque sessilia, sparsa vel opposita, nonnunquam in ramulis unicellularibus singula vel bina.

The species forms numerous small, dark-purple tufts or cushions on fronds of *Dumontia filiformis*. They consist of numerous erect branched filaments given off from the creeping filaments, partly also from the endophytic threads. The germination takes place as in *Ch. cytophaga* and others of the above described species (fig. 52 *A*, *B*). The epiphytic creeping filaments are often somewhat irregular, thick and short-celled, and, as shown in fig. *E*, they are not always densely attached to the surface of the host. I am not able to say if the first endophytic filaments are given off from the underside of the creeping filaments or not. At all events endophytic filaments are also given off from the base of the erect filaments (fig. *D*). The endophytic filaments are much branched growing intercellulary in the host, and free erect filaments may again be given off from them through the surface of the frond. I believe that this may take place also at a greater distance from the point of departure of the endophytic filaments, these thus serving to propagate the *Chantransia* in the host. The free filament shown in fig. *D* has probably emerged from the endophytic one. It appears that relatively few endophytic filaments are given off in the same cushion.

The erect filaments arise in great number from the creeping filaments, from their peripheral as well as their central parts, and the plant forms therefore tufts or cushions of $\frac{1}{2}$—1 mm. in diameter. These filaments are fairly strongly branched, as a rule from the base, and often a branch is given off from each cell in a great part of the primary filaments, and the branches may also be branched. The cells are usually broader at the upper end than below, depending on the abundant ramification. In the central part of the stellate chromatophore I was not able to detect any pyrenoid staining stronger with hæmalum than the remaining substance of the chromatophore, while the nucleus, lying under the chromatophore but near the periphery of the cell, more rarely at the same level as the chromatophore, was very intensely stained by this reagent.

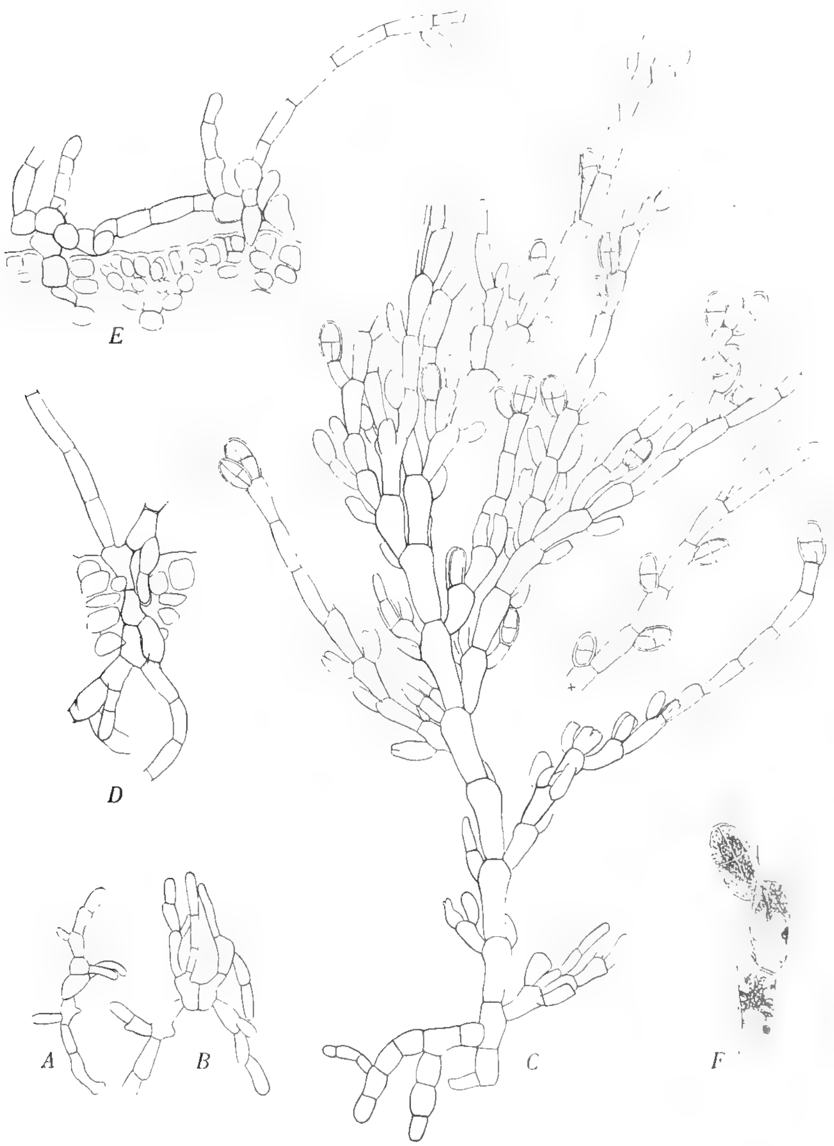


Fig. 52.

Chantransia Dumontiæ. A and *B*, young plants seen from above. *C*, plant with tetrasporangia, below horizontal and descending filaments. *D* and *E*, transverse sections of Dumontia with Chantransia, showing endophytic, horizontal and erect filaments of the latter. *F*, two cells and a sporangium, the cells showing chromatophore and nucleus. A—E 390 : 1, F 550 : 1.

The sporangia are most frequently sessile on the sides of the filaments, or they are placed on unicellular branchlets singly or two together, or lastly they may be terminal on the long branches. From the first the cells bear usually only one sporangium or a sporangium-bearing branchlet, but later further sporangia may develop so that a great number of the cells bear two or three sporangia. When two sporangia occur, they may be opposite or near to each other, but a sporangium may also be placed under another sporangium or under a branch (fig. *C*). The cells giving off a branch bear frequently a sporangium opposite to it. Monosporangia were not observed.

Identical specimens were found in two localities on the north coast of Sealand, growing in *Dumontia filiformis* in the month of May. It cannot be confused with any other known species. As to its relation to *Ch. cytophaga* see this species.

Localities. **Ke:** Harbour of Gilleleje, inner side of the mole. — **Su:** Harbour of Helsingør.

18. **Chantransia Nemalionis** (De Not.) Ard. et Straf.

Ardissone e Strafforello, Enum. delle Alghe di Liguria, Milano 1877 p. 167.
Callithamnion Nemalionis De Notaris, Erbar. Crittogam. Italiano, no. 952 (c. descript.); Ardissone, Prospetto delle Ceramiee italiche, 1867 p. 17, Tav. I fig. 1—3.
Acrochætium Nemalionis Bornet (1904) p. XX.
Chantransia Saviana (Menegh.) Ardissone, Phycol. Mediterr. 1883 p. 276 ex parte.

As shown by Bornet, the *Callithamnion Nemalionis* described by De Notaris has a system of filaments endophytic in the frond of *Nemalion lubricum*, on which it forms numerous 4—5 mm. high tufts. The same mode of growth was observed in a *Chantransia* growing in *Nemalion multifidum* at Struer in the Limfjord. As it fully agreed with the description of De Notaris and with his above-quoted original specimens, which I have been enabled to examine through the great kindness of Dr. Bornet, I refer it to the same species without any doubt. Ardissone has later confused this species with one or perhaps more others under the name of *Chantransia Saviana* (Menegh.) Ard.; as however Meneghini's description refers to a species growing on *Zostera* leaves and certainly different from De Notaris' species, it is unwarranted to replace the name of the latter with that of Meneghini.

The plant has long ramified filaments growing widely in the interior of the host and here and there sending out through the surface of the host free filaments giving rise to new tufts; the number of tufts occurring on the same frond of *Nemalion* may therefore be very great. The walls of the endophytic filaments are often a little sinuous on account of their growth between the cells of the host; the cells are usually 8 to 11 μ thick, 3,5 to 5 diameters long. They contain in the middle a narrow belt-shaped chromatophore with a parietal pyrenoid. When the endophytic filaments rise from the basal part of the erect filaments they are given off from the lower end of the cells while the upright branches are given off at their upper end, and a similar polarity is as a rule, though not always, present in the endophytic filaments (fig. 54 *A*).

The erect filaments greatly resemble those of *Ch. corymbifera* and *Ch. Thuretii*; they form up to 5 mm. high tufts with spread branches which are multilateral but with some tendency to unilaterality. The cells are cylindrical, not constricted at the transverse walls, (7,5—) 9—11 (—12) μ broad, 3—7, usually 4—5 diameters long. They contain a parietal chromatophore with a large parietal pyrenoid much projecting into the interior of the cell. In the older cells the chromatophore is larger than in the younger and perhaps somewhat lobed. Hyaline hairs do not occur. The germination was unfortunately not observed.

The sporangia are borne on branchlets, usually placed on the inner side of the branches near their base, very often two or three seriate. The branchlets are as a rule one- or two-celled; in the first case it bears a terminal and a lateral sporangium, in the latter the upper cell behaves in the same way, while the lower cell bears one or two sporangia. It happens however that the branchlets may consist of more than two cells and that they may be branched (fig. 54 *D*). Only rarely the sporangia may be sessile directly on the filaments. The sporangia are always monosporous, oblong, 18—19 μ long, 9—10,5 μ broad. Renewal of the emptied sporangia from the underlying cell frequently occurs.

As already said, the Danish specimens agree with the original specimens of De Notaris from Genoa. Ardissone figures certainly only two single, apparently sessile sporangia (1867 fig. 3); the sporangia are however nearly always borne on branchlets at least two together in De Notaris specimens as well as in mine.

Fig. 53.
Chantransia Nemalionis. Erect filament with sporangia, below an endophytic filament. 95:1.

This species greatly resembles *Ch. corymbifera* Thur.[1], which grows on *Helminthocladia purpurea.* It differs from it by the absence of sex-organs and by the want of a larger cell originating from the germinating spore and giving off erect filaments and descending endophytic filaments. In spite of repeated search I have never found such a cell and that is in accordance with Bornet's statement

[1] G. Thuret in Le Jolis Liste p. 107; Bornet et Thuret, Not. alg. I p. 17 pl. V; Bornet 1904, p. XX.

that the cell rising from the germinating spore is not different from the cells which it produces. To judge from the figures of BORNET and THURET the sporangia become a little larger in *Ch. corymbifera* than in *Ch. Nemalionis*, namely up to 22 μ long. It is interesting that this species hitherto only known from the Mediterranean and the Gulf of Gascony has been found in the Limfjord, a water with relatively high salinity and summer temperature.

Locality. **Lf:** Struer, outer side of the mole, September.

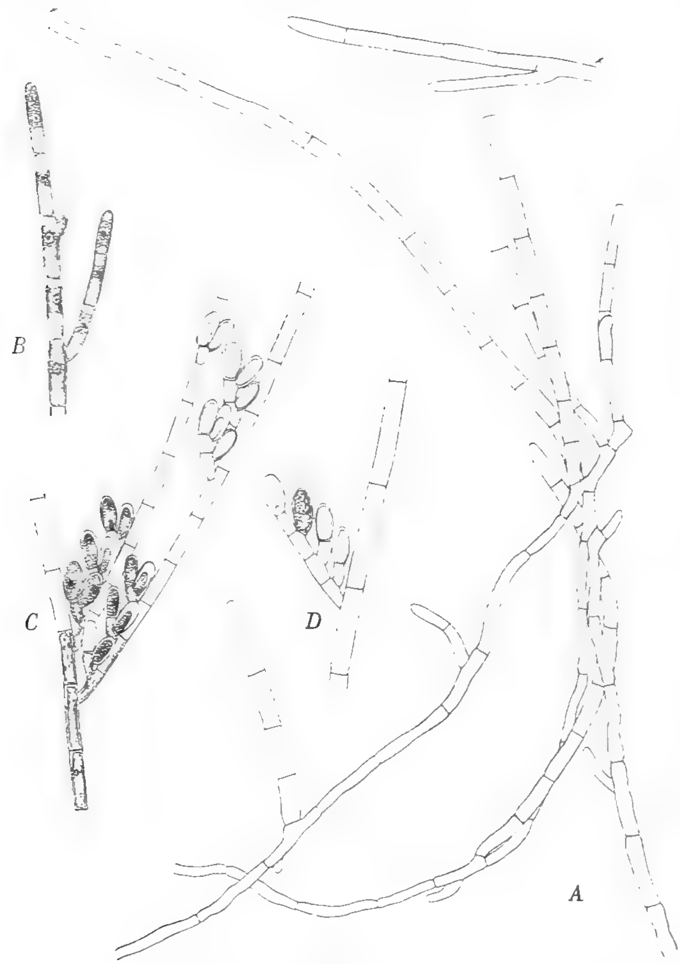


Fig. 54.
Chantransia Nemalionis. *A*. endophytic filaments giving off a number of erect filaments. *B*, upper end of erect filament showing chromatophores with pyrenoid. *C* and *D*, filaments with sporangia-bearing branchlets. 200 : 1.

19. **Chantransia endozoica** Darbish.

O. V. DARBISHIRE, Chantransia endozoica Darbish., eine neue Florideen-Art. Ber. deutsch. bot. Ges. 1899, Bd. 17 p. 13 Tafel I.

The greater part of the frond of this species grows in the thick outer wall of the Bryozoan *Alcyonidium gelatinosum*. The endozoic filaments are dichotomously branched and give off numerous free, short, branched fertile filaments bearing monosporangia. I have only met with very few specimens and must therefore content myself by referring to the above-quoted paper of DARBISHIRE. I regret that I am not able, any more than this author, to give information on the form and structure of the chromatophore. The sporangia were 13,5—17 μ long, 9—10 μ broad.

Locality. **Sk:** In a specimen of *Alcyonidium gelatinosum* washed ashore on the beach of Hirshals, August, with ripe sporangia.

20. **Chantransia emergens** sp. nov.

Fila vegetativa endophytica infra cuticulam hospitis (*Polysiphoniæ urceolatæ*) horizontaliter expansa, ramosa, ramis sparsis vel oppositis, sub angulo recto plerumque egredientibus, cellulis subcylindricis medio vel paullo supra medium plus minus inflatis, 6—10,5 μ longis, 2—3,5 μ latis. Chromatophorum ut videtur, unicum parietale pyrenoide instructum. Pili hyalini desunt. Monosporangia extra cuticulam emergentia solitaria breviter stipitata, stipite unicellulari, rarius in filis endophyticis sessilia, ovata, 5—6,5 μ longa, 3—4 μ lata.

In a specimen of *Polysiphonia urceolata* dredged in the Skagerak off Hirshals

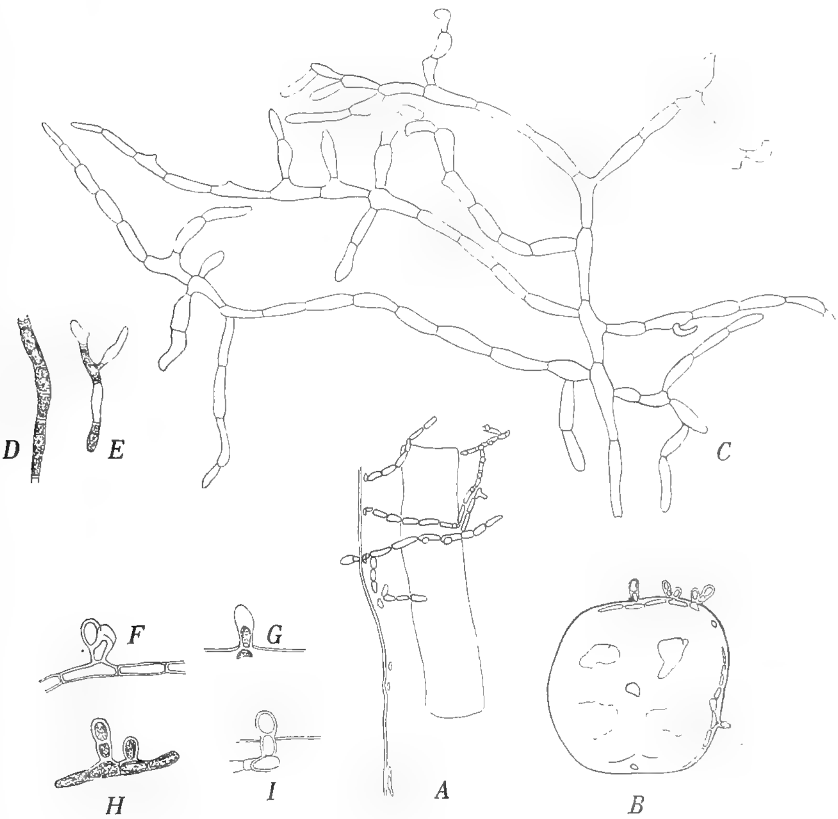


Fig. 55.
Chantransia emergens. *A*, filaments growing under the cuticle of the host, seen partly from the face partly in profile (at left); a pericentral cell of Polysiphonia is shown. *B*, transverse section of Polysiphonia with the endophyte. *C*, endophytic filaments. *D* and *E*, cells showing the chromatophore and the supposed pyrenoid. *F—I*, filaments with sporangial branchlets seen in profile, in *G* an emptied sporangium, in *F* a new sporangium is formed besides an emptied one. *A—B* 290 : 1, *C—I* 610 : 1.

this little species was found rather abundantly, growing in the outer wall close within the cuticle but never penetrating into the radial walls between the pericentral cells. The filaments are very thin, the cells very thin-walled, usually 3—5 diameters long; they were in the dried specimens, the only ones I examined, uniformily rose-coloured and seemed to contain a parietal chromatophore occupying the greater part of the periphery of the cell. In the middle or somewhat over the middle of the cell a body staining in hæmalum is visible, probably a pyrenoid. The branches are given off at a certain distance from the acroscopic transverse wall, sometimes from the middle of the cell or even, though rarely, a little under the middle. All the vegetative branches are given off in a plane parallel to the surface of the host, while the extremely short fertile branchlets break through the cuticle in a direction perpendicular to that plane. These branchlets consist of a short partly immersed stalk-cell and an entirely free sporangium, but sporangia arising directly from the endophytic filaments also occur. In the fertile part of the plant a sporangium is usually given off from each cell in the endophytic filament (fig. 55 *A*). After the evacuation a new sporangium may be formed within the empty sporangial wall, but it may also occur that a new lateral sporangium is given off from the stalk cell besides the emptied terminal one.

The species appears to be nearly related to *Acrochætium endophyticum* Batters (Journ. of Botany Vol. 34 1896 p. 386) living in "the cortical layer" of *Heterosiphonia coccinea*. As far as can be seen from Batters' description this species is distinguished from *Ch. emergens* mainly by longer erect filaments, which are composed of from one to three cells.

Locality. **Sk:** Møllegrund off Hirshals (XO), 11,5 to 15 meters, with ripe sporangia in August.

21. **Chantransia immersa** sp. nov.

Thallus endophyticus; fila omnino immersa, intercellularia, varie ramosa, ramis sparsis vel ex una cellula pluribus egredientibus. Cellulæ nunc cylindricæ plerumque tamen medio vel supra medium inflatæ, 8—10 μ latæ, 40—53 μ longæ, nunc, præcipue superficiem hospitis versus, breviores plus minus rotundatæ, usque ad 15 μ latæ. Chromatophorum unicum stellare pyrenoide centrali et ramis longis sursum et deorsum protractis munitum. Cellulæ ultimæ breves obovatæ vel rotundatæ, in superficie hospitis prorumpunt, cellulas periphericas illius plerumque non superantes, nonnunquam pilum hyalinum gerentes. Sporangia, transformatione cellularum ultimarum orta, obovata, 15—17,5 μ longa, 11—12 μ lata, monospora, post evacuationem sæpe sporangio novo e cellula suffultoria formato repleta.

This species occurs in *Rhodomela subfusca* and in species of *Polysiphonia*. As the endophytes are essentially identical in structure, they are referred to the same species, but as their behaviour to the different hosts is somewhat different, two forms may be distinguished.

Forma *Rhodomelæ*. In *Rhodomela* I have only found the endophyte growing in tumours and occurring in fairly great quantity at Frederikshavn in July 1895 and 1896. These tumours are irregularly roundish and somewhat remind one in form and size of *Harveyella mirabilis*. I conclude that they are occasioned by this endophyte, but it deserves notice that these tumours also contained an endophytic *Ectocarpus* or *Streblonema* and the very common endophyte *Bolbocoleon piliferum*. The *Chantransia* grows intercellularly through the whole tumour, the filaments running mainly in a radial direction. The swellings have essentially the same structure as the normal branches; there appears to take place only an acceleration of the growth, their structure assuming the appearance of that of much older branches. In the interior of the tumour the cells of the endophyte are usually several times as long as broad, nearly cylindrical; towards the periphery they become shorter, lastly only a little longer than broad. At the same time the filaments become more branched. The outermost cells reaching the surface of the host bear sometimes a short hair ca. 4,5 μ thick at the base but quickly tapering upwards.

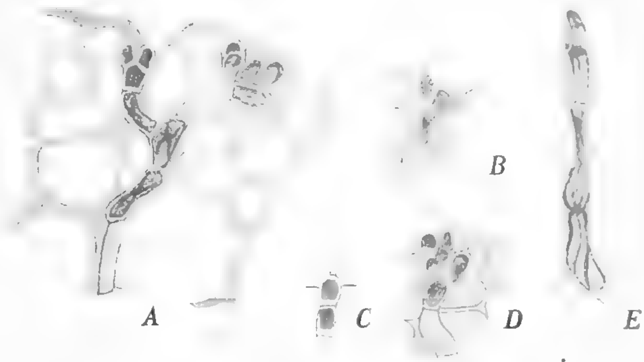


Fig. 56.
Chantransia immersa f. *Rhodomelæ.*[1] *A*, section of tumour of Rhodomela with the endophyte: a new sporangium is about to be formed within an emptied sporangial-wall. *B* and *C*, ends of filaments with hair. *D*, filament with sporangia, one emptied. *E*, filament showing the chromatophores. 300 : 1.

The structure of the cells was studied on material hardened with picric acid. The pyrenoid is large and contains an angular body, probably a crystalloid. It is situated nearly in the middle of the cell but not always in the axis of the cell (fig. 57 *B*, *C*). The arms of the chromatophore are long and narrow and extend from the central part containing the pyrenoid upwards and downwards to the ends of the cell. The nucleus is difficult to see; by aid of borax-carmine it was determined in young cells, lying in a pit in the chromatophore near the pyrenoid (fig. 57 *A*, *n*).

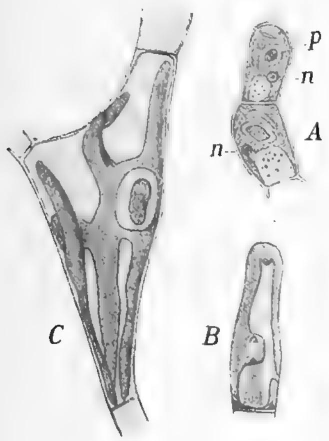


Fig. 57.
Chantransia immersa f. *Rhodomelæ.* Cells showing the chromatophore; hardened with picric acid. *A*, young cells, *p*, pyrenoid, *n*, nucleus. *B*, the pyrenoid contains a crystalloid. *C*, the chromatophore with long arms, the pyrenoid excentric. A 730 : 1. B 580 : 1. C 1100 : 1.

The sporangia arise almost without change of form from the outermost cells lying at the level of the surface of the host or a little prominent. After the evacuation a new sporangium may be formed within the emptied wall from the under-lying cell (fig. 56 *A*).

Forma *Polysiphoniæ*. Of this form which has been found growing in *Polysiphonia nigrescens* and *P. violacea* I have particularly examined specimens infesting *P. nigrescens* collected at Hirsholmene in September. It occasions here no tumours but grows intercellularly between the central cell and the pericentral cells as well as between the latter mutually. Long straight filaments consisting of cylindrical or feebly swollen cells often run longitudinally between the central cell and the pericentral cells, sending off between the pericentral cells radiating filaments ending with short cells breaking through the cuticle of the host (fig. 58 *C, E*). But longitudinal filaments running a short distance from the surface between the pericentral cells also occur, and these filaments give off short unicellular branchlets (fig. 58 *F*). The peripheral cells may reach the surface of the host or be somewhat prominent, and the same is the case with the sporangia; these are only seldom so prominent as that shown in fig. 58 *C*. The peripheral cells bear sometimes a hair which may be more vigorous than in f. *Rhodomelæ* and two hairs in one cell may even be observed (fig. 58 *A*). The chromatophore has the same structure as in f. *Rhodomelæ*, and the sporangia are also alike. Formation of a new sporangium within an emptied sporangial wall frequently occurs, apparently repeatedly (fig. 58 *C, D, G*). The sporangia were as a rule better developed than in f. *Rhodomelæ*, probably on account of the later season.

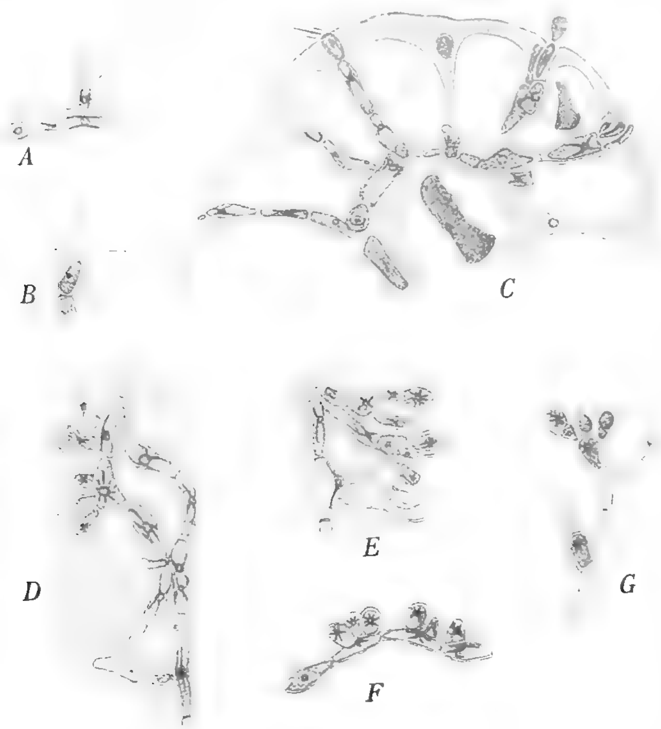


Fig. 58.
Chantransia immersa f. *Polysiphoniæ*. *A*, filament giving off an emerging cell bearing two hairs. *B*, end of filament with hair. *C*, transverse section of Polysiphonia nigrescens with the endophyte. *D* and *E*, longitudinal filaments giving off radiating filaments with sporangia. *F*, longitudinal filament with unicellular branchlets. *G*, filament with sporangia-bearing branches. 300:1.

The more or less immersed monosporangia distinguish this species from all other described endophytic *Chantransiæ* known to me.

Localities. Forma *Rhodomelæ*. **Kn:** Frederikshavn, outer side of the mole.

Forma *Polysiphoniæ*. **Kn:** Hirsholmene, in *Polysiphonia nigrescens*, September; dry rock at Jegens Odde in the same, Sept.; Trindelen (Nl), 9,5 to 10,5 met., in *Polys. violacea*, Sept.

22. **Chantransia Polyidis** sp. nov.

Thallus endophyticus; fila in cortice exteriori et interiori hospitis (*Polyidis rotundi*) intercellularia, vario modo, in directione radiali et transversali vel etiam intermedia, præsertim tamen radiali, peripheriam versus crescentia, ramosa, ramis sparsis. Cellulæ forma varia, plerumque cylindricæ vel utriculosæ, sæpe aliquantum curvatæ, long. 30—56 μ, lat. 10,5—14 μ, peripheriam versus breviores, adultæ ut videtur chromatophorum unicum valde ramosum, fere reticulatum continentes. Cellulæ ultimæ rotundatæ, oblongæ vel clavatæ, superficiem hospitis attingentes sed non superantes, raro pilum paullo evolutum portant. Sporangia in apice filorum radiantium singula vel rarius bina, immersa, superficiem hospitis non vel vix superantia, monospora, oblonga, long. 15,5—18 μ, lat. 9 μ.

This species was found only once in dried specimens of *Polyides rotundus* collected in the Northern Kattegat in September. In mode of growth it reminds one somewhat of *Ch. immersa* from which it is distinguished in particular by the form of the chromatophore. It does not occasion any deformation of the host plant in the intercellular substance of which it lives. It grows principally in a radial direction but has also stoloniform filaments growing out in a transverse direction and giving off new radiating filaments (fig. 59). The filaments are as a rule fairly strongly branched, however, one branch only is given off from each joint, and some cells bear no branch. Sometimes the branches are fasciculated in the radial filaments (fig. 59 *A*). The cells are usually somewhat swollen; at some distance from the surface very thick cells, over 20 μ broad, may frequently be met with. Hyaline hairs seem to occur only in very small quantity and feebly developed. The end-cell shown in fig. 60 *B* is probably a young hair which has not yet reached above the surface of the host.

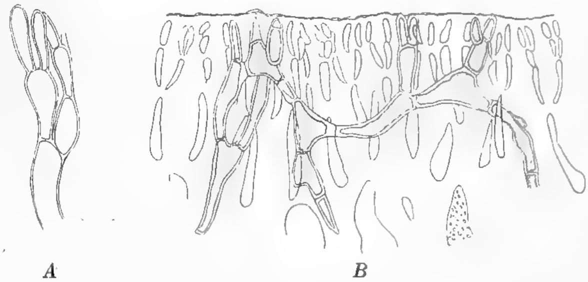


Fig. 59.
Chantransia Polyidis. *A*, radiating filament with fasciculated branches. *B*, transverse section of Polyides with Chantransia showing transverse and radiating filaments. 300 : 1.

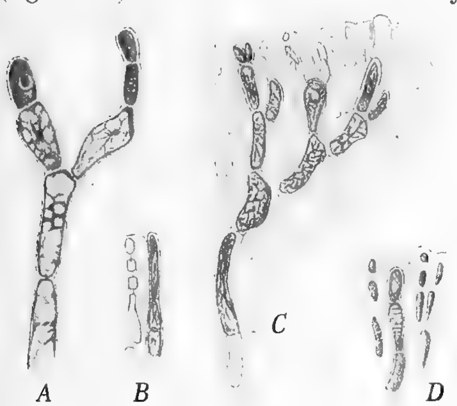


Fig. 60.
Chantransia Polyidis. *A*, radiating filament showing the chromatophores. *B*, end of filament the end-cell of which is apparently about to form a hair. *C*, branched filament with partly emptied sporangia. *D*, end of filament with terminal sporangium. *A* 390 : 1. *B—D* 300 : 1.

As I possess only dried material I cannot give a sufficient account of the structure of the chromatophore, which seems to be rather peculiar. In the end-cells the chromatophore appears often as a compact mass filling out the greater part of the cell, in the centre of which a body is visible which seems to be a pyrenoid (fig. 60 *A*). In the somewhat older cells the chromatophore shows often an upper dome-shaped part while the rest of it is divided into a number of strands or plates, concerning which I am not able to decide if they are all continuous or partly separate. The dome-shaped part soon disappears and the supposed pyrenoid was also as a rule not visible in the more developed cells. The whole process has apparently the character of a vacuolization of the chromatophore.

The sporangia are terminal on the outward growing filaments. Besides the really terminal sporangium another lateral is often developed, inserted at the same level. The sporangia are entirely immersed or only a little prominent above the surface of the host; they are about twice as long as broad.

Locality. **Kn:** Tønneberg Banke, TP, 16 meters, September.

Subgenus Grania.

Group IV. Frond epiphytic (or partly endozoic); chromatophores long, usually spiral-shaped, more than one; carpogonia often intercalary, carpospores seriate.

23. **Chantransia efflorescens** (J. Ag.) Kjellm.

KJELLMAN, N. Ish. algfl. p. 166 (Alg. Arct. Sea p. 129) tab. 12 fig. 1—2 (f. *tenuis* Kjellm.); GRAN, Kristianiafj. Algefl. p. 19 tab. I fig. 1—3; E. LEHMANN, Beitr. z. Kenntn. von Chantransia efflorescens J. Ag. sp., Wiss. Meeresuntersuch. N. F. 6. Bd. Abt. Kiel 1902 p. 1, Taf. I; BØRGESEN (1902) p. 355; KYLIN (1906) p. 113.
Trentepohlia Dawiesii α. ARESCHOUG, Phyc. Scand. 1846 p. 117. tab. V D.
Callithamnion efflorescens J. AGARDH, Sp. Vol. II p. 15.
Rhodochorton chantransioides REINKE, Algenfl. p. 23, Atlas Deutsch. Meeresalg. Taf. 21.

Much has been added to our knowledge of this interesting Alga during the last thirteen years. GRAN described the sex-organs in 1896, showing that the formerly known clusters of spores were cystocarps. According to GRAN and other observers the sexual plants do not bear sporangia; but later, sporangia have been observed on other individuals supposed to belong to the same species. Thus, in 1902 E. LEHMANN recorded monosporangia-bearing plants growing together with sexual plants on stones in the bay of Kiel, and in the same year BØRGESEN mentioned similar plants with monosporangia found at the Faeroes, while sexual plants were not met with. Finally, KYLIN has shown in 1906 that *Rhodochorton chantransioides* REINKE belongs to this species, representing an asexual generation provided with tetrasporangia. KYLIN doubts, however, that the asexual plants mentioned by LEHMANN and BØRGESEN ought to be referred to this species, as they bear monosporangia and have somewhat thicker filaments than the Swedish specimens.

Referring to the careful description of the species by KYLIN, it must be pointed out that I do not fully agree with this author in the delimitation of the species, as I have found that it may have monosporangia as well as tetrasporangia, and that the filaments may often be somewhat thicker than stated by him. While the filaments according to KYLIN are 5 μ thick, I have found, on the basis of a great number of measurements, that in plants from all Danish waters they are usually 5—6 μ thick, but that the thickness varies from 4 to 7,5 μ. My observations are not sufficiently numerous to allow any certain conclusion as to the influence of the outer conditions upon the thickness; I shall only state that the specimens from the Baltic were 4—5 μ thick, while plants collected in the North Sea in 38 meters depth were 6 μ thick.

The germination, which was hitherto unknown, has been studied in specimens growing on the theca of a hydroid polyp, collected in the Samsø Waters (YV) in

June. The germinating plants were found among fully developed plants bearing monosporangia and originated undoubtedly from monospores. As shown in fig. 61 the germinating spore becomes a hemispherical basal cell the diameter of which is much greater than that of the filaments, namely 8—10 μ. This cell keeps its form, at all events for some time, and divides only by peripheral walls, by ramification. An erect filament is early given off from the upper face of the cell, and from the margin small cells are cut off which grow out into irregularly bent creeping filaments. In somewhat older plants two erect filaments rising from the basal cell and an increasing number of radiating creeping filaments are visible (fig. 61 *E*). In some cases it was observed that a filament, after having run some distance on the surface of the wall of the hydroid, had suddenly penetrated the wall and continued its way within it (fig. 61 *E*). I do not know if this species can also penetrate the Algæ on which it grows. Lehmann figures a basal part of the f. *petrophila* described by him (l. c. fig. 10), which is rather different from the young stages observed by me, as it is a parenchymatous disc giving off three erect filaments from three different cells, and no cell is distinguishable as being the originally single basal cell. The difference may be possibly due to the difference in age, in part also to the different substratum.

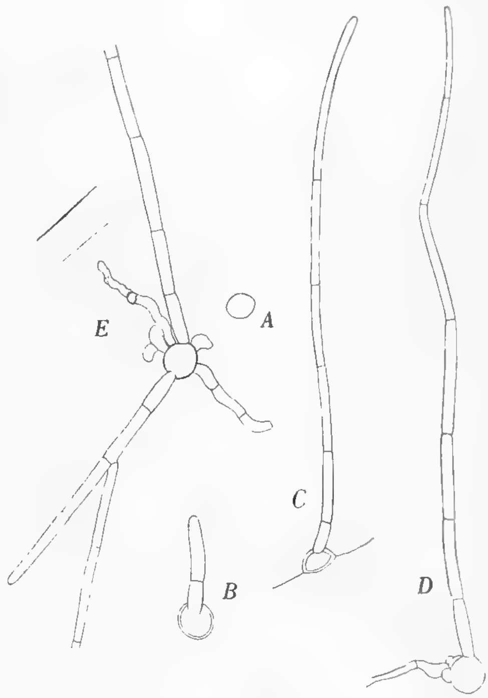


Fig. 61.
Chantransia efflorescens. Germinating plant on tube of Hydroid, from YV, June 1904. *A*, spore, provided with membrane but still undivided. *B*, the basal cell has given off an erect filament. *C*, older plant in the same stage. *D*, creeping filaments are given off from the periphery of the basal cell. *E*, the basal cell has given off two erect and four creeping filaments; one of the latter has penetrated into the membrane of the Hydroid. The endozoic part of the filament is shaded. 560 : 1.

As shown by Kylin, free descending filaments often occur in the lower part of the plant; they are met with in the asexual individuals as well as in the sexual plants; in the first named, however, they are often wanting.

The chromatophores are, as shown by Reinke and Kylin, parietal spiral-shaped bands. Usually there appears to be two, sometimes only one, and in other cases they are more irregular, either more numerous or more branched, a matter difficult to decide. Lehmann states expressly that the cells contain one much-branched chromatophore only, the apparently distinct chromatophores being always connected by anastomoses. Though this statement is in contradiction to the figures of Kuckuck (Reinke, Atlas Taf. 21 fig. 3) and Kylin and though I also think I have observed more than one chromatophore in the cells (fig. 64). I dare not deny it decidedly, as it is in reality very difficult to convince oneself of the absence of anastomoses between the chromatophores, which never run quite regularly. According to KYLIN (l. c. p. 115) the chromatophores contain small granules which are interpreted by him as pyrenoids. I have observed the same granules but cannot give any information as to their nature; their appearance seemed not to be constant. While the cells in LEHMANN's specimens contained fat and no starch, I found in cystocarp-bearing specimens the vegetative cells containing no fat but minute starch-grains staining red-brown in iodine, and the cystocarps, especially the carpospores, contained a great quantity of the same substance. The reaction with iodine was rather similar to that of glycogen.

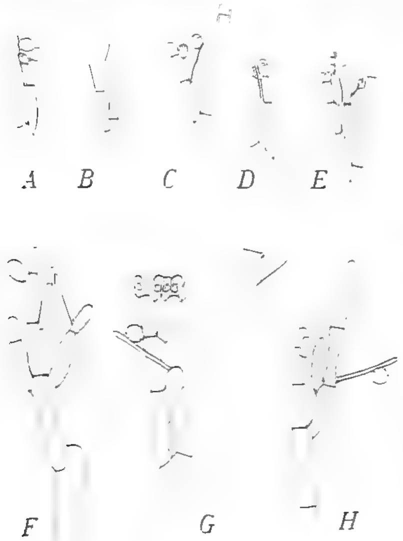


Fig. 62.
Chantransia efflorescens. Fertile branchlets. See the text. The carpogonia and the cells produced by them after fertilisation are shaded. *A—D* 390:1. *E* 300:1. *F—H* 620:1.

The sex-organs develop, as shown by GRAN, on special fertile branchlets, generally very near each other. Later, KYLIN has accounted for the various combinations of the sex-organs on the same branchlet, but he has not noticed the curious fact that the carpogonia are not always lateral on the fertile branchlet but often intercalary, rising by transformation of the second or even the third cell from the top. The intercalary carpogonia, which were already observed in 1893 by the late Professor FR. SCHMITZ who mentioned them in a letter to me, are very common. A very frequent case is represented in fig. 62 *A*, *C*, *D* where the lower cell in a two-celled branch has become a carpogonium, pushing forward a trichogyne from the upper end of the cell along the upper cell which in all cases is sterile bearing two antheridia. In fig. 62 *B* both the cells have developed into carpogonia, the one superposed on the other. In fig. 62 *G* the carpogonium has arisen from the lowest cell in a three-celled branched branchlet, and in fig. 62 *E* and *F* they are lateral. In the same branchlet a lateral and a terminal carpogonium frequently occur. The intercalary carpogonia show very often a swelling at the base of the trichogyne (fig. 62 *D*) which may formerly perhaps have been interpreted as the whole ventral part of the carpogonium. Fertilized carpogonia with adhering globular spermatia frequently occur. After fertilization the separation of the trichogyne takes place in the intercalary carpogonia at the upper end of the swelling (fig. 62 *G*). Thereafter the fertilized carpogonium increases in length, the trichogyne is pushed aside, and the lengthened body divides by a transverse wall a little under the insertion of the trichogyne (fig. 62 *E*, *F*, *H*). Even in this stage and later the trichogyne with adhering spermatium may yet be visible. In fig. 62 *H* the primary filament of the young cystocarp is three-celled and has produced a branch. The further divisions and branchings I have not followed; they result in the formation of a glomerule of radiating filaments, the two or three last cells of which are swollen and produce each a carpospore. As each fertile branch bears as a rule more than one carpogonium, the glomerules may perhaps sometimes be composed of two or even three cystocarps, being thus syncarps. The position of the antheridia in the neighbourhood of the carpogonia results in emptied antheridia being frequently visible in ripe cystocarpia amongst the spore-producing filaments (fig. 63).

I have no doubt that Kylin is perfectly right in referring the *Rhodochorton chantransioides* to this species, as it agrees with it in all but the reproduction. However, the tetraspore-bearing plants are as a rule smaller, ca. 2 mm. high, and it may be added that they usually form continuous felted coverings while the sexual plants form isolated tufts. On the other hand specimens fully agreeing with those described by Reinke and Kylin, only bearing monosporangia instead of tetrasporangia, also occur. Young still undivided tetrasporangia are out of the question in this connection, for I have in many cases met with specimens bearing numerous well-developed monosporangia, some of which were emptied but not one with divided contents. Usually each plant bears either tetrasporangia or monosporangia, but the two kinds of plants often grow together side by side, as the plants represented in fig. 64. The only difference is that the monosporangia are smaller than the tetrasporangia. The monosporangia I found (10—) 11—18 μ long, 5—7 (—8,5) μ broad, the tetrasporangia 15—28 μ long, 8—12,5 μ broad. Referring to the above quoted descriptions it may be added that two sporangia-bearing branchlets are frequently sitting on one cell in the monosporangia-bearing as well as in the tetrasporangia-bearing plants; they are usually opposite but may also be placed near each other on one side of the filament (fig. 64).

Fig. 63.
Chantransia efflorescens. Branchlet with ripe cystocarp showing still two emptied antheridia at the top of the branchlet. 835:1.

The species has been met with in the Danish waters in the months April to August. Sporangia-bearing plants occur in April to June, more rarely in July. Sex-organs have been met with in all the months named, fully developed cystocarps only in June to August. This in connection with the fact that the two kinds of reproductive organs occur in different individuals suggest the existence of an alternation of an asexual generation appearing in spring with a sexual one occurring principally in summer. If this supposition is right, the germinating plants mentioned above (fig. 61) must be young sexual plants. Unfortunately Lehmann does not mention if the basal disc figured by him (l. c. fig. 10) belonged to an asexual or a sexual plant.

The species attains in the Danish waters a length of 5 mm., but it is relatively seldom more than 3 mm. high. As mentioned above, the asexual plants are as a rule smaller than the sexual ones; however I have found in the Little Belt a specimen with monosporangia measuring 5 mm. in length. It grows principally on other Algæ; I have recorded it on 15 different species, most frequently on *Delesseria sangvinea*, *Furcellaria*, *Desmarestia aculeata*, *Cystoclonium purpurascens*, *Polysiphonia elongata*, further on leaves and roots of *Zostera*, on tubes of Hydroids, Ascidians, shells of *Buccinum* and finally on stones. It has been met with in depths of 7,5 to 38 meters, most frequently 11 to 23 meters. In the following list of localities the depth is only indicated when it is outside the last named limits. It is interesting that this subarctic species has been met with in nearly all the Danish waters, also in the Baltic, but not in the Limfjord nor in other shallow waters where the summer temperature is comparatively high.

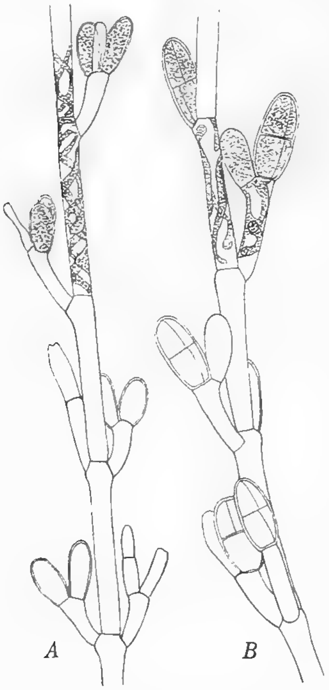


Fig. 64.
Chantransia efflorescens. *A*, filament with monosporangia, partly emptied. *B*, filament with tetrasporangia. 560 : 1.

Localities. **Ns:** AG near the Jutland Reef, 28 met. — **Kn:** FG, Herthas Flak; FH near Frederikshavn 4—7,5 met.; VU and VT, 9,5 met., N. of Læsø. — **Ke:** FC; ZE[1] and VY, Fladen; IK, Lille Middelgrund; IA, Store Middelgrund; RL. — **Km:** XF, Læsø channel, 8,5 met. — **Ks:** OS, Hastens Grund. — **Sa:** FS, Vejrø Sund; YV, south of Hatterbarn; DK, Bolsaxen. — **Lb:** XP, Middelfart; common around Fænø. — **Sb:** Z; near Sprogø (Ostenfeld); Langelandsbelt: UH, UT and LB. — **Su:** bM, south of Hveen; OG[1]. — **Bw:** LC, south of Langeland; Femerbelt: UL and KX. — **Bb:** XZ[4], Davids Banke, 19—20,5 met.

24. Chantransia pectinata Kylin.

Kylin (1906) p. 120.

I have repeatedly met with a *Chantransia* agreeing with Kylin's description and figures of this species, which appears to be related to *Ch. efflorescens.* The only discordance is that in some cases I have found free descending filaments near the base of the erect filaments, while *Ch. pectinata* according to Kylin is distinguished from *Ch. efflorescens* just by the want of such filaments. They occur however seldom and are not so long as in the latter and they appear to have partly the character of stolons, growing out in horizontal direction (fig. 65 *C*). In spite of the presence of these filaments I regard the two named species as quite distinct, *Ch. pectinata* being characterized by thicker filaments, shorter, more thick-walled cells and by the sporangia-bearing branchlets being seriate on the inner side of the lateral filaments.

The main filaments were in my specimens 6—9 μ thick near the base; they are repeatedly branched. Opposite branches sometimes occur (fig. 65 *D*). The branches are tapering upward, finally only 3,5—4 μ thick. The cells of the main filaments are usually 4—7 times as long as broad. As shown by KYLIN, the chromatophores have almost the same shape as in *Ch. efflorescens*; they may also contain small refractive bodies which are possibly pyrenoids.

The sporangia-bearing branchlets are sometimes composed of more than 3 cells and transitions to longer filaments may then occur. Sometimes the sporangia may also be terminal on long filaments (fig. 65 *A*). The sporangia are always monosporous; after the evacuation a new sporangium is often formed within the emptied membrane. In some cases the sporangial wall was distinctly lamellate, consisting of two layers at least (fig. 65 *A*, *B*) in other cases this could not be observed. The sporangia were in the Danish specimens 10—14 μ long, 5,5—7,5 μ, most frequently 7 μ thick.

The species has been found in depths of 13 to 24,5 meters, growing on ***Phyllophora Brodiæi*, *Desmarestia aculeata*, *Buccinum undatum*** and ***Flustra foliacea***, in June and July.

Localities. **Ke**: VZ, Groves Flak. — **Lb**: Fænø Sund and N. and W. of Fænø.

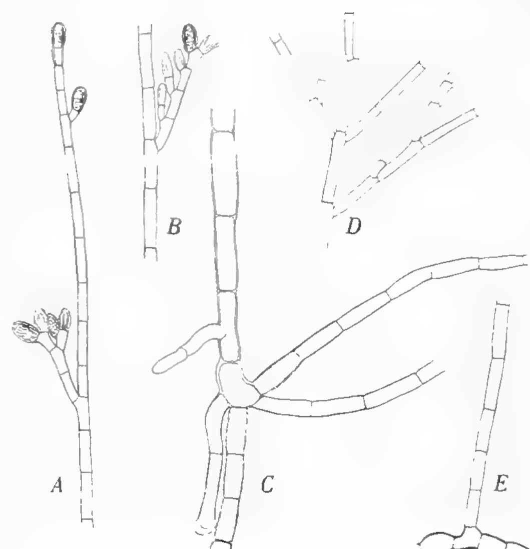


Fig. 65.
Chantransia pectinata. From Little Belt near Fænø. *A*, end of long filament with terminal sporangium and lateral sporangia-bearing branchlets. *B*, 4-celled sporangia-bearing branchlet. *C*, lower part of erect filament with descending and horizontally outgrowing filaments. *D*, erect filament with opposed branches. *E*, fragment of a filament of the basal layer with erect filament. A. B. D 270:1. C 560:1. E 350:1.

β, *cimbrica* var. nov.

Filis principalibus crassioribus, inferne 8—10,5 μ crassis, sporangiis partim tetrasporis 18—19 μ longis, 10,5—13 μ latis, partim monosporis, 11—13 μ longis, 6—8 μ latis.

In the Skagerak a *Chantransia* was found in May, growing on *Flustra foliacea*, which differed from the typical *Ch. pectinata* by thicker filaments and by the presence of tetrasporangia, but for the rest resembling the latter so much that it must be considered as a variety or form. Some specimens were almost the same as the typical species or only differing by a little thicker filaments, having the typical seriate sporangia-bearing branchlets with monosporangia. But others showed less numerous fertile branchlets bearing at most 2 sporangia, which were larger than the others and containing 4 spores. As I have had very scarce material I cannot say if the two kinds of sporangia may occur in the same individual. At all events some specimens bore exclusively monosporangia; the tetrasporangia occurred only in small quantity.

As in the main species short descending filaments occurred at the base of the

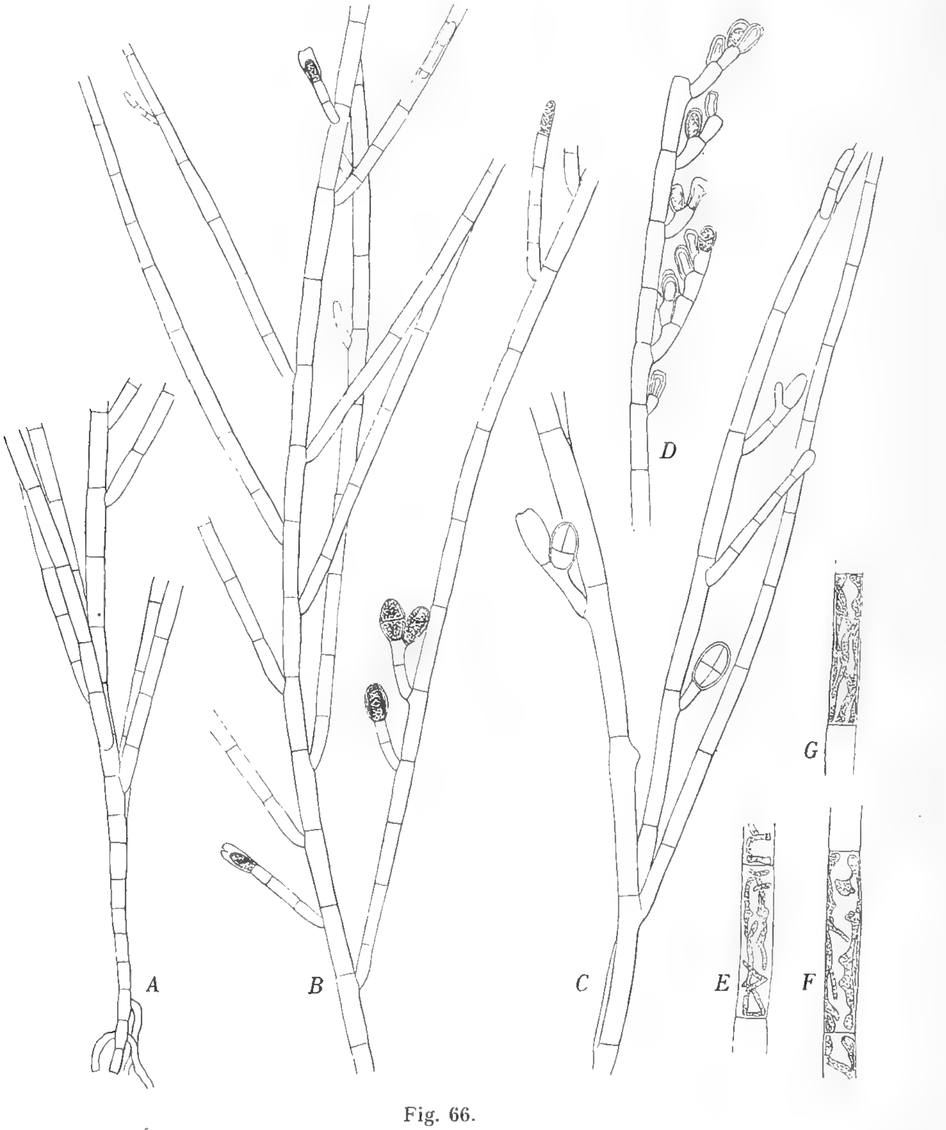


Fig. 66.

Chantransia pectinata β, cimbrica. *A*, lower part of erect filament. *B*, upper part of the same with sporangia; one of these showing a transverse wall. *C*, branched filament with tetrasporangia. *D*, filament with branchlets bearing monosporangia. *E—G*, cells showing the chromatophores. *A*, *B* 260:1. *C*, *D* 340:1. *E—G* 550:1.

erect filaments (fig. 66 *A*). The branches taper upwards, at last 5,5 μ thick. There is more than one chromatophore, parietal, long and narrow, sometimes spiral-shaped but more frequently rather irregular.

Similar specimens to those just described, but bearing only monosporangia, were found attached to *Flustra foliacea* near the Jutland Reef. To this variety may also be referred some small specimens found nearly in the same place as the first described, and on the same substratum (no. 7109). Their primary erect filaments were up to 11 μ thick but consisted of rather short cells, 1,5—5 diameters long, and the fertile branchlets were placed more irregularly, often on the primary filaments and occurred often in small quantity. As they otherwise agreed with the just described f. *cimbrica* they must be regarded as poorly developed specimens belonging to this variety.

Localities. Ns: aG, near the Jutland Reef, 38 meters, August. — Sk: N.W. of Hirshals, 13—15 meters, May.

Kylinia gen. nov.

Plantæ minutissimæ, habitu et crescendi modo *Chantransiæ*. E cellula basali germinatione sporæ orta fila libera plus minus ramosa horizontaliter egrediuntur. Monosporangia in filis terminalia vel lateralia. Antheridia singula vel bina, in cellulis androphoricis erectis, multo angustioribus quam cellulis vegetativis, hyalinis, terminalia. Carpogonia terminalia vel lateralia vel in cellula basali sita, post foecundationem primo latitudine aucta et longitudinaliter divisa. Carpospora ut videtur pauca oblonga vel leviter curvata, in una planitie subflabellatim disposita.

1. **Kylinia rosulata** sp. nov.

Cellula basalis hemisphærica fila plura, usque ad 7, horizontaliter emittens. Fila simplicia vel plus minus ramosa, ramis plerumque oppositis horizontaliter egredientibus. Cellulæ 4,5—5,5 μ crassæ, latitudine vulgo 1,5—2-plo longiores, rarius ultra, chromatophorum parietale continentes. Fila nonnunquam pilo hyalino tenuissimo terminata. Sporangia terminalia vel lateralia, ovata, 6,5—8,5 μ longa, 5—5,5 μ lata. Cellulæ androphoricæ 1—1,5 μ latæ, c. 4—7 μ longæ, ad apicem et dorsum cellularum vegetativarum vel, ut videtur, carpogoniorum, singulæ rarius binæ. Antheridia 2—4 μ longa, 1,5—2,5 μ lata. Cystocarpia, ut videtur, paucicellularia, carposporis c. 3.

This curious little plant has only been met with once in the Northern Kattegat where it was found growing fairly abundantly on a specimen of *Sporochnus pedunculatus*. It occurred only on the assimilating filaments which form a tuft on the fertile branches of this plant, and their number was often so great that these filaments were rose-coloured in spite of the extreme smallness of the epiphyte. Its appearance is that of a *Chantransia* of the group with one basal cell; it is indeed somewhat similar to *Chantransia hallandica* γ, *parvula*. The basal cell is hemispherical, attached to the substratum by a thin layer of cementing substance (fig. 67 *E*). It gives off at all sides in a horizontal direction, but not from the upper side, a number of filaments, in well developed plants 6 or 7. These filaments grow out along the surface of the filament of *Sporochnus* but are not attached to it; they are thus growing in a cylinder, and the branching takes place in the same plane. The filaments attained only an inconsiderable length; I found them at most 5-celled. As I possess only dried specimens of the plant, I have not been able to determine with certainty the form of the chromatophore; I can only state that it is parietal and probably single. In the spores it appeared to be distinctly belt-shaped (fig. *A—D, N*). In some cases I believed I saw a pyrenoid (fig. *H, P*). The end-cells

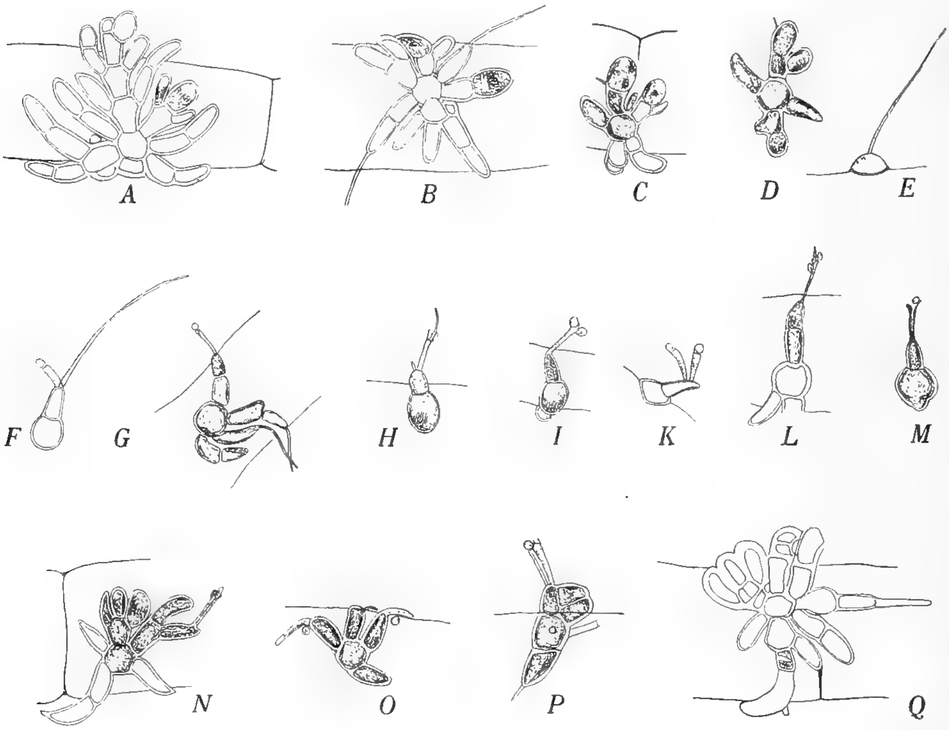


Fig. 67.

Kylinia rosulata. *A—D*, plants with sporangia. *E*, basal cell, still undivided, bearing a hair. *F*, plant consisting of a basal cell giving off a one-celled branch which bears a terminal hair and an androphore-cell with an antheridium. *G*, plant with androphore-cell. *H*, *I*, plants with androphore-cell bearing two antheridia. *K*, a cell giving off two androphore-cells. *L*, the outer cell in a two-celled filament transformed into a carpogonium; two spermatia adhering to the trichogyne (compare text). *M*, the cell given off from the basal cell seems to be a carpogonium; the threadlike organ to the right is probably the trichogyne, that to the left an androphore-cell. *N*, to the right probably a carpogone with adhering spermatium; at the upper side a short filament with sporangia. *O*, the thin cell to the left is probably a young androphore; above possibly a trichogyne. *P*, the basal cell bears to the right an androphore-cell, above a three-celled complex, probably a young cystocarp; this bears an androphore-cell with two antheridia and a trichogyne. *Q*, plant bearing above a three-celled, presumed young cystocarp and to the left a more developed cystocarp. 550 : 1.

bear frequently a very thin, hyaline hair tapering upwards; such a hair is also sometimes given off from the upper side of the basal cell even before branching. The plants are often much reduced, the basal cell giving off only one or a few short filaments consisting of one or very few cells (fig. *E—M, P*).

The sporangia-bearing plants bear usually no other reproductive organs. The sporangia are often terminal on primary filaments, being frequently separated from the basal cell only by one sterile cell (fig. *A—D*). Sporangia sitting immediately on the basal cell I have not observed.

The antheridia arise at the end of peculiar narrow, cylindrical, colourless or feebly coloured cells given off from the apical end of the end-cells, not rarely from cells sitting directly on the basal cell; in fig. *P* such a cell is even situated directly on the basal cell. These androphore-cells, as they may be named, are not given off in the same plane as the other branches but rise more or less vertically from the horizontally directed cells. Usually one androphore only is given off from the same cell, but two androphores situated near each other also occur (fig. *K*). As mentioned below, the androphore-cells may also be situated on the carpogonia. The end of these androphore-cells gives rise to one or two antheridia. In the first case a small cell, a little longer than broad, is cut off by a transverse wall (fig. *F, G, K*), in the latter the antheridial cells are cut off by inclined walls from the end of the androphore-cell, leaving a little point between the two antheridia (fig. *H, I*); this point may sometimes be lengthened into a short hair-like organ.

As to the carpogonia and cystocarps, I am sorry to say that I have not arrived at clearness, on account of the state of preservation of the material and perhaps also because these organs occurred in very small number and in insufficient stages of development. In particular it appeared difficult to find unquestionable trichogynes. I think however that the cell shown to the right in fig. *N* is really a carpogonium with a spermatium attached to the trichogyne. In fig. *P* a cell-complex, probably a young cystocarp, is seen bearing an androphore and quite near to it a thin thread, which is perhaps a trichogyne, but no spermatium is attached to the latter. A similar case is shown in fig. *M*, where a cell bears two thin, threadlike organs, the one being certainly an androphore-cell, the other probably a trichogyne. The great resemblance between the androphore-cells and the trichogynes cause great difficulty, in particular when the antheridia are formed on the side of the androphore-cell. Thus the case represented in fig. *L* might perhaps raise some doubt. The resemblance between the filiform organ figured here and the androphores represented in figs. *H* and *I* might perhaps suggest that it is an androphore with two antheridia and prolonged point; the continuity of the protoplasmic contents in the filiform organ and that of the cell from which it is given off goes however to prove, that these two organs belong together, being a carpogonium, and that the two spermatia must have come from elsewhere and become attached to the trichogyne. Small round cells looking like spermatia have sometimes been found attached to various points on the surface of the plants (fig. *A, O, Q*). In the latter case (fig. *Q*) the small cell was adhering to a hyaline curved cell, the significance of which I do not know.

Of stages which could be supposed to be fertilized carpogonia or cystocarps I have only found very few. The three-celled complex situated at the side of the basal cell turned upwards in fig. *P* I regard as a young cystocarp. A similar three-celled stage is shown in fig. *Q* at the upper side, partly hidden by an over-lying filament. If this interpretation is right, the fertilized carpogonium is first divided by a vertical wall and thereafter one of the daughter-cells is divided by a wall perpendicular to the first. The cell-complex shown to the left in fig. *Q* I take to be a more developed, perhaps a fully ripe cystocarp. The three larger, upwards directed cells are probably the carpospores; they are somewhat diverging, lying in one plane, the same as that of the branching of the plant. A stage so much developed was only once observed.

In spite of the likeness of our plant to the genus *Chantransia* in habit and in the monosporangia, it seems correct not to refer it to this genus but to regard it as the representative of a new genus, characterized in particular by the androphore cell being very different from the ordinary cells, and further by the development and structure of the cystocarps. Among the sexual species of *Chantransia, Ch. hallandica* seems to be the one where the cystocarp offers most similarity with that of *Kylinia*, but unfortunately its development is not known. The fact that the androphore-cell is often situated on the carpogonium is analogous to the above described case, that an antheridia-bearing cell is often superposed on the carpogonium in *Chantransia efflorescens*.

The genus is called after the Swedish phycologist, Dr. H. Kylin, who has contributed so much to our knowledge of the northern marine Algæ.

Locality. **Kn:** TP, Tønneberg Banke, 16 meters, on *Sporochnus pedunculatus*, September.

Tribe Nemalieæ.

Nemalion Targioni Tozzetti.

1. **Nemalion multifidum** (Web. et Mohr) J. Ag.

J. Agardh, Linnæa Bd. 15 p. 453, Spec. II, p. 419, III p. 508; Harvey, Phyc. Brit. pl. 36; Bornet et Thuret, Rech. féc. Florid., Ann. sc. nat. Ve sér. t. 7, 1867 p. 141, pl. 11 fig. 1—5; Janczewski (1877) p. 113, Plate 3 fig. 3; Wille, Ueber die Befrucht. bei Nemal. multif., Ber. deut. bot. Ges. 1894 p. 57; Grace D. Chester, Notes concerning the development of Nemalion multifidum, Botan. Gazette Vol. 21, 1896 p. 340 Pl. XXV and XXVI; J. J. Wolfe, Cytolog. Stud. on Nemalion, Annals of Botany, Vol. 18, Oct. 1904; Oltmanns (1904) p. 539, 540, 542.

Rivularia multifida Weber et Mohr, Naturhist. Reise 1804 p. 193 Taf. III fig. 1.

Chordaria multifida Lyngb. Hydr. p. 51; Flora Dan. Tab. 1669.

As to the structure of the frond reference may be made to the descriptive works and the paper of Grace D. Chester. The ramification is said to be dichotomous and it may possibly be so, but it may also be lateral, as shown in fig. 68 *A*, representing a young plant. The structure of the cells has been studied by Wolfe, from whose statements it appears that the presumed pyrenoid is not a true pyrenoid but a vacuolar cavity without organized contents. While the chromatophore is in general stellate, I found it in a basal disc globular without branches given off towards the periphery of the cell.

As stated by Miss Chester the germinating spores develop at first into short branched, creeping filaments consisting of short rounded cells. Later on filaments composed of long, narrow cells with less protoplasmic contents are developed in the continuity of the primary ones. They form later at their upper end fasciculated branches reminding one of the peripheral assimilative filaments in the older frond. The author named supposes that such thin erect filaments may meet and twist together, thus giving rise to an erect frond. I have not observed the species in this stage of development. In February at Gilleleje I found crusts apparently formed by densely united creeping filaments like those described by Miss Chester, but almost no erect filaments were observed. Young plants with the normal structure are shown in fig. 68; the assimilative filaments were only less numerous in the lower part of the plants than later.

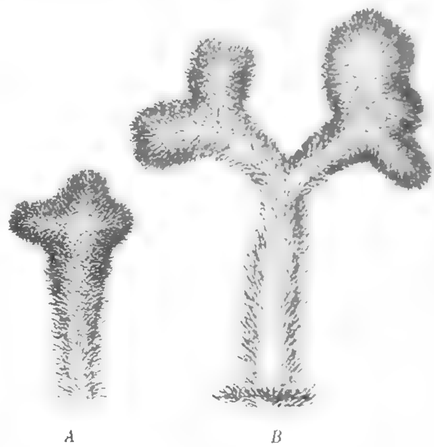


Fig. 68.
Nemalion multifidum. Young plants from the mole at Gilleleje, November 1902. C. 33 : 1.

The assimilative filaments terminate in hyaline hairs of various length, generally rather short. The shortest are almost entirely filled with protoplasm, while in the longer the protoplasm with the nucleus is concentrated in the upper end, the rest of the cell containing only a thin parietal layer. When a hair dies a new one is often formed at the same place from the subjacent cell: the lower part of the old membrane remains however surrounding the base of the new hair as a sheath. A new hair may also be formed beside and below the terminal one, and this may also be renewed (fig. 69).

Fig. 69.
Nemalion multifidum. End-cells of assimilative filaments with hairs; in *D* the nucleus is visible. 630 : 1.

The antheridial branches form clusters at the ends of the assimilative filaments as described by Bornet and Thuret (1867) and Wolfe. Each cell in the antheridial branch gives rise to four antheridia or fewer (fig. 70). The spermatogenesis has been worked out by Wolfe.

The carpogenic filaments are terminal on the assimilative filaments and usually 3-celled, (according to Wolfe 2- to 5-celled). Concerning the fertilization and the development of the cystocarp reference may be made to the quoted papers of Bornet and Thuret, Janczewski, Schmitz, Wille and Wolfe. The fertilised carpogonium divides by a transverse wall into a basal or placental cell, remaining undivided, and an upper cell dividing by vertical walls into a number of cells giving rise to branched sporogenous filaments, the end-cells of which produce carpospores.

The species occurs in all the Danish waters except the Baltic, growing in the littoral region, thus being out of the water at low-tide. It varies but little in shape in the different localities; it attains very often a length of ca. 20 cm., but larger specimens not seldom occur; thus specimens measuring 40 cm. were met with at Harboøre and Gilleleje. It has been found in the months July to November; in the remaining part of the year it is probably represented by the creeping filaments described by Miss CHESTER which were, as mentioned above, observed by me in February. It may be supposed that the germination takes place immediately after the setting free of the spores but that the erect plants only develop in the next summer. I found however in November on the mole at Gilleleje young plants from less than 1 mm. to a few cms. in length; they would probably have perished during the winter, but possibly the basal portions would have been able to produce new erect fronds.

The species is said to be as a rule monoecious; I found it however most frequently dioecious in the Danish waters. In the proportionally few monoecious specimens (about 10 per cent) I found the two kinds of sexual cells near to each other in all parts of the plant and there is thus no reason to believe that the dioecious specimens would have proved to be really monoecious on closer examination. Antheridia occur in all the months July to November, but in the last months they are in a great measure emptied. Ripe cystocarps may occur already in July; in August a great part of the spores are often set free as well as later, in November however cystocarps containing most of the spores may still be found.

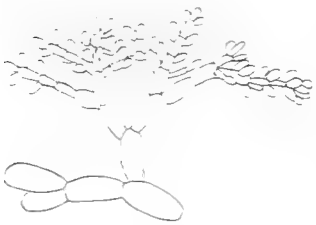


Fig. 70.
Nemalion multifidum. Antheridial branches at the ends of assimilative filaments. 340:1.

In autumn or the beginning of the winter the plants gradually die, the assimilative filaments being the first destroyed. This may begin already in August, but on the other hand fairly well-kept specimens are to be found still in November.

The species prefers agitated water; it therefore grows on the outer, not on the inner sides of the moles. It occurs on stones but also on wood, often together with *Fucus*.

Localities. **Ns:** Groins at Harboøre and Thyborøn. — **Sk:** Hanstholm, on a boulder near land; Lønstrup (Warming); Hirshals (!, Børgs.); Skiveren, on wreck. — **Lf:** Oddesund; Struer; Ejerslev Røn. — **Kn:** Frederikshavn; harbour of Vesterø, Læsø; Hornex, Læsø (J. P. Jacobsen). — **Ke:** Gilleleje (Lyngb., !). — **Km:** Anholt harbour; Herringholm (Lyngbye). — **Ks:** Grenaa harbour; Tisvilde (C. Rasch); near Klintebjerg, Odsherred (J. Vahl); Isefjord: Nykøbing; Lynæs; off Nordskov; Ourø; Holbæk Fjord; Bramsnæs Vig. — **Sa:** Kyholm, in the middlemost Fucus-zone; Sælvig (Hjalmar Jensen); Koldby Kaas; Hofmansgave (Hofm. Bg., Lyngb., C. Rosenb.); Juelsminde. — **Lb:** Bogense. — **Sf:** Rødlok Grund off Nakkebølle Fjord; Svendborg; Birkholm; Rudkøbing. — **Sb:** Kerteminde; Korsør; Lohals. — **Sm:** Guldborg. — **Su:** Hellebæk; Helsingør; Humlebæk (Henn. Petersen); near Hveen (Ørsted); Trekroner near Copenhagen (Ørsted).

Helminthocladia J. Agardh.

1. **Helminthocladia purpurea** (Harv.) J. Ag.

J. Agardh, Spec. II, p. 414, III, p. 506; Flora Danica tab. 2699; Schmitz, Chromatophoren der Algen, p. 63 fig. 11—12.
Mesogloia purpurea Harvey in Hooker Brit. Flora II, 1833, p. 386.
Nemalion purpureum Chauv.; Harvey, Phyc. Brit. Pl. 161; Kützing, Tab. phyc. 16. Band Pl. 62 c, d.

The structure of the frond is somewhat similar to that of *Nemalion multifidum*, but the assimilative filaments are composed of larger cells, of which the terminal ones are the largest (fig. 71). These terminal cells bear no hairs, and these organs are upon the whole rare in the older parts of the plants, while they occur fairly abundantly in the younger parts. They are given off from thinner branches not reaching the surface of the frond and are partly terminal, partly lateral; they have the same structure as other similar hairs, are fairly thick and attain a considerable length (fig. 71 *A*, *B*). Besides the hair a little cell with fairly dense contents is visible; such cells are also to be found in the older parts of the frond without hairs. The chromatophores which are particularly large and well developed in the terminal club-shaped cells, contain as shown by SCHMITZ (l. c.) a large central pyrenoid which in some cases was readily visible as a dense body, while in other cases they conveyed rather the impression of being vacuolar cavities like those stated for *Nemalion* by WOLFE (figs. 71 *A*, 72 *A*, *B*).

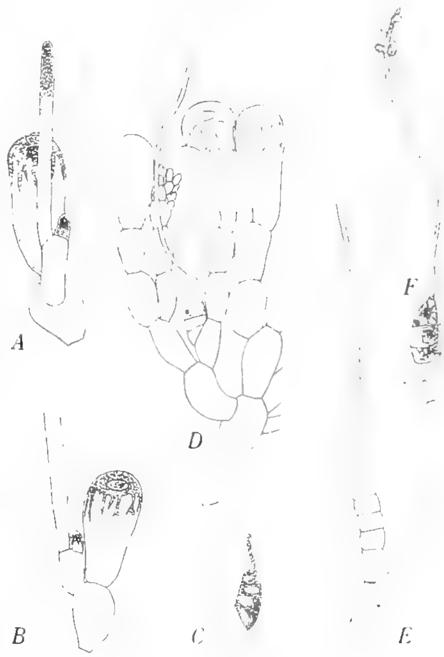


Fig. 71.
Helminthocladia purpurea. *A*, end of assimilative filament with young hair. *B*, similar with base of hair. *C*, young 4-celled carpogenic filament. *D*, assimilative filaments with antheridia and carpogenic filament. *E*, end of branch with a terminal 4-celled and a lateral 2-celled carpogenic filament. *F*, carpogenic branch in stage of fertilization. 350 : 1.

The antheridia form dense, often hemispherical clusters at the end of the assimilative filaments. The outermost cells are then small and bear a number of short much branched antheridia-bearing branchlets. These branchlets are shorter than in *Nemalion* and *Helminthora* and their joints are often nearly globular (fig. 72 *A*—*C*). In some cases a number of globular cells were found crowded together at the upper end of the last cells in the assimilative filaments (fig. 72 *E*, *F*). These cells, which were larger than the antheridia and contained a thin chromatophore, might be suggestive of monosporangia; they were however certainly no such organs but probably only checked antheridial branches.

which had not produced antheridia. The case represented in fig. 72 *D* goes to prove the correctness of this interpretation.

The carpogenic filaments are, as stated by SCHMITZ and HAUPTFLEISCH (1896 p. 333), lateral on the assimilative filaments and consist usually of 3 cells, the lowest of which is often wedge-shaped (fig. 71 *D, F*), 4-celled carpogenic filaments however also occur (fig. 71 *C*). Only once have I seen a carpogenic filament terminal on a vegetative filament which bore also a 2-celled lateral carpogenic filament (fig. 71 *E*). After fertilization the carpogonium is not divided, as in *Nemalion* and *Helminthora*, by a transverse wall into a stalk-cell and an upper cell producing the sporogenous filaments, but it divides by an oblique wall going from the upper side of the cell to the margin of the basal wall (fig. 73 *B, C*) and thereafter follows variously orientated walls, giving as result a cell-complex growing out into numerous radiating, branched sporogenous filaments, the end-cells of which produce carpospores. The succession of the divisions in the carpogonium I have not been able to follow; they seem to take place in such a manner that a number of peripheral cells are cut off while a larger placentar cell remains in the centre (fig. 73 *F, a*). The sporogenous filaments are rather long-celled, the mother-cells of the carpospores long and narrow. After the discharge of the carpospore a new mother-cell may be produced by proliferation from the subterminal cell. At the time when the divisions

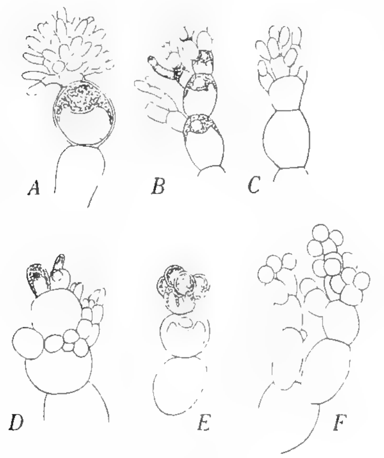


Fig. 72.
Helminthocladia purpurea. *A—C*, ends of assimilative filaments with clusters of antheridia. *D*, checked antheridial branches which have developed only very few antheridia. *E, F*, ends of filaments bearing globular cells, probably sterile antheridial branchlets. *A—D* 560 : 1, *E—F* 350 : 1.

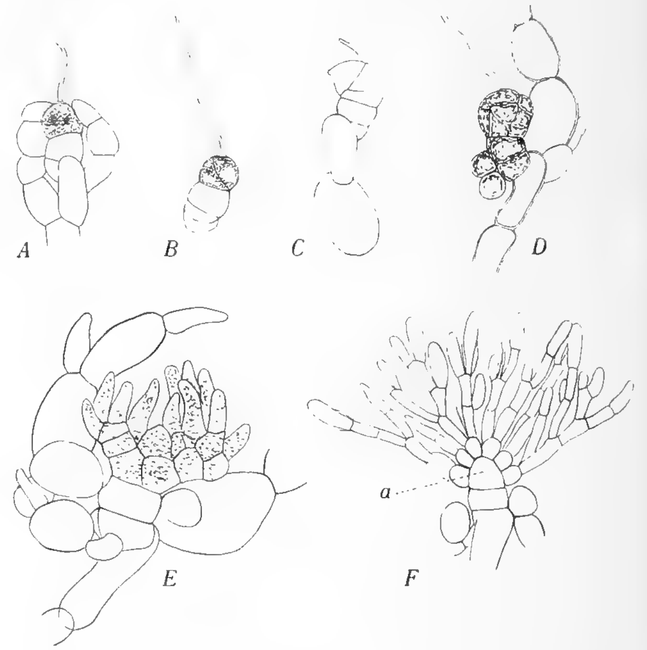


Fig. 73.
Helminthocladia purpurea. *A*, fertilized carpogonium, still undivided but with divided nucleus. *B*, fertilized carpogonium divided by an oblique wall. *C*, similar stage, the one daughter-cell appears about to divide. *D*, more advanced stage. *E*, the sporogenous filaments begin to grow out. *F*, median section of ripe cystocarp. *A—D, F* 350 : 1, *E* 560 : 1

of the carpogonium begin the sterile cells in the carpogenic filament and the nearest-lying cells in the supporting filament give off branches forming an involucre round the young cystocarp. The ripe cystocarp is a somewhat flattened capitulum, the filaments of which radiate outwards and to the sides.

All the specimens examined were monoecious. The largest specimens were 57 cm. long.

The species has only been found on the Skagerak coast, either washed ashore or in a seine, and no certain information can therefore be given as to the conditions under which it occurs. At Skagen I took it in a seine fishing in ca. 7 to 9 meters depth, and at Løkken I found it on the beach attached to *Lithothamnia* washed ashore. Probably it grows near the land in relatively small depths. It has only been met with in August and the beginning of September.

Localities. **Sk:** Tværsted (M. L. Mortensen), washed ashore; Løkken; 2 miles W. of Skagen, on the beach (Caroline Rosenberg Sept. 1st 1859); in a seine off the Marine Hotel on Skagens Gren, 7—9 met.

Helminthora J. Agardh.

1. **Helminthora divaricata** (Ag.) J. Agardh.

J. Agardh Spec. II p. 416, III p. 507; Bornet et Thuret, Féc. Flor. p. 142 Pl. 11 fig. 7; Janczewski (1877) p. 114 Pl. 3 fig. 4—6; Thuret, Études phycolog. p. 63 Pl. 32.
Mesogloia divaricata Ag. Syst. Alg. p. 51.
Mesogloia Hornemanni Suhr, Flora Dan. tab. 2202 (?).

Of this species, which is easily recognizable from the two foregoing species by its distinctly limited inner axis giving off the assimilative filaments, I have only had very little material from Danish waters; I shall therefore content myself with referring to the above quoted works, in particular those of Janczewski and Thuret.

The species has only been found in one locality and was represented only by two slightly developed specimens; the largest measuring 5,5 cm. in length was not much branched and bore numerous antheridia. They both grew on *Polyides rotundus*[1].

Locality. **Kn:** TL, W. of Nordre Rønner, 4—5,5 meters, September.

Fam. 3. Chætangiaceæ.

Scinaia Bivona.

1. **Scinaia furcellata** (Turn.) Biv.

J. Agardh Spec. I, p. 422, II p. 512; Bornet et Thuret, Not. alg. I p. 18, Pl. VI; Schmitz, Befrucht. 1883, p. 15, Taf. V fig. 5—7; Schmitz and Hauptfleisch, Rhodophyc. p. 337; Oltmanns, Morph. I p. 556.
Ulva furcellata Turner in Schrader, Journal für Botanik 1800 p. 301.
Ginnania furcellata (Turn.) Mont.; Harvey, Phyc. Brit. Pl. 69.

[1] When the printing of this paper was almost finished, L. Kurssanow has published interesting investigations on the cytology of the three last-named genera of Helminthocladiaceæ (Beiträge zur Cytologie der Florideen. Flora 99. Bd., 4. Heft 1909, p. 311), but further reference could not be made to them here.

Two specimens of this widely distributed species, the occurrence of which on the shores of Europe extends from the Mediterranean to Scotland and Helgoland, were found washed ashore at Løkken. As they were quite fresh and were attached to a fragment of an acorn shell, they must undoubtedly have grown near the place where they were found. They attained a length of 6,5 cm. and contained ripe and unripe cystocarps. Small antheridial groups were also found on the surface of the frond. As to the structure of the frond and the structure and development of the fruit I have no new observations; reference may be made to the above quoted papers, in particular those of BORNET and THURET, and SCHMITZ. The species is easily recognizable by its soft, cylindrical, dichotomous frond having a thin solid axis and by the characteristic, immersed cystocarps provided with a dense fruit-wall.

Locality. **Sk:** Washed ashore at Løkken, August.

CORRIGENDA.

P. 9, l. 9 from top, for "Antithammion" read "Antithamnion", for "Lithothamion" read "Lithothamnion".

P. 56, l. 8 from top, for "cushon" read "cushion".

P. 80, l. 5 from top, should read "Fam. 2".

P. 88, l. 14 from top, for "egrediunt" read "egrediuntur".

P. 91, l. 11 from top, for "egrediunt" read "egrediuntur".

P. 97, l. 6 from bottom, for "egrediunt" read "egrediuntur".

EXPLANATION OF PLATES.

All figures are photographs after dried specimens, about $^4/_5$ nat. size.

Plate I.

Porphyra umbilicalis (L.) J. Ag.

1. Monoecious specimen showing a longitudinal limiting line between the male and the female part of the frond. (Helsingør, September).
2. Small male specimen (f. *laciniata*); the marginal zone has produced antheridia. (Helsingør, September).
3. Female plant. The fertile zone above shows irregularly ramified spots caused by earlier maturation of the cystocarps here than in the surrounding parts. (Nørre Sundby, Limfjorden, September).

Plate II.

1—3. *Porphyra umbilicalis* (L.) J. Ag. f. *linearis* (Grev.). 1, monoecious, 2, female, 3, male specimen (Frederikshavn, December—January).

4—13. *Porphyra leucosticta* Thur.

4—7. Sexual plants, (harbour of Skagen, April 1905, M. L. Mortensen).

8. Asexual plant, possibly producing gonidia, (harbour of Skagen, July 1907).

9—13. Small specimens being the under part of specimens which have exhausted their spermatia and carpospores, (harbour of Skagen, July 1905).

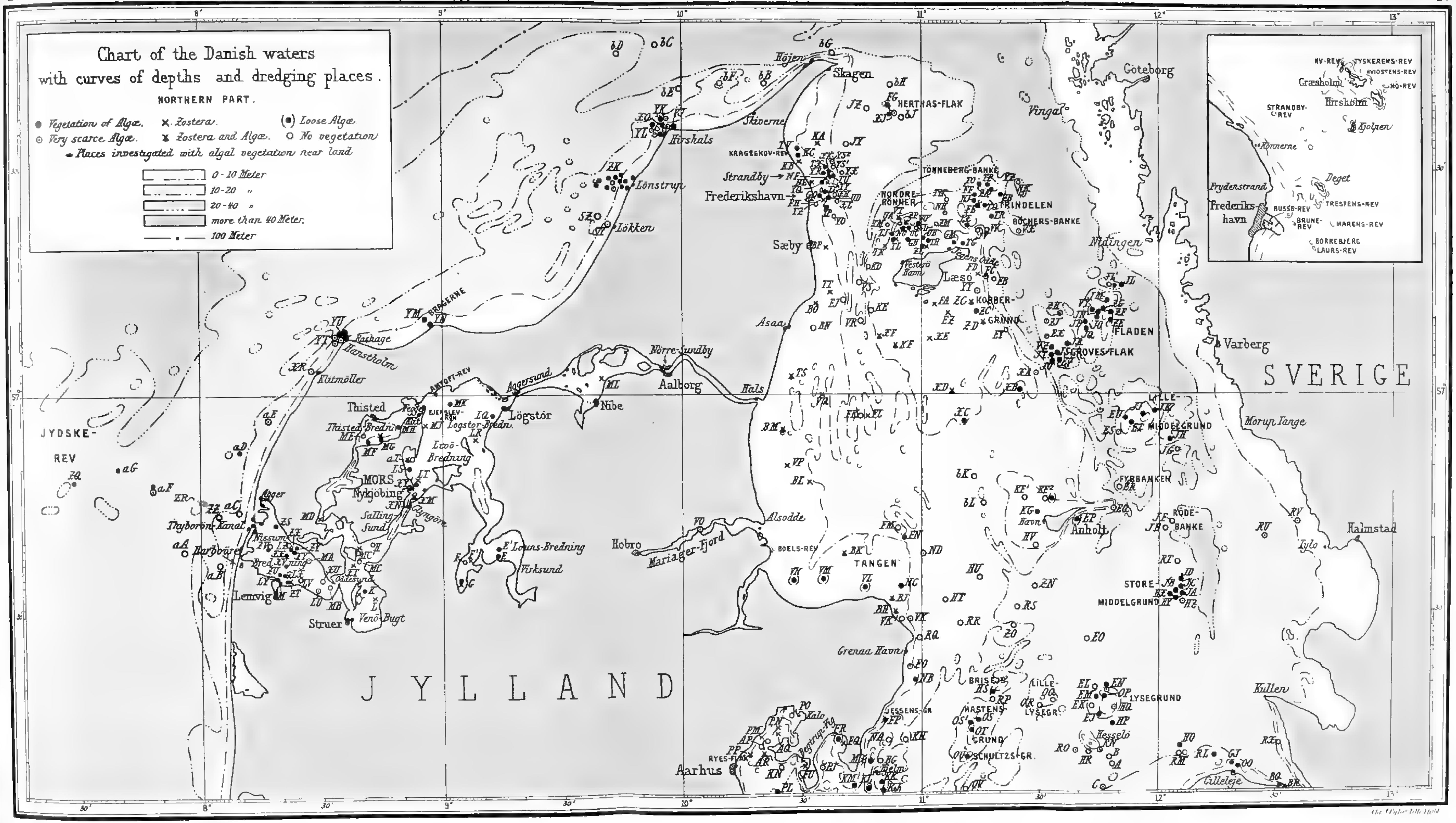
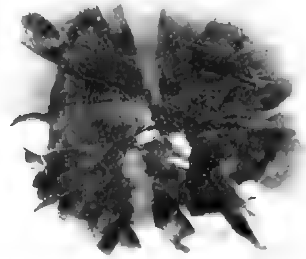


Chart of the Danish waters
with curves of depths and dredging places.
NORTHERN PART.
Vegetation of Algæ.
× Zostera.
(●) Loose Algæ
Very scarce Algæ.
Zostera and Algæ.
○ No vegetation
Places investigated with algal vegetation near land
0-10 Meter
10-20 "
20-40 "
more than 40 Meter.
100 Meter
JYLLAND
SVERIGE
Skagen
Hirshals
Lönstrup
Lökken
Hanstholm
Klitmöller
Thisted
Aggersund
Lögstör
Nörre-Sundby
Aalborg
Nibe
Hals
Frederikshavn
Strandby
Sæby
Asaa
Læsö
Anholt
Göteborg
Varberg
Halmstad
Kullen
Gilleleje
Aarhus
Hobro
Mariager-Fjord
Grenaa Havn
Struer
Lemvig
Harboöre
Thyborön-Kanal
MORS
Nykjöbing
Salling Sund
Venö Bugt
Virksund
Louns-Bredning
Löstör-Bredn.
Livö-Bredning
Thisted-Bredn.
JYDSKE-REV
Vinga
Nidingen
Morup Tange
Tylö
FLADEN
LILLE-MIDDELGRUND
STORE-MIDDELGRUND
TANGEN
TRINDELEN
HERTHAS-FLAK
TÖNNEBERG-BANKE
NORDRE-RÖNNER
BÖCHERS-BANKE
KRAGESKOV-REV
KOBBER-GRUND
GROVES FLAK
FYRBANKEN
RODE-BANKE
LYSEGRUND
Hesselö
SCHULTZS-GR.
BOELS-REV
Alsodde
Kalo
Begtrup-Vig
RYES-FLAK
JESSENS-GR.
Frydenstrand
Frederikshavn
Græsholm
Hirsholm
Kjolpen
Deget
STRANDBY-REV
BUSSE-REV
TRESTENS-REV
MARENS-REV
BORREBJERG
LAURS-REV


Chart of the Danish waters
with curves of depths and dredging places.
SOUTHERN PART
Vegetation of Algæ.
Very scarce Algæ
Zostera
Zostera and Algæ.
Loose Algæ
No vegetation
Places investigated with algal vegetation near land.
0-10 Meter
10-20 "
20-40 "
more than 40 Meter
JYLLAND
FYEN
SJÆLLAND
SVERIGE
LOLLAND
FALSTER
MOEN
BORNHOLM
RÜGEN
HANÖ-BUGT
Fredericia
Kolding
Middelfart
Horsens
Vejle
Esbjerg
Fanø
Ringkøbing-Fjord
HORNS REV
Blaavands-Huk
Assens
Nyborg
Kerteminde
Bogense
Svendborg
Faaborg
Als
Samsø
Kallundborg
Korsör
Skelskör
Nakskov
Nykøbing
Gjedser
Köge
KØBENHAVN
Roskilde
Holbæk
Frederikssund
Helsingör
Helsingborg
Landskrona
Malmö
Trelleborg
Ystad
Simrishamn
Åhus
Christiansö
Rönne
Nexö
Gudhjem
Falsterbo
Stege
Præstö Fjord
Kragevig
Femern
Arkona
Darserort
DAVIDS-BANKE
RÖNNE BANKE
ADLER GRUND
KRIEGERS FLAK
Langeland

1



2

3

Porphyra umbilicalis (L.) J. Ag.

1—3 *Porphyra umbilicalis* (L.) J. Ag. f. *linearis*. 4—13 *Porphyra leucosticta* Thur.

THE MARINE ALGÆ OF DENMARK

CONTRIBUTIONS TO THEIR NATURAL HISTORY

PART II

RHODOPHYCEÆ II.

(CRYPTONEMIALES)

BY

L. KOLDERUP ROSENVINGE

WITH TWO PLATES

D. Kgl. Danske Vidensk. Selsk. Skrifter, 7. Række, naturvidensk. og mathem. Afd., VII. 2

KØBENHAVN
BIANCO LUNOS BOGTRYKKERI
1917

III. Cryptonemiales.

Fam. 4. Dumontiaceæ.

Dumontia Lamour.

1. Dumontia incrassata (O. F. Müll.) Lamour.

Lamouroux, Essai. Mus. d'hist. nat. Paris 1813; Batters, Catalogue, 1902, p. 93.
Ulva incrassata O. Fr. Müller, Flora Danica tab. 653, 1775.
Ulva spongiformis O. Fr. Müller, Flora Danica tab. 763 fig. 2, 1778 (?). Fragment not determinable with certainty.
Ulva filiformis Hornemann, Flora Danica tab. 1480,2, 1813.
Gastridium filiforme Lyngbye, Hydr. p. 68 tab. 17.
Gastridium filiforme var. *intestiniformis* Liebman, Flora Danica tab. 2457, 1845 = f. *crispata* Grev.
Dumontia filiformis (Hornem.) Greville, Alg. Brit. p. 165 tab. 17 (cystocarp); Harvey, Phyc. Brit. pl. 59 and 357 B; Nægeli, Die neueren Algensysteme 1847, p. 243 Taf. IX fig. 4—8 (structure of frond); J. Agardh, Spec. II p. 249, III p. 257; Kützing, Tab. phyc. 16. Band Taf. 81 (transverse section of tetraspore-bearing plant; Schmitz, Befr. Flor. 1883 p. 18, 20, fig. 22 (carpogonial filament); Reinke, Algenflora d. westl. Osts. p. 26; G. Brebner, On the Origin of the filamentous thallus of Dumontia filiformis. Journ. Linn. Soc. Bot. Vol. 30, 1895, p. 436; Kuckuck, figure of a young basal disc in Oltmanns' Morph. I, p. 573; Okamura, Icones of Jap. Alg. Vol. I No. IV pl. 16 figs. 1—8, p. 65.

The fronds arise from a crustaceous disc produced by the germinating spore. A 5 days old plant is shown in fig. 74 *A*. It is not much larger than the tetraspore from which it arose, but it is divided into a number of small cells and has become a hemispherical body from the border of which short one- or two-celled filaments proceed.[1] A later stage is figured by Kuckuck (Oltmanns l. c.); a group of short-celled filaments is here seen given off from the upper side of the disc, and it is said that only one of these filaments serves to form the erect frond, some of the others forming the bark on the base of it. The basal discs may be perennial (Reinke, Brebner); they form large expansions on stones, *Mytilus*, *Chondrus* a. o. In sunny localities they have a light violaceous colour and often show radial folding (in a dried state), in greater depths they are darker, They are easily distinguishable by their structure and by the occurrence of groups of short-celled filaments giving rise to new erect fronds. As shown by Brebner (l. c.) the fronds may be endogenous

[1] The germination of the tetraspores has quite recently been described by Kylin (Über die Keimung der Florideensporen. Arkiv för Botanik. Band 14. N:o 22. Stockholm 1917, p. 9). The author kept the sporelings in culture during more than two months but did not obtain any production of erect shoots. The sporelings produced after 10 days long unicellular hairs, but after addition of nitrate to the culture no hairs were produced.

or exogenous and, according to this author, the cells of the short-celled filaments are divided by intercalary divisions.

The structure of the frond has been described in 1847 by Nægeli (l. c.). It terminates in an apical cell which is said to be divided by oblique cell-walls producing segments at all sides, and this is affirmed by Schmitz and Hauptfleisch (Engler u. Prantl, Nat. Pflfam. I, 2 p. 517); it is however at least not general. The young fronds arising from the basal disc have at all events an apical cell divided by horizontal parallel walls, and this is also the case with young slender branches (fig. 74, *B*, *C*). In thicker shoots still in development I have found the segment walls somewhat inclined, but not so much that they reached the foregoing segment wall (fig. 24, *C*). The cells of the frond contain a single nucleus and a number of disc-shaped chromatophores.

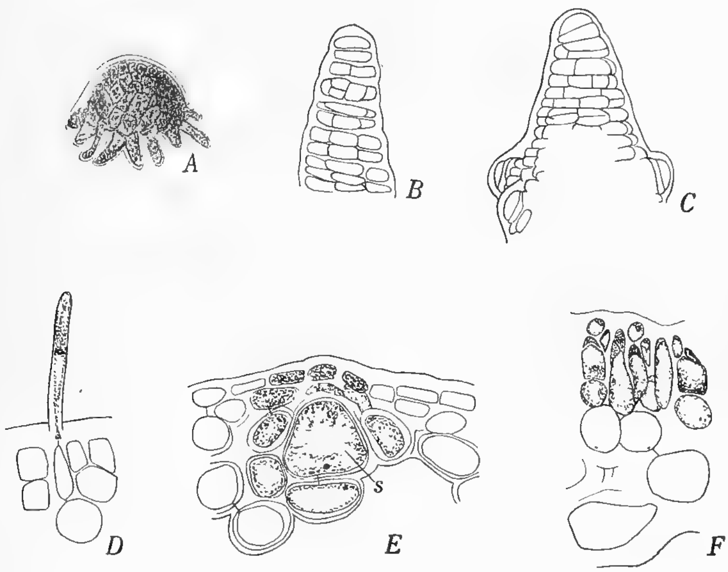


Fig. 74.
Dumontia incrassata. *A*, five days old plant from germinating tetraspore. *B*, upper end of side branch showing transverse segment walls. *C*, tip of young frond (November), the segment walls in the main axis slightly inclined. *D*, young hair. *E*, transverse section of frond showing a young sporangium. *F*, transverse section of frond showing the development of the antheridia. *A* 300:1. *B*, *C*, *E* 390:1. *D*, *F* 630:1.

Some of the surface-cells may produce a hyaline hair of the same character as in other Florideæ (fig. 74, *D*). In spring (March to May) they are most developed, numerous, long and rich in protoplasm; at other seasons they are often wanting.

The frond is at first cylindrical, but in an advanced age it becomes irregularly compressed and crisped (f. *crispata* Grev.). In winter and in shaded localities it is dark red-brown, while in sunny places in spring and summer it has a light yellowish colour, the tips at last becoming green.

The central cavity contains a thin slimy matter which seems to consist of pectic substances; it forms a network in the cavity, the meshes containing probably only water.

The sporangia are, as is well known, immersed in the wall of the frond; they are born of a cell in the inner cortex bearing moreover at least two cortical filaments (comp. Kützing Phyc. gen. tab. 74 II). The sporangium is connected through a pit with the bearing cell but not with other of the cortical cells (fig. 74, *E*); thus it is terminal and not intercalary as in *Dilsea*. The division is always cruciate; but it is often somewhat irregular, the longitudinal walls being inclined. I have not been able to decide if real cell-walls are formed between the spores in the sporangium. The latter is surrounded with a distinct wall consisting of more than one layer; at the lines of separation between the spores the inner layer is seen to be continuous, without penetrating between the spores. The sporangia develop in the main axis as well as in the branches down to 1 to 2 cm. from the base.

The antheridia (spermatangia) form a continuous layer on almost the whole surface of the male individuals. They are cut off by inclined, often upwards convex, intersecting walls of the upper end of the antheridia-bearing cells (SVEDELIUS' spermatangial mother-cells), at two (or perhaps more than two) sides (fig. 74, *F*). The form of the antheridia-bearing cells is rather variable according to the varying length and breadth; they contain a single nucleus but seem to be destitute of chromatophores. Beneath a fully developed antheridium a new one can arise, a little cell very rich in contents being cut off in the same direction as the former. In the middle of fig. 74 *F* above, the oldest antheridium is seen to be connected through a pit with the youngest one formed right under it. The continued formation of antheridia thus takes place by intercalary divisions, and the antheridia are placed in two (or more) series, but owing to the evacuation of the spermatia, at most two antheridia are to be seen at the same time in the same series. The antheridial development in this plant thus does not correspond with any of the types set up by SVEDELIUS (Martensia, K. Sv. Vet. Ak. Handl. Band 43. No. 7. 1908 p. 76).

The development of the cystocarp was found to agree with what OKAMURA found in examining Japanese specimens. The carpogonial branches arise from the inner part of the wall of the hollow frond, frequently from a cell in a longitudinal filament or from a cell given off from it. They are 5-celled and curved, in particular at the upper end, where the carpogonium is cut off by an oblique wall intersecting the underlying wall (comp. SCHMITZ l. c. fig. 22, OKAMURA l. c. fig. 4).

The auxiliary-cell filaments, being very numerous, as the carpogonial filaments as well, have a similar position to these. They are somewhat curved, and consist of 4 to 5, more rarely 6, rather low cells with rich contents. They are frequently placed quite near the carpogonial filaments; it may even happen that a carpogonial filament arises from the base of an auxiliary-cell filament (fig. 75 *A*). After fecundation, fusions take place between the carpogonium and one or more cells in the carpogonial filament, resulting in the formation of a great fusion-cell of very irregular form, giving off sporogenous filaments in various directions; in fig. 75 *E* 4 such filaments are present. The auxiliary cells with which they become connected are usually the second cell from the base of the auxiliary-cell filaments, sometimes the third or even the fourth cell. After fusion, the auxiliary-cell, when giving rise to a cystocarp, produces, at the convex side of the filament, a number of cells which after several divisions form a group of carpospores placed around a placentar cell originating from the auxiliary cell (or the fusion cell). A curious anomaly is shown in fig. 75 *F*. In the ventral part of the carpogonium no nucleus was visible, but

Fig. 75.

Dumontia incrassata. *A*, two carpogonial branches, the upper representing a side branch of an auxiliary-cell filament. *B*, carpogonial branch; the carpogonium does not reach the third cell from the top. *C*, carpogonial branch and auxiliary-cell branch. *D*, carpogonial filament after fecundation; the fertilized carpogonium has fused together with the three uppermost cells of the carpogonial branch, has become very enlarged and formed sporogenous filaments. *E*, the fertilized carpogonium has fused with one or two cells of the carpogonial filament and has given rise to four sporogenous filaments. At right a four-celled auxiliary-cell filament; the auxiliary-cell after having fused with a sporogenous filament has produced a young gonimoblast. *F*, the trichogyne of the unfertilized carpogonium contains two nuclei, while the ventral part contains no nucleus. The lowest or second cell from the base has fused with a sporogenous filament from another carpogonium. *G*, auxiliary-cell filament; the auxiliary cell has fused with a sporogenous filament and produced a new sporogenous filament. *H*, auxiliary-cell filament with young cystocarp. *I*, transverse section of frond with ripe cystocarp. *a*, auxiliary cell. *af*, auxiliary-cell filament. *s*, sporogenous filament. *t*, trichogyne. *A, B, D, E, G, H* 380:1 *C, F* 610:1. *I* 220:1.

in the middle of the trichogyne two bodies were found which were probably nuclei. As no spermatia were found fixed to the trichogyne, the two nuclei must have derived by division from the original carpogonial nucleus, the undermost representing probably the sexual nucleus, the upper the trichogynal nucleus. It must however be admitted that the upper end of the trichogyne was not quite distinctly visible. This filament is further remarkable in that the second cell from the base acts as an auxiliary cell, having fused with a sporogenous filament from another carpogonium. It is however not fully clear if the great fusion cell has arisen from the second cell or by division from the first cell, which is rather small and half enclosed by it. In the first case the carpogonial filament has been 6-celled.

The species is widely distributed on the Danish coasts, and occurs often abundantly. It grows particularly in somewhat sheltered localities, and attains there the greatest dimensions. In **Sk**, **Lf**, **K**, **Sa**, **Lb** and **Sf** it has been found only at low-water mark or a little lower; on the other hand, in the southern and eastern waters (southern parts of the Great Belt and of the Sound and the Baltic) it has also been met with in depths of 4 to 12 meters, and it occurs in a similar manner in the western Baltic according to Reinke (l. c.), while it otherwise appears to grow only at a slight depth. On the shores of North Europe it grows, where tide occurs, in the middlemost part of the littoral region ("à mi-marée"). The explanation of this peculiar distribution in the western Baltic and the adjacent waters might perhaps be sought in the lesser salinity of these waters. It deserves to be mentioned in this connection that the species, according to Crouan (Fl. Finist. p. 144), in the neighbourhood of Brest occurs particularly where fresh water runs out. When growing at low-water mark in Danish waters of comparatively high salinity, the plants are also temporarily exposed to fresh water at least by rainy weather during low-water. On the other hand it will be seen from the following maximal lengths for specimens collected in a series of localities in the Sound ranged from North to South that the length decreases with much decreasing salinity: Hellebæk 47 cm, Humlebæk 30 cm, Sletten 28 cm, Trekroner (Copenhagen) 20 cm, Dragør 8 cm. These specimens were all collected near the low-water mark. A length of over 50 cm has been met with in specimens from **Lb**, **Sf** (70 cm) and **Sb**. In the other waters the following maximal lengths have been recorded: **Sk** 37, **Lf** 28, **K** over 30, **Sa** 40, **Su** 47 cm.

The species has been found with erect fronds at all seasons, but only abundantly in the first half of the year, from the middle or the end of the winter to the beginning of the summer. Most of the specimens die in June or July; only single, rare specimens are therefore met with in the more advanced summer and in autumn. As the spores germinate easily immediately after having been shed, the species must be supposed to endure the summer in a crustaceous form, originating for the most part from the spores shed in the last spring but partly also of older date. The sexual organs have been met with in winter and spring and in September, ripe cystocarps in May to July, ripe tetrasporangia in May to July, once even in August

(Sk). Sexual organs and tetrasporangia occur always in distinct specimens. The same is the case with the antheridia and the carpogonia; I have found, however, some few specimens which seemed to be monoecious, but the supposed antheridia were not fully developed.

Localities. **Sk:** Lønstrup (loose on the shore); Hirshals, mole and reef. — **Lf:** Oddesund; Nykøbing (Th. Mort., F. Børg. !); Glyngøre; Agersund (Th. M.); Aalborg (Th. M.); Hals (F. Børg.). — **Kn:** Hirsholm; Kølpen; Frederikshavn; Nordre Rønner. — **Km:** Anholt, harbour. — **Ks:** Harbour of Grenaa; Hesselø; Isefjord: Lynæs, harbour. — **Sa:** Coast below Ris Skov; Aarhus, harbour; Odense Fjord: inner side of Enebærodden; Hofmansgave (Lyngbye, Hofm. Bang, C. Rosenb.). — **Lb:** Bogense; Fredericia; Middelfart; Kongebro; Snoghøj; Fænø Sound; Assens; Faaborg; Dyreborg. — **Sf:** CT west of Taasinge; Svendborg; Marstal, specimens up to 70 cm long, among Zostera in shallow water, frequently on Littorina; Skaarupør; Lohals. — **Sb:** South side of Refsnæs; Kerteminde; Korsør; Nyborg, harbour and Avernakhage; Vresen; Spodsbjerg, harbour; DQ, 5,5 meters; UR, 7,5 meters. — **Sm:** VC, Venegrund 4—4,5 meters. — **Su:** Hellebæk; Helsingør (Liebman, C. Rosenb., !); Humlebæk; Sletten; TF[1], Staffans Flak, 12—13 meters. OG[1], between Trekroner and Middelgrund, c. 9,5 m; Trekroner (Liebman, Ørsted a. o.); RH, Knollen, 9,5 m; Dragør; PR, off Dragør, 7,5—9,5 m. — **Bw:** KU, Schönheyders Pulle, 6,5 m.

Dilsea Stackhouse.

1. Dilsea edulis Stackhouse.

Stackhouse, Mém. soc. Mosc. II, p. 55,71 (non vidi).
Fucus edulis Stackhouse, Ner. Brit. 1. ed. p. 57 (non vidi), II. edit. 1816 p. 22, tab. 12 (good).
Halymenia edulis (Stackh.) Agardh; Flora Danica tab. 2258, 1839.
Iridæa edulis (Stackh.) Bory; Harvey, Phyc. Brit. pl. 97; Areschoug Phyc. scand. p. 89; Kützing, Tab. phyc. 17. Band, tab. 3a.
Schizymenia edulis (Stackh.) J. Agardh, Sp. g. o. II, 1851, p. 172.
Sarcophyllis edulis (Stackh.) J. Agardh, Sp. g. o. III, 1876, p. 265.

From a basal disc a number of flat fronds arise. Their number may be considerable, but when they are numerous they are for the greatest part feebly developed. They attain not seldom a length of about 30 cm; the largest specimen I have measured was 61 cm long in a dried state. As to the anatomy of the frond, reference may be made to the papers of Wille (Bidrag til Algernes physiologiske Anatomi. K. sv. Vet. Ak. Handl. Bd. 21, 1885, p. 71. tafl. V fig. 61—67, and Beiträge zur Entwickl. d. physiolog. Gewebesyst. Nov. Act. Leop. Car. Ak. Bd. LII Nr. 2, 1887, p. 83, Taf. 5 fig. 72—74 and Taf. 6 fig. 75).

In summer the species is always sterile. It is evidently fructiferous in winter, just as on the British coasts. Tetraspores were found in specimens collected in February to April; they were confined to round or oblong patches measuring at the most 1 cm in diameter. In a specimen collected in May the spots were still visible, but the sporangia were emptied. The sporangia are more or less deeply immersed in the cortex. They arise directly from cells of the inner cortex, and are thus intercalary, being outwardly connected through pits with filaments of the cortex (fig. 76). The ripe sporangium is surrounded by a double sporangial wall. The spores are paired, decussately or cruciately, the dividing walls are often inclined. The spores contain a number of small chromatophores.

The cystocarps are situated in the inner cortex, or at the limit between it and the medulla. The carpogonial branch is five-celled, the auxiliary-cell branches are curved, and composed of a great number of short cells (fig. 77). Ripe cystocarps have been met with in March. — Antheridia have not been met with.

The species is distributed in the Skagerak, in the northern and eastern Kattegat and in the northern part of the Sound. In the Skagerak it does not attain the same dimensions as in the Kattegat, its length scarcely exceeding 30 cm, probably owing to the more agitated water. It has here only been met with at comparatively slight depths, viz. 4 to 9,4 m. In the Kattegat it is mainly distributed in the eastern part, where it has been met with almost only at depths of 16 m or

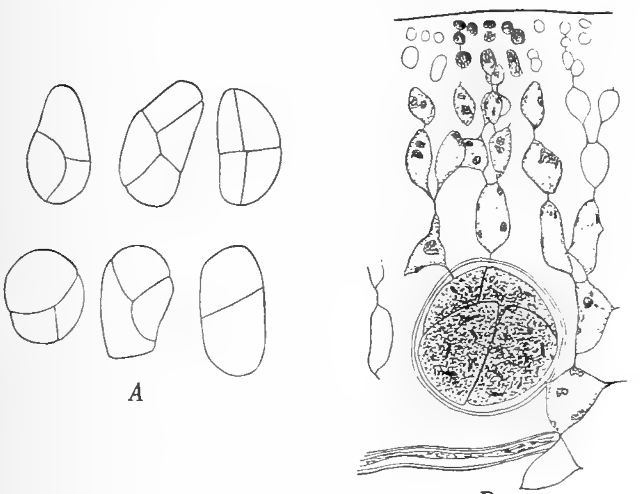


Fig. 76.
Dilsea edulis. *A*, six sporangia showing various forms and modes of division. 220 : 1. *B*, transverse section of cortex with a sporangium. 390 : 1.

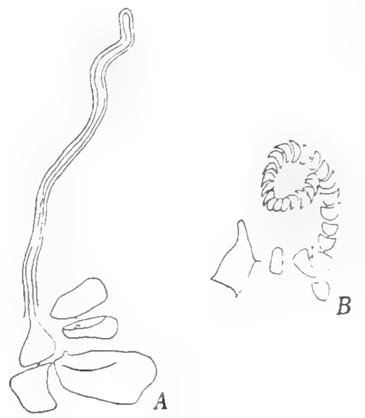


Fig. 77.
Dilsea edulis. *A*, carpogonial branch. *B* auxiliary-cell branch. 390 : 1.

deeper, where the salinity is high and little variable and the variations of temperature are also relatively small; it attains here its greatest size. — In most localities it is taken only in small quantities in the dredge; I have found it most abundantly at Hanstholm (**Sk**), where it was dominant in some places at 7,5 meters depth. LYNGBYE found it off Gilleleje on the North coast of Sealand, 12 miles from land at 26 meters depth, abundantly in places where other algæ are not met with, but only *Mytili* and other molluscs, barnacles etc. It was here often fixed to the mytili and attained a size of up to 63 cm; the fishermen called it here "røde Klude" (red rags).

Localities. **Sk:** YT off Hanstholm lighthouse, 7,5 met., rather abundantly; Thorup Strand, washed ashore (C. M. Poulsen); Løkken, washed ashore, FK Kongshøj Grund off Lønstrup, 8,5 met.; NW of Hirshals, 30 met., some fragments (A. C. Johansen); west side of Hirshals mole, 4 met., washed ashore by Lønstrup and Hirshals, Tværsted (V. Schmidt) and Skagen. — **Kn:** Herthas Flak, 20—22 met., 6 cm long; Hirsholmene, 5,5—7,5 m, 6 cm long; North of Læsø (Edv. Bay), 29 cm long; IX, 11 m; TR near Trindelen, 23,5 m. — **Ke:** Fladen, ZF, 22,5 m, and IQ, 22—30 m; south side of Groves Flak (Børgesen);

IK Lille Middelgrund. 17—19 m. 61 cm; IH. south side of Lille Middelgrund. 20—28 m: ER. Fyrbanken east of Anholt. 23 m, 28 cm; IA. Store Middelgrund. 16,5 m; same locality (Børgesen); off Gilleleje, 12 miles from land (Lyngbye): Nakkehoved (Lyngbye). — **Su:** Washed ashore at Hellebæk (Rasch, Børgesen), 29 cm, and north of Helsingør (Steenberg, C. Rosenberg.) 26 cm. bM. south of Hveen. 22,5 m, loose. 40 cm.

Fam. 5. Nemastomataceæ.

Platoma (Schousboe) Schmitz.

1. **Platoma Bairdii** (Farlow) Kuckuck.

P. KUCKUCK, Beiträge zur Kenntn. d. Meeresalgen. 12. Ueber Platoma Bairdii (Farl.) Kck. — Wissensch. Meeresuntersuch. Neue Folge. V. Bd. Abt. Helgoland, Heft 3. 1912, p. 187—203. Taf. IX—XI.

Nemastoma (?) *Bairdii* Farlow, Proceed. Amer. Acad. Arts and Sciences, 1875, p. 351; Mar. Algæ of New England, 1881. p. 142; BATTERS, Cat. Brit. Mar. Alg., 1902, p. 94.

Helminthocladia Hudsoni Batters, Journ. of Bot. 1900, p. 377, Tab. 414 fig. 15–16, non J. Agardh.

In July 1915 I found by dredging in Lille Belt some small specimens of this interesting Alga, hitherto only recorded from three widely remote places (coast of Massachusetts, coast of Northumberland and Helgoland). As the structure and development of the species have recently been exhaustively treated by Prof. KUCKUCK, I shall only make some few remarks upon the Danish specimens, referring for the rest to KUCKUCK's excellent description.

The plant forms small bundles on a granitic pebble, each given off from a well developed basal disc, and reaching only a length of 1 cm. The upright fronds are more or less branched, rarely unbranched, terete, or the thickest fronds somewhat flattened. As shown by KUCKUCK, the frond branches by dichotomy[1], but one of the shoots produced by the division often becomes more vigorous than the other, and the ramification then seems to be lateral. Hyaline hairs were not met with; according to KUCKUCK their occurrence is variable.

The plants bore either tetrasporangia or carpogonia and cystocarps, while antheridia were not met with either here or at Helgoland. The two kinds of individuals were quite distinct; no carpogonia were observed in the tetrasporiferous specimens or vice versa (comp. KUCKUCK l. c. p. 192). The emptied sporangia were frequently replaced by a sporangium produced from the subjacent cell. "Prospory" ɔ: production of sporangia from the basal disc, was not met with in the Danish specimens.

Locality. **Lb:** At Lyngs Odde, right opposite Middelfart, stony bottom, about 20 meters depth.

[1] KUCKUCK thinks (l. c. p. 190) that the dichotomy in this plant is only apparent, as it cannot be derived from a longitudinal division of the apical cell. This, however, must be considered a too narrow definition of the conception of dichotomy. In my opinion, dichotomy exists in all cases where the growing point divides into two equal parts by a vertical dividing plane or furrow, the two parts at first diverging equally from the original direction of growth, no matter whether the growing point consists of a single cell (*Dictyota*) or of several cells (*Furcellaria*, *Lycopodium*, *Selaginella*, roots of *Isoëtes* etc.) or is a part of a coenocytic organism (*Thamnidium*, *Piptocephalis*).

Halarachnion Kützing.

1. Halarachnion ligulatum (Woodw.) Kützing.

Kützing, Phycol. gener. p. 394, Taf. 74. I; Berthold, Cryptonem. d. Golfes von Neapel, Leipzig, (1884) p. 22 (an eadem species ?); T. H. Buffham, On the Antheridia etc. of some Florideæ. Journ. of the Quekett microscop. Club, Vol. V, ser. II p. 299, tab. 14 fig. 37—39.

Ulva ligulata Woodward, Linn. Trans. III p. 54.

Halymenia ligulata (Woodw.) Agardh, Spec. Alg., 1821, p. 210; Flora Danica tab. 2199 (1836) from Helgoland; Harvey, Phyc. Brit. vol. I pl. 112, 1846; J. Agardh, Spec. g. o. Alg. II,2 1851 p. 201; Bornet et Thuret, Notes algologiques, fasc. 1, Paris 1876, p. 44 pl. XIV, XV.

I have only found a few small specimens of this species and have not submitted them to closer examination As to the structure of the frond, reference may be made to the descriptive works and the quoted figures of Harvey, Kützing, Bornet and Thuret, which show that the inner part of the compressed frond consists of a slimy substance through which run widely spread medullary filaments, while the cortex is composed of two or three layers of cells. Colourless, rather thin hairs proceeding from peripheral cells were observed in specimens from Hirshals, but none in the other examined specimens. Berthold (l. c. p. 7) did not observe them. In a small specimen from Herthas Flak I found in slender shoots two filaments running to the very end of the shoot, with the two apical cells at the same level and higher than those of the other filaments (fig. 78 *B*). In thicker shoots such structure is not to be found; the end of the shoot seems to be composed of a greater number of equal filaments.

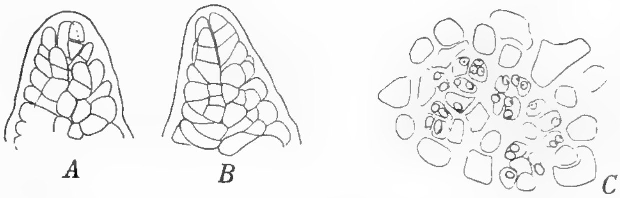


Fig. 78.
Halarachnion ligulatum, from XJ. *A* and *B*, tips of slender shoots showing two filaments reaching the top. — *C*, surface of male plant. 630:1.

Sporangia have never been found in this species.

The antheridia occur in the same specimens as the carpogonia (comp. Bornet et Thuret, l. c. p. 45; Berthold, l. c. p. 9). They have been briefly described and figured by Buffham (l. c.). According to this author they arise from "a cell which produces four male cells above, and these emit the pollinoids, which are minute." I found their arrangement less regular, their number, seen from the face, varying from 1 to 4 (fig. 78 *C*). As I had not occasion to examine them in transverse sections, I am not able to decide whether the small cells shown in the figure are really the antheridia (spermatangia) or possibly partly antheridia-producing cells (spermatangial mother cells after Svedelius), as Buffham's fig. 39 may suggest.

The carpogonial branches are 4-celled, situated on the inner side of the cortex, and bent outwards (Bornet and Thuret l. c. fig. 1). According to Berthold and Schmitz, the fertilized carpogonium gives off in various directions a number of sporogenous filaments which fuse with the auxiliary cells occurring in great numbers on the inner side of the cortex. After the fusion the auxiliary cell produces on its inner side the gonimoblast (Bornet and Thuret l. c. fig. 2—5). The ripe cystocarp is globular or somewhat lobed; it projects in the slimy medullary space (Kützing l. c., Bornet and Thuret fig. 2—4).

The species has only been found in three localities in the northern Danish waters. The largest specimen (from TQ) is 4,5 cm long, 3 mm large. It has been found with antheridia and carpogonia in July, with cystocarps in August and September. It occurs on stony or gravelly bottom. — At Helgoland it has been found in well developed specimens, and it has been met with at Väderöarne, Bohulän.

Localities. **Sk:** 1 mile NW of Hirshals, 15 m. — **Kn:** XI, Herthas Flak, 20—22,5 m; TQ, at Trindelen light-ship.

Furcellaria Lamouroux.

1. Furcellaria fastigiata (Hudson) Lamouroux.

Lamouroux, Ann. du Mus. XX. 1813, p. 46; Greville, Alg. Brit. 1830, p. 67, tab. XI; Kützing, Phyc. gener. 1843, p. 402, Taf. 71 (habit and anatomy); Harvey, Phyc. Brit. I, 1846, pl. 94, III, 1851, pl. 357 (cystocarps and tetraspores); Areschoug, Phyc. Scand. mar. 1850, p. 88, Tab. IV A; Caspary, Observations on Furcellaria fastigiata, Huds. and Polyides rotundus Gmel. Ann. & Mag. N. Hist. Ser. 2, Vol. VI, 1850; J. Agardh, Spec. I, 1851, p. 196; Thuret, Rech. s. l. fécondation des Fucacées et des anthéridies des Algues. II. Ann. d. sc. nat. 4e sér. tome 3, 1855, p. 42 pl. 3 fig. 6—7; Kützing, Tab. phyc. Bd. 17, tab. 99, 1867.

Reinke, Allgem. Botanik, 1880, p, 134 fig. 97 (longitudinal section of extremity of frond), Algenflora w. Ostsee, 1889, p. 26 (f. aegagropila); Wille, Alg. physiolog. Anatomi, 1885, p. 55, 63, 84 ex parte, not Tafl. VIII fig. 14, Beitr. physiol. Gewebesyst., 1887, p. 86, Taf. 6 (VIII) fig. 76—78; Kolkwitz, Beitr. z. Biol. der Florideen. Wiss. Meeresunters. N. Folge. 4. Bd. Abt. Helgoland Heft 1. 1900, p. 31, 46, fig. 4; Svedelius, Stud. Östersj. hafsalgfl., 1901, p. 130; Oltmanns, Morph. u. Biol. d. Alg. I, 1904, p. 545, fig. 329 (longitudinal section of upper end of frond and transverse section of frond); Denys, Untersuch. an Polyides rotundus Gmel. und Furcellaria fastigiata Lamour., Beih. z. Jahrb. d. Hamburg. wissensch. Anstalten. 1910.

Fucus fastigiatus Hudson Fl. angl. ed. 1. 1762, p. 588; Oeder, Flora Danica tab. 393, 1768 (with adventitious shoots).

Fucus furcellatus Oeder Fl. Dan. tab. 419, 1768.

Fucus lumbricalis Gmel., Hornemann, Flora Dan. tab. 1544, fig. 6, 1816 (tetrasporangia).

Furcellaria lumbricalis Lyngbye, Tent. Hydr. p. 40, tab. 40 A, 1—4.

Fastigiaria furcellata (L.) Stackhouse, Le Jolis, Liste Alg. Cherbourg, 1864, p. 124.

The mode of growth, ramification and structure of this common alga has so often been described and figured that it may be sufficient to refer to other works, adding only some supplementing remarks.

The apex of the frond consists of a great number of densely joined cell-filaments which are parallel and vertical in the middle, becoming gradually more divergent towards the periphery. ("Springbrunnentypus" of Oltmanns). The central filaments continue downwards in long longitudinal filaments, which constitute an essential part of the medulla, while the more peripheral ones gradually develop into the cortex, which consists of radiating, dichotomously branched filaments. The outer small cells form an assimilatory tissue; the cells of the inner cortex are much larger, containing also several bandlike and ramified chromatophores, but the total mass of these bodies is small compared with the volume of the cell. WILLE mentions these cells as store-cells, "Speicherzellen" (1887 p. 87), as floridean starch is stored in great quantity in them. These cells are connected with each other by small pits.

The cell-rows of the cortex depart from the longitudinal filaments of the central tissue, which consists not only of these filaments but also of irregular hyphæ originating as outgrowths from the barrel-shaped cells of the inner cortex (fig. 79). The difference between these two kinds of filaments in the medulla has already been remarked by older authors as KÜTZING and CASPARY; WILLE on the other hand (1885 and 1887) only refers to the secondary hyphæ but not to the primary longitudinal filaments[1]. The difference is conspicuous, the longitudinal filaments running very regularly and consisting of long cylindrical cells connected with large pits, while the hyphæ run irregularly, though chiefly in a transversal direction, and are composed of more heterogenous cells, those of the proximal part being more or less inflated, while the cells of the distal part are cylindrical. The cells of the hyphæ contain narrow, partly branched chromatophores. In the longitudinal filaments I did not observe any chromatophores, but DENYS (l. c. p. 10) states that their cells contain colourless ones. This author states that the hyphæ are given off from the longitudinal filaments[2]; it is possible that they may also be produced by these,

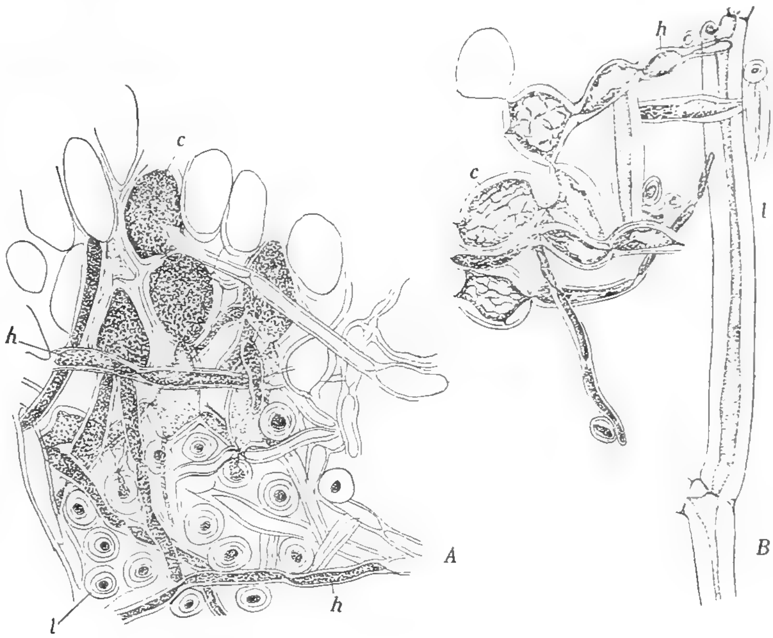


Fig. 79.
Furcellaria fastigiata. *A*, transverse section of frond, at the limit between the medulla and the inner cortex. *B*, longitudinal section of the same. *c*, inner cortical cells; *l*, longitudinal filaments; *h*, hyphæ. After living material, April. (190:1).

[1] For illustration of the anatomical structure of this species WILLE gives only a copy of a figure by KÜTZING (Phycol. gener. tab. 72 fig. 6; WILLE Taf. VIII fig. 14), representing *Furcellaria lumbrialis*; but this is identical with *Polyides rotundus*, which differs from Furcellaria just in the structure of the medulla. OLTMANNS makes the same error (1904 p. 546 fig. 330).

[2] DENYS calls the longitudinal filaments "Längshyphen," but incorrectly, as these filaments have not the active apical growth combined with slipping growth ("gleitendes Wachsthum") characteristic of the hyphæ.

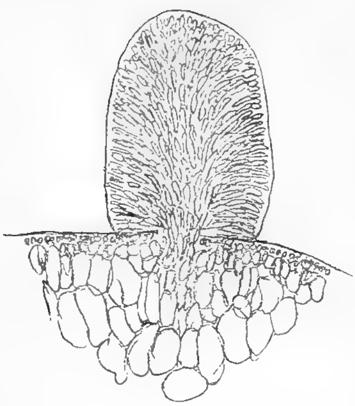


Fig. 80.
Furcellaria fastigiata. Adventitious shoot in longitudinal section. 95:1.

though I have not observed it, but when DENYS says that they "schliessen nach kürzerem oder längerem Verlauf an die inneren Zellen der mittleren Rinde" (l. c. p. 10) he must have misinterpreted the facts observed. WILLE'S statement (1887, p. 87) that these cells "mit einander sowohl als auch mit den Speicherungszellen durch Poren in Verbindung treten" might be understood as if the pits were secondary, whereas in reality they are primary. Whether secondary pits may be formed between the hyphæ, or between these and other cells, I have not observed. — In late summer, autumn and winter these cells are rich in starch. As to the starch compare for the rest KOLKWITZ (l. c.). All the vegetative cells contain a single nucleus. Hairs are never produced.

As to the stolons reference may be made to the descriptive works and to KOLKWITZ (l. c. p. 46) and DENYS (l. c. p. 8).

The erect fronds are, as is well known, branched by dichotomy, but besides this normal ramification adventitious branches sometimes occur, especially in the inner Danish waters (**Sa, Sf, Sb, Su, Bw**) (Flor. Dan. tab. 393). They originate from a little group of superficial cells. In developing they increase early in thickness so that their basal plane is much larger than their plane of insertion (fig. 80). They may be very mumerous, as for instance in some specimens dredged in January in Store Belt (NU, no. 4250) at 11 meters depth, the shoots of which were, for a length of one to three cm or longer, more or less densely beset with very short adventitious shoots; some older shoots of this kind had again produced adventitious buds. The cause determining the appearance of these shoots is unknown; the plants producing them may be fertile. Another sort of adventitions shoots develop from the scars arising from the decaying and falling off of the fructifying parts of the shoots (fig. 81, comp. HARVEY, Phyc. Brit. Plate 94). As shown by CASPARY (l. c. p. 93, fig. 10) this regeneration can be once or twice repeated.

The reproductive organs are produced in the upper part of the fronds; their development begins at the end of the summer or in the beginning of the autumn. In August very young sporangia may be found

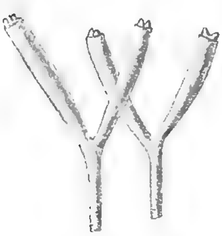


Fig. 81.
Furcellaria fastigiata. Adventitious shoots growing out from scars. Hirshals June. 1,5:1.

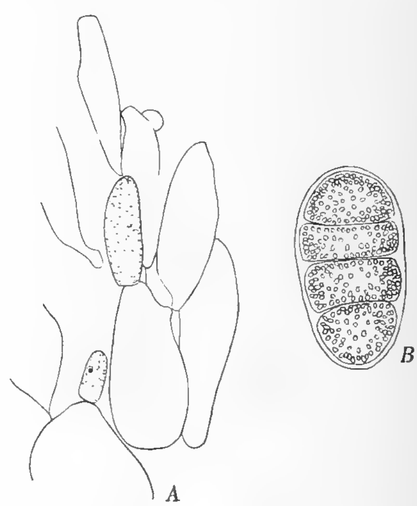


Fig. 82.
Furcellaria fastigiata. *A*, young sporangia in transverse section of frond, August. 220:1. *B*, ripe sporangium. 230:1.

in the inflated ends of the frond. They appear as small cells cut off from the outer end of the large cells of the inner cortex, and differ from these by the want of starch, by the higher staining power in presence of hæmatoxyline, and in containing a large, intensily staining nucleus (fig. 82 *A*). The sporangia increase in September and October; in November specimens with undivided and divided sporangia may be met with. In December the sporangia are always ripe; at the end of

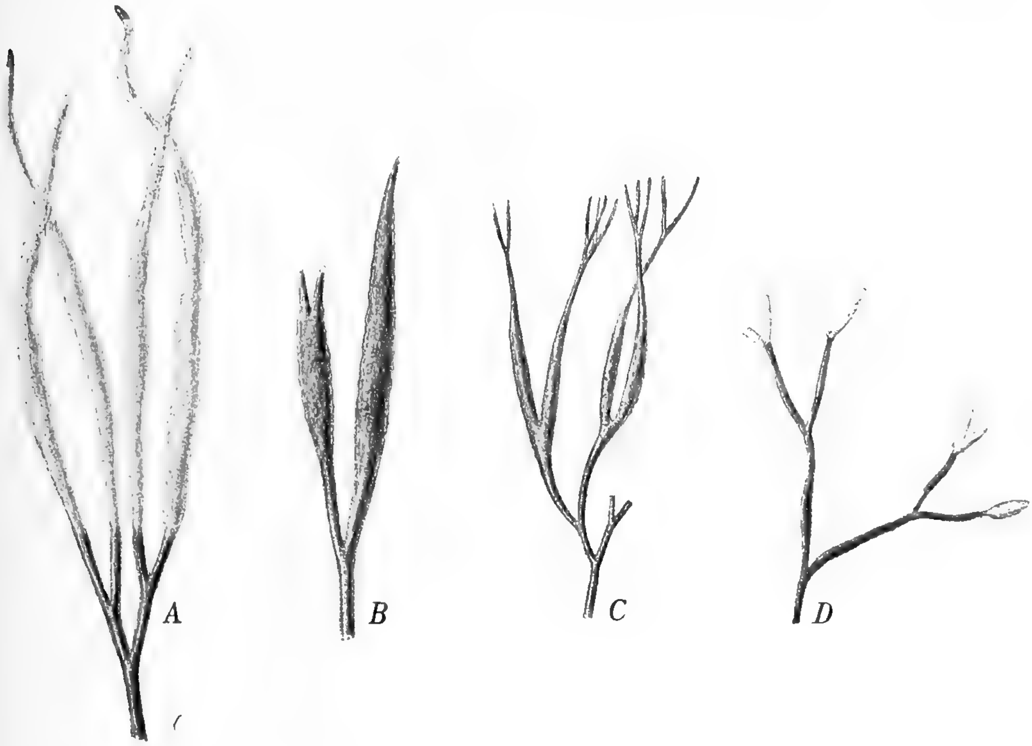


Fig. 83.
Furcellaria fastigiata. *A*, part of frond with emptied tetrasporangia, December. *B* and *C*, parts of fronds with ripe cystocarps, December. *D*, part of frond with antheridia, March. Nat. size.

December and in January they are often emptied, but in February many sporangia containing spores are still to be found. As is well known, the sporangia are oblong and "zonate" ɔ: divided by parallel walls; the spores contain numerous small chromatophores (fig. 82 *B*). The parts of the frond producing tetrasporangia are somewhat inflated, fusiform; after the exhaustion of the spores they are a little more inflated, soft and green, while the other parts of the frond in winter are dark red-brown. The upper tip of the frond sometimes remains sterile and therefore retains its dark colour. Downwards the fertile part is sharply marked off from the sterile frond and loosens here in decaying during the winter (fig. 83 *A*).

The antheridia cover the surface of small terminal inflated segments of the frond; which are about 1 cm long, of a pale rose colour (fig. 83 *D*). They are given off

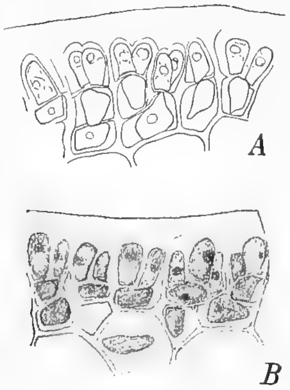


Fig. 84.
Furcellaria fastigiata. Transverse sections of antheridia-bearing fronds, Decemb. 835:1.

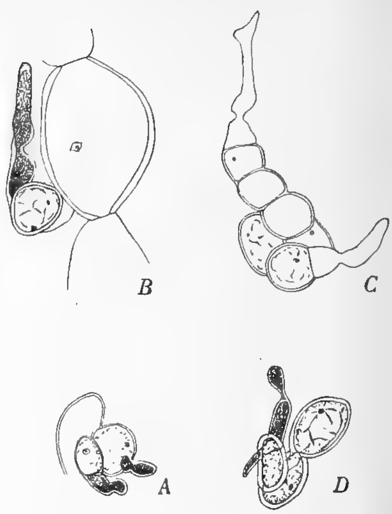


Fig. 85.
Furcellaria fastigiata, Carpogonial branches. *A* and *B*, two-celled, *C* and *D*, 3- and 4-celled. In *D*, the carpogonium has produced an outgrowth (sporogenous filament ?) at the base, although the trichogyne is very short and unfertilized. *A*, September, 230 : 1, *B—D*, August, 390 : 1.

from small cells, not infrequently smaller than themselves. In a transverse section of the frond these androphore-cells, which seem to contain chromatophores, are seen bearing two antheridial cells of different age. Probably they may sometimes bear more than two, and the production of antheridia may possibly be continued after the first has been exhausted. The antheridia always occur in particular male plants; they were first described and figured by THURET in 1855. Fully developed antheridia have been met with in December, but they may probably occur much earlier. Antheridia containing ripe spermatia have further been found in January to March, and in May I have still found specimens with white antheridial branches containing numerous spermatia (no. 5793, UL, Øjet, in **Bw**, 20 meters depth).

The carpogonia appear at the end of the summer, and in August young gonimoblasts may already be met with. The carpogonial branches arise in the inner cortex or at the limit between the cortex and the central tissue; they are frequently placed in small groups, and two or three of them may be given off from one of the large storage cells. They are almost always two- or three-celled. The inferior cells of the carpogonial branches are globular or ovate, they contain one or two nuclei, small chromatophores and numerous small starch grains. The carpogonium is much narrowed over the basal part, the narrowing being deepest on one

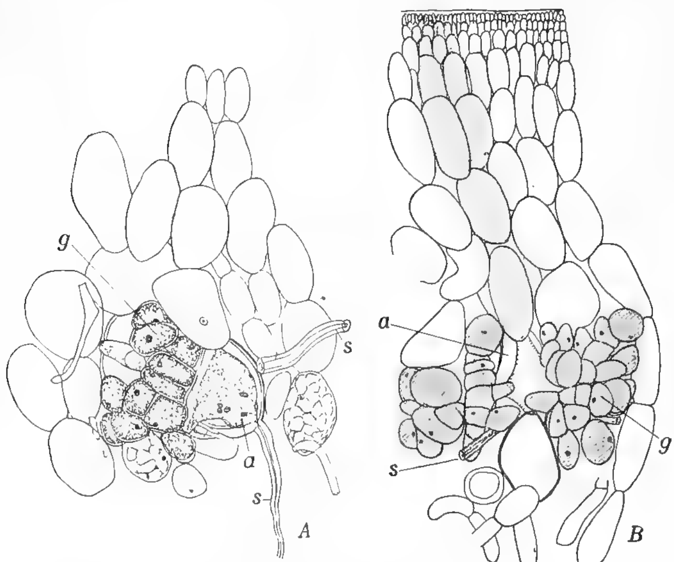


Fig. 86.
Furcellaria fastigiata, sections of fronds with young cystocarps, August. *a*, auxiliary cell; *s*, sporogenous filaments, *g*, gonimoblast. 210 : 1.

side (fig. 85 *B*). I cannot give any details about the contents of the carpogonium, as on staining with hæmatoxyline it was in a great part very dark and intransparent. In the specimens collected in August and September numerous carpogonia with short trichogynes were found; other carpogonia had long trichogynes making their way outwards through the cortex, and tips of trichogynes protruding through the surface of the frond were also met with, but I have not yet seen spermatia fixed to them, and it remains thus to state whether fertilization takes place normally or the cystocarp may develop parthenogenetically, as in *Platoma Bairdii*. The car-

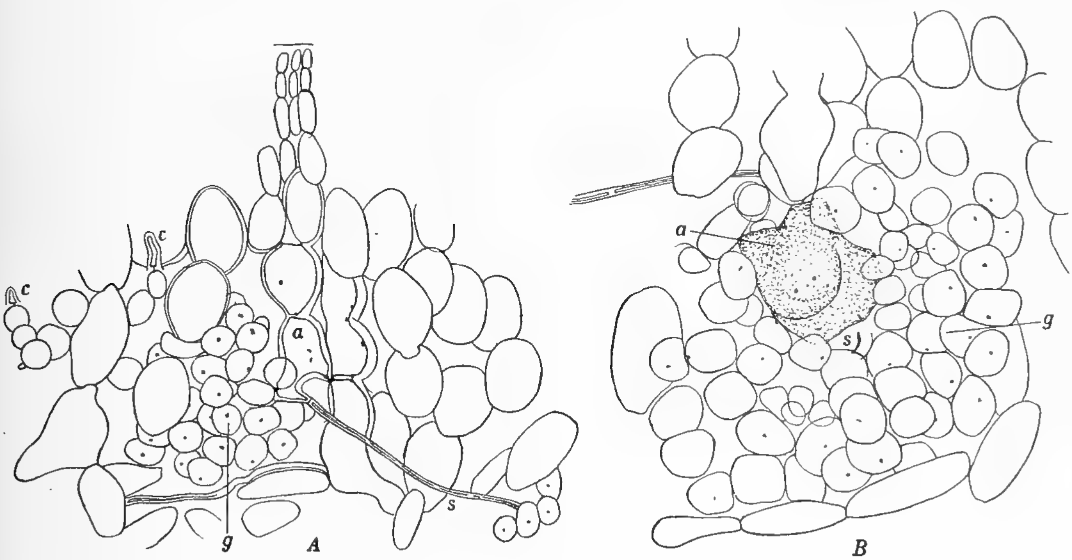


Fig. 87.
Furcellaria fastigiata. Sections of frond with young cystocarps. *c*, carpogonia; *a*, auxiliary cells; *g*, gominoblasts. September. *A* 180 : 1. *B* 190 : 1.

pogonium shown in fig. 85 *D* seems to agree with the latter assumption, as an outgrowth is given off from the base of the carpogonium, while the trichogyne is very short and unfertilized.

The auxiliary cells (*a* in the figs.) arise, as stated by Schmitz (Engler u. Prantl, p. 526), from single cells in the inner cortex which seem to be at first but little different from the vegetative cells. They fuse with the long sporogenous filaments produced by the carpogonia and growing widely between the inner cortical cells and the medullary filaments. The fusion takes place at the inner end of the cell. After the fusion the auxiliary cell soon begins to produce gonimoblast cells laterally and at the inner side, and thus young cystocarps may occur already in August (fig. 86). The auxiliary cell after fertilization contains a number of nuclei, four or more, some of which certainly derive from the original nucleus of the cell, while the others are sporogenous (fig. 86 *A*, 87). The cell increases in volume and takes a more irregular outline. Fusions between neighbouring cortical cells seem to occur (fig. 87).

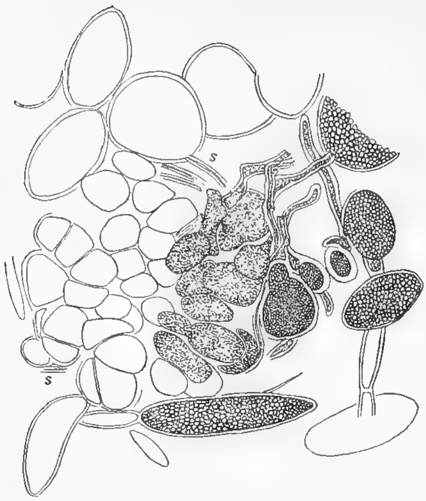


Fig. 88.
Furcellaria fastigiata. Section of young cystocarp. At right several carpogonia. *s*, sporogenous filaments. The cells of the young cystocarp contain minute starch grains while those of the surrounding cells are much larger. August. (200 : 1).

I have also in the same specimens observed the production of small cells at the under end of the large cells of the inner cortex, resembling the formation of secondary pits in the Rhodomelaceæ, but what their significance may be I do not know. The cortical cells situated outside the auxiliary cells have richer contents and stain deeper with hæmatoxyline than the others, forming thus a darker stripe towards the surface (fig. 86 *B*). The ripe cystocarp appears as a globular heap of carpospore cells, grouped around the auxiliary cell or containing in the centre also a few other sterile cells. The particular gonimolobes are usually not distinguishable. At the periphery of the cystocarp some long cells are frequently found forming an incomplete envelopė around it, as shown by Areschoug and Caspary, ll. cc. At the time of ripening a pore is formed in the cortex through which the spores are exhausted. This pore arises by destruction of the cells of the darker stripe mentioned above. The fructiferous part of the female fronds is more or less inflated, almost as in the sporangia-bearing ones, but the upper part of the fronds frequently remains sterile; this part may be 1 to 2 cm long and branched (fig. 83 *C*).

Germinating spores of what must be supposed to be *Furcellaria fastigiata* are frequently met with on various Algæ, as *Delesseria, Phyllophora* a. o. They are at first hemispherical, and are divided by rather regular anticlinal and periclinal walls without changing form, but increasing in size (fig. 89 *A*). Later on, a cylindric upright shoot of the typical structure is produced from this hemispherical body, the shoot being a little narrower as the basal part (fig. 89 *B*). These shoots later branch and produce rhizomes at their base.

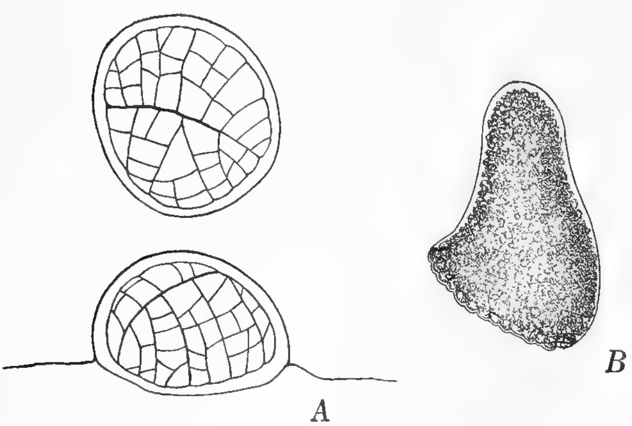


Fig. 89.
Furcellaria fastigiata. A, germinating spores, seen from above and from the side. *B*, older stage showing a cylindric shoot growing out from the hemispherial body.

This Alga is one of the commonest and most widely distributed in the Danish waters. It attains its highest degree of development in the Kattegat and the Belts, where it becomes up to 28 cm high. In the western Baltic it attains a length of 24,5 cm, whereas at Bornholm I have not found it higher than 9 cm. In the inner Baltic Sea SVEDELIUS found it scarcely more than 10 cm high. He refers the plants here found to f. *minor* Agardh, a form differing only by smaller dimensions, in citing Fl. Dan. tab. 393 and ARESCHOUG, Alg. Scand. exs. No. 257. In the most feebly developed specimens the erect shoots are not branched, or but little so (fig. 90). — *Furcellaria* grows usually on stones or pebbles, but may also be found fixed on other Algæ, as *Phyllophora, Chondrus.* In some places north of Fyn (especially aZ, near Fyns Hoved) it was found growing in company with other, mostly loose, Algæ forming a dense cover over the bottom, which consisted of coarse sand. I am not certain whether these specimens were at first loose or originally fixed at this stationary bottom. In other places detached specimens lying loose on the bottom are met with, often in great quantities, particularly in fjords, as Limfjorden, but also in the Kattegat, e. g. around Anholt. It is apparently able to live long in this condition, for plants in which the under part is in a state of disorganization are often met with. Some of these plants are not much different from the normal ones; in other cases they are more branched, and form globular bushes corresponding to those mentioned by REINKE (1889) and SVEDELIUS as f. *œgagropila* (fig. 91).

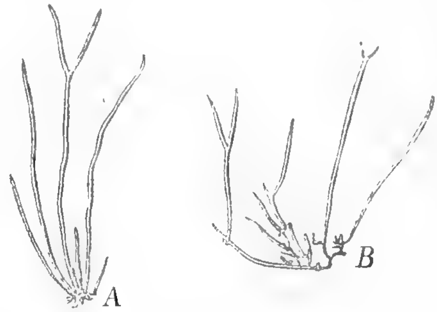


Fig. 90.
Furcellaria fastigiata. Plants from the Baltic Sea off Gudhjem, Bornholm. Nat. size.

The species has been found in depths from 2 to 28 meters and once in 38 m depth (near Bornholm). It is often a predominant element of the vegetation, particularly in depths of 4 to 15 m. It is perennial, but the fructifying shoots are shed in winter. In sunny localities the upper parts of the fronds are green in summer.

Localities. Ns: Only found at ZQ, jydske Rev, 24,5 m and at

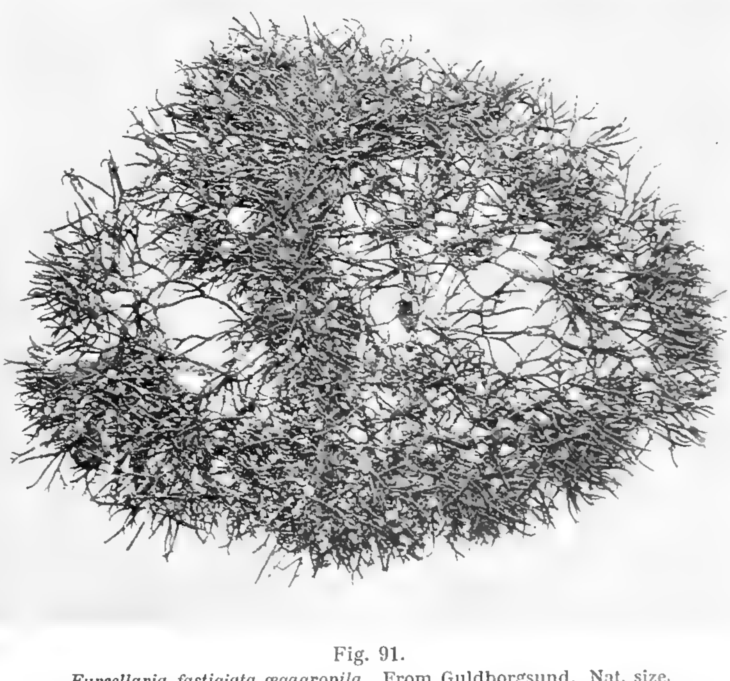


Fig. 91.
Furcellaria fastigiata œgagropila. From Guldborgsund. Nat. size.

Ørhage by Klitmøller inside the point at 2 meters depth, farther from land off Klitmøller only a few small specimens. — **Sk:** Collected at various places (Hanstholm; Bragerne; washed ashore by Svinkløv and Blokhus; Lønstrup; Hirshals; Skagen) in 2 to 13 m depth, in most of the places only in small and scarce specimens. Found in greatest number and best developed at Hirshals, near land in 5 m depth, in company with *Polyides*. Greatest length observed 15 cm. — **Lf:** Widely distributed, down to a depth of 6,5 m, but in most places loose, often in abundance on soft bottom (f. *ægagropila*). Reaches a length of 8—14 cm. — **Kattegat:** Common and often abundant everywhere on stony bottom in depths down to 15 cm. It reaches here a length of up to 28 cm and is very often over 20 cm high. It has also been dredged in several places in greater depths, down to 30 m (e. g. ZB, Trindelen, about 30 m; ZS, Fladen, 26,5 m; HZ, Store Middelgrund, 25,5 m), but it is more frequently missing than present in these greater depths, and, at all events, it occurs only in small quantities. In Herthas Flak in **Kn**, where I have dredged several times in 20 to 24,5 meters depth, it has never been met with. In Isefjord it has been recorded in various places, in Holbæk Fjord it occurs abundantly in a loose condition. — **Sa** and **Lb:** Common in depths down to 24 m; at aZ growing gregariously over coarse sand (see above). — **Sf:** Several places. — **Sb:** Common in depths down to 20 m, greatest length observed 27 cm; generally well developed specimens. — **Sm:** Several places down to 12 m depth; greatest length observed 10,5 cm — **Su:** North of Helsingør up to 25 cm high, south of Helsingør in depths down to 13 m, up to 16 cm high. — **Bw:** Found in depths down to 20 m; greatest length observed 24,5 cm. — **Bm:** Greatest length observed 12 cm. — **Bb:** Found in depths from one to 38 m (YA, east of Bornholm) in several places, but reaching only 9 cm in length.

Fam. 6. Rhizophyllidaceæ.

Polyides Agardh.

1. **Polyides rotundus** (Gmel.) Grev.

Greville, Algæ Britann., 1830, p. 70, Tab. XI. Harvey, Phycol. Brit. pl. 95, 1840. Caspary, Ann. and Mag. N. Hist. Ser. 2, Vol. VI, 1850, p. 93. Thuret in Le Jolis Liste des Alg. mar. de Cherbourg, 1864, p. 140. Thuret et Bornet, Etudes phycologiques, 1878, p. 73—80, pl. 37—39. Guignard, Développ. et const. des anthérozoïdes. Revue gén. de Botanique. I, 1889, extrait p. 44, pl. 6 fig. 10—12. Fr. Schmitz, Kleinere Beitr. z. Kenntn. d. Florideen. II. La Nuova Notarisia. Ser. IV. 1893, Estratto p. 8. Kolkwitz, Beitr. z. Kenntn. d. Florideen. Wiss. Meeresunters. N. F. 4. Bd. Abt. Helgoland. Heft 1, 1900. Denys, Anatom. Untersuch. an Polyides rotundus Gmel. und Furcellaria fastigiata Lamour. Beih. z. Jahrb. d. Hamburg. wissensch. Anstalten 1910.

Fucus rotundus Gmelin, Hist. Fucor., 1768, p. 110 tab. VI fig. 3. Flora Danica tab. 1544 a (Hornemann 1816).

Furcellaria rotunda Lyngbye, Tent. Hydr., 1819, p. 49.

Polyides lumbricalis C. Agardh, Spec. Alg., 1822, p. 392, J. Agardh, Sp. g. o. II, 1863, p. 721.

Furcellaria lumbricalis Kützing, Phycol. gener., 1843, p. 402, Taf. 72, Tab. phycol., Bd. 17, 1867, pl. 100.

The external resemblance between this Alga and *Furcellaria* is well known and has often been mentioned, as well as the difference of the basal part being a disc in *Polyides*, while in *Furcellaria* it consists of branched rhizomes. The structure of the erect frond has already been thoroughly studied by Kützing (1843)[1] and Caspary (1850). The structure of the upper end of the frond is that of the fountain type (Oltmanns' "Springbrunnentypus") as plainly shown by Kützing (l. c.). As to the structure of the erect fronds, reference may be made to the papers of

[1] The troublesome synonymy of this Alga is responsible for the fact that Wille (Bidr. t. Alg. phys. Anat. K. Svenska Vetensk. Ak. Handl. Bd. 21. 1885, tafl. VIII fig. 14) and Oltmanns (1904, p. 546, fig. 330) have used copies of Kützing's figures of it to demonstrate the anatomy of *Furcellaria fastigiata* (comp. p. 165).

Kützing, Caspary, Thuret (1878, p. 75, pl. 37, fig. 6) and Denys. The outer cortex consists of a greater number of layers of small cells (up to 4 or 5) than in *Furcellaria*. The longitudinal filaments of the central tissue are mostly thicker at the ends than in the middle "so that they have the form of a femur" (Caspary, p. 94). The cells which form the connection between these filaments and the cortical ones are arranged in regular feebly curved rows running obliquely upwards, while secondary hyphæ are wanting[1]. Hyaline hairs produced by superficial cortical cells may occur, according to Thuret (1878, p. 75, pl. 37, fig. 6). I have not observed these hairs, but in specimens collected in April I found that some of the peripheral cells were colourless, narrower and longer than the others; probably they were about to develop into such hairs. As to the cell-structure, reference may be made to the paper of Denys. The pit in the transverse wall between the cortical cells is very narrow, while that of the longitudinal filaments is broad, and provided with a double plate. Secondary pits do not occur. The structure of the basal disc has been figured by Kützing (1843); according to Kolkwitz (1900, p. 51) older discs are stratified.

The tetrasporangia arise at about the limit between the outer and inner cortex (comp. Caspary, 1850, fig. 21, Thuret, 1878, pl. 36, fig. 6 and 7). As shown by Thuret, an issue is formed outwards to each sporangium by removal of the cells from each other, through which issue the contents of the sporangium is emptied. Specimens with undivided sporangia have been met with in October, with ripe sporangia in January and with emptied sporangia in April.

The antheridia arise, as shown by Thuret, in nemathecia in particular individuals. According to Guignard (1889, p. 44, pl. 6, fig. 10—12) they are placed in tetrads directly on the nemathecial filaments, while Schmitz asserts (1893, p. 8) that they are situated on short cells given off from the filaments. I cannot give any information on this point, as I have not met with male plants in the Danish waters.

As to the structure and development of the female nemathecia, reference may be made to the classical researches of Thuret and Bornet (1878, p. 77—80, pl. 38—39). These bodies begin to develop in the Danish waters in August or September. In specimens dredged at the entrance to Vejle Fjord, August 20th, nemathecia with well developed but unfertilized carpogonia were found. Similar carpogonia but also others with fertilized carpogonia are frequently met with in September. Ripe cystocarpia were found in December and January. After the exhaustion of the carpospores, the nemathecia are thrown off, while the fronds which have produced them possibly may continue growing. — The germination of the carpospores has been observed by Thuret et Bornet (1878, p. 79, pl. 39, fig. 32); they obtained hemispherical bodies producing rhizoids from their under face.

[1] Denys speaks (l. c. p. 7) of "Querhyphen, welche die Masse der längs verlaufenden durchflechten und seltener auch zwischen die Elemente der grosszelligen Rinde eindringen". But as he designates the longitudinal filaments also as "Hyphen", it is not clear if it is a case of real hyphæ or only of the above named connecting filaments. As he says, on p. 18, that they occur only "ganz vereinzelt", it seems that he has really observed secondary hyphæ, although in very small number.

This species is only little variable in shape and size. It often reaches a length of 14 cm, even in the Baltic, almost to the limit of its distribution. The largest specimens, 18 cm high, were found in the Skagerak and the South Fyen waters. The depth has no influence on its size, save that when growing at low-water mark it does not become longer than 6 cm. The greatest length is reached in 5,5 to 9,5 meters depth. Adventitious shoots from scars left by decayed ends of frond frequently occur, as in *Furcellaria*, but rarely developing from the surface of the frond.

The species grows on stones, but is frequently met with loose on the bottom, particularly in the Zostera formation, but also on bare sandy bottom, as for instance around Anholt, where it occurs in great quantities together with *Furcellaria fastigiata*. It occurs in all the Danish waters, with exception of the eastern Kattegat and the Baltic around Bornholm, from a little below low-water mark to about 11 meters depth. In greater depths it occurs more rarely; certainly it has been found in several places down to 23,5 m depth, but in most cases it was certainly or probably loose. As sure deeper localities may be named, in the Skagerak: off Hanstholm and Lønstrup, 13 m; and in the Kattegat: Tønneberg Banke, 16 m. It does not thrive in fjords; in the Limfjord it has however been found in one locality.

Specimens with tetraspores seem to occur much more rarely than sexual specimens in the Danish waters; I have met them only in one locality in the Skagerak and in two in the northern Kattegat, while female specimens have been found in several places from the Skagerak to the Baltic.

Localities. **Ns:** Ørhage, 2 m. — **Sk:** Hanstholm, 5,5 to 13 m, abundantly in 13 m depth; washed ashore by Blokhus and Svinekløv (P. Petersen); off Lønstrup 8,5—13 m, most well developed in 8,5 m depth; Hirshals, near land 1—4,5 m, in some places dominant. — **Lf:** Only found on the mole of Lemvig, 6 cm long. — **Kn:** Harbour of Skagen; Hirsholmene; Krageskovs Rev; Frederikshavn; N. Rønner 1—5,5 m; several places north of Læsø, 2—9,5 m; Trindelen, about 18,5 m; Tønneberg Banke, 16 m. — **Km:** NE, NW of Fornæs; around Anholt, abundantly loose. — **Ks:** Hesselø (Lyngbye). — **Sa:** PN (Kaløvig); PE (Refsnæs); Hofmansgave (Hofman Bang, J. Vahl, C. Rosenberg): OA (Æbelø). — **Lb:** AX (Bjørnsknude), 9,5 m; Middelfart (Rasch, !); Fænø Sund, 1 m; DF; CC; DB; UX. At several places it reaches a length of 18 cm. — **Sf:** CU. — **Sb:** GQ; harbour of Kerteminde; DO; Y; UR. — **Su:** North of Helsingør (Liebman, Joh. Lange, !); Taarbæk Rev; RK; PS, off Charlottenlund. — **Bw:** UY[1], 18 m, probably loose. LC (Gulstav); South of Nysted. — **Bm:** QM (Juels Grund); washed ashore at Stevns.

Fam. 7. Squamariaceæ.

Petrocelis J. Agardh,

1. **Petrocelis Hennedyi** (Harvey) Batters.

Batters in Holmes Alg. Brit. Exsicc. No. 89 (non vidi), Mar. Alg. Berw. Tweed, 1889, p. 94, tab. XI, fig. 3—4.
Actinococcus Hennedyi Harvey, Natural History Review, Vol. 4, 1857, p. 202, pl. 13 A, fig. 1 (non vidi).
Cruoria pellita Lyngbye Hydroph. 1819, p. 193, tab. 66 ex parte, teste specim.
Chætophora pellita Flora Dan. tab. 1728, 1821.
Petrocelis Ruprechtii Hauck Meeresalg. 1883, p. 30.

The species forms dark-red fleshy crusts, in a dried state glossy, 1—3 cm in diameter. The basal layer is a monostromatic disc composed of radiating filaments.

The margin is somewhat lobed, and the filaments of the basal layer radiate towards the border of the lobes (fig. 92 *A*). When the surface of the substratum is uneven, small rudimentary rhizoid cells may be given off from the basal layer (fig. 92 *C*). Fusions between the cells of this layer have not been met with. The upright filaments which are given off from the acroscopic end of the cells in the basal layer are decumbent at the base, so that there often seem to be more than one layer of basal cells. At the border the filaments are directed obliquely forwards. The upright filaments have almost the same thickness in the upper and the lower part

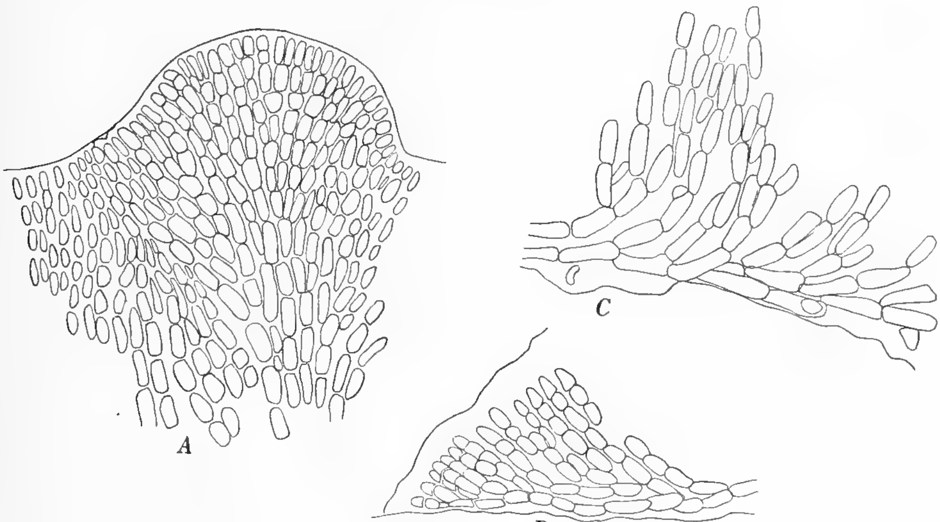


Fig. 92.
Petrocelis Hennedyi. *A*, basal layer seen from the under face (230 : 1). *B*, vertical section of border of frond. *C*, vertical section of older part of frond. *B* and *C* 390 : 1.

of the crust; in the upper part they are 4—6 μ thick. They are imbedded in a glutinous intercellular substance which swells greatly in fresh water, whereby the filaments are separated. The upper end of the filaments is nearly always a little attenuated, the uppermost cell usually being narrower than the other, and more or less conical, or the upper part of the filament is gradually tapering (fig. 95). In some cases, however, particularly in thin crusts, I found the filaments of the same thickness to the very end (fig. 96). The cells are usually twice or thrice as long as broad, they contain a nucleus and a cap-shaped chromatophore with more or less lobed border; in a specimen examined in July the cells contained numerous small starch grains. The upright filaments are simple or little branched. The ramification is lateral, subdichotomous or sometimes sympodial; the latter reminds one of the false ramification of the Cyanophyceæ, the penultimate cell growing out and throwing aside the apical cell, which does not usually develop further. In fig. 93 *B* the wall of the outgrowing cell is seen to have been burst. Hyaline hairs are sometimes found given off from intercalary cells in the vertical filaments. The cells producing them are usually more or less projecting, but the hairs are feebly developed; they do not ordinarily reach the surface of the frond, and soon decay. Once only have I seen a few such hairs projecting over the surface, as in fig. 94 *E* where the hair, however, is terminal on a one-celled branchlet[1]. — The crusts may certainly reach an age of more than one year. In crusts growing on stems of *Laminaria hyperborea* a stratification is often visible which seems to be due to the cessation of the growth in winter; in the part of the crust beneath the limitating line empty or abortive fructifications may be found, while new fructifications have not yet been produced in the upper part of the frond apparently formed after the hibernal rest.

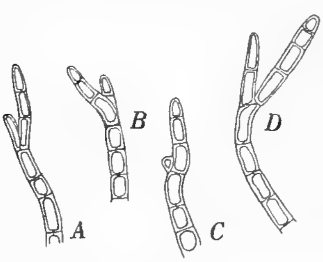


Fig. 93.
Petrocelis Hennedyi, from the Limfjord (ZY), showing peculiar ramifications of vertical filaments. 390.1.

Characteristic of the genus are the intercalary sporangia. In this species there are as a rule several consecutively in the same filament, in Danish specimens frequently six at least in a row, but there may be up to nine. The row is never interrupted by sterile cells. The sporangia are situated in the upper part of the vertical filaments, only the (1—) 2—5 uppermost cells being sterile. The sporangiferous vertical filaments are usually unbranched, but sometimes a branch is given off, rarely from the articles transformed into sporangia, more frequently from the cell subjacent to the sporangial series (fig. 95). The sporangia are first divided by an inclined transverse wall and then by two walls perpendicular to the wall first formed. The latter are frequently parallel, but the lines of intersection with the transverse wall do not coincide. These seriate sporangia are of about the same height as breadth, 14—17 μ broad, 16—23 μ high.

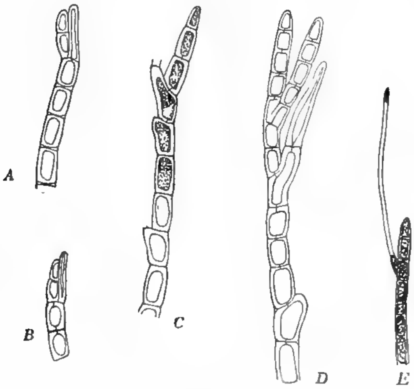


Fig. 94.
Petrocelis Hennedyi. Vertical filaments with hyaline hairs. *A—C* from Begtrup Vig; in *C* the hairs have been thrown off, the chromatophore of the cells is visible. *D—E* from Hellebæk, *E* after a living plant with a well developed hair at the top of a unicellular branchlet. *A—D*, 400:1; *E*, c. 200:1.

In most of the crusts only seriate sporangia are present; but in some cases the sporangia were single or at most two in a series. These sporangia are more lengthened than the seriate ones. A transitional case is shown in fig. 95 *D*, where the series contains only two sporangia. But in fig. 95 *G* and *H* single, terminal or subterminal sporangia are represented. In fig. 95 *H* the sporangium seems to be terminal, but I cannot assert that there has not been one or more sterile cells which may be decayed or possibly removed by the preparation. Similar sporangia were found in a thin crust with the ends of the filaments truncate; fig. 96 shows

[1] Comp. L. Kolderup Rosenvinge, Hyaline hairs (Biol. Arbejder, tilegn. E. Warming, 1911, p. 206).

at left a sporangium with a single small sterile cell at the top and at right an apparently terminal sporangium. There is no doubt that the sporangia here mentioned are transformed cells of the filaments in which they are situated; this is more doubtful in the case represented in fig. 95 *I*, where the sporangium has the appearance of being lateral, but as it has been found in the same crust as those figured in fig. 95 *F*—*H*, it must be supposed that it has really been terminal. The single sporangia are 2 to 3 times as long as broad, 26—50 μ long, 11—14 μ broad. Their great length depends probably on their terminal or subterminal place, which permits them to develop unhindered by sporangia or sterile cells lying above. In some crusts only such lengthened sporangia, singly or in pairs, are found; in others they are found in company with the ordinary seriate ones, as a rule, however, in different parts of the frond. By this fact it is shown that the two kinds of sporangia really belong to the same species. Single sporangia have been met with in three places in spring (**Ks:** Hastens Grund; **Sa:** Rønnen in Begtrup Vig and **Lb:** off Middelfart).

There is no resemblance between the single sporangia of this species and those of *Petrocelis cruenta* J. Ag., which are strictly intercalary and globular (comp. Le Jolis Alg. mar. Cherb. pl. III, fig. 4).

In specimens gathered in November in the Great Belt I have found spores germinating in the seriate sporangia (fig. 95 *E*). The spores were divided by variously orientated walls and some of the uppermost resulting cells were growing out upwards into filaments.

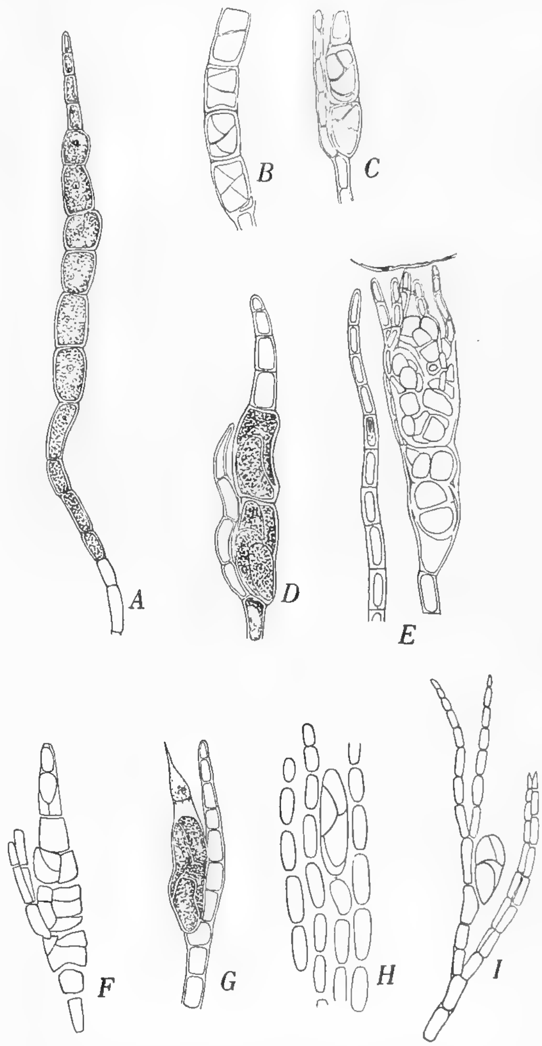


Fig. 95.
Petrocelis Hennedyi. Vertical filaments with tetrasporangia. *A*, six still undivided sporangia, November. *B* and *C*, ripe sporangia, July. *D*, filament with two sporangia only, April. *E*, tetraspores germinating in the sporangia, April. *F*—*I*, from Begtrup Vig, May, *F* with seriate sporangia, *G* with subterminal, *H* and *I* apparently with terminal sporangia (in *I* possibly lateral ?). *A, D, E, G, H* 390 : 1 *B, C, F, I*, 300 : 1.

The antheridia arise in the upper part of the vertical filaments, where they form small lateral bushes, rather similar to those of *Cruoria*. They are borne on the upper end of small, usually unicellular, more rarely bicellular, branchlets, two

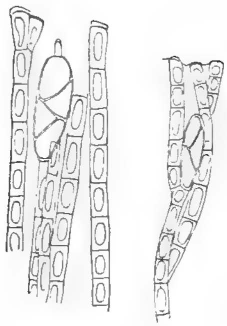


Fig. 96.
Petrocelis Hennedyi, thin crust from Lillebelt, March. Vertical filaments with truncate end-cell Sporangia subterminal or terminal. 390 : 1.

or three on the same stalk (fig. 97). Sometimes they appear to be produced directly from a cell of the vertical filament.

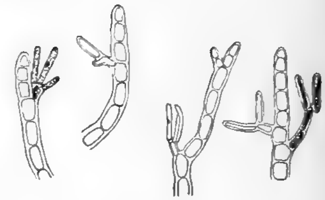


Fig. 97.
Petrocelis Hennedyi, from the North Sea (Klitmøller), August. Vertical filaments with antheridia. 390 : 1.

The carpogonial branches are situated laterally on the vertical filaments. They are somewhat variable in shape and number of cells. Usually they are two-celled, and the undermost cell then frequently projects considerably downwards beyond the insertion point (fig. 99 *A*). More rarely the carpogonial filament is 3-(or 4-)celled. A carpogonium situated directly on the vertical filament was also met with, but the cell from which it was given off had in this case the character of the cells of carpogonial branches (fig. 98 *A*), its contents being more homogenous and staining more intensely by hæmatoxyline than the ordinary cells. This may also sometimes be the case with the cell bearing 2-celled carpogonial branches (fig. 98 *B*). The cell bearing a carpogonial branch is frequently swollen, resembling the auxiliary cells.

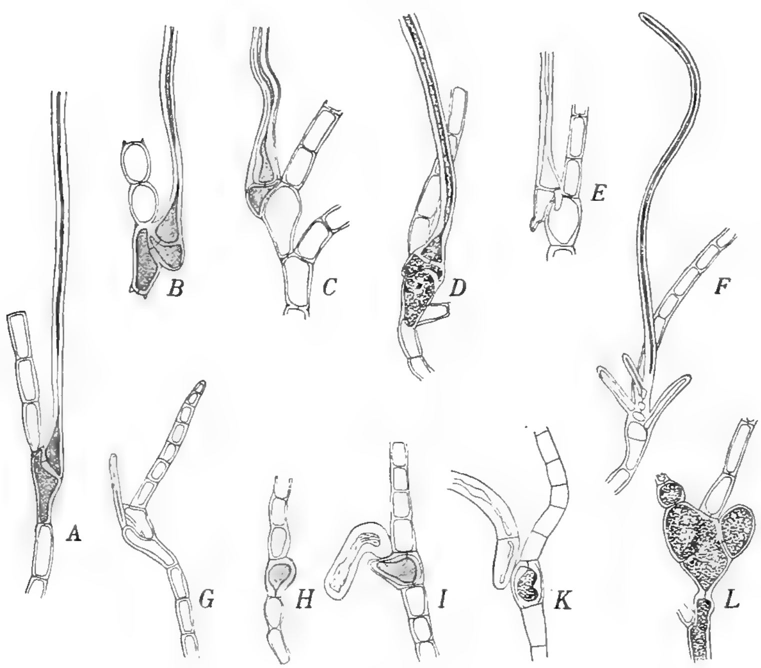


Fig. 98.
Petrocelis Hennedyi, from Bornholm, July. *A*, carpogonium situated directly on the vertical filament. *B–D*, two-celled carpogonial branches; in *B* and *D* the supporting cell has the same character as those of the carpogonial branch. *E*, carpogonial branch with short sporogenous filaments given off from the carpogonium and the subjacent cell. *F*, carpogonial branch producing (sporogenous ?) filaments. *G*, vertical filament with two larger cells, one of which bears a hyaline hair. *H*, vertical filament with a presumed auxiliary cell with scar after a decayed hair. *I* and *K*, auxiliary cells in contact with sporogenous filaments. *L*, probably young gonimoblast. *A–E* and *L*, 630 : 1 *F–K* 390 : 1.

The auxiliary cells arise from single cells in the vertical filaments, which become somewhat swollen and more susceptible to colouring matter. They appear to arise in some cases from cells having produced a hair (fig. 98 *G*, *H*). The development of the cystocarps has not been followed; I have only observed a few stages succeeding the presumed fertilization[1]. Sporogenous filaments are found given off not only from the carpogonium but also from other cells in the carpogonial branch; in the latter case, however, fusion between these cells and the carpogonium could not always be discerned, as for instance in fig. 98 *E*, where two young sporogenous filaments are seen projecting from the carpogonium and the subjacent cell. Older stages are shown in fig. 99 *C* and *E*; in *C* the filaments causing the fusion between the cells of the carpogonial branch are easily visible. The sporogenous filaments are here seen growing out in a horizontal direction from the carpogonial branches. Fig. 98 *I*, *K* show auxiliary cells in contact with sporogenous filaments, and fig. 99 *G* represents probably the same after the fusion. The stages shown in figs. 99 *D* and 98 *L* are probably young gonimoblasts, though sporogenous filaments are not visible. Ripe cystocarps are shown in figs. 99 *H*, *I*; they consist, as shown by Batters (l. c. pl. XI, fig. 4), of an almost spindle-shaped heap of carpospores which easily segregate on preparation. The spores are 14 to 17 μ in diameter.

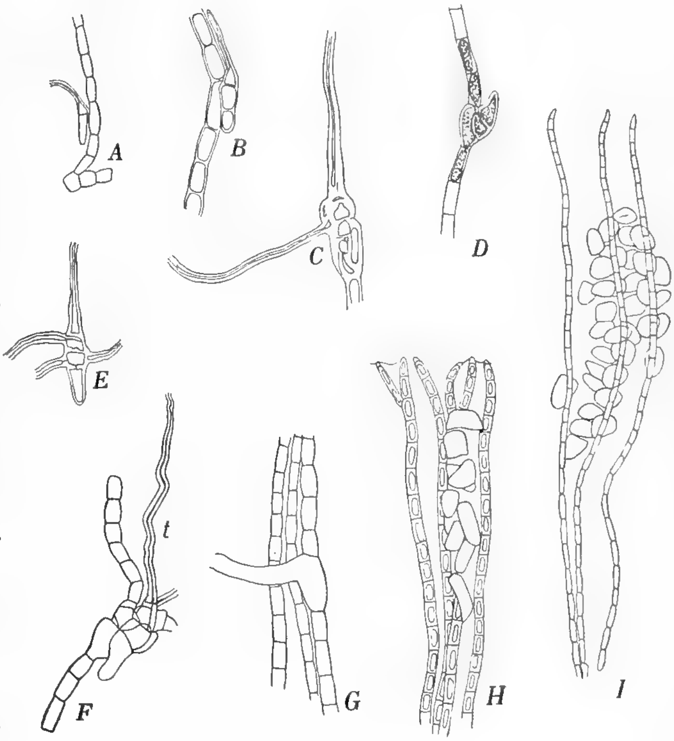


Fig. 99.
Petrocelis Hennedyi. *A*, two-celled carpogonial branch, January. *B–D*, Begtrup Vig, May. *B*, three-celled carpogonial branch, unfertilized. *C*, carpogonial branch after fertilization (?), giving off sporogenous filaments. *D*, young gonimoblast arising from an auxiliary cell (?). *E*, carpogonial branch giving off three sporogenous filaments (Skagerak, April). *F–G*, Hellebæk, July. *F*, carpogonial branch giving off sporogenous filaments. *G*, presumed auxiliary cell fused with a sporogenous filament. *H*, cystocarp, not fully developed, Lysegrund, May. *I*, ripe cystocarp, Storebelt, January. *A*, *H* 300:1. *B–G* 390:1. *I* 230:1.

The species has been found in almost all the Danish waters, in depths of 1 to 19 meters. It grows on stones and shells of *Mytilus edulis* and *Littorina littorea*, often in company with incrusting *Lithothamnia* and growing over them. In the North Sea and Skagerak it has principally been found growing on the stem of *Laminaria hyperborea*. The sporangia begin their development as a rule in the autumn; they were found undivided in September and November, ripe in January to July, emptied or abortive in June to September and November. But young sporangia

[1] Spermatia have not been found adhering to the trichogynes, and in some cases carpogonia having produced sporogenous filaments show no interruption of the protoplasm over the ventral part (fig. 98 *E*, 99 *E*) which might suggest a parthenogenetic development of the cystocarp.

were also met with in July. The antheridia have only been met with in particular male specimens from the North Sea and the Limfjord, collected in August, and a cystocarp-bearing specimen from Lillebelt collected in July also appeared to bear emptied antheridia. The cystocarps develop, as it seems, at about the same seasons as the tetrasporangia. They have been found ripe in January, May and June, emptied or degenerated in August. The carpogonia seem to arise at various seasons. In specimens collected in November I have found very young carpogonia still without trichogynes, but in crusts collected at Bornholm in July carpogonia with long trichogynes, partly also with sporogenous filaments, were met with (fig. 98), and unfertilized and fertilized carpogonia (at all events producing sporogenous filaments) have also been found in spring. In some cases sporangia and cystocarps have been found in the same crust.

Localities. **Ns:** Klitmøller, on the stem of Laminaria hyperborea washed ashore; Hanstholm (YU), 2 meters. — **Sk:** 4 miles N¼E of Svinkløv beacon (A. C. Johansen); Løkken, on Lam. hyp. on the shore; off Lønstrup, about 9 m; off Hirshals, on Lam. hyp. — **Lf:** Nissum Bredning off Helligsø, 6 m (C. H. Ostenfeld); at Mullerne (ZY), 4,5 m; Søndre Røn near Lemvig; Holmtunge Tange (MK). — **Kn:** Krageskov Rev (TV). — **Ke:** JO, Fladen; OO, Søborghoved Grund, 8,5 m. — **Km:** XC, NW of Anholt. — **Ks:** OS, OS[1], Hastens Grund, 14—16 m; HQ, Lysegrund; EJ, entrance to Isefjord. — **Sa:** GD, near Sejerø; FS, Vejrø Sund; Rønnen in Begtrup Vig, 1 m; North side of Refsnæs Reef, 13 m, (Ostenfeld); DK, Bolsaxen; MQ, South of Paludans Flak, 12 m; Halsgab near Hofmansgave, "in saxis maris Hindsholm" (Lyngbye, Hofman Bang); DJ, east of Æbelø. — **Lb:** FZ, Kasserodde, 6,5 m; North of Fænø Kalv; off Middelfart, about 15 m. — **Sb:** Stavreshoved; GP, Halskov Reef; NN, SW of Sprogø, 19 m; Avernakhage near Nyborg, 2 m; GZ, north of Egholm; DN, Vengeance Grund; near Vresen (Ostenfeld); DP, north of Onsevig. — **Su:** BQ, off Ellekilde, Ellekilde Hage, 11 m; North of Lappegrund, about 20 m (H. E. Petersen). — **Bw:** DU, off Dimesodde, 11 m. — **Bm:** QQ, off Rødvig. — **Bb:** YG, Arnager Rev, 7 m.

Cruoria (Fries).

1. Cruoria pellita (Lyngb.) Fries, Areschoug.

El. Fries, Corpus florar. prov. Suec. I. 1835, p. 317; J. E. Areschoug, Algarum pug. sec. Linnæa, Vol. 17, p. 267, tab. IX fig, 6—8, 1843, ex parte, Phyceæ scand. mar., 1850, p. 157; Alg. scand. exsicc, No. 309 (1872); J. Agardh, Sp. II, 1852, p. 491, III, 1876, p. 377; Le Jolis, Liste alg. Cherbourg p. 108, pl. IV, fig. 1—3; Batters, Mar. Alg. Berw. 1889, p. 95, pl. XI fig. 5.
Chætophora pellita Lyngbye Hydr., 1819, p. 193, pl. 66 *B*, ex parte (quoad specim. færoëns.).
Cruoria adhærens Crouan in J. Agardh Sp. II, p. 491, III, p. 377, (comp. Le Jolis, Liste, p. 108).

An examination of the specimens of *Chætophora pellita* in Lyngbye's herbarium has shown that this name includes two distinct species, the specimens from the Færøes belonging to *Cruoria pellita*, while those from Denmark belong to *Petrocelis Hennedyi* (comp. p. 174). The description and the figures, which treat only of sterile specimens, agree tolerably well with both species; it appears most probable, however, that they have been worked out after the Danish specimens, as the filaments in the fig. 2 are not thicker towards the base, and as they are described as "æqualia, apice parum attenuata" (l. c. p. 194), which agrees best with the last named species. The genus *Cruoria*, to which the species of LYNGBYE was referred in 1835 by FRIES, was also very ill defined. ARESCHOUG and the later authors, however, have applied the name of LYNGBYE and FRIES to the species here treated of, and it must be used in the future in the same sense, as the specific name of LYNGBYE in fact comprises both species.

This species, in habit quite resembling *Petrocelis Hennedyi*, forms crusts on the stems of *Laminaria hyperborea*, stones, shells of *Mytilus* and barnacles, more rarely on *Fucus serratus* and the basal part of *Halidrys siliquosa*, from 1 to 12 cm in diameter or more. The crust has at first a basal layer consisting of one layer of cells from which the vertical filaments are given off. The filaments of the basal layer are radiating towards the margin (fig. 100 *A*). According to SCHMITZ and HAUPTFLEISCH (1897, p. 535) the thallus is quite coalesced with the substratum and without root-hairs (Wurzelhaare); the first is true, but the latter assertion is not quite correct. As shown in figs. 100 and 101, short filaments are here and there given off from the under side of the basal layer; these filaments have first the character of unicellular rhizoids, but increase in length and form long septate filaments running under the primary basal layer, and in older crusts they may form a continuous layer consisting of one to more layers of variously disposed cells, the undermost of which may have the character of rhizoids penetrating into the unevennesses of the substratum, while the upper cells in thicker fronds resemble those of the primary basal layer. According to SCHMITZ and HAUPTFLEISCH (l. c.), rhizoids are frequently produced in the undermost part of the cortical layer.

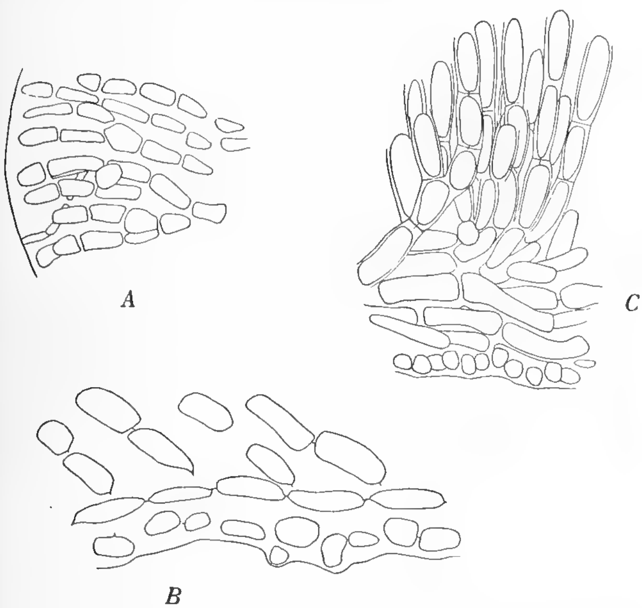


Fig. 100.
Cruoria pellita. *A*, border of frond seen from above. *B*, vertical section of under part af frond showing basal layer and sub-basal layer. *C*, similar, older crust. *A*, *B* 390 : 1. *C* 230 : 1.

Fig. 101.
Cruoria pellita. Basal layer of frond seen from the under face, showing creeping rhizoidal filaments. 390 : 1.

The vertical filaments are ascendent at the base; they are thicker near the base than in the upper part, and consist there of somewhat swollen cells, about 12,5—14 μ thick, while the cells of the upper part are 6—11 μ, frequently 7,5—9 μ thick.

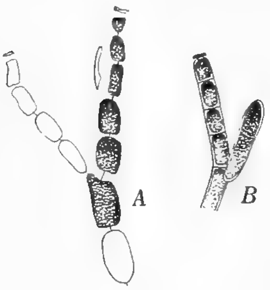


Fig. 102.
Cruoria pellita. A, vertical filament with branch, above a carpogonium (?); the cells contain a chromatophore and starch grains. *B*, vertical filament with young sporangium. 300:1.

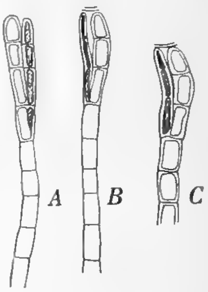


Fig. 103.
Cruoria pellita. Branches consisting of narrower cells with refringent contents. 300:1.

The lower part of the filaments tapers gradually upwards, while the upper part is usually of equal thickness. The ultimate cell is truncate or rounded, but never pointed. The cells contain a nucleus and a single calotte-shaped chromatophore, the border of which seems to be more or less lobed. The cells, particularly those of the undermost part of the filaments, are usually filled with starch grains. The filaments are sparingly branched, by lateral ramification (fig. 102 *A*). Hyaline hairs were not observed, but I sometimes found septate branches thinner than the filaments and with more refringent contents, reaching the same level as the ordinary filaments (fig. 103).

The tetrasporangia and the sexual organs occur as a rule in distinct individuals; carpogonia have, however, been met with in tetrasporangia-bearing crusts. The tetrasporangia are lateral on the vertical filaments. As shown in the figure published in Le Jolis' Liste (l. c.) they are attached in such a manner that their under part projects below the point of attachment. They are very large and divided by three horizontal walls. In specimens from Frederikshavn they were 250—283 μ long, 45—60 μ broad. A young sporangium is shown in fig. 102 *B*. In one case the spores seemed to contain several nuclei, but the observation was not certain, owing to the numerous starch grains contained in the spores.

The antheridia form small lateral tufts at the upper end of the vertical filaments, as shown by Thuret (Le Jolis l. c. pl. IV fig. 3). They are usually produced in small numbers on the upper end of a unicellular branchlet (fig. 104). The antheridia are linear, but the liberated spermatia, according to Thuret (l. c.) are globular. I have only once observed antheridia, in a specimen collected at Frederikshavn in July, having also carpogonia and cystocarpia.

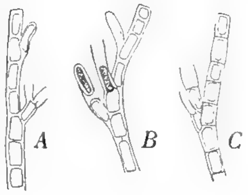


Fig. 104.
Cruoria pellita. Upper ends of filaments with antheridia, mostly emptied. 390:1.

The development of the cystocarps has only been incompletely followed. The carpogonial filaments are lateral on the vertical filaments. Their number of cells may be variable, at most four (fig. 105 *A*), more frequently less, e. g. two in fig. 105 *B*, and in fig. 106 *A*, where the trichogyne reached over the surface of the frond. Most of the carpogonial filaments observed had short trichogynes, and were probably young or abortive. Carpogonia sitting directly on the vertical filaments also occur, but in such cases it was often difficult to decide whether they were really carpogonia. Such dubious cases are shown in fig. 105 *C, D*; I have been inclined to interpret them as carpogonia, since they had the same refringent and colourless contents as the others. In some cases the supporting cell in the vertical filament had a similar appearance (fig. 105 *C, D*) (Comp. *Petrocelis Hennedyi*, p. 178). The undermost cell in the carpogonial filament is sometimes connate in its whole length with the supporting filament. Sporogenous filaments were not seen in connection with the carpogonium, but they were found fusing with the auxiliary cells. These cells are intercalary in the vertical filaments and differ but little from the other cells, possibly sometimes swollen before fusion. The sporogenous filaments run principally in a horizontal direction, but sometimes give off upward branchlets,

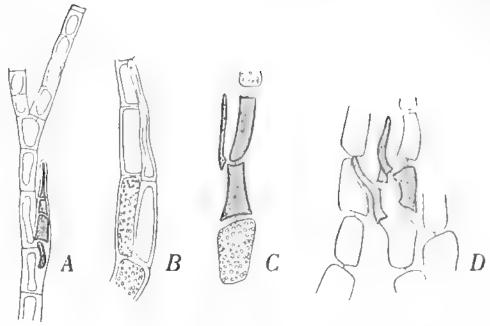


Fig. 105.
Cruoria pellita. Carpogonia *A*, four-celled carpogonial branch. *B*, two-celled carpogonial branch. *C*, presumed carpogonium sitting directly on the vertical filament; the supporting cell and the next following have the same homogenous and refringent contents as the carpogonium. *D*, Carpogonia given off directly from the vertical filament. *A, D* 300 : 1; *B, C* 390 : 1.

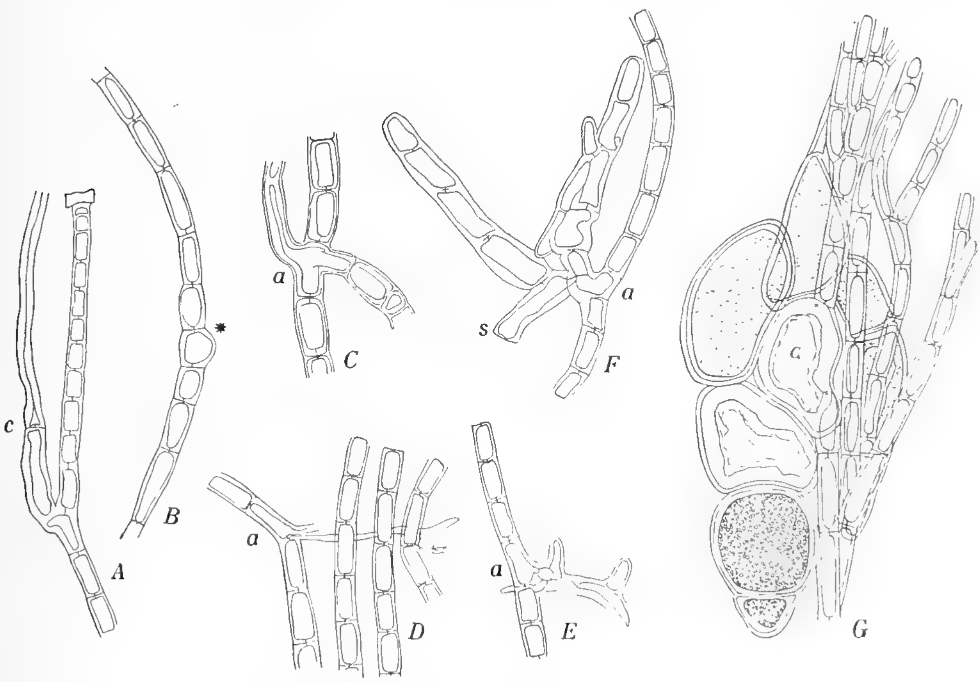


Fig. 106.
Cruoria pellita. *A*, two-celled carpogonial branch. *B*, filament with a somewhat swollen cell *, possibly an auxiliary cell. *C*, auxiliary cell fused with sporogenous filament. *D*, similar; the sporogenous filament has given off a branchlet upwards. *E*, auxiliary cell fused with a sporogenous filament which has given off two upwards directed branchlets. *F*, auxiliary cell in connection with an incompletely developed cystocarp *G*, ripe cystocarp; the pits connecting the auxiliary cell with the neighbouring cells in the vertical filament are marked with a ×. c, carpogonium; *a*, auxiliary cell; *s*, sporogenous filament. *A—F* 390 : 1. *G* 300 : 1.

the signification of which is unknown (fig. 106 *D, E*). An incompletely developed cystocarp is shown in fig. 106 *F*, it consists of a very small number of upwardly directed filaments, which have been somewhat displaced by pressure; the auxiliary cell has produced a lateral outgrowth, but is otherwise not swollen. Fig. 106 *G* shows a ripe cystocarp; the auxiliary cell, or better, the fusion cell, is here seen as a large cell connected by pits with the neighbouring cells of the vertical filament. All the cells of the cystocarp seem to produce a very large carpospore. The ripe cystocarp consists of a spindle-shaped heap of large cells, few in number, reaching downwards considerably beyond the insertion of the auxiliary cell; it has earlier been shortly described and figured by Batters (l. c.).

The species occurs from low-water mark down to 30 meters depth. In some places in the eastern Kattegat it occurs abundantly, covering the stones with extensive crusts, forming an association. The sporangia arise in autumn; they are found ripe in winter and spring, emptied in spring and summer. Carpogonia were met with at all seasons, often abortive however; cystocarps have only been met with once in July.

Localities. **Sk:** Off Lønstrup (ZK[2]), on Laminaria hyperborea. — **Kn:** Herthas Flak (!, Børgesen); TX, at Hirsholmene; Krageskovs Rev; Busserev at Frederikshavn; harbour of Frederikshavn; VU, east of Nordre Rønner, 15 m; TO, TP, Tønneberg Banke, 16—18 m; FF, TR, Trindelen, — **Ke:** IR, IT and VZ, Groves Flak, 24,5 m; IQ, ZE[1], Fladen; II, IK, Lille Middelgrund; Store Middelgrund (Børgesen), 30 m; IA, Store Middelgrund, 16 m; OO, Søborghoved Grund. — **Km:** XC, NW of Anholt, 11 m, on the base of Halidrys; D, north of Isefjord, on Fucus serratus, 11 m. — **Sa:** BF, off Sletterhage, 14 m; PH, Lindholms Dyb, 20,5 m; Northside of Refsnæs (C. H. Ostenfeld), 19 m; DK, Bolsaxen, 14 m. — **Lb:** CC, South side of Hornenæs, on Mytilus, 7,5 m. — **Sb:** NN, Southwest of Sprogø, 19 m. — **Su:** bM, South of Hveen.

Cruoriopsis Dufour.

Dufour, Elenco delle Alghe della Liguria, Genova 1864, p. 35 (non vidi), Schmitz and Hauptfleisch in Engler u. Prantl. I_2 p. 535.

1. **Cruoriopsis danica** sp. nov.

Crusta sanguinea, diametro c. 2—3 mm, ad 74 μ crassa. Stratum basale unistratosum, substrato arcte adnatum, e filis radiantibus compositum, cellulis 4—9 μ plerumque c. 6—9 μ latis, c. 6—7 μ altis, latitudine plerumque c. duplo longioribus, nonnunquam lateraliter confluentibus. Fila erecta 4—7-cellularia, æqualia vel in inferiore parte nonnunquam sursum paulo attenuata, 5—11 μ lata, cellulis longitudine vario, inferioribus nonnunquam non nisi dimidiam partem latitudinis attingentibus, superioribus latitudine sæpe duplo longioribus, chromatophorum singulum continentibus. Pili hyalini terminales nonnunquam sparse occurrunt. Sporangia in filis erectis terminalia, solitaria, rarius bina, ellipsoidea, 23—30 μ longa, 14—18 μ lata, oblique cruciatim divisa. Organa sexualia ignota. Cellulæ auxiliariæ (?) brevissimæ in parte media vel superiori filorum seriatæ.

The cells of the basal layer form regularly radiating filaments of varying breadth. Lateral fusions may be wanting in some cases, while in others they occur in great numbers (figs. 107 *I*, 108 *A*). More than two cells may sometimes fuse together. The cells of the basal layer are low, and the same may also be the case with the undermost cells in the erect filaments, while those of the middle and the upper part of the filaments may reach a length of up to 2,5 times the breadth. The erect filaments have almost the same breadth in their whole length, frequently, however, they are a little thicker towards the base, and the uppermost cell may be a little thicker than the second from the top. The filaments are rather firmly connected, but not or only to a slight degree united by a gelatinous collode. In the undermost part of the frond fusions may sometimes take place between contiguous cells of different filaments, as in the following species. The surface is covered with a rather firm outer wall. Each cell contains a calotte-shaped chromatophore and a small nucleus, little susceptible to staining reagents. The frond is, at all events in some cases, polystromatic to the border (fig. 108 *F*).

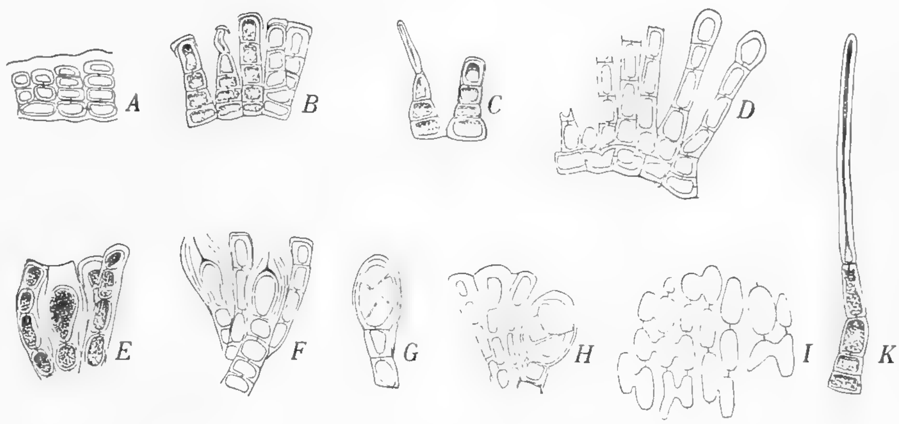


Fig. 107.
Cruoriopsis danica. A—H from M. *A—D,* vertical sections of frond, in *B* a young hair, in *C,* a more developed hair, in *D,* fully developed erect filaments, a little swollen at the top, *E,* unripe sporangium. *F,* new sporangia formed within emptied sporangial walls. *G, H,* ripe sporangia. *I, K* from MK. *I,* basal layer from the face showing fusions. *K,* erect filament ending in hair. 390 : 1.

Here and there some of the erect filaments terminate in hyaline hairs; these occur in varying quantity, usually solitary. They are fairly rich in protoplasm. The subjacent cell is somewhat lengthened, conical (fig. 107).

The sporangia arise from the terminal cell of erect filaments. They reach the surface of the frond and are originally, like the vegetative cells, covered with a thick outer wall (fig. 108). The first wall is inclined, the two following perpendicular to it (figs. 107 *G*, 108 *E*). After evacuation of the sporangium a new one may sometimes be formed from the subjacent cell within the emptied sporangial wall (fig. 107 *F*).

In specimens dredged in the Little Belt in July 1915 I found very short-celled filaments which were supposed to be auxiliary-cell filaments, though carpogonia were not found. They arose from erect filaments, which in a smaller or greater extent of their length consisted of low, disc-shaped cells, the undermost and one, or more rarely two or three, of the uppermost cells showing the ordinary length. The short cells were of a feebler colour than the other cells; they resembled the auxiliary-cell-rows of several other Cryptonemiales, but they seem to be different from those found in *Cruoriopsis cruciata* Dufour, which, according to SCHMITZ (Sitzungsber. d. niederrhein. Ges. für Natur- u. Heilk. zu Bonn. 1879) are lateral and 3- to 5-celled.

As may be judged from the above description, our species much resembles *Cruoriopsis Hauckii* BATTERS, according to the description given in the Journ. of Botany 1896 p. 387 (New or critical Brit. mar. Algæ), and I have indeed been much in doubt, whether it might not be identical with it. BATTERS' species differs however, by the erect filaments consisting towards the apices of longer and narrower cells, three or four times as long as broad and only 4 or 5 μ in diameter, while at the base of the filaments the cells are 10—15 μ in diameter. Nevertheless I should perhaps have referred my plants to the named species, had I not, through the kindness of the late Mr. BATTERS, received from him a microscopical preparation with two sections of a plant designed as *Cruoriopsis Hauckii* Batt. Plymouth 24th

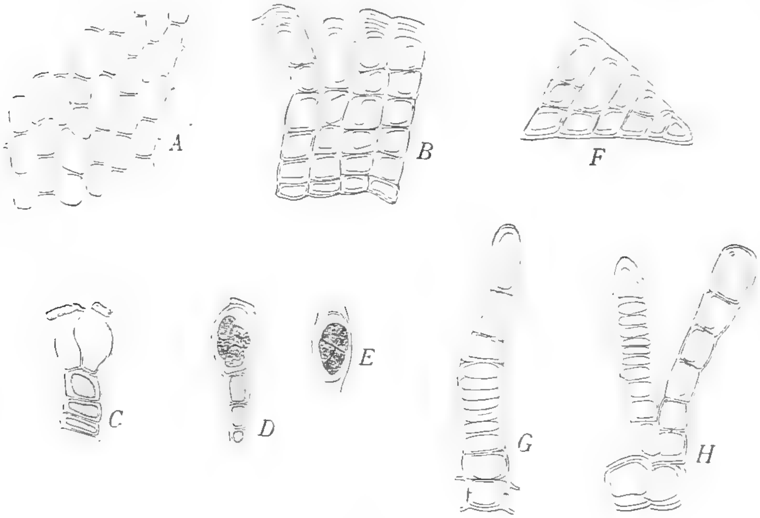


Fig. 108.
Cruoriopsis danica. *A—E* from Groves Flak. *A*, basal layer from the face. *B*, vertical section of frond: at left probably two young sporangia. *C*, two emptied sporangia on the end of a filament. *D*, *E*, ripe sporangia. *F—H*, from Lille Belt; *F*, vertical section of the margin. *G*, *H*, supposed auxiliary-cell filaments. *A—E* 390:1. *F—H* 625:1.

Fig. 109.
Cruoriopsis Hauckii Batt., after preparation sent from Batters. *A*, basal layer from the face. *B*, vertical filaments. *C*, sporangium. 390:1.

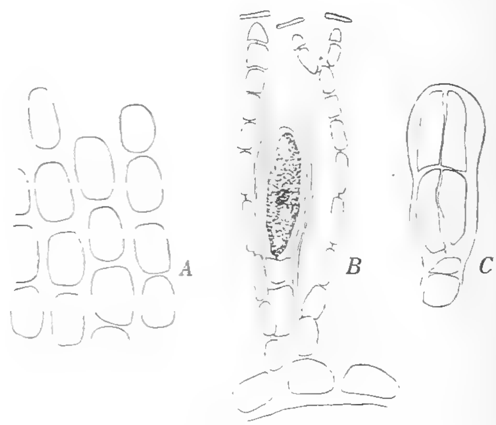


Fig. 110.
Cruoriella armorica Hauck, after specimen from Naples, from Hauck's collection. *A*, basal layer from the face. *B*, vertical section, showing unripe sporangium within an emptied sporangial wall. *C*, ripe sporangium. 390:1.

January 1896, thus apparently a type specimen, but differing from the author's description in the dimensions of the erect filaments and the sporangia, the first being thin in their whole length, 3,5—5 μ in diameter, not broader at the base, thus much thinner than in our species, and consisting of much more lengthened cells (fig. 109). Further, the crust appeared to have another consistency than the Danish plant, the filaments being connected by a gelatinous substance, while the special membranes of the cells were not distinct. The sporangia were smaller, more lengthened, 18—25 μ long, 7—11 μ broad. Hyaline hairs were not present. I think it therefore best to consider the Danish alga as representing a distinct species.

According to Batters (l. c.), *Cr. Hauckii* is identical with *Cruoriella armorica* Hauck, Meeresalg. p. 31 (non Crouan). An examination, through the kindness of Mrs. Weber-van Bosse, of a microscopical preparation of this species from Hauck's collection, labelled Neapel 1878, has shown me that this plant is different from the Danish, and also from Batters' species. The crust is thicker, up to 164 μ, the basal layer consisting of much larger cells, the erect filaments are thinner, more loosely united, sometimes dichotomous above, the sporangia regularly cruciate and much larger, 46—56 μ long, 26—28 μ broad (fig. 110)[1].

Cr. danica reminds one not a little of *Cr. arctica* K. Rosenv. (1910, p. 102); it forms, like this, small, thin, blood-red crusts on stones. It differs by lower cells in the basal layer, occasionally fusing with the neighbouring cells, by the presence of hairs, by the oblique division of the sporangia, and by the fact that the sporangia are always terminal, never lateral. It must be admitted that two sporangia may sometimes be found at the end of an erect filament, one of which must possibly be regarded as lateral, but they are in fact both placed terminally on the filament (fig. 108 *C*), while in *Cr. arctica*, true lateral sporangia occur. Finally, the sporangia are somewhat larger.

The species grows on stones in 1 to 17 meters depth; it has been found with ripe sporangia in April (Groves Flak) and September (Søndre Røn by Lemvig).

Localities. **Lf:** M, Søndre Røn by Lemvig, c. 1 m; MK, Holmtunge Tange, 1—2 m. — **Ke:** North end of Groves Flak (Børgesen). — **Lb:** At Lyngsodde off Middelfart, 15—19 m.

2. **Cruoriopsis gracilis** (Kuckuck) Batters.

E. A. L. Batters, Catal. of the Brit. Mar. Algæ (Suppl. to the Journ. of Botany 1902), p. 95.
Plagiospora gracilis Kuckuck, Bemerk. z. mar. Algenveg. v. Helgoland II. Wiss. Meeresunters. N. F. II. Bd. Heft 1, 1897, p. 393.
Cruoriopsis cruciata Batters, New or critical Brit. Mar. Algæ. Journ. Bot. 1896, p. 388.

In July 1915 I found by dredging in the Little Belt near Middelfart a few crusts on stones, agreeing perfectly with the plant described by Kuckuck under the name of *Plagiospora gracilis*. A few additional remarks may be given here to Kuckuck's rather short description.

[1] Another specimen in Hauck's herbarium, labelled *Cruoriel la armorica*, from Rovigno was sterile, and evidently belonged to another species, possibly a species of *Cruoria*.

The crusts are thin, bright purple, up to 1,5 cm in diameter. The basal layer consists of isodiametrical cells. The erect filaments are 4,5—5,5 μ thick. Not unfrequently transversal fusions between contiguous cells in different erect filaments occur (fig. 111 *B*). The sporangia are normally lateral on the erect filaments and sessile. In some cases however I found them pedicellate, on a one-celled stipe, as shown in fig. 111 *C, D*. The sporangia are first divided by an oblique transversal wall (fig. 111 *A*) and later by two walls perpendicular to the first; at maturity they are 21—22 μ long, 11—14 μ broad.

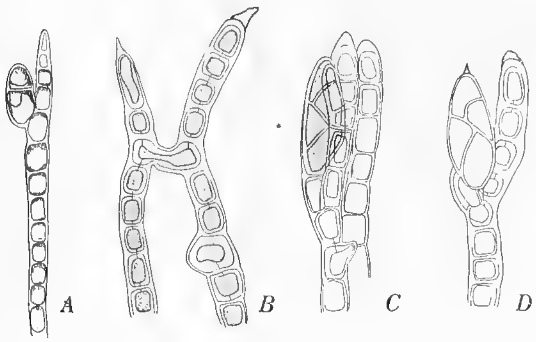


Fig. 111.
Cruoriopsis gracilis. *A*, erect filament with two-celled sporangium. 430 : 1. *B*, fusion between cells of two different filaments. *C* and *D*, filaments with sporangia on one-celled stipe. *B*—*D*, 730 : 1.

Kuckuck has established the genus *Plagiospora* on the oblique division of the tetrasporangia. As such divisions occur not only in *Hildenbrandia*, as mentioned by Kuckuck, but also in *Cruoriopsis* (and further in *Petrocelis*), and as in the genus *Cruoriopsis* both terminal and lateral sporangia occur, even in the same species (*Cr. hyperborea*), it is justified to refer the species here mentioned to the genus *Cruoriopsis*.

Locality. **Lb:** At Lyngsodde, right opposite to Middelfart, about 15 meters, with sporangia in July.

Cruoriella Crouan.

1. Cruoriella codana sp. n.

Thallus tota superficie inferiori paulum calcaria substrato adhærens, rhizinis unicellularibus affixus, diametro 2—5 (?) cm latus, purpureus. Stratum basilare (hypothallium) e lobis lateraliter conjunctis e filis flabellatim ramosis compositis formatum, cellulis 14—33 μ longis, 9—14 μ latis, 9—11 μ altis. Thallus adultus e pluribus frondibus superpositis compositus. Fila verticalia frondium singularum plerumque e cellulis 3—10 formata. — Paranemata nematheciorum sexualium sursum attenuata, e 4—5 cellulis composita, basi 7—8 μ, superne 2—3(—4) μ lata. Antheridia, in nematheciis specialibus aut in iisdem ac carpogonia, divisionibus transversalibus et longitudinalibus filorum orta, diametro 2 μ. — Carpogonia in ramulis specialibus 4—5-cellularibus terminalia, membrana obliqua curvata a cellula penultima limitata. Cellulæ auxiliariæ in filis aliis intercalariæ. Cystocarpia e filis erectis paucis parce ramosis composita. Carposporæ 11—12 μ diametro.

The specimens on the base of which this species has been described were for a long time referred by me to *Cruoriella armorica* Crouan[1], a species which has

[1] Ann. d. scienc. nat. 4e sér. t. 12, 1859, p. 289.

often been confounded with other species. It was only by becoming acquainted with the recently published description of *Peyssonnelia* (*Cruoriella*) *Nordstedtii* Weber-van Bosse[1] and by the final revision of my material that I arrived at the conclusion that it was not identical with the former, but more resembled the last named species. As it proved to be different also from this and did not appear to agree with any other well known species, I describe it here as a new species.

Cruoriella codana has only been met with once on a calcareous stone much bored by worms. It forms thin crusts of a bright purple colour, brighter than in *Cr. Dubyi*, and is adherent to the substratum in its whole extent, being fixed to it by unicellular rhizoids. The greatest crust is more than 5 cm in diameter, but it has probably arisen by coalescence of several distinct crusts; the other were at most 1 cm broad. When seen from the underside, the young basal layer appears composed of distinct lobes, which coalesce laterally. The lobes have a flabellate structure. Even when having a continuous outline, the margin is composed of very distinct lobes (fig, 112 *A*), and the same structure is found in the older parts of the hypothallium, where there are no principal rows of larger cells, as found in *P. Boergesenii* and *P. Nordstedtii* by Mrs. Weber-van Bosse (l. c. p. 138 and 140). The cells of the basal layer are 14—33 μ long, 9—14 μ broad and 9—11 μ high. Unicellular rhizoids, bounded by a cell wall, are given off from its under face. The marginal cells of the frond divide by vertical cell-walls, and the segments divide immediately by a horizontal wall, the hypothallic cell becoming thus lower than the marginal cell (fig. 114). The monostromatic basal layer or hypothallium is only little distinct from the "perithallium" consisting of the vertical filaments given off from it. These filaments are vertical in their whole extent or slightly ascending; they are only rarely branched. The cells are of almost equal breadth in the same filament, 9—12 μ, or the undermost may be a little broader. Their height is as a rule a little less than the breadth, near the surface sometimes much less, more rarely the same or a little greater. The number of cells in the erect filaments usually varies from 3 to 10.

Old crusts are composed of two or more fronds growing one over the other. At first observation these superposed fronds might be supposed to come into existence in the same way as recently described by Mrs. Weber-van Bosse in *Peyssonnelia* (*Cruoriella*) *Nordstedtii* (l. c. p. 141, fig. 146), by the formation of a horizontal split in the frond and following constitution of the part situated over the split as a new crust with a new-formed hypothallium. I have seen several cases which were favorable to this interpretation, in particular some apparently young cases and such where the under face of the upper crust was very irregular, and I might suppose that the new upper frond may really arise in this manner. But in other cases it is without doubt that the upper frond arises from horizontal outgrowths from certain parts of the crust which have preserved their growing power, while the covered

[1] Rhizophyllidaceæ in F. Børgesen, Rhodophyceæ of the Danish West Indies. Dansk Botan. Arkiv, Bd. 3. Nr. 1, 1916, p. 140.

parts have lost it by formation of nemathecia or from other causes. The meeting point between the overlapping frond with another similar one or with the forth-growing old frond is usually easily found (fig. 112 *B* *). The places from which the new fronds are given off are frequently inverted conical, being upwardly enlarged and composed of filaments slightly diverging upwards. The number of these

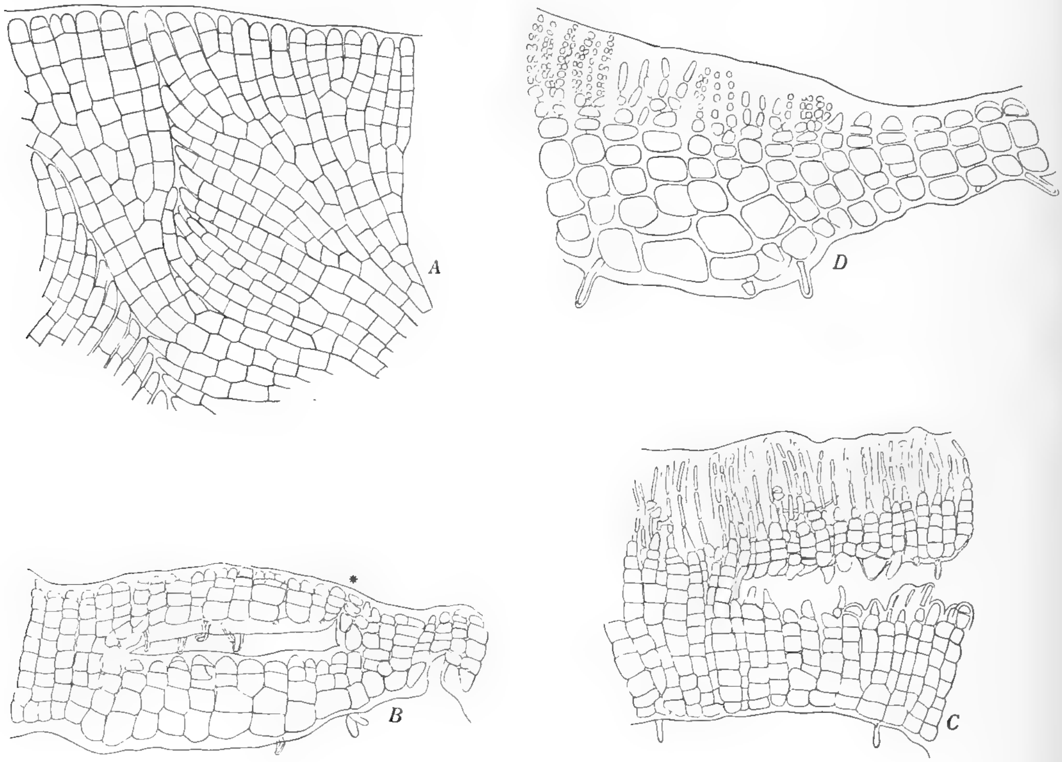


Fig. 112.
Cruoriella codana. *A*, marginal part of frond seen from below. 195 : 1. *B* and *C*, vertical sections of frond showing the overlapping of the frond by a new lobe; at * the point of concretion of this lobe with another part of the frond; in C the basal layer of the new lobe is not normally developed. In *C* auxiliary-cell filaments and sporogenous filaments are visible 205 : 1. *D*, vertical section of frond with antheridial nemathecium. 350 : 1.

points of departure is variable; sometimes they are very close, in other places they are more distant. The new-formed fronds coalesce laterally and form together a uniform plain surface. The cells of the basal layer of the overlapping fronds were frequently found connected with pits, a fact which supports the here proposed explanation of their development. As the new fronds were evidently not produced at the season when the specimens were collected, I have not been able to follow their development, but must content myself with examining the advanced stages. A further fact confirming my view is that nemathecia are frequently found on the surface of the covered crust (fig. 112 *C*). The under face of the frond is often irregular; in some places the frond projects downward sand, consists there of larger cells, which may here be up to 17 μ high.

The cells of the frond contain, as far as could be judged from the examination of dried specimens, a vaulted chromatophore in the upper part of the cell. Numerous starch grains often fill the cells, particularly in the under part of the frond.

The under face of the frond is covered with chalk, but the frond itself does not appear to be incrusted.

The sexual organs are always situated in nemathecia on the upper side of the frond. The nemathecial filaments consist of 4 or 5 cells, the undermost of which have the same breadth as the upper cells of the crust, or about 7—8 μ, while the thickness of the filaments tapers towards the middle and in the upper part it is only 2—3(—4) μ, without considering the gelatinous outer wall (fig. 112 *C*). The upper cells are 3 or 4 times as long as broad or even longer.

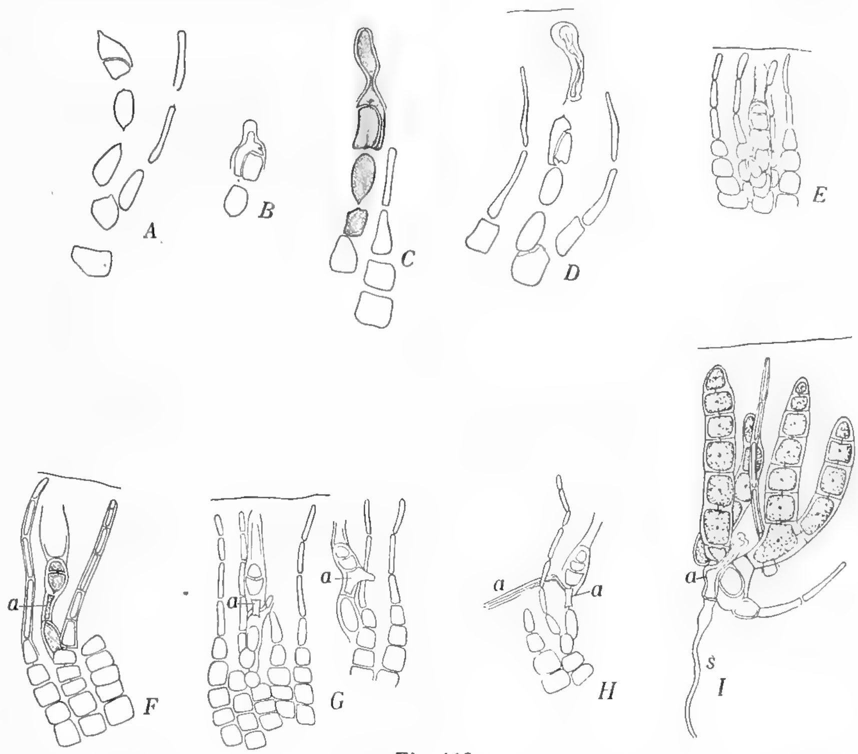


Fig. 113.

Cruoriella codana. A and *B*, young carpogonia. *C*, more developed carpogonium with short, thick trichogyne. *D*, carpogonium showing disjunction of the trichogyne but no other signs of fecundation. *E—H*, auxiliary-cell filaments; *a*, auxiliary cell; *s*, sporogenous filament. *I*, not fully developed cystocarp; *a*, auxiliary cell or fusion cell. *A—D* 630 : 1. *E—I* 400 : 1.

The antheridia arise from the nemathecial filaments by division of all the cells or with the exception of the undermost one or two cells. The cells are divided by transversal walls or at the same time by longitudinal walls in small antheridial cells (spermatangia), which are about 2 μ in diameter; in a longitudinal section each filament appears as composed of one or two longitudinal series of cells (fig. 112 *D*). The antheridia occur in particular male nemathecia or in the same nemathecia as the carpogonia.

The carpogonia are terminal on 4- or 5-celled branches given off from the lower part of the nemathecial filaments. They are cut off by an oblique curved wall going from the middle of the longitudinal to the border of the basal wall of the mother-cell. Two young stages are shown in fig. 113 *A*, *B*. The carpogonium shown in fig. 113 *C* is a little more developed, though yet unfertilized; the trichogyne is short and thick, the carpogonium encloses completely the right side of the hypogynous cell. The carpogonium represented in fig. 113 *D* has the appearance of being fertilized, the continuity of the trichogyne with the ventral part being interrupted, but the carpogonium has not reached the surface of the frond, and no spermatia adhere to it, nor have any sporogenous filaments been formed. Later stages of the carpogonia I have not observed.

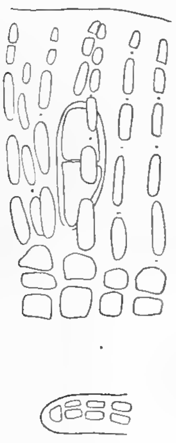


Fig. 114. *Cruoriella codana*. *A*. vertical section of margin of frond. *B*, vertical section of sporangial nemathecium. 350 : 1.

The auxiliary cells are more numerous than the carpogonia; they occur in particular branches given off at the base of ordinary nemathecial filaments and are shorter than these (fig. 113 *E*—*H*). The cells of these filaments have a dense protoplasm and are somewhat swollen, particularly the two uppermost cells, while the third cell from the top (more rarely the fourth) is not swollen. This latter cell is the auxiliary cell, which may be concluded from the fact that it is sometimes found in connection with thin sporogenous filaments running in a horizontal direction between the nemathecial filaments. Over the auxiliary-cell filament a space containing a hyaline substance and provided with a membrane open above is visible; it resembles an abortive hair (fig. 113). The development of the cystocarps has not been followed, but a cystocarp, not quite ripe it is true, but apparently not far from ripeness, is shown in fig. 113 *I*. It consists of a few upward directed, slightly branched filaments, the cells of which each produce a carpospore. In the most developed cystocarp I have seen the carposporal cells were 11—12 μ in diameter.

The sporangial nemathecia, of which I have only observed one, much resemble those of *P. Nordstedtii* (Mrs. Weber-van Bosse l. c. p. 142). The nemathecium had a height of 88 μ, the paraphyses were less tapering than those of the sexual nemathecia, the upper cells being 4 μ broad; the undermost cells were usually 2—3 times as long as broad. The tetrasporangia, fixed at the base of the nemathecium, are certainly cruciately divided, but the ripe sporangia were disturbed by the preparation. Some were divided by a transverse or slightly oblique wall, but the direction of the following walls could not be stated (fig. 114). The almost ripe sporangia are about 50 μ long, 18 μ broad.

As mentioned above, I at first referred the specimens here described to *Cruoriella armorica* Crouan, and I maintained this determination also after having examined, through the kindness of Prof. Nordstedt, a type specimen of this species from Crouan in J. Agardh's herbarium at Lund (Nr. 27630), having in one specimen found a still sterile nemathecium with thin upwardly tapering nemathecial filaments as in the sexual nemathecia of the Danish species. The sporangial nemathecia, which at that time were unknown to me in *Cr. codana,* present, however, such differences that it is impossible to identify our species with that of Crouan, the nemathecial filaments of the latter being forked, fastigiate, and the sporangia being terminal on undivided erect filaments and reaching the surface of the nemathecium, in which respect I found the specimens of Crouan corresponding to his description and figures.

Our species is apparently related to *Cr. Nordstedtii,* which shows resemblances in the structure of the frond and of the sporangial nemathecia, but there seems to be a difference in the superposed fronds arising only by splitting of the frond in *Cr. Nordstedtii,* while in *C. codana* they seem to arise principally as excrescences from the surface of the frond. The first-named differs further, according to Mrs. Weber-van Bosse, by the want of principal rows of cells thicker than the others in the basal layer and by the presence of pluricellular rhizoids besides the unicellular ones. The sexual nemathecia are unknown in *C. Nordstedtii.*

It is highly probable that this species has been met with earlier, but confounded with *Cr. armorica*; this, however, cannot be stated without examination of the corresponding specimens.

Locality. **Ku:** TR, near Trindelen, 23,5 meters, September.

2. **Cruoriella Dubyi** (Crouan) Schmitz.

Fr. Schmitz, Syst. Übersicht, Flora 1889, p. 20; id. in Kolderup Rosenvinge, Grønl. Havalger, 1893 p. 783; Fr. Schmitz und P. Hauptfleisch in Engler u. Prantl, 1897, p. 536.

Peyssonnelia Dubyi Crouan, Ann. sc. nat. IIIe sér. t. 2. 1844, p. 367, pl. 11; id., Alg. mar. du Finistère (Exsicc.) 2e vol. no. 236, Brest 1852; id. Florule du Finistère, 1867, p. 148, pl. 19; Harvey, Phycol. brit. I, 1846, plate 71; J. Agardh, Sp. II, 1852, p. 501; III, 1876, p. 384; Hauck, Meeresalg., p. 35; Batters, Mar. Alg. Berw., 1889, p. 90; Kuckuck, Bemerkungen, II, 1897, p. 393, fig. 18 (antheridia).

The purple-coloured crusts are 1 to 3 (4) cm in diameter. In a dried state they show characteristic radial folds. The outline of the frond is undulate; the course of the cell-filaments in the marginal part is not regularly radiating, owing to its composition of coalescing lobes, the growth being usually arrested in one of the meeting lobes (fig. 115 *C*). From the underside of the frond, which is covered with a layer of chalk, a varying number of rhizoids are given off; when fully developed they are separated by a wall from the producing cell (fig. 115 *A*).

The thickness of the frond is variable. As shown in a vertical section, it is divided immediately behind or at a small distance from the border by horizontal walls (fig. 115 *A*). The cells of the undermost layer, which produces the rhizoids, are usually somewhat lengthened in the radial direction. Two erect cell-rows are frequently given off from one cell in the basal layer or the subbasal layer (fig. 115 *B*); the cells are therefore greater in the under part of the frond than in the upper. Each cell contains a nucleus and apparently a vaulted chromatophore in the upper part of the cell. To judge from the figure given by Kuckuck (l. c. p. 394, Fig. 18 *B*) the chromatophore is either divided into ribbonlike branches or there are several bandlike chromatophores; they are not mentioned in the text. The cells, particularly those of the undermost part of the frond, often contain a great quantity of starch grains taking a brownish colour on treatment with iodine.

Old crusts are often composed of several crusts growing one over the other. This is principally caused, as in the foregoing species, by the cessation of growth of great parts of the fronds, particularly those which have produced nemathecia, while in other parts the erect filaments continue growing in the next season, giving rise to a new frond growing in a horizontal direction over the old frond, and this may be repeated several times, so that old fronds may be composed of 6 or more

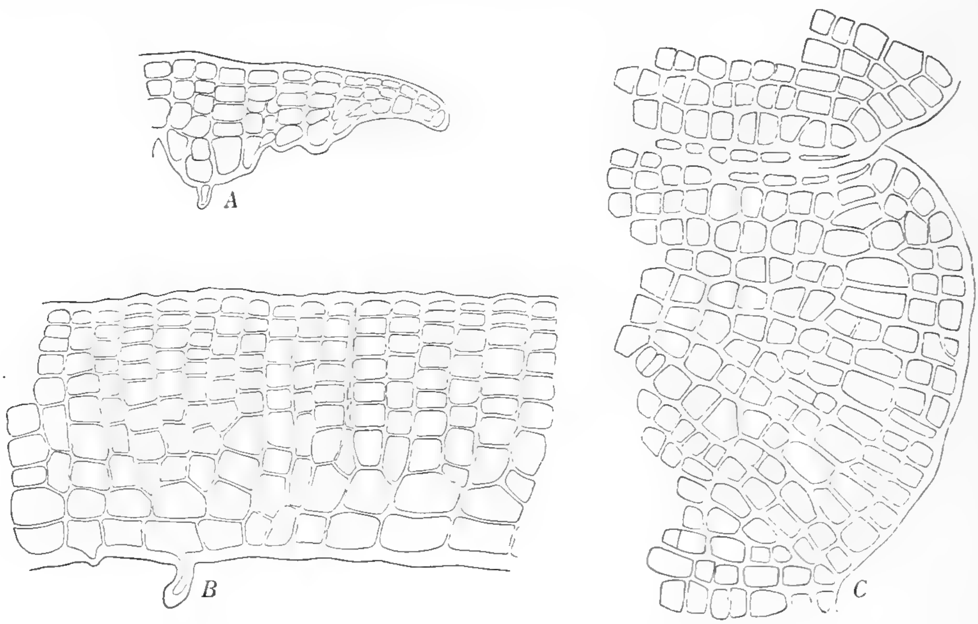


Fig. 115.
Cruoriella Dubyi. *A*, marginal part of frond in vertical section. *B*, inner part of frond in vertical section. *C*, marginal part of frond seen from above. *A* and *B*, 295:1; *C*, 215:1.

distinct crusts. The under side of fronds or lobes thus produced is usually rather irregular (fig. 115 *A*). Overlapping, though in a smaller degree, may also take place in the border of the frond, where the lobes sometimes grow over one another, and the same may occur on the meeting of two of the fronds produced in the manner first described. A formation of superposed fronds by horizontal splitting, as described for *Cr. Nordstedtii* by Mrs. Weber-van Bosse may also occur (see above p. 189).

The sexual nemathecia are cushion-shaped, of various extent. The antheridia occur in particular nemathecia or interspersed in the female ones. As shown by Kuckuck (l. c. fig. 18) the spermatangia arise by transverse and longitudinal divisions of the cells of the nemathecial filaments (fig. 116 *A*).

The nemathecial filaments of the female nemathecia are of equal thickness in their whole length, and consist at the stage of fertilization of about 5 cells, which are a little longer than broad; up to twice as long. When the cystocarps are ripe, the cushion is thicker, the filaments somewhat longer, the constituting cells more numerous and sometimes longer. The carpogonia are terminal on particular (3—)4—5-celled branches given off from one of the undermost cells in a nemathecial filament or from one of the bottom cells of the nemathecium (fig. 116). As in the foregoing species, the carpogonium encloses one side of the subterminal

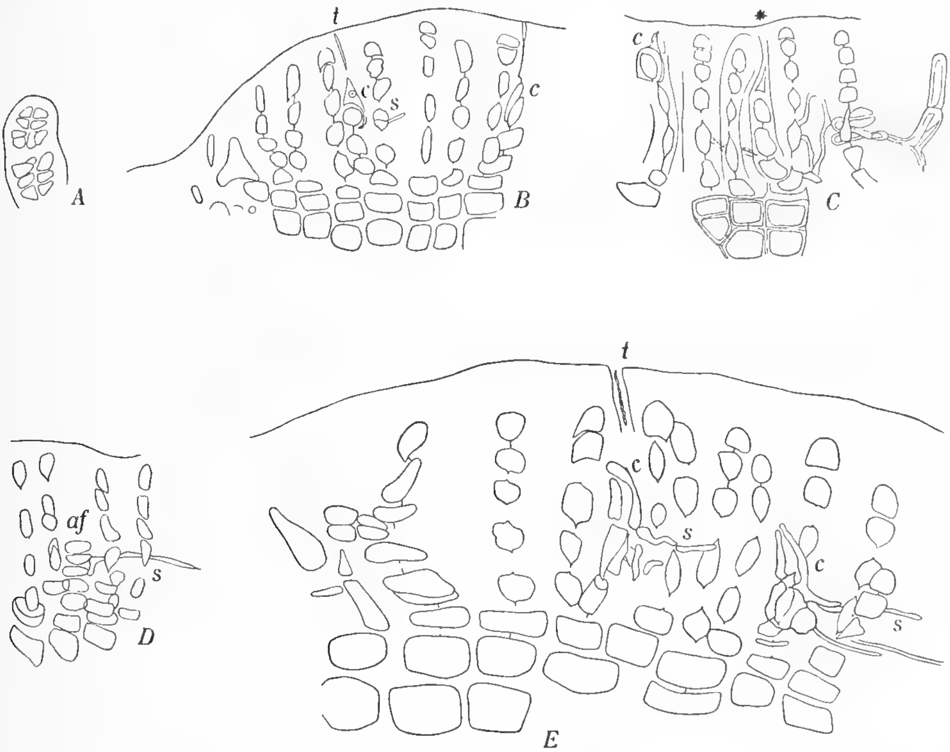


Fig. 116.
Cruoriella Dubyi. A, antheridia, upper part of male nemathecial filament. *B—E,* vertical sections of nemathecia with carpogonia (*c*), trichogynes (*t*), sporogenous filaments (*s*) and auxiliary-cell filaments (*af*). *A, E* 630:1; *B–D* 390:1.

cell, giving off a production reaching beyond the under face of this cell. In some cases no such lateral production was found, but these carpogonia were doubtless abnormally developed, abortive (fig. 116 *C**). The auxiliary-cell branches which are given off from the lowest part of the nemathecial filaments consist of about four low seemingly equal cells. In fig. 116 *E* two fertilized carpogonia are shown, from which sporogenous filaments growing in a horizontal direction are given off. A similar filament in connection with an auxiliary-cell filament is shown in fig. 116 *D*. The development of the cystocarp has not been followed. At maturity the cystocarpial nemathecium contains numerous rows of carpospores, each row consisting of up to five almost globular carpospores, each surrounded by a thick hyaline wall.

The carpospores are 19—29 μ in diameter, with the envelope 35—40 μ; a nucleus is seen in the centre. How many such rows belong to each cystocarp I cannot say; according to BATTERS (l. c. p. 91) each cystocarp consists of one, two or three rows.

Sporangia were only met with in two specimens after evacuation. According to CROUAN, HARVEY and others they are regularly cruciate[1].

The species has been met with in several places from Skagerak to the Samsø waters and the Sound, usually in considerable depths viz. from 13 to 25 meters, in Skagerak however also in 2 m and in the Limfjord in 6 meters depth. It grows on stones (granite and flint) and old shells of bivalves (*Cyprina, Mytilus modiola* a. o.) and gastropods, and *Serpula*, frequently in company with *Cruoria pellita*. It is perennial, but has only been collected in the months of April to September. Most of the specimens were sterile, but two specimens with emptied sporangia were found in the eastern Kattegat in April and May, and some collected in the Samsø waters in August had antheridia and carpogonia, partly fertilized, and long sporogenous filaments. Specimens with ripe cystocarpia were collected in August off Lønstrup in Skagerak. According to BATTERS it is fructifying in January to June at England's east coast.

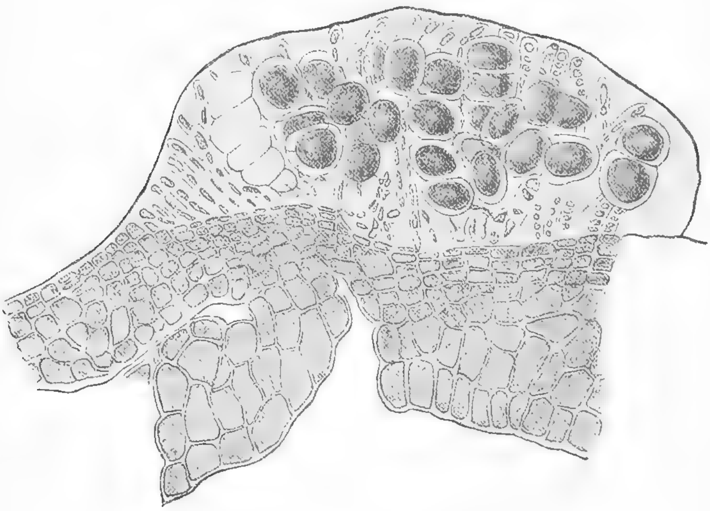


Fig. 117.
Cruoriella Dubyi. Vertical section of nemathecium with ripe cystocarps. 200:1.

Localities. **Sk:** At Roshage, Hanstholm, near land, 2 m; ZK⁰ and ZK⁶ off Lønstrup, 7—13 m. — **Lf:** Nissum Bredning, off Helligsø, 5,5 m. — **Kn:** Herthas Flak; Böchers Banke, 29 m; TO, Tønneberg Banke; ZB, east of Trindelen, about 30 m; TR, FF and TQ near Trindelen; VU, east of Nordre Rønner, 15 m; N.E. of Hirsholmene, 9,5 m (Henn. Petersen). — **Ke:** IL, IP, IQ, ZE¹ Fladen, 21—25 m; ZJ, IR, IS, VZ, Groves Flak, 22,5—26,5 m; Groves Flak (Børgesen); IK, IH, Lille Middelgrund; Store Middelgrund, IA, 16,5 m (!) and 30 m (Børgesen). — **Sa:** KI, south of Hjelm, 13 m; BF, off Sletterhage, 14 m. — **Su:** bM, South of Hveen, 22,5 m.

[1] The above was written long before I received V. SCHIFFNER's Studien über Algen des adriatischen Meeres (Wiss. Meeresuntersuch. N. F. 11. Bd. Abt. Helgoland, Heft 2, 1916). The author describes here (l. c. p. 148) a species named *Cruoriella Dubyi*, which he supposes is identical with the Atlantic species of the same name. This supposition, however, seems to be doubtful, the Adriatic plants apparently differing, in the structure of the frond and of the nemathecia as well. Thus, the frond is said to be rarely more than 6 cells thick; nothing is said as to the complex structure of older fronds described above; and the rhizoids seem to be much more numerous. Further, the paraphyses are said to be attenuated upwards. The author says, p. 148, that the species has been wrongly referred by DE TONI to *Cruoriella*, but p. 501 he approves that SCHMITZ has made the same determination.

Rhododermis Crouan.

Crouan in J. Agardh, Sp. Vol. II, pars 2, 1852, p. 504.

1. **Rhododermis elegans** Crouan.

Crouan in J. Agardh, Sp. Vol. II, pars 2, p. 505. Crouan, Florule de Finistère, 1867, p. 148, pl. 19, fig. 130, Batters, Mar. Alg. Berw., 1889, p. 91, pl. XI fig. 1 (forma *polystromatica* Batters). Kolderup Rosenvinge, Deux. mém., 1898, p. 18, id., Mar. Alg. N. E. Greenl. 1910, p. 104.

This small arctic and north-atlantic species has been collected in several places in the Danish waters. It forms small, thin crusts of a lilac-rose colour with an irregular outline, the diameter of which scarcely exceeds 5 mm. It resembles in many respects *Rh. parasitica* of which Kuckuck has given an exhaustive description and splendid figures (Beitr. z. Kenntn. d. Meeresalg. 1. Wissensch. Meeresunters. N. F. II, Heft 1. 1897). According to Batters, one of the principal differences is that the cells of the frond in *Rh. elegans* are broader than long, while in *Rh. parasitica* they are longer than broad. This difference is in reality general though not absolute, as may be judged from the figures of Kuckuck and from the fact that cells may be found in *Rh. elegans*, which are at least as high as broad. *Rh. parasitica* differs further by its greater diameter, greater thickness and darker colour. A difference exists also in the structure of the border of the frond, this consisting in *Rh. parasitica* of distinct filaments (Kuckuck, l. c. p. 7, Taf. VIII fig. 10) while it is continuous in *Rh. elegans* (fig. 118 *A*).

The basal layer consists of radiating cell-rows, the cells of which are more or less lengthened in a radial direction. In the marginal part of the frond the cell-rows are frequently flabellately radiating towards the irregularly lobed border, here and there showing lateral ramifications (fig. 118 *A*). The cells are usually 5,5—7 μ broad, $1^1/_2$ to 3 times as long as broad. In the basal layer lateral fusions between cells belonging to different cell-rows frequently occur, the cells corresponding through a broad open canal. Such fusions may occur at the very margin of the frond. More than two cells may sometimes fuse together (fig. 118 *A*, *B*).

The crust is at first monostromatic, and a rather broad monostromatic marginal part may often be found. The inner part of the frond was always found to be from 2 to at least 5 cells thick. I have never found it distromatic in a greater extent, and I must therefore suppose that it is only accidentally that Crouan has attributed a distromatic frond to this species, and that there is no reason to maintain the var. *polystromatica* Batters. The cells contain several chromatophores as in *R. parasitica*. In the upper part of the crust the cells are 8—11 μ broad. In several specimens I found, projecting from the surface, scattered hyaline hairs (fig. 118 *C*). Their number varied; they were placed between the paraphyses or in the sterile parts of the crust.

The sori form irregular spots on the surface of the frond; they consist of feebly curved paraphyses, usually 4- or 5-celled, 40—50 μ long, at the base 5—9 μ broad, and between them the sporangia, which are terminal on the vertical filaments of the crust, the upper cell of which has often the character of an upward slightly broader stalk-cell. In some specimens from the Little Belt (Middelfart) the paraphyses were but few in number, in some cases almost wanting; the plant had then a certain resemblance with *Rhododiscus pulcherrimus.*

The sporangia are first divided by a transverse wall; the vertical walls occur at a later moment, for which reason sori containing only bipartite and undivided sporangia are not infrequently met with (comp. Kuckuck l. c. p. 7 and Batters l. c. pl. XI fig. 1*a*). The ripe sporangia are usually 24—33 μ long, 16—20(24) μ broad.

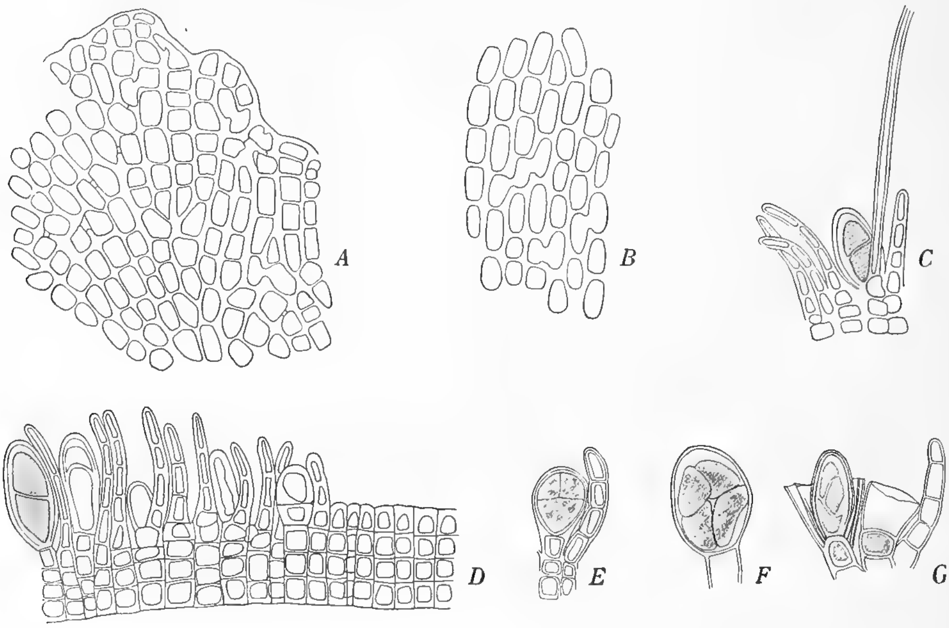


Fig. 118.
Rhododermis elegans. A, marginal part of frond seen from above. *B,* basal layer of fructifying frond seen from below. *C,* vertical section of fertile part of frond with paraphyses, a bipartite sporangium and a hyaline hair. *D,* vertical section of frond with sorus; sporangia bipartite. *E,* almost globular ripe sporangium from Hornenæs. *F,* ripe sporangium. *G,* regeneration of sporangium. 385:1.

The greatest sporangium was found in a specimen from Refsnæs; it measured 33 μ in length and 24 μ in breadth. In the southernmost place in the Danish waters (at Hornenæs in the Little Belt) I found almost globular sporangia, 20—21 μ long, 18 μ broad (fig. 118 *E*). After evacuation a new sporangium may be produced from the stalk-cell within the empty sporangium wall (fig. 118 *G*).

Sexual organs were not met with. Antheridia are only known in specimens from North-East Greenland (K. Rosenvinge 1910).

As to the time of fructification only incomplete information can be given. In winter (October to February) the species has not been met with, but it must be supposed from observations from the coasts of England and of Greenland, that it will be found fructifying in winter with us, and this supposition is in accordance with the fact that it has been found with ripe sporangia in March (Lille Belt) and with empty sporangia in April (Limfjord, Samsø waters). On the other hand it has also been found with ripe sporangia in June, July and September, and it seems thus that it may produce ripe sporangia at all seasons.

The species occurs on stones (flint, limestone, granite), shells and carapaces of animals (*Mytilus, Serpula, Hyas*) and Algæ (*Polysiphonia elongata, Chondrus crispus*, hapters of *Laminaria digitata*), in 5,5—19 meters depth.

Localities. **Sk:** YN[2], S.E. of Bragerne, 10,5 m. — **Lf:** XX in Nissum Bredning, 5,5 m. — **Kn:** TG, north of Læsø, 9,5 m. — **Ke:** VY, Fladen, 18 m. — **Ks:** OP, Lysegrund, 6 m. — **Sa:** Northside of Refsnæs, 19 m. — **Lb:** NV and XQ, near Middelfart, 15—19 m; CC, south side of Hornenæs, 7,5 m.

2. **Rhododermis Georgii** (Batters) Collins.

F. S. Collins in Phycotheca Bor. Amer. No 1299; id., Notes on Algae, III, Rhodora, August 1906, p. 160.

Rhodophysema Georgii Batters, New or critical Brit. mar. Algæ. Journ. of Botany, Vol. 38, 1900, p. 377. Kylin, Algenfl. schwed. Westk., 1907, p. 194—196, fig. 41.

Rhododermis Van Heurckii Heydrich, Über Rhododermis Crouan, Beihefte z. Botan. Centralblatt, Bd. 14, 1903, p. 243, Taf. 17.

Strange to say this characteristic little species was first described in 1900, though it has later proved to be widely distributed. It has also been recorded in several places in the Danish waters, always growing, as elsewhere, on *Zostera*-leaves, but it has further been found growing on uncovered roots of *Zostera*.

The plant begins as a thin monostromatic crust much resembling that of *Rhododermis elegans*, and with the same marginal growth. The marginal part is usually continuous with an irregularly undulating outline, and consisting of radiating filaments which are 4—6 μ broad; more rarely the ends of the filaments are free, not laterally connate. Lateral fusions between cells of these cell-rows not unfrequently occur (fig. 119 *A*). The crust is early divided by horizontal divisions, which advance from the centre towards the periphery, with the result that the crust usually becomes polystromatic to the margin. The radial growth has meanwhile ceased, so that the diameter of the crust rarely exceeds 300 μ.

As shown by Heydrich, Collins and Kylin, the species occurs in two forms, a disc-shaped and a globose or pear-shaped or irregularly lobed. In the disc-shaped form, the frond is usually 4 to 5, at most 7 cells thick, when fully developed and fructiferous. The cells of the erect cell-rows are 4—6 μ thick. As shown by Heydrich and Kylin, some of the superficial cells may produce long, vigorous hyaline hairs of the usual type in the Florideæ; they are 5—7 μ thick near the base, and contain a nucleus near the top. The cells of the frond contain a nucleus and several chromatophores.

In the disc-shaped specimens the sorus often originates shortly after the formation of the first horizontal walls. The upper cell produced by these divisions in the central part of the frond develops then in a paraphyse or in a sporangium with its stalk cell, and there is only one layer of vegetative cells under the sorus. When the surrounding cells now continue growing in a vertical direction and dividing by horizontal walls, the sorus will finally be placed in a groove in the frond (fig. 119 *C*, comp. HEYDRICH l. c. Fig. 3). When rising later it takes a more superficial position.

The other specimens arise from disc-shaped ones by very strong enlargment of the under cells of the frond with the exception of the peripheral ones. The figures of BATTERS and HEYDRICH show a great number of large hyaline cells in the interior of the frond, suggesting that the erect cell-rows from which they arose consisted of about 10 cells. Such figures represent, according to my observations, eccentric sections in which a greater number of the outward bent cell-rows have been intersected. According to KYLIN, the cells of the basal layer remain for a long time unchanged, and differ from the cells of the inner tissue through their small size and rich contents. "Schliesslich tritt indessen auch eine Vergrösserung in den Zellen der Basalscheibe ein, indem sie sich zwischen die vergrösserten Basalzellen der verticalen Zellfäden einkeilen." This latter assertion is not in accordance with my observations. In specimens attaining only a smaller height, being only cushion-shaped, the cells of the basal layer remain often unchanged, but in typical specimens of the inflated form they are enlarged at an early period, and there seems to be ordinarily no question of protruding of these cells between those of the second layer. But the cells increasing not only in length but also in breadth, there is no room for all the cells of the basal layer when enlarging their volume, and a number of them must therefore remain unchanged in size. Connected with the growth of the inner cells is the enlargment of the surface of the frond which makes its appearance in the lateral branching of the cell-rows in the periphery of the frond (fig. 120 *C*). — In the large vesicular cells a number of small chromatophores are easily visible; in some cases these cells were poor in cell-contents, in others they contained small starch grains.

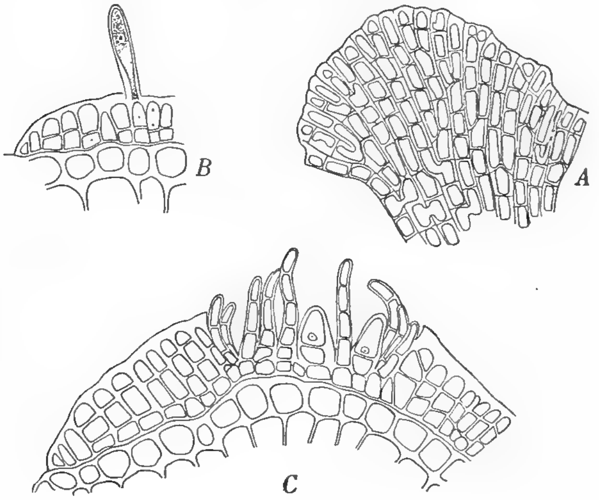


Fig. 119.
Rhododermis Georgii. *A*, basal layer seen from below, showing the border and lateral fusions. *B*, marginal part of frond in vertical section, showing a young hair. *C*, vertical section of disc-shaped frond showing a sorus sunk in a groove. 350:1.

The simultaneous occurrence of the two forms of the species on the same leaf of *Zostera* is very curious. As a rule, the specimens growing on the faces of the leaves are disc-shaped or low cushion-shaped, while those placed on the margins are inflated. Cushion-shaped specimens may, however, be found on the margins and inflated on the faces, thus the two forms of specimens may occur side by side apparently under equal external conditions; this may perhaps be caused by a different moment of development. The possibility that there might be two distinct forms is quite precluded by the fact that transitional forms are everywhere met with, and by their accordance in all other respects. Specimens are sometimes found which are partly cushion-shaped, partly inflated and bearing sori in both parts of the frond. It cannot be doubted that the inflated specimens arise under certain conditions which are usually only realised on the margins of the Zostera-leaves. It

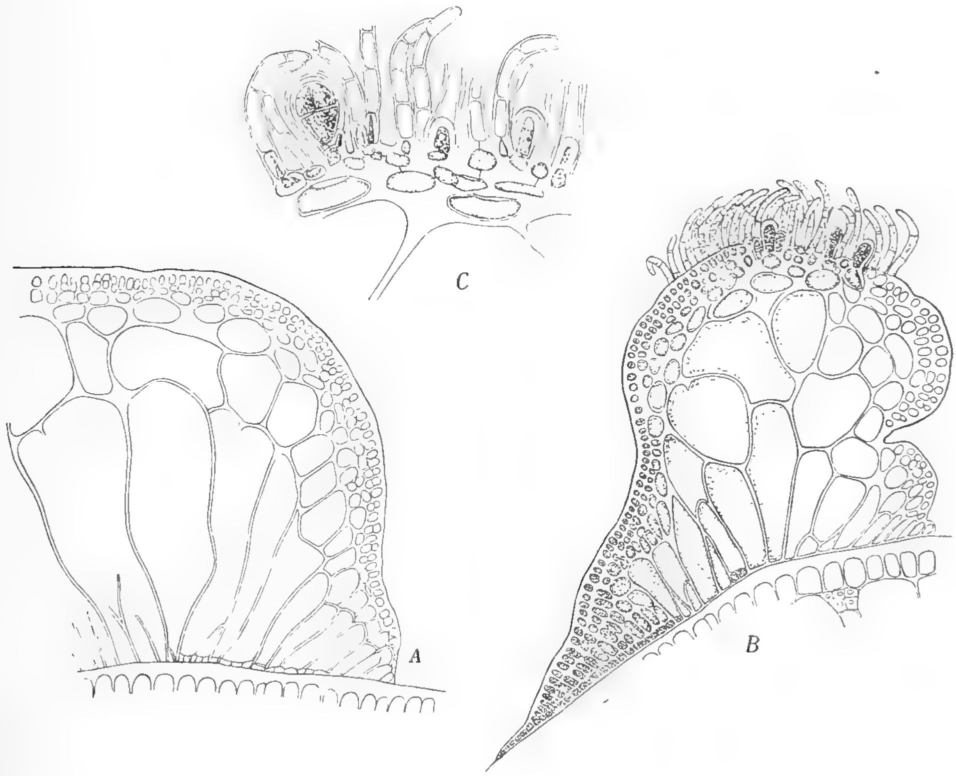


Fig. 120.
Rhododermis Georgii, vertical sections of the inflated form. *A*, sterile plant. *B*, plant with sorus with unripe sporangia. *C*, part of sorus with ripe and emptied sporangia, the latter becmoing filled with new sporangia from the stalk-cells. *A*, *B* 200 : 1; *C* 350 : 1.

might be supposed that the causa efficiens must be sought in the movements of the water which are much greater at the margins than on the faces of the undulating leaves. It must be left to experimental studies to decide this and to determine whether it is the friction against the water, or the better conditions for nutrition caused by the stronger movements which induce the increased growth of the inner cells of the frond.

The sorus occupies the central part of the frond. Usually there is only one, but sometimes two (or more?) are met with, which perhaps fuse together. As mentioned above, the sorus may sometimes be sunk in a groove. The paraphyses are curved towards the centre of the sorus; they are 3—5-celled, 6 μ broad at the base, upwards a little thinner. The sporangia are born of a stalk cell as in the other species; they are 26—32 μ long, 21—24 μ broad. After the evacuation, a new sporangial cell is cut off from the stalk cell within the empty sporangial wall.

I agree with HEYDRICH and COLLINS in retaining the species in the genus *Rhododermis*. When occurring in its disc-shaped form it resembles *R. elegans* so much that it differs only in the dimensions of the cells of the frond, and there but slightly.

The species grows on the leaves of Zostera produced in the foregoing year, but also in shed leaves. It has been met with in the months of April to August, in all these months in disc-shaped and inflated specimens and with sori. In April the sporangia were yet undivided; in May and June unripe and ripe sporangia were met with, in July and August ripe sporangia were found, but also emptied and regenerated ones. The species has also elsewhere been found with sporangia in spring and summer.

Localities. **Lf:** Repeatedly at Nykøbing (!, C. H. Ostenfeld). — **Kn:** In several places at Hirsholmene (!, Ostenfeld, Henn. Petersen); Frederikshavn, Busserev, and between Borrebjergs Rev and Marens Rev; ZL, S.E. of Nordre Rønner, 6,5 m and 11 m. — **Sa:** Off Risskov at Aarhus.

Fam. 8. Hildenbrandiaceæ.

The family of the Hildenbrandiaceæ, established long since (Comp. RABENHORST, Fl. eur. Alg. III, 1868, p. 408) and still maintained by SCHMITZ in 1882 (Hauck, Meeresalgen, p. 37), was later abandoned by this author as the presumed cystocarpia of the genus *Hildenbrandia* had proved to be conceptacles of tetrasporangia, and he therefore ranged this genus under *genera incertæ sedis* in 1889 (Flora, p. 22). In 1897 SCHMITZ and HAUPTFLEISCH range it as a dubious *Corallinacea*. On the other hand DE TONI places it under the *Squamariaceæ* in a subfam. *Hildenbrandtieæ* (Sylloge Alg. Vol. IV, sect. IV 1905, p. 1713). I think it better to consider the genus as a representative of a particular family intermediary between the *Squamariaceæ* and the *Corallinaceæ*. Although the sexual reproduction is unknown, the family is sufficiently characterized by the want of incrustation with lime of the frond, by the presence of immersed conceptacles of sporangia, and by the oblique divisions of the sporangia. The conceptacles resemble those of the *Corallinaceæ* but develop in another way, as will be mentioned below. Oblique divisions of the sporangia do not occur in the *Corallinaceæ*, but are characteristic of several *Squamariaceæ*.

Hildenbrandia Nardo.

1. Hildenbrandia prototypus Nardo.

Nardo, De novo genere Algarum cui nomen est Hildbrandtia prototypus. Oken's Isis 1843, p. 675; Hauck, Meeresalg. p. 38.

Zonaria deusta Lyngbye, Hydr., 1819, p. 19 ex parte; cfr. notula.

Erythroclathrus pellitus Liebman in Flora Danica, tab. 2317, fig. 2, 1840 (sterile).
Hildenbrandtia rosea Kützing, Phycol. generalis, 1843, p. 384; J. Agardh, Spec., II, pars 2, 1852, p. 495.
Hildenbrandtia sanguinea Kützing, Phycol. generalis, 1843, p. 384, tab. 78, V.
Hildenbrandia Nardi Zanardini, Synops. Alg. in mar. Adriat., p. 238; J. Agardh, Spec. II, p. 494.

When young, the crusts are nearly orbicular, or with a more or less lobed margin. A number of such young crusts frequently fuse together into a large crust, leaving no traces of the limits between the particular crusts. On the other hand, older crusts may, when meeting, be separated by a very distinct limiting line.

The margin is composed of radiating filaments, the ultimate cells of which are long and almost colourless, frequently swollen at the end. Not only the outermost cell, but also the second cell from the border may be several times as long as broad, longer than the next inward following cells of the basal layer, from which it must be concluded that intercalary divisions may occur. Now and then the number of the cell-rows is increased by ramification. The fig. 121 *A* suggests that the cell-rows may branch by dichotomy; but a closer examination showed that their ramification is really lateral (fig. 121 *B*. The crust represented in this figure showed numerous lateral branches, some of which penetrated between and under the primary filaments, in the latter case causing irregularities in the structure of the basal layer. In other cases this layer showed a very regular structure; it is densely appressed to the substratum, without rhizoids.

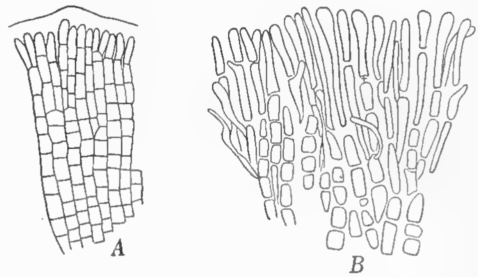


Fig. 121.
Hildenbrandia prototypus, borders af young fronds, seen from the under face. *A* 350 : 1. *B*, showing the lateral ramification and some branches growing under the primary filaments. 560 : 1.

Horizontal divisions occur at a small distance from the margin. The adult frond is composed of regular vertical rows of nearly cubical cells, which are 4 to 6,5 μ broad. The cell-walls are firm, not swelling at the death of the cells. There is a single calotte-shaped chromatophore situated in the upper part of the cell (fig. 123 *C*).

The tetrasporangia occur in immersed conceptacles, which often occupy the whole crust except the marginal part and are uniformly spread over it, but may also be arranged in groups. In a fully developed state, the nemathecia are nearly globular or a little depressed, about 100 μ in diameter. The sporangia are situated on the bottom and the sides, and even on the under side of the peripheral part of the roof, the thickness of which diminishes towards the aperture. The conceptacle is not prominent; on the contrary, the surface is often a little sunk towards the aperture.

The conceptacles arise from a small group of superficial cells which produce tetrasporangia, while the contiguous cells remain vegetative and continue dividing by horizontal walls, with the result that the sporangia are placed in a low cavity.

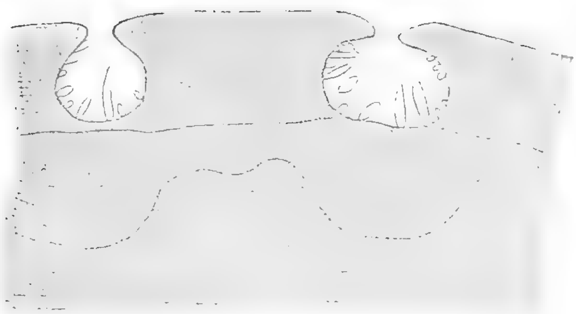
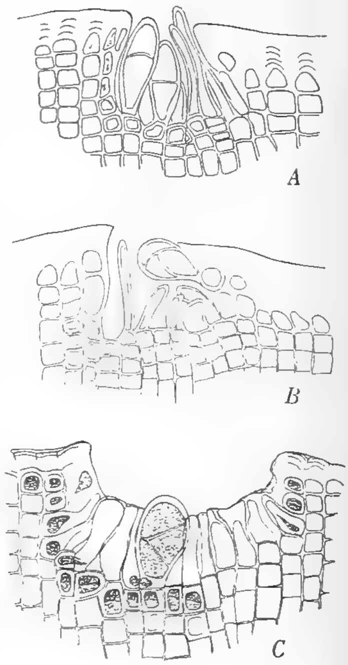


Fig. 122.
Hildenbrandia prototypus, vertical section of old crust showing two conceptacles and limiting lines between the productions of three years. 195 : 1.

In specimens collected in June I found such cavities about 6 cells in diameter and not so deep but that the sporangia reached the border of the aperture (fig. 123 *A*). The sporangia in these young conceptacles are of different age. Besides fully developed or two-parted sporangia young ones are found, but also aborted sporangia occur, having sometimes the character of paraphyses (fig. 123 *A*, *B*). The production of sporangia continues a very long time, usually apparently a year (or more ?), while the crust grows gradually in thickness. When the sporangia have been emptied, new ones are produced on the same place from the cells forming the bottom of the cavity, within the emptied sporangial walls or between them, and at the same time the formation of sporangia extends at the sides and upwards on the lateral walls of the cavity, the cells of the vertical cell-rows limiting the cavity at the sides producing sporangia directed obliquely or horizontally towards the centre of the cavity, which gradually takes a nearly orbicular outline. The sporangia-producing cells divide into a small stalk-cell and a greater outer cell, the sporangium. The stalk-cells of the lateral sporangia seem usually to decay, and the replacing sporangia must therefore be produced by the cells of cell-rows situated within the stalk-cells. In such a manner the conceptacle increases in transversal outline, new vertical cell-rows being gradually engaged in the production of sporangia. The parts of the cell-rows which are active in this manner are consumed by this production, and the continuity between the upper part forming the roof of the conceptacle and the under part is thus abolished. The upper part of these cell-rows therefore finally decays, at least in those situated nearest the aperture, where the regular arrangement of the cells is disturbed; the cell-walls swell, and the contents become discoloured and degenerate (fig. 125 *A*). In the peripheral part of the roof, the undermost cells of the interrupted vertical cell-rows often undergo a growth in a transversal direction, in consequence of which the cell-rows become bent inward below (fig. 122). The above



A

B

C

Fig. 123.
Hildenbrandia prototypus, vertical sections of young conceptacles. *A* and *B* from specimen collected in June (near Refsnæs), *C*, from spec. collected in January (Store Belt). 560 : 1.

described development of the conceptacles has evidently been known to SCHMITZ, as can be seen from the diagnosis of the genus *Hildenbrandia* in SCHMITZ and HAUPTFLEISCH Corallinaceæ in ENGLER u. Prantl, Nat. Pflanzenfam. I,2, p. 544. It is here said that the conceptacles are "anfangs sehr klein, unter allmählich fortschreitendem Verbrauch des nächst angrenzenden Gewebes allmählich an Grösse zunehmen", and that they frequently fuse laterally together. The development is designed as "lysigen" though it is not lysigenous in the usual significance of the word.

Fig. 124.
Hildenbrandia prototypus. Vertical section of conceptacle with undivided and empty sporangia. Above a ripe sporangium. 560 : 1.

The sporangia are somewhat variable in shape and dimensions; they are now ovoid or obovate, e. gr. 21 μ long, 14 μ broad, now long, nearly cylindric, e. gr. 30 μ long, 9,5 μ broad. The length varies between (16—)21 and 30 μ, the breadth between 9 and 12 (14) μ. No relation between the dimensions of the sporangia and the locality has been found. The dividing walls are always oblique. The first wall is much inclined to one side, the two following to the opposite side and often parallel to each other. But the first wall is often broken where it meets the following walls, in such a manner that the succession of the walls is not always easily discernible. The upper part of the first wall is often bent downwards so that it goes in continuation of the upper secondary wall, and the sporangium thus presents the appearance of having been divided first into three by two parallel walls and afterwards by a wall dividing the middlemost cell into two (fig. 125 *J, B, E, F*). The secondary walls nearly always intersect the primary one, but usually near its border; this is true particularly of the undermost wall, which may also meet it at the very border or even intersect the outer wall under the border (fig. 125 *C*). An extreme case is shown in fig. 125 *K* where the sporangium has the appearance of having been divided by nearly parallel walls; but on regarding only the insertions and not the curvatures of the walls, it

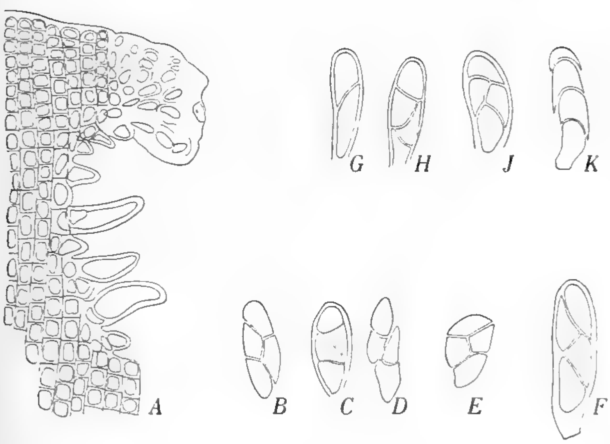


Fig. 125.
Hildenbrandia prototypus. *A*, left side of conceptacle in vertical section. *B–K*, ripe sporangia. *A–F* from Karrebæksfjord, *G–K*, from Guldborg. 560 : 1.

will be seen that the middlemost (primary) wall is inclined to the left, the two others to the right; the walls, however, do not intersect, in accordance with the unusually narrow shape of the sporangium.

After the evacuation of the tetraspores, the sporangial walls are kept for a long time; they swell and fill the conceptacle. They have been considered as paraphyses by Kützing and others, but such organs do not occur in the adult conceptacles (comp. Schmitz and Hauptfleisch l. c.). Small *Sarcina*-like bacteria sometimes form strings between the empty sporangial walls.

Conceptacles are met with at all seasons, and ripe sporangia have been found in all the months of the year, most frequently, however, in summer. As a rule empty, ripe and unripe sporangia are found simultaneously, from which it must be concluded that the formation of sporangia continues during the whole year, in the winter only with diminished activity. At what moment the development of the conceptacles begins I cannot say with certainty as I have seen but a small number of young stages. The youngest of the observed stages (fig. 123 *A*, *B*) were met with in June, which might suggest that the development of the conceptacles begins in spring, when the growth of the crust must be supposed to be active.

In older crusts the periodicity of the growth is marked by distinct limiting lines between the layers of the successive years. The upper line in fig. 121 probably represents the surface of the frond at the end of the foregoing season, but the lower, more irregular line does not represent an old surface; the deepenings are the bottoms of emptied conceptacles, and the higher parts between them represent the limit of the crust after disorganisation of its upper parts. It really frequently happens that the outer cell-layers die in winter over a greater or lesser part of the crust, and the faculty of growth is then often restricted to limited portions of the frond, which then become higher, and provided with conceptacles, while the other parts are low and sterile.

The species is widely spread in the Danish waters, particularly in shallow water, also over the low-water mark, and in sheltered places, where it is often a characteristic element of the vegetation, covering the stones with a red crust in company with *Ralfsia* etc., frequently under *Fucus*. But it is also common in deeper water, even in the greatest depths where vegetation has been met with, e. g. in the North Sea at 31 meters depth, in the Little Belt at 26,4 m and near Bornholm at 38 m, but it seems to be less abundant at greater depths. It has repeatedly been met with in a fructiferous state at about 19 meters depth, at Bornholm even at 29 m. In very insolated localities in shallow water it takes a yellowish colour during summer.

Localities. **Ns:** aF, off Thyborøn, 31 meters, small sterile specimens; groin at Thyborøn. — **Sk:** YU, Roshage, Hanstholm, 2 m, small sterile spec.; washed ashore near Bulbjerg, sterile; Hirshals, on stones adhering to the hapters of Laminariæ washed ashore after storm, sterile. — **Lf:** Rønnen near Lemvig, 3 m, MA, off Jestrup, 5 m; Oddesund, stone slope, fr.; Nykøbing and otherwhere in Sallingsund; aT[1], Draaby Vig; Livø Bredning (C. H. Ostenfeld); west side of Feggeklit. — **Kn:** Herthas Flak, 21—25 m, ster.; Hirsholmene; Deget; Busserev; Frederikshavn; Nordre Rønner. — **Km:** Mariager Fjord, at Hobro;

ND, off Fornæs, 11,5—13 m. — **Ks:** HR south of Hesselø; shore at Gilleleje; D, off the entrance to Isefjord; Ourø, near Roskilde and Boserup in Isefjord. — **Sa:** FS, Vejrø Sund; PG, west of Hatter Rev; north end of Besser Rev; north-side of Revsnæs (Ostenfeld); shore by Koldby Kaas; Bolsaxen; Hindsholm (Lyngbye); NZ, off Tørresø; Odense Fjord, inner side of Enebærodden (!) and shore at Hofmansgave (Car. Rosenberg); Juelsminde. — **Lb:** OB, off Stavrshoved; Snoghøj, Middelfart, Fænø a. o. places from 0 to 19 meters; CE, south of Helnæs, 26 meters. — **Sf:** UV, north of Ærø; Birkholm. — **Sb:** Refsnæs; Romsø Sund (Ostenfeld); NU, off Strandskoven near Bogense; stone reef at Korsør; GP, Halskov Rev; near Sprogø, 10—15 m (Ostenfeld); AC, off Knudshoved, 17 m; DN, Vengeance Grund; Nyborg Fjord, shallow water; near Vresen, 23—24 m (Ostenfeld). UT and US[1] in Langelandsbelt, about 19 m. — **Sm:** Karrebæksfjord off Skraverup (Warming); Guldborg (C. Christensen); HF, west of Farø. — **Su:** bM south of Hveen, 22,5 m; Hvidøre; off Charlottenlund; south end of Middelgrund; Trekroner (Rützou); QC, QD, Saltholms Flak; PR[1] off Dragør, 4 m. — **Bw:** DV, south of Marstal; LC, near Gulstav, 11 m; UP off Kramnisse Gab; UM, Kadetrenden. — **Bm:** HG, Præstebjerg Rev, 7 m; QS, N. of Møens Klint 21 m; at Møens Klint; VD, Bøgestrømmen; QQ off Rødvig; RG, N.W. of Falsterbo; QN, off Køge Søhuse 6,5 m. — **Bb:** SF, Ádler Grund; SH, Rønne Banke; Off Rønne, 13 and 38 m (Børgesen, !), reef at Rønne; Davids Banke, 29 m; off Gudhjem; YA, east of Dueodde lighthouse 38 m; Christiansø.

1. **Hildenbrandia Crouani** J. Agardh.

J. Agardh, Spec. G. O. II, 1852, p. 495, III, 1876, p. 379; Batters in Journal of Botany 1897, p. 438.
Hildenbrandtia rosea Crouan, Florule de Finistère, 1867, p. 148, pl. 19 fig. 126, non Kützing.

In the Little Belt I found by dredging in depths of 15 to 19 meters a stone covered with crusts of a *Hildenbrandia* which in hanit scarcely differs from *H. prototypus*. It forms pretty blood-red crusts with similar conceptacles. In the structure of the frond and the shape and dimensions of the conceptacles it agrees also with the named species. The cells are 6—7 μ broad and contain a calotte-shaped chromatophore, the conceptacles are up to 100 μ in transverse diameter. On the other hand, it differs decidedly by its cylindric sporangia divided by parallel oblique walls, in which respect it agrees with *Hildenbrandia Crouani* J. Agardh.

This species was first described on the basis of specimens sent from Crouan, but, as shown by Agardh and Batters, the brothers Crouan have confounded it both with *H. rosea* Kütz. (*H. prototypus*) and with *Hæmatocelis rubens* J. Agardh (Batters l. c. p. 438). I have had an opportunity of comparing my specimens with those in Agardh's herbarium sent from Crouan (herb. Agardh n° 27613 "roches de l'anse du Corsens, environs de Brest") upon which his description is founded, and I have found them fully agreeing. I found also accordance with microscopical preparations from Batters in Agardh's Herbarium.

The conceptacles are similar in structure and development to those of *H. prototypus*. The cell-rows in the peripheral part of the roof are much bent inward below, in consequence of the transverse growth of the undermost cells, as sometimes also occurs in *H. prototypus* (comp. p. 204), while the cell-rows in the inner part of the roof decay. The sporangia are produced, as in *H. prototypus*, from the bottom and the sides, and also from the peripheral part of the roof. A little stalk-cell is present; J. Agardh has already perceived that the sporangia are pedicellate, but he wrongly indicates that the stalk is articulated (Sp. III, p. 379). The sporangia were found to be 19—30 μ long, 6—7 μ broad; the normal length of the fully ripe sporangia is probably nearest the upper limit indicated. The sporangia have thus the same length as those of *H. prototypus*, but are narrower.

Zonate sporangia, divided by transverse walls, were described and figured in *Hildenbrandia rubra* Harvey in Phycol. Brit. pl. 250, 1851; but it is rather probable that this figure really represents *H. prototypus*, as it shows the same shape of the

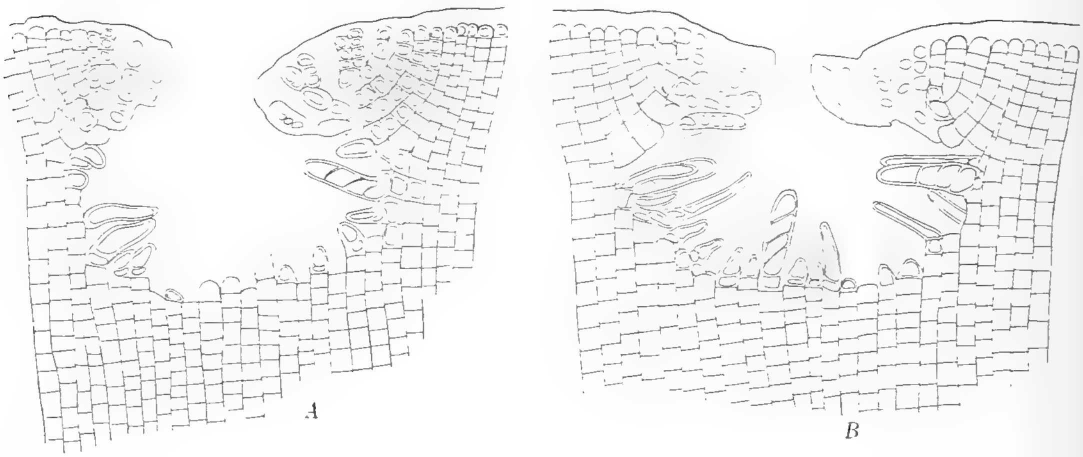


Fig. 126.
Hildenbrandia Crouani. Vertical sections of conceptacles. 560 : 1.

sporangia as in this species, and the pretended zonate division might then be due to an inexact observation of the irregularly divided sporangia.

Zonate sporangia have further been described in *H. prototypus* var. *kerguelensis* Askenasy (Forschungsreise S. M. S. Gazelle. Botanik, Berlin 1888 p. 30), the sporangia of which are said to be cylindric and divided by exactly parallel walls in 4 parts. As nothing is said with regard to the direction of the walls it must be presumed that they are transverse. It otherwise differs from *H. Crouani* by its conceptacles being up to 200 μ high but only half as broad, while those of *H. Crouani* are broader than high.

Locality. **Lb:** Opposite to Middelfart, 15—19 m, July 1900.

Fam. 9. Corallinaceæ.

J. Areschoug (1852), Corallineæ in J. G. Agardh, Spec. gen. et ord. Alg. Vol. II pars 2.
M. Foslie (1891), Contribution to Knowledge of the Marine Algæ of Norway. II. Tromsø Museums Aarshefter. 14.
— (1895), The Norwegian Forms of Lithothamnion. D. kgl. norske Videnskabers Selsk. Skrifter. 1894. Trondhjem.
— (1898 I), Systematical Survey of the Lithothamnia.
— (1898 II), List of Species of the Lithothamnia. Ibid. 1898, No 3.

M. Foslie (1900), Revised systematical Survey of the Melobesieae. Ibid. 1900. No 5.
— (1905), Remarks on Northern Lithothamnia. Ibid. 1905. No 3. (Issued 1906).
— (1909), Algologiske Notiser. VI. Ibid. 1909, No 2.
F. Hauck, Die Meeresalgen Deutschlands und Oesterreichs. Leipzig 1885 (1882—1885).
F. Heydrich (1900), Die Lithothamnien von Helgoland. Wissensch. Meeresunters. N. F. IV. Band. Abt. Helgoland. Kiel und Leipzig.
Mme Paul Lemoine (1911), Structure anatomique des Mélobésiées. Application à la classification. Annales de l'Institut Océanographique. Tome II fasc. 2.
F. Minder, Die Fruchtentwicklung von Choreonema Thureti. Freiburg i. Br. (s. a.)
R. Pilger (1908), Ein Beitrag zur Kenntnis der Corallinaceae. Engler, Botan. Jahrbücher. 41. Bd.
S. Rosanoff (1866), Recherches anatomiques sur les Mélobésiées. Mémoires de la soc. sc. nat. Cherbourg.
Fr. Schmitz und P. Hauptfleisch (1897), Corallinaceae. Engler u. Prantl, Nat. Pflanzenfam. I. 2. Leipzig,
Solms-Laubach (1881), die Corallinenalgen des Golfes von Neapel. Leipzig.
H. F. G. Strömfelt (1886), Om algvegetationen vid Islands kuster. Göteborg.
N. Svedelius (1911), Corallinaceae. Engler u. Prantl, Nat. Pflanzenfam. Nachtr. zu I. Teil, Abt. 2. Leipzig.
G. Thuret (1878), Études phycologiques. Publ. par les soins de M. le dr. E Bornet. Paris.

When carrying out my systematic investigations in the Danish waters, I arranged with M. Foslie, the well-known authority on calcareous algæ, that he should deal with the *Melobesieæ*-group of the family of *Corallinaceæ,* and forwarded to him accordingly, from time to time, such material as I had collected of these algæ, which he also mentioned in various publications. Unfortunately, M. Foslie's energetic work in this field was brought to a close by his unexpected and premature decease in 1909. Since then, I have collected but few calcareous algæ, and nearly all the present specimens from Danish waters have thus been determined by Foslie. As we know, this writer repeatedly altered his view concerning the limitation of these difficult species, and his last great work on Northern Melobesieæ (Remarks 1905) bears evident witness to his indecision on this point. When, after his demise, I myself took up the task of dealing with this group, I considered it necessary to investigate all species by means of microtome sections, in order to obtain closer knowledge as to the structure of the frond and reproductive organs, being also further instigated hereto by the newly published works of Pilger, Mme Lemoine and Minder. In many cases, the results attained were disproportionate to the amount of time involved, partly owing to the fact that the great bulk of the material had only been preserved in a dried state, and also because suitable developmental stages of the various sorts of conceptacles were in many cases lacking. With regard to distinction of species, for the *Lithothamnia* I have in the main followed Foslie in his valuable work above-mentioned; on the other hand, closer investigation has led me to distinguish several new *Melobesia* species.

With regard to structure and development of the frond and reproductive organs, I may refer to the works above quoted by Rosanoff, Solms, Pilger, Mme Lemoine, Minder and Svedelius, as also to what is stated below with regard to the various species. It will here suffice to mention certain particular features.

The frond is in all cases composed of branched cell filaments, the cells of which are connected up by pits of the structure characteristic in Florideæ, in the middle of the transverse walls. These pits are however, very thin, and are often not distinctly visible in the dried material; they are therefore in many cases not shown in the illustrations, or if so, only in small numbers, though as a matter of fact, they are always present, or have at any rate been so. I mention this point, as Mme Lemoine states that the cells are in some cases connected by open channels, (Struct. p. 35) and that in other instances, neither pits nor channels were found (l. c. p. 37). As illustrations of the latter, the writer in question cites *Lithothamnion læve* and *L. norvegicum*; I can here refer to my figs. 129 and 143, where the pits are shown.

Pits between cells belonging to different filaments are found in the Danish species only within the genus *Lithophyllum*, where the cells in the perithallium form transverse layers, in which they lie at equal height, and are then connected by pits with all the cells in the same layer, with which they are in contact. This has, it is true, been known before, but the importance of the fact as a systematic character has not been sufficiently emphasized. The character in question would in particular seem to afford an excellent means of distinguishing between the genera *Lithophyllum* and *Melobesia*, which otherwise closely resemble each other. Unfortunately, I have not been able to ascertain how these pits arise; they are formed at an early stage, and I must presume that they originate in a similar manner to the secondary pits in the *Rhodomelaceæ* etc., though I have not been able to demonstrate the co-operation of nuclei in the process, probably owing to insufficient fixing and staining of the material.

In all other genera (where, as we have seen, no such transverse pits are found) the cells possess another means of entering into connection with cells in other filaments, viz. by forming an open communication between them, the separating wall being partially dissolved. These fusions, which were first described by Rosanoff, are of common occurrence in the Danish species of the family which do not belong to the genus *Lithophyllum*[1].

Where the cells lie densely packed and the walls are thin, the fusions make themselves apparent merely by the fact that the longitudinal walls are partially dissolved (*Lith. Lenormandi* fig. 133 *D*); where the cell walls are thicker, on the other hand, a distinct connecting channel of varying length is seen. These appear both in the hypothallium and in the perithallium, and may very often take place between more than two cells. They are particularly easy to distinguish in the basal layer of *Melobesia* and in the central tissue of the upright, branched *Lithothamnia*. In the latter, they often form characteristically curving partially branched bodies, which may embrace almost all the cells in the central tissue (fig. 139). In the perithallium also, however, of the mentioned *Lithothamnia*, they may be extraordinarily frequent (*Lith. calcareum*, fig. 144, etc.). Fr. Schmitz, who has investigated these fusions with regard to the behaviour of the nuclei, found in 1880 (Untersuch. über die Zellkerne der Thallophyten. Sitzungsber. der niederrhein. Gesellsch. f. Natur- u.

[1] Of the species mentioned below, they appear to be lacking only in *Choreonema Thureti*, where the vegetation organs are highly reduced (cf. Minder l. c.) and in *M. minutula* (fig. 172).

Heilkunde zu Bonn 1880) that the nuclei, in two fusing cells of *Jania rubens* did not fuse together. I came to a different result on investigating this point in several other species, especially *Corallina officinalis*. In a tetraspore-bearing plant of this species I found the fusions followed by a fusion of the nuclei. The process was studied in the central tissue under a young conceptacle where numerous fusing cells were found, partly in pairs, partly a greater number fusing together. As shown in fig. 127, the two nuclei of a fusing pair of cells are frequently found lying near each other at the place where the two cells have fused together, and there is reason to believe that the nuclei have been active in the realisation of the cell-fusion. In some cases the nuclei were found touching, and finally fused cells were found containing only one nucleus situated at the same place and derived from fusion of the two nuclei (fig. 127 *D*). These fusional nuclei seem to be able to fuse with other nuclei when fusion takes place between more than two cells. In fig. 127 *D* is shown a syncytium produced by fusion of four cells and containing at left two nuclei in mutual contact and near the middle a nucleus which must be supposed to have arisen from fusion of the nuclei of the two cells at right. This nucleus has approached the middlemost opening, where it would perhaps later on have fused with the other fusional nucleus. Syncytia arising from fusion of four cells but containing only one nucleus, undoubtedly produced by fusion of the nuclei of the cells, I have observed in *Lithothamnion glaciale* var. *Granii* (fig. 128). Also in *Melobesia* uninucleated syncytia produced by fusion of two cells were observed. It must therefore be supposed that fusion of nuclei generally occur in the fusing cells.

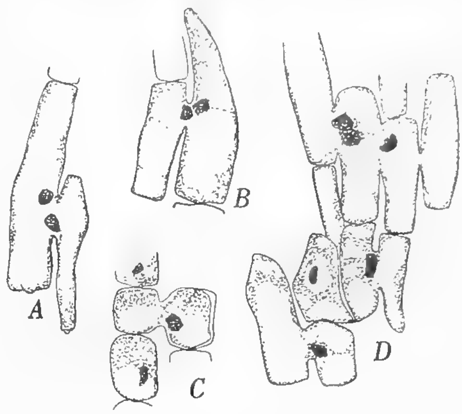


Fig. 127.
Corallina officinalis. Fused cells from a vertical section of a young joint under a young sporangial conceptacle. 730 : 1.

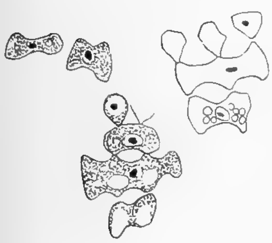


Fig. 128.
Lithothamnion glaciale var. *Granii*. Syncytia produced by fusion of from two to four cells, all showing only one nucleus; at right a cell containing starch grains. 650 : 1.

That Schmitz has not observed them may be due to the fact that the process was not so far advanced in the plant investigated by him; it might also be imagined, however, that fusion does not take place in all cases, since multinucleate syncytia are found even in older tissue. It is not unlikely that the nuclei may themselves co-operate in the process of fusion, the nuclei of the two cells placing themselves opposite each other in the two cells and bringing about a dissolution of the cell wall. The reason of their taking up such a position would then be, that a mutual attraction exists between them, in which case it would be natural to suppose that such attraction should continue to exist after the fusing of the cells, finally resulting in a fusion of the nuclei themselves. If this were so, then the fusion of the nuclei would be of no particular importance in itself, but merely a consequence of the cell-fusion. Such supposed co-operation of the nuclei in effecting the fusion of cells is, however, purely hypothetical: I have not with certainty observed the nuclei immediately prior to commencement of the fusions, and it must be admitted that certain cases where cell fusions took place between four cells (fig. 127 *D*) do not tend to support the theory. Fusion of nuclei in vegetative cells of higher plants has recently been observed in several cases, where cells have, for some reason or other, proved to contain more than one nucleus (cf. for instance Schürhoff, Kernverschmelzungen in der Sprossspitze von Asparagus officinalis. Flora, N. F. 8. Bd. 1916, p. 55).

The cells always contain, fusions apart, a single nucleus. The only exception is the female plant of *Corallina officinalis*, where the cells of the central tissue contained from two to four nuclei. The chromatophores are small, disc-shaped; there is often a rather small number in each cell (figs. 130, 143 *E*; comp. Pilger l. c. p. 253).

Starch-grains occur in all the species. They are often very numerous, particularly in the older tissues. Mme LEMOINE distinguishes between single and compound (coalescents) starch grains. According to my observations, this distinction appears to depend exclusively on whether the cells are more or less densely filled with starch grains, in the first case the grains may be applanated on the faces where they meet, as also stated by PILGER (l. c. p. 254), but they are not really connate. In *Lithothamnion glaciale* var. *Granii*, which is said by Mme LEMOINE to possess compound starch grains, I found distinct single grains (fig. 128). The starch-grains frequently contain a small air-bubble in the centre in the preparations from dried specimens (comp. figs. 130 *B*, 143 *F*, 174).

The well known transversal limiting lines which undoubtedly indicate periods of stand-still in the growth occur in all the species of *Lithothamnion*, except those with thin crust, but they are also met with in *Lithophyllum orbiculatum* (fig. 180 *A*), whereas Mme LEMOINE did not find them in any species of this genus (l. c. p. 28). As shown by this author they are very intensely stained by hæmatoxyline; they may pass between the cells, coinciding with the middle-lamella, but more frequently they meet the longitudinal walls of the cells without bending under them (figs. 136, 138, 143, 144, 145). Mme LEMOINE describes further alternating zones with varying power of staining with hæmatoxyline. Such zones, not limited by a blue line, were met with in *Lithophyllum norvegicum* where the ordinary limiting lines were otherwise also present (fig, 143 *B*, *C*).

In some genera (*Melobesia*, *Lithophyllum*, *Corallina*) unicellular, hyaline hairs occur. They resemble those occurring in numerous other Florideæ (com. L. KOLDERUP ROSENVINGE, Remarks on hyal. unic. hairs; Biolog. Arb. tilegn. E. Warming, 1911, p. 203) but differ, however, in not being limited from the cell producing them by a transversal wall. The hair-producing cells have been long known in the species of *Melobesia*, particularly *M. farinosa*, where they were given the name of heterocysts by ROSANOFF (1866 p. 70), but as shown by SOLMS (1881, p. 24), they are really hairs or hair-producing cells. They are easily recognizable after the hair has been shed, showing a scar left by the latter; I propose to name them trichocytes or hair-cells.

The sporangia are always divided by one or three transversal walls, dividing the cells into two or four spore-cells. Vertical divisions I have only found as rare exceptions in *Lithothamnion Sonderi* (fig. 137 *E, F*). The tetrasporic sporangia are first divided by a transversal wall, but the formation of this wall proceeds slowly from the periphery towards the centre, and the formation of the two following walls has frequently begun before that of the first is completed. In *Corallina officinalis* I found that the primary nucleus of the young sporangia divides into four nuclei which arrange themselves in a longitudinal row in the middle of the sporangia, and that these rest for a long time in this stage before the divisions, which take place almost simultaneously (fig. 197). Also in *Epilithon membranaceum* the three divisions are almost simultaneous (fig. 152, comp. otherwise fig. 134). The dividing wall is shown in figs. 131 *B* and 142.

The number of spores is constant in most of the species, either 4 or 2; but in some species both disporic and tetrasporic sporangia are met with. One of these species is *Lithothamnion læve* which, however, in the Danish waters has only been found with disporic sporangia. The above mentioned fact that the divisions of the tetrasporic sporangia are, at least in several cases observed, almost simultaneous, makes it improbable that the disporic sporangia can here be interpreted as unripe, not fully divided. It is an incontestable fact that some species may, according to circumstances, have tetrasporic or disporic sporangia. This I have also found to be the case in *L. Lenormandi*, in which only tetrasporic sporangia were previously known. In *Melobesia Fosliei* also, and in *M. minutula*, both kinds of sporangia would seem to occur.

In material fixed in Juel's liquid the protoplasm of the tetraspores showed a foamy structure. The central part containing the nucleus was brighter and distinctly marked off from the outer (figs. 132, 142 *B* and Plate III fig. 1).

The antheridia present considerable differences as to their position and development. In *Lithothamnion Lenormandi* they have a similar position to that previously described in *L. polymorphum*, being produced on the surface of great bushes extending from the periphery towards the centre of the conceptacle (Plate III fig. 2). If this structure is to be found in all the species of the genus, we have here an important generic character. In *Epilithon membranaceum*, referred by some authors to the genus *Lithothamnion*, the antheridia are, as shown by GUIGNARD (Rev. gén. de Bot. I. 1889, p. 182) seriate in short filaments clothing the bottom of the conceptacle, and in the other genera the antheridia (spermatangia) are also placed on the bottom of the conceptacle, being produced as outgrowths from a layer of small cells, but they are not seriate. The antheridia are more or less lengthened, short cylindrical or upwards somewhat thickened and more or less curved. In *Melobesia*

Lejolisii, the spermatia are produced at the end of long sterigmata, as shown by Mrs. Weber-van Bosse, and the same was found in *Lithophyllum Corallinæ*. In the last named species the isolated spermatia found in the conceptacles were seen to contain two nuclei (fig. 189), an interesting fact, as spermatia with two nuclei have formerly only been observed in spermatia fixed to the trichogyne, but not at an earlier term.

Concerning the development of the cystocarp in the Corallinaceæ, diverging statements have been advanced. As I have had no occasion of making thorough researches on this question, I must, in referring to the quoted papers of Solms, Schmitz u. Hauptfleisch, Pilger and Minder, content myself with stating some few facts noted in some of the species in question.

The carpogonial filaments are, at least usually, two-celled, being composed of a terminal carpogonium and a cell situated under it, separated from it by a more or less inclined wall; probably an auxiliary cell (fig. 148 *C*). A hypogynous cell as that described in *Choreonema* by Minder (l. c. p. 12) was in no case observed. As shown by Bornet and Thuret (1878) and Solms (1881) a large disciform cell, from the border of which the carpospores are produced, arises after the fertilization in the bottom of the female conceptacle. Solms and Schmitz were of the opinion that in *Corallina* it arose from fusion of all the auxiliary cells. Pilger showed that in *Lithothamnion Philippii* the two cell-layers situated below the carpogonial branches in fusing together take part in the formation of the disc-cell. On the other hand, Minder, by a careful study of *Choreonema Thureti*, showed that the disc-cell arises in this plant from the fertilized carpogonium, which increases, becomes lobed and gradually fuses with all the auxiliary cells, the contents of which is absorbed by the disc-cell, which is thus no fusion-cell. The statements of Minder appear to be so well founded that they cannot be doubted and it must be supposed that similar processes also take place in other *Corallinaceæ*, though with various modifications in the different genera, e. g. combined with other cell-fusions. Having in most cases had only insufficiently preserved material of female conceptacles, I can only state, that the carpospores are in most of the species examined produced at the periphery of the cystocarp, as in *Corallina* and others, but that in *Lithothamnion Lenormandi* and *Lithothamnion polymorphum* they arise also from various points of the bottom of the conceptacle. In these cases a disc cell could not be observed in the dried material and it was impossible to state whether the aberrant position of the carpospores is founded on the fact that the disc-cell is more irregularly lobed or whether it must be otherwise explained. As to Heydrich's statement of the development of the carpospores in *Lith. polymorphum*, reference may be made to the mention of this species below.

Lithothamnion Philippi.

Subgenus *Eulithothamnion* Fosl., char. mut.

Conceptacles of sporangia superficial or more or less immersed; the roof plane or vaulted.

1. Lithothamnion læve (Strömf.) Fosl.

Foslie in K. Rosenv. Deux. Mém., 1898, p. 14; Rev. Surv., 1898, p. 15; Remarks, 1906, p. 16 and 131; Algol. Notiser V, 1908, p. 6; K. Rosenvinge, Mar. Alg. N. E. Greenl., 1910, p. 100, fig. 1; Lemoine, Struct., 1911, p. 74, figs. 36 and 37.
Lithophyllum læve Strömfelt, Isl., 1886, p. 21, tab. I fig. 11—12.
Lithothamnion Lenormandi (Aresch.) Rosanoff, f. *læve* (Strömf.) Foslie, Contrib. II., 1891, p. 11.
Lithothamnion tenue K. Rosenvinge, Grønl. Havalg., 1893, p. 778, figs. 4—7 (Alg. mar. Gr. p. 58).
Lithothamnion Strömfeltii Foslie, Norw. Forms, 1895, p. 145.

This species, very common in the Arctic Sea, has been found in two localities in the sea north of Sealand, the most southerly stations known in Europe. The specimens from the Kattegat were mentioned by Foslie in 1906 (Remarks p. 131). I have examined the structure of the specimen from the Sound which was preserved in Juel's liquid. The species is easily distinguished from *L. Lenormandi* by its smooth surface and the large conceptacles.

The thallus in the Danish specimens is thin. The filaments of the hypothallium are, as pointed out by Mme Lemoine, loosely connected. When seen from the surface, they show here and there transversal fusions. The cells are 21—33 μ long, 7,5—9,5 μ broad. According to Mme Lemoine, the undermost cells of the hypothallium form rectangular cells directed towards the substratum, thus constituting "une rangée de rhizoides obliques". I have not been able to see anything of this kind in the specimen examined. The filaments of the perithallium are composed of a small number of roundish cells, 7 μ thick or a little more, up to 10 μ. These dimensions, which I found in specimens from both localities, are in accordance with Foslie's statement (Remarks p. 18), while Mme Lemoine gives the thickness as only 4—5 μ[1]. The

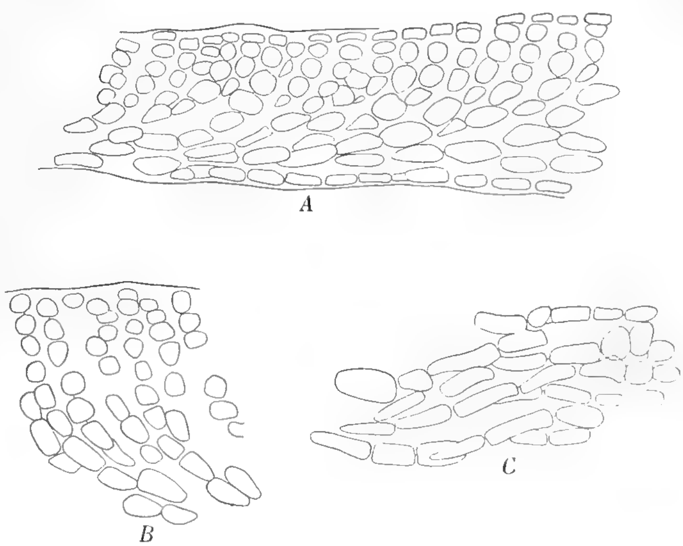


Fig. 129.
Lithothamnion læve. *A* and *B*, vertical sections of crust. *C*. Hypothallium seen from below. From Hellebæk. 350 : 1

[1] This indication is not in accordance with the figures of Mme Lemoine, in which the cells are thicker.

cells of the hypothallium and the undermost part of the perithallium often contain a number of distinct starch grains. In the cells of the perithallium a nucleus and a small number of disc-shaped chromatophores could be distinguished. (fig. 130).

Fig. 130.
Lithothamnion læve. A, cells from the perithallium showing chromatophores and nucleus. B, cells from the hypothallium showing starch-grains. 730 : 1.

In the Danish specimens, only conceptacles of sporangia were met with. Their diameter is somewhat smaller than in the Greenland specimens; in the plants from Hesselø it is 500—650 μ, in those from Hellebæk 600—800 μ. The roof consists of narrow filaments of cells which are longer than in the vegetative frond, and connected with numerous transverse fusions, while the cells are only rarely fusing in the perithallium. The sporangia I found always disporic when fully developed, 126—129 μ long, 67—72 μ broad, thus somewhat smaller than in the specimens from Greenland. The species has otherwise been found with two and with four spores in the sporangia. Foslie has (1908, p. 7) given all the localities where it has been found with two-celled sporangia only and those where it has been met with only with four-celled sporangia. Both are found in a number of localities in the arctic regions and at the Norwegian coast as well.

Fig. 131.
Lithothamnion læve. A, vertical section of conceptacle of sporangia. B, part of a similar section. 200 : 1.

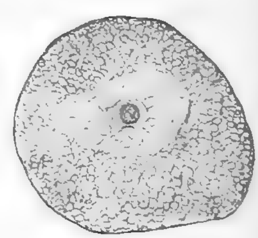


Fig. 132.
Lithothamnion læve.
Tetraspore.
390 : 1.

Localities. **Ks:** A, S.E. of Hesselø, 28 m on stone and shell. — **Su:** Hellebæk Aug., on *Mytilus Modiola*, Henn. Petersen.

2. **Lithothamnion Lenormandi** (Aresch.) Foslie.

Foslie, Norw. Forms, 1895, p. 150; Heydrich, Lithoth. von Helgoland, 1900, p. 78, Taf. II, fig. 23—25; Foslie, Remarks, 1905, p. 12; Mme Paul Lemoine, Struct. anat., 1911, p. 81[1]; Deux. expéd. antarct. franç. 1913, p. 10.

Melobesia Lenormandi Aresch. in J. Agardh. Sp. G. o. II p. 514.

[1] Mme Lemoine cites the fig. 7 of my paper, "Grønlands Havalger" as representing *Lith. Lenormandi*; however, it does not represent this species but *L. tenue* Rosenv. (= *L. læve* Strömf.).

Lithophyllum Lenormandi (Aresch.) Rosanoff, Rech. anat. p. 85, pl. V, fig. 16 et 17, pl. VI, fig. 1, 2, 3, 5. (Fig. 5 is said in the text to represent L. Lenormandi, while in the explanation of plates it is attributed to L. lichenoides). Hauck, Meeresalg. p. 267, Taf. III fig. 4; Strömfelt, Algveg. Isl. kuster, p. 21, tab. I, fig. 9—10.

Lithothamnion squamulosum Foslie, Norw. Forms of Lithoth p. 155, Tab. 19 fig. 24—26.

Squamolithon Lenormandi (Aresch.) Heydrich, Die Lithoth. von Roscoff. Ber. deut. bot. Ges. 1911, p. 26, Taf. II.

This widely spread species has been met with in almost all the Danish waters. It is particularly characterized by its thin reddish-violet crust with a lobed, whitish border, by its hypothallium composed of densely joined filaments, and at all events in the typical species, by the densely crowded conceptacles.

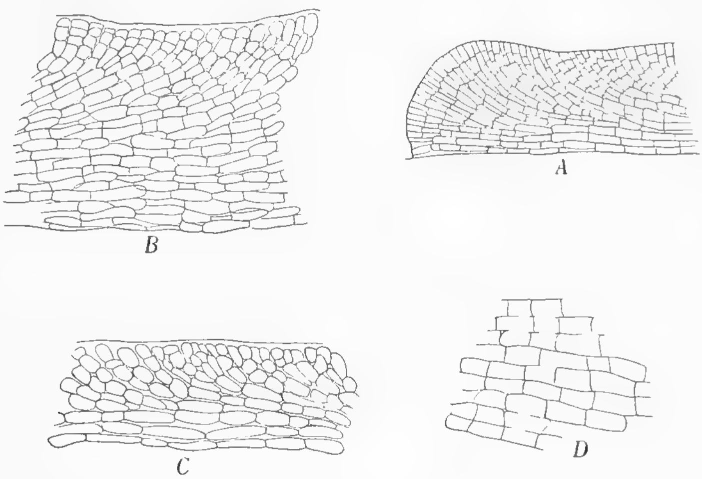


Fig. 133.
Lithothamnion Lenormandi. A, vertical section of border of frond, not decalcified, made by grinding. *B* and *C*, vertical sections of thick and thin crusts, made by microtome through decalcified fronds. *D*, horizontal section of hypothallium showing fusions. *A* 195:1. *B—D* 350:1.

As pointed out by Mme Lemoine, the hypothallium is composed of more densely joined filaments than in the other crustaceous species. According to this author, the number of horizontal filaments in a vertical section is usually 7—8; in thicker crusts it may be greater (fig. 133 *B*), in thinner it may be only 3—4 (fig. 133 *A*, *C*). In horizontal sections through the hypothallium transverse fusions are frequently seen (fig. 133 *D*). Mme Lemoine states that the filaments of the hypothallium "se relèvent d'une façon très brusque pour constituer les files du périthalle". This, however, is, in my opinion, not characteristic of the species, as will be seen in my fig. 133. The cells of the hypothallium which, according to Mme Lemoine, are 3—4 μ thick, I generally found somewhat thicker, 3,5—6 μ, in specimens from the Limfjord 5—6 μ, the length 12—18,5 μ. The cells of the perithallium I found 4—6 μ thick, 4—13 μ long. In the perithallium also numerous transverse fusions occur, but as the cells are closely joined, the fusion canals are very short.

The sporangial conceptacles are very crowded, in particular in f. *typica;* they measure 200—300 μ in diameter. The flat roof is, according to Foslie, intersected by 25 to 35 muciferous canals, which is in accordance with my observations; I have, however, met with up to 45 canals. Transverse fusions between the cells of the roof are frequently met with. The sporangia which are otherwise always tetrasporic, are also normally so in the Danish waters. Conceptacles with disporic sporangia only, however, not infrequently occur (fig. 134 *A*). It might be suggested that the sporangia in such cases were not quite ripe, and would later on have been divided into four spores, but as in other cases the divisions have shown to be almost simultaneous (fig. 134 *C*) it seems most probable that disporic sporangia occur besides tetrasporic ones, as in several other species. Sporangia with 4 spores found in the Limfjord and in the Kattegat were 100—112 μ long, 34—48 μ broad; in specimens collected in Bramsnæs Vig (Ise Fjord) they were only 53—91 μ long, 14—25 μ broad.

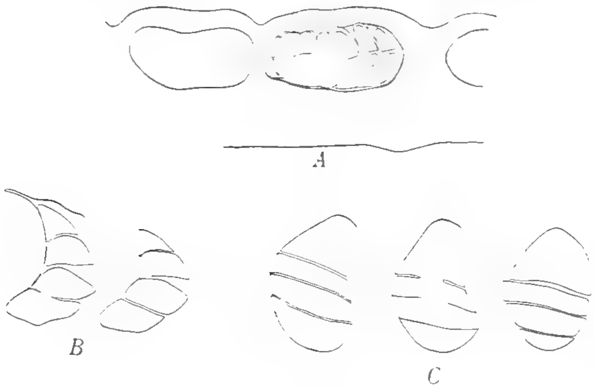


Fig. 134.
Lithothamnion Lenormandi. *A*, vertical section of crust with sporangial conceptacles. *B*. tetrasporangium in two consecutive sections. *C*. tetrasporangium in three consecutive sections. *A* 63:1. *B* 200:1.

Antheridial conceptacles were found in specimens from Staffans Flak in the Sound and from Bramsnæs Fjord. In both cases they were 300—350 μ in diameter, thus much larger than stated by FOSLIE (150—200 μ). In the specimens from the first named locality collected in September they were fully developed and showed a rather complicated structure, the spermatia being produced on the ultimate ramifications of dendroid systems of filaments given off from several points of the inner surface of the conceptacle, from the bottom and from the upper side as well (Plate III fig. 2). The structure of the antheridial conceptacles is thus rather similar to those of *Lith. polymorphum* described by HEYDRICH (Lith. Helg. p. 65, Taf. II fig. 1—3). The dimensions of the spermatia seem to be 3 × 4 μ.

The cystocarpic conceptacles are hemispheric to conical, 320—350 μ in diameter. It is remarkable that the carpospores are not only produced at the periphery of the bottom of the conceptacle but from the whole face of the floor, a fact by which our species differs, as it appears, from the type not only of the genus but also of the family. The carpospores are 50—63 μ long, 21—32 μ broad[1].

Fig. 135.
Lithothamnion Lenormandi. Vertical section of cystocarpic conceptacle. 200:1.

[1] HEYDRICH has in 1911 (l. c.) established a new genus, *Squamolithon*, founded on *Lithothamnion Lenormandi*,

This species occurs on stones and rocks, and on shells of molluscs (*Mytilus, Modiola, Trochus, Littorina*), from ordinary water-mark to 19 meters depth. Almost all the specimens belong to f. *typica*, a few only have been referred by Foslie to f. *sublævis*, which differs by smoother surface and less crowded sporangial conceptacles. It was rather surprising to me to find the species growing at low-water mark on the granitic rocks of Bornholm, where the salinity of the water is about 7—8 ‰ only. It was here fairly typical though sterile, and with numerous adventitious fronds, and occurred in fairly great numbers. In the other locality in the Baltic (RG), only sterile but rather large crusts were found.

Ripe sporangia have been met with in July (partly together with undivided) and September. Antheridial conceptacles with spermatia were found in July and September, and ripe cystocarpic conceptacles in July.

Localities. **Ns:** Thyborøn, groin no. 58, stunted specimens. — **Lf:** Søndre Røn by Lemvig; Thisted harbour (!, C. H. Ostenfeld); Sallingsund (Th. Mortensen); LS[1], off Bjørndrup, east of Mors, 5,5 m. — **Kn:** Frederikshavn, at low-water mark; Trindelen, 15 m (small spec.). — **Ke:** EU, Lille Middelgrund, 14 m (small specim.); IA, Store Middelgrund, 16 m. — **Ks:** Ourø Sund; Bramsnæs Fjord. — **Lb:** At Lyngsodde off Middelfart, 15—19 m, large fertile crusts. — **Sb:** GP, at Halskov Rev, 9,5—11,5 m; Avernakhage by Nyborg, low water. — **Sm:** VC, Venegrund, 3—5,5 m. — **Su:** TF[1], Staffans Flak, 11—13 m; PS, off Charlottenlund, 5,5 m. — **Bm:** RG, 6 miles N.N.W. of Falsterbo lighthouse, 11,5 m. — **Bb:** Helligdomsklipperne, Rø, Bornholm.

3. **Lithothamnion Sonderi** Hauck.

Hauck, Meeresalgen, p. 273, Taf. III, fig. 5; Foslie, Norweg. Forms, 1895, p. 127; Heydrich, Lithoth. Helgol., 1900, p. 77, Taf. II fig. 20—22; Foslie, Remarks, 1906, p. 23; Lemoine, Structure, 1911, p. 96.

Though this species has been met with in a number of different localities in the Danish waters, it has in most cases been found only in small quantities together with other species. I have therefore only little to communicate with regard to it, but must refer to the descriptions of Hauck, Foslie and Mme Lemoine.

As pointed out by Foslie and Mme Lemoine, the hypothallium is feebly developed. According to the last-named author it consists only of a single layer of cells; "les autres se relèvent très rapidement pour former le périthalle". The ascending filaments may, however, rise more gradually, and the hypothallium may then consist of two or three cell-layers (fig. 136 *B*). The hypothallic cells measured 5—7 μ broad, 15—21 μ long; those of the vertical filaments I found to be 3,5—7 μ broad, 5,5—11 μ long. These measurements are somewhat smaller than those of Foslie and Mme Lemoine. Transverse fusions between the cells are very frequent in the perithallium. In sections stained with hæmatoxyline the middle lamellæ are very distinct. In the same sections the horizontal limiting lines are intensely stained; their course is somewhat irregular (fig. 136). Older crusts may have a considerable number of layers. The cells of the under part of the frond are often filled with

and characterized principally by cytological statements relating to the development of the cystocarp. These statements are, however, very insufficiently supported, and I have had no opportunity of verifying them.

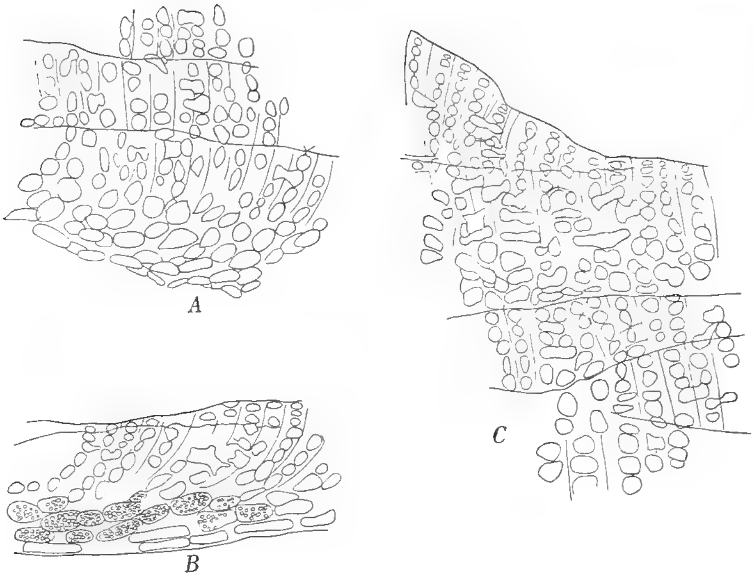


Fig. 136.
Lithothamnion Sonderi. *A*, vertical section of frond with a single-layered hypothallium. *B*, thinner crust with two or three layers of cells in the hypothallium, containing starch grains. *C*, upper part of a thick frond with an uneven surface. 350:1.

starch grains, but in other cases starch is wanting.

Fructiferous specimens I have had no opportunity to submit to closer examination. The sporangial conceptacles are, according to FOSLIE very little prominent, 300—500 μ in diameter, not overgrown, the sporangia tetrasporous.

A crust dredged at the beacon of Halskov Rev in Nov. (no. 3171) and referred by FOSLIE to this species, differs by having overgrown sporangial conceptacles, but seems otherwise to agree with this species. The conceptacles of sporangia were however a little smaller than usual, 260—280 μ in diameter (inner diameter about 200 μ). The sporangia were tetrasporous, in some cases showing vertical divisions (fig. 137).

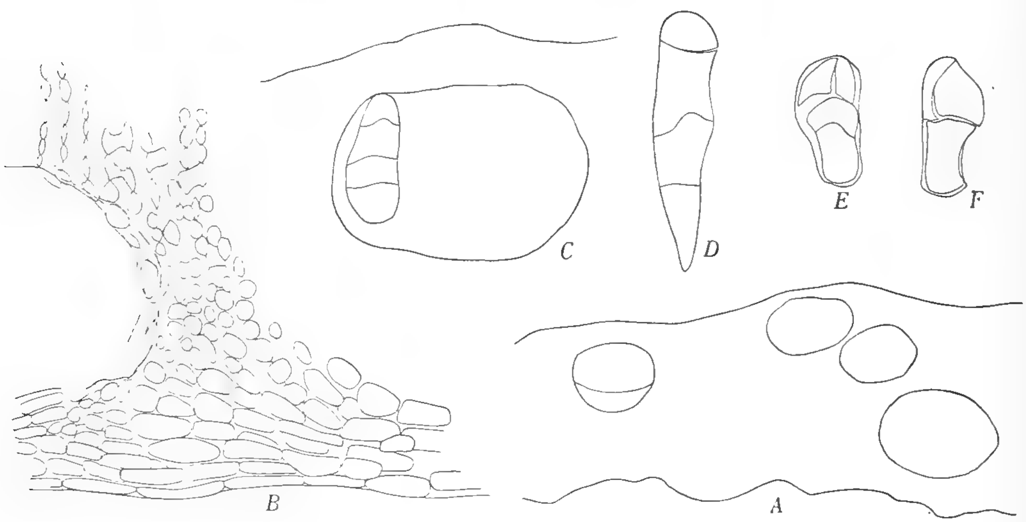


Fig. 137.
Lithothamnion Sonderi (?), from Halskov reef (no. 3171). *A*, vertical section through a crust with overgrown conceptacles. 63:1. *B*, part of a similar section with an overgrown conceptacle, showing the hypothallium. 350:1. *C*, sporangial conceptacle with sporangium. 205:1. *D—F*, sporangia with anomalous divisions. 205:1.

The species forms crusts on stones and gravel, in depths from 5 to 24,5 meters. In one case it was found growing on a dead specimen of *Lithothamnion calcareum*. It has been found with sporangial conceptacles and cystocarpic conceptacles in May and September.

Localities. **Sk:** Off Hirshals, 13 met. (F. Børgesen). — **Lf:** ZY, Nissum Bredning, 5 met. (determination uncertain). — **Kn:** Herthas Flak, 20—23 met.; FF and TR, Trindelen, 23,5 and 15 met. **Ke:** IP and IL, Fladen, 20,5—24,5 met.; IK, Lille Middelgrund, 17—19 met. — **Sb:** GP near the light-buoy at Halskov Rev (no. 3171, see above); Strandby reef, W. side of Langeland (?). — **Sm:** VC, Venegrund, 4—5,5 met.

4. **Lithothamnion glaciale** Kjellm.

F. R. Kjellman, Norra Ish. algfl. p. 123 (93) tab. 2 and 3. Foslie, Norw. Forms p. 13; Remarks p. 26. Mme P. Lemoine, Struct. p. 92.

Nearly all the rather numerous Danish specimens referred to this species have been determined by Foslie, who received them from me at different times and accordingly gave them different names. In 1895 he described and figured Norwegian specimens, corresponding exactly to those mentioned here as var. *Granii*, under the name of *L. flabellatum* f. *Granii*. Later on this variety was referred to *L. glaciale*, an opinion which has only been expressed in Rev. Surv. (1900, p. 11, where after the name *L. Granii*, which is here a nomen nudum, is added: "(*L. glaciale* f. ?)"). As late as in 1905 Foslie referred specimens of these algæ to *L. glaciale*, partly to f. *Granii*, partly to other forms. But in the same year (Remarks p. 59,[1]) Foslie established *L. Granii* as a distinct species. That he has been uncertain at the last as to the limitation of the species can be concluded from the fact that the same species, on p. 10 of the same paper, is mentioned as *L. glaciale* f. *Granii*. It is easy to understand that it has been difficult to come to a decision as to the delimitation of species when considering that Foslie (Remarks p. 28) "found it almost impossible to draw any line between *L. Granii*, admitted below, and *L. glaciale*". L. c. p. 59 is said, as to the relation between *L. Granii* and *L. tophiforme* f. *divergens*, that there are many specimens "which are quite like each other in almost every respect, but that the specimens of one species show a somewhat greater tendency in one direction and the other in a different one". It is however not to be seen in the named paper on which characters the difference between the two species really rests, save that *L. Granii* has thinner, usually more ramified branches. Some Danish specimens formerly determined as *L. glaciale*, in part as f. *colliculosa*, are now (Remarks p. 34) referred to *L. colliculosum* which is here regarded as a separate species, while he had formerly considered it a form of *L. glaciale;* a description of it is given, but he does not emphasize how it differs from *L. glaciale*. As I cannot see any distinct difference between these specimens and some of those referred by Foslie to *L. Granii* I prefer to adhere to Foslie's somewhat older opinion in regarding *L. colliculosum* and *L. Granii* as varieties of *L. glaciale*.

[1] Foslie's "Remarks" appeard however only in 1906.

var. *colliculosa* (Fosl.)

Lithothamnion colliculosum Foslie, Contrib. II, 1891, p. 8, tab. 3 fig. 1 ex p.; Norw. Forms, 1895, p. 75 ex p.; Remarks, 1905, p. 34.

Foslie has referred to *L. colliculosum* specimens from two localities in the western part of the Limfjord. They resemble arctic specimens of *L. glaciale* with not much developed processes which are thicker than in *L. glaciale* f. *Granii* and, as it seems, less closely placed, up to 4 mm high. The crust is well developed, expanded, and contains conceptacles. These specimens were found growing on *Mytilus* and stones.

var. *Granii* (Fosl.)

Lithothamnion flabellatum K. Rosenv. f. *Granii* Foslie, Norw. Forms (1895) p. 70, tab. 17 fig. 1—7, tab. 22 fig. 1.
L. Granii Foslie, Remarks (1905) p. 59.

All the other Danish specimens belong to this variety. It differs from the typical *L. glaciale* by more closely placed, thinner and often more ramified branches. The thickness of the branches, however, varies somewhat; it is lesser, for instance in f. *reducta* Foslie. The crust is usually much developed and may be widely expanded over the substratum. In the latter case the processes are frequently small, wartlike and rather spread, and the crust then frequently contains numerous conceptacles (fig. 138 *A*). When growing on pebbles on gravelly bottom it often completely encompasses the pebble, and when this is small, branches may project from it at all sides. Usually however, they grow principally to one side, viz. upwards, and these upward growing branches may branch repeatedly. In branching they often have a tendency to take globular form, and such globular branch-systems may at last be loosened, the conjunction with the pebble being given up. On gravelly bottom, loose individuals, "Ægagropila-forms", exactly similar to these branch-systems, are often found (Plate IV figs. 1—4). H. Jónsson assumes that the loose Ægagropila-forms of *L. Ungeri* and *L. tophiforme* are produced in the same manner off the shores of Iceland[1]. Probably loose individuals may also arise by division of other loose ones. On gravelly bottom the plurality of the individuals may be loose (e. gr. Lille Middelgrund, **Ke**). In the inmost localities in the Danish waters (**Ks**, **Sa**, **Lb**, **Sb**, **Su**) only specimens with well developed crust but small processes were met with.

The crust contains a hypothallium composed of few cell-layers from which obliquely ascending filaments continuing in the perithallium are given off. The cells of the hypothallium were in the specimen examined 20—22 μ long, 5—7 μ broad. Mme Lemoine states the dimensions for L. glaciale to be $12—18 \times 2\ \mu$. The latter figure, however, must be presumed to be exceptionally low. Mme Lemoine further states that the hypothallium gives off a layer of rhizoids or rectangular cells inclining against the substratum; this I have not found in the Danish specimens

[1] H. Jónsson, Om Algevegetationen ved Islands Kyster. Botan. Tidsskrift **30**. 1910 p. 322. — The Marine Alg. Veg. of Iceland. The Botany of Iceland, Part I,1 1912 p. 154.

(comp. fig. 138). The same author finally states that the filaments of the hypothallium are "formées de cellules arrondies, très serrées les unes contre les autres, de sorte qu'il est impossible de suivre le trajet de chaque file". As will be seen in my fig. 138, the filaments of the hypothallium are very distinct in well developed crusts. The cells of the perithallium are roundish, sometimes almost globular, usually however longer than broad, 7—10,5 μ long, 4—8 μ broad. They are often fused together two or three in a horizontal direction. The crust is divided in zones by horizontal lines stained intensely by hæmatoxyline.

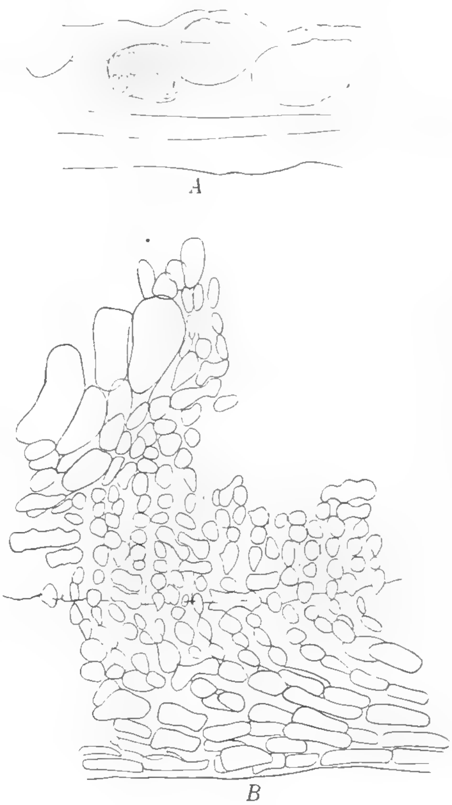


Fig. 138.
Lithothamnion glaciale var. *Granii*. *A*, vertical section of crustaceous frond with sporangial conceptacles. 65:1. *B*, part of the same section, showing the hypothallium and a peripheral part of a conceptacle. 350:1.

The branches have a similar structure to the perithallium in the crust. The cells are usually oblong or rectangular with rounded angles. They are sometimes situated more closely together in the outer layer than in the inner, that is to say, the walls are thinner (fig. 139 *A*). The cells are 5—7 μ broad, 7—11 μ long. Transverse fusions between the cells are frequent, often connecting several cells; in tangential sections they are often especially numerous and appear as irregular, curved, partly ramified formations (fig. 139 *C*). In transverse sections of the central tissue they may present a similar appearance (fig. 139 *B*). These cell-fusions contain, at least usually, only one nucleus (comp. p. 211, fig. 128). Starch grains appear very irregularly, without relation to the layers. The cells may contain a greater or smaller number of them, and they may consequently be placed closely together; but composed grains (comp. Mme Lemoine, l. c. p. 94) do not seem to occur.

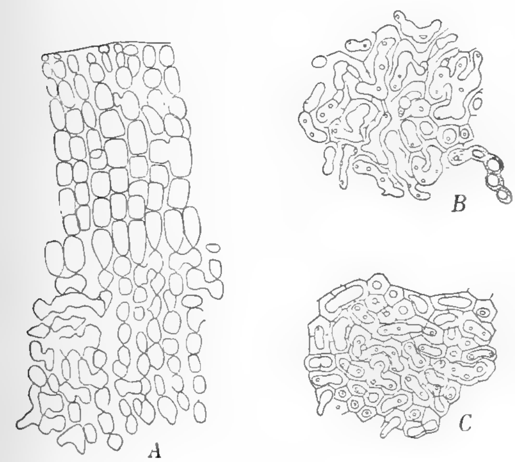


Fig. 139.
Lithothamnion glaciale var. *Granii*. *A*, longitudinal section of upper end of a branch. *B*, transverse section of branch, from the centre. *C*, tangential section of branch. 400:1.

Conceptacles are frequently found, but only sporangial conceptacles were observed. They are usually placed on the branches, especially on the upper part of them, but they may also occur in the crusts when these are much developed. They are slightly prominent, about 260—350 μ in diameter. The conceptacles in the crusts show the same aspect as those of the branches (figs. 138, 140). By proportionally few countings I found 30—60 muciferous canals in the roof. The conceptacles are usually gradually overgrown and immersed in the tissue of the branch, and this is also the case with those of the crusts. In such immersed conceptacles the septa between the sporangia are frequently visible for some time (Plate III fig. 4). Slime-strings may also remain distinct after the immersion. Conceptacles filled out by tissue produced from the bottom of the cavity frequently occur (fig. 140 *A*). The sporangia are always two-parted, 70—110 μ long, 39—50 μ broad.

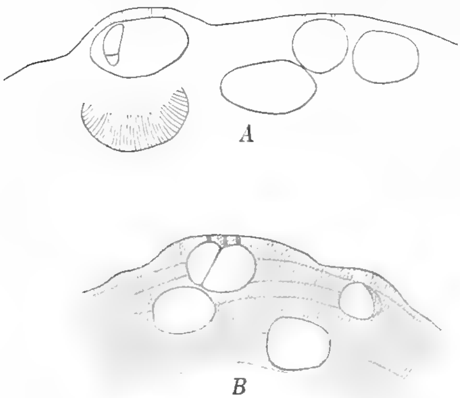


Fig. 140.
Lithothamnion glaciale var. *Granii*. Transverse sections of branches with tetrasporangial conceptacles. In *A* an immersed conceptacle filled out by tissue from the bottom. 65 : 1.

As mentioned above, the var. *colliculosa* has only been found in two localities in the Limfjord while a specimen found in a third locality of the same fjord seems to belong to the var. *Granii*. The specimens from the other localities were all referred to this variety, which is best developed in the eastern Kattegat where it was found in most of the localities in rather great quantities as branched specimens, partly loose. In the inner water it occurs only in the form of crustaceous specimens with short, often densely placed wartlike processes. The species has been found growing on stones, gravel and shells, in the Limfjord in 5,5 meters' depth, in the Kattegat in 17—30 m, in the Samsø waters in 9,5—19 m, in the Great Belt in 19 m and in the Sound in 34 meters' depth. Ripe sporangia have been found in April—May.

Localities.

var. *colliculosa*. **Lf:** north of Rønnen by Lemvig (6874); Nissum Bredning off Helligsø tile-kiln, 5,5 m (C. H. Ostenfeld).

var. *Granii*. **Lf:** western Limfjord, on an oyster-bed, brought up by a diver; form with rather long unbranched branches. — **Kn:** FG, Herthas Flak; off Frederikshavn; TR, Trindelen. — **Ke:** IR and ZI, Groves Flak; IL and IQ, Fladen; IH and IK, Lille Middelgrund, in quantity, on pebbles and gravel and loose; IA, Store Middelgrund (! and F. Børgesen). — **Km:** Læsø Rende, a crustaceous specimen with scarce low papillæ, on a piece of coal; ND, N.E. of Fornæs. — **Ks:** HO, E. of Hesselø; EO, 26,5 m; A, S.E. of Hesselø. — **Sa:** E. of Samsø (C. Løfting); BE, off Sletterhage, 10 m; KM, E. of Øreflippen; PL, Wulffs Flak; north side of Refsnæs, 19 m (C. H. Ostenfeld); MS, S. of Klophagen by Endelave. — **Lb:** Middelfart. — **Sb:** MO, S.W. of Refsnæs (? young specimens); near Sprogø, 19 m (C. H. Ostenfeld). — **Su:** Øretvisten (Johs. Schmidt); on the beach by Hornbæk (Mrs. M. Fibiger), probably brought by fishermen from the southern Kattegat; bM, 22,5 m, crusts up to 1,5 cm in diameter with small wartlike processes.

5. **Lithothamnion norvegicum** (Aresch.) Kjellman.

Kjellman, N. Ish. algfl. p. 122 (93), pl. 5 fig. 9—10; Foslie, Remarks 1905, p. 65; Lemoine, Structure, 1911, p. 108 fig. 11 and 48.

Lithothamnion calcareum Ellis et Sol. var. *norvegicum* Areschoug, Observ. phycolog. III. 1875, p. 4.
Lithothamnion coralloides Crouan f. *norvegica* (Aresch.) Foslie, Norw. Forms 1895, p. 62, tab. 16 fig. 1—11.

According to Foslie, this species is almost always freely developed on the bottom (Remarks p. 66). The specimens found in the Danish waters were all loose. Foslie has referred them all to f. *pusilla* which, in his opinion, is "perhaps the typical form of the species". He observes however (l. c. p. 64 and 67) that they "partly approach stunted forms of *L. nodulosum* f. *gracilescens*". They give off branches in all directions and become up to 3 cm (more rarely 3,5 cm) in diameter.

The anatomical structure is not very different from that of *L. glaciale*. According to Mme Lemoine, the cells are in the greater part of the frond rectangular, while

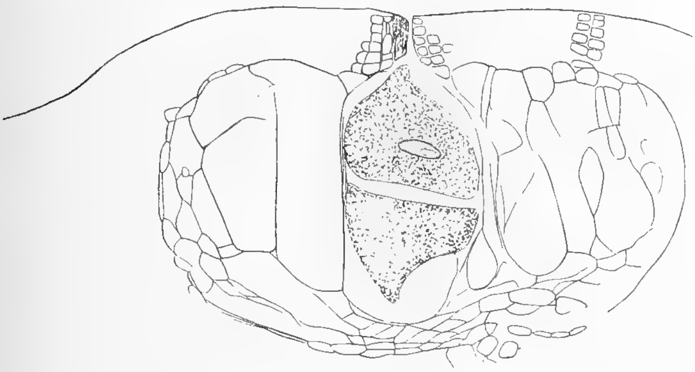


Fig. 141.
Lithothamnion glaciale var. *Granii*. Vertical section of sporangial conceptacle with ripe sporangium. 350 : 1.

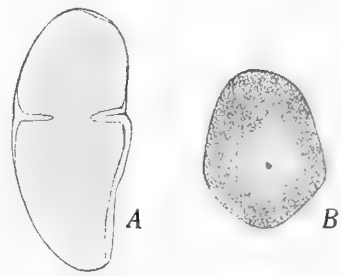


Fig. 142.
Lithothamnion glaciale var. *Granii*. *A*, sporangium; the process of division not yet completed. *B*, ripe spore. 390 : 1.

near the periphery they are ovoid. This may be so, but it frequently happens that rectangular cells in the inner parts of the frond alternate with ovoid ones (fig. 143 *C*). The change may take place at the distinctive lines between the zones or independently of them. The zones are limited by somewhat irregular lines staining deeply by hæmatoxyline, and the staining power of the single layers may sometimes be a little different, but the limit between such zones is not always marked as a blue line (fig. 143 *C*). The irregular course of the distinctive lines is probably in accordance with the irregularity of the increase. Transverse fusions between the cells frequently occur, though not so frequently as in *L. Granii*, and not uniting so many cells as in that species. The cells are 8—14 μ long, 6—9 μ broad; the rectangular ones are 11—14 μ long, 6—7 μ broad. The central tissue shows a different aspect in transverse section, according to whether the section has fallen in a zone with rectangular or with roundish cells. The appearance of the starch is variable. It may appear in great quantities in the more deeply stained and in the less stained zones as well, all the cells being filled with starch grains except the outermost ones. In other cases it is entirely or almost entirely wanting.

Conceptacles were found in specimens from most of the localities named below:

they were in all cases, when examined, empty and more or less destroyed. I found sporangial conceptacles 300 μ or somewhat more in diameter.

On stony bottom in 10—21 meters depth, usually associated with *Corallina officinalis*, in some places abundantly. Only found in the Samsø area.

Localities. **Sa:** KI, south of Hjelm; PH, Lindholms Dyb; east of Samsø (Løfting); Stenpladen off Sletterhage (G. Winther); BE and BF off Sletterhage.

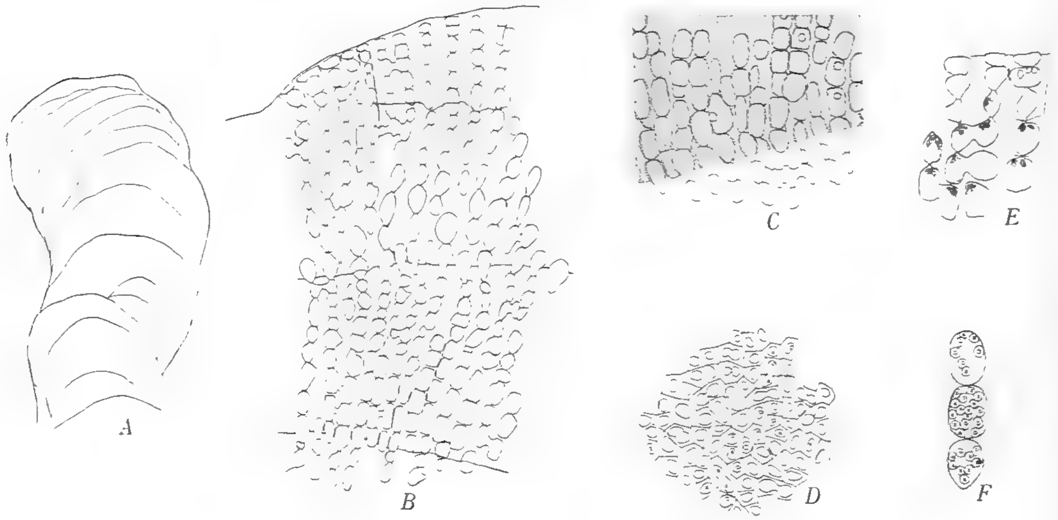


Fig. 143.
Lithothamnion norvegicum. *A*, axile longitudinal section of branch. *B*, part of a similar section near the top. *C*, part of axile longitudinal section of frond. The upper part of the tissue was deeper stained by hæmatoxyline than the under part. The fusion canals with the over-lying cells appear as round figures. *D*, transverse section of the central tissue of a branch. *E*, cell-rows from the periphery of a section of a branch. *F*, cells with starch grains. *A* 31:1; *B–D* 350:1; *E, F* 560:1.

6. **Lithothamnion calcareum** (Pallas) Aresch.

J. Areschoug in J. Agardh, Sp. g. o. II, 1851, p. 523. Foslie, Lith. Adriat. Meeres u. Marokko, Wiss. Meeresunt. VII. Heft 1, 1904, p. 13 and 32, Tafel II; Remarks, 1905, p. 67; Mme P. Lemoine, Répartition et mode de vie du Maërl (Lithothamnion calcareum) aux environs de Concarneau (Finistère), Annales de l'Institut océanographique, tome I, fasc. 3, 1910; Structure. 1911. p. 102.
Millepora calcarea Pallas, Elench. Zooph. 1766, p. 265.
Lithothamnion coralloides Crouan. Flor. Finist., 1867. p. 151, pl. XX no. 133.

This species has been found in a few localities, in particular in the eastern Kattegat, but always only in loose specimens without or with imperfectly developed conceptacles. It is, as elsewhere, rather variable. The Danish specimens have been referred by Foslie to the following forms.

1. F. *squarrulosa* Foslie, Lith. Adr. Meer. Taf. II fig. 1—4; Lemoine, Répart. du Maërl fig. 1, 5, 14, Structure pl. I, fig. 5. To this form approaches f. *corallioides* (Crouan) Foslie, Norw. Lith. p. 62 pl. 16 figs. 24—25, 27—31. — This form has terete branches spreading in all directions.

2. F. *compressa* (M'Calla) Foslie, On some Lithothamnia, 1897, p. 9, Lith. Adr.

Meer., 1904, p. 32 Taf. II figs. 15—23; Lemoine, Répart. du Maërl pl. I fig. 14. — It is "flabellate, the branch-systems spreading like a fan in all directions from the centre of the frond almost in one plane. Sometimes it forms rather thick and compressed fronds" (Foslie, Remarks p. 69).

3. F. *palmatifida* Foslie, Some new or crit. Lith., 1898 p. 6, Remarks p. 69; Lemoine, Répart. du Maërl pl. I fig. 3, Structure, p. 104. — "With branches more distant and palmate" (Foslie, 1905).

4. F. *subsimplex* (Batt.) Foslie, Norw. Lithoth. 1895 p. 62 pl. 16 figs. 38—42; Lemoine, Rép. du Maërl pl. I fig. 10, Structure p. 104. Frond "simple or feebly branching" (Foslie Remarks).

There are no distinct limits between these forms, which occur together at the same locality.

The structure has been mentioned by Mme Lemoine (Structure p. 105), whose description may here be referred to. It will suffice to add some small remarks. According to Mme Lemoine there is always at the periphery a cortex composed by 5 or 6 layers of cells which are rectangular, while the other cells are ovoid. I have certainly observed such a cortex in some cases, but it does not occur normally; the outer tissue, in the sections examined by me, more frequently consisted of cells of the same shape as those of the inner tissues (fig. 144). Transverse fusions between the cells are very frequent. The size of the cells is somewhat variable, generally they are 9—13 μ long, 5—7 μ broad. Starch grains were found in great quantity in all cells except the outermost. On being treated with acetic acid and iodine in potassium iodide the starch grains swelled and filled the cells with a homogenous violet-brown mass.

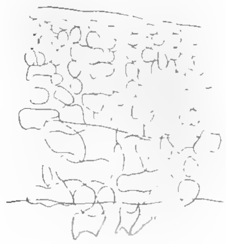


Fig. 144. *Lithothamnion calcareum*, Transverse section of frond, at the periphery. Several transverse fusions. 350 : 1.

In a specimen from Trindelen (ZB, July) empty conceptacles were found, the kind of which could not be determined; they were almost entirely immersed. Possibly they were antheridial conceptacles.

The species has been found in 17 to 30 meters depth, on gravelly or stony bottom, generally associated with other *Lithothamnia*, in particular *Lith. glaciale*, and with *Corallina officinalis*.

Localities. **Kn:** ZB, near Trindelen, 28—30 meters. — **Ke:** IL and IP, Fladen; IK, Lille Middelgrund. — **Km:** Læsø Rende, clayey bottom, small fragments (C. H. Ostenfeld).

Subgenus *Phymatolithon* Foslie.

In 1898 Foslie (Syst. Surv., p. 4) established the genus *Phymatolithon*, founded on *Lithothamnion polymorphum*, and distinguished from the genus *Lithothamnion* chiefly by immersed conceptacles and the roof of the sporangial ones being depressed or cup-shaped. Later on he has referred *L. lævigatum* and another species to the same genus. I must, however, agree with Mme Lemoine, who observes (Struct.

p. 63) that the characters pointed out by FOSLIE are not sufficient for generic distinction but only for separation of sections beyond the genus. The roof of the sporangial conceptacles is frequently scarcely immersed, and it is often, particularly in *L. lævigatum,* convex within a feebly elevated border.

7. **Lithothamnion polymorphum** (L.) Aresch.

J. E. Areschoug in J. Agardh, Spec. II, pars 2, 1852, p. 524 ex parte; Rosanoff, Mélobés., p. 99; Strömfelt, Algveg. Isl., 1886, p. 19, pl. I, fig. 1—3 (sporangia); Foslie, Norw. Forms, p. 86, pl. 17, fig. 17—23 (f. *tuberculata*, f. *valida* and f. *papillata*); Mme P. Lemoine, Structure, 1911, p. 87, pl. V fig. 2.
Phymatolithon polymorphum (L.) Foslie, Syst. Survey, 1898, p. 4, Remarks, 1906, p. 75.
Eleutherospora polymorpha (L.) Heydrich, Lith. Helgol., 1900, p. 65, Taf. II, fig. 1—14.

The species forms more or less irregular crusts extended over larger boulders, of a thickness of up to 6 mm. As to the structure reference may be made to the papers of FOSLIE (1906) and Mme LEMOINE. The hypothallium is shown in fig. 145 *A*. The cells of the perithallium are somewhat variable in thickness, 4—7 μ, in some specimens proportionally narrow, 4—5 μ (fig. 145 *B*). Mme LEMOINE mentions as an interesting character that the starch grains are single, very small and grouped at the ends of the cells. This is, however, not always so, for I found the starch grains up to 3 μ in diameter, and in some parts, frequently the greater part of the crust, all the cells were filled with starch grains, while they were totally wanting in others, Particularly abundant starch grains were found in the tissue filling out the emptied conceptacles in the inner part of the crusts. Cells containing starch grains at the ends of the cells but not in the middle were indeed observed, but only as exceptions. Transversal fusions between the cells of the perithallium occur here and there.

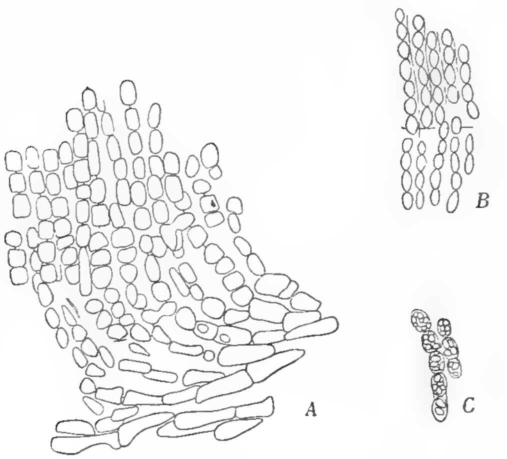


Fig. 145.
Lithothamnion polymorphum. *A*, vertical section of frond showing the hypothallium and the lower part of the perithallium. *B*, vertical filaments of another frond with narrower cells. *C*, cells of perithallium with starch grains. 350:1.

The increase in thickness of the crust normally takes place by continued growth of the perithallium, which may show several zones limited by horizontal, but somewhat irregularly running lines. In older crusts a more complex structure may be found, the frond being composed of two or more crusts one over the other, each with a particular hypothallium. This arises through cessation of growth in thickness in certain parts of the perithallium, which become overgrown by new crusts developing from other parts of the crust. This structure has been mentioned by Mme LEMOINE (Struct. p. 24 and 88, pl. V fig. 2), who appears to consider it as arising through differentiation of the same crust. In the new overgrowing crusts, the limiting lines between the successive zones of tissue are more or less inclined. This complex structure is not always found even in old fronds. Crusts up to 1,5 mm in thickness showing only one hypothallium are frequently met with,

The muciferous canals of the sporangial conceptacles open outwards in a low hollow surrounded by a slightly elevated border, but it is sometimes very slight or

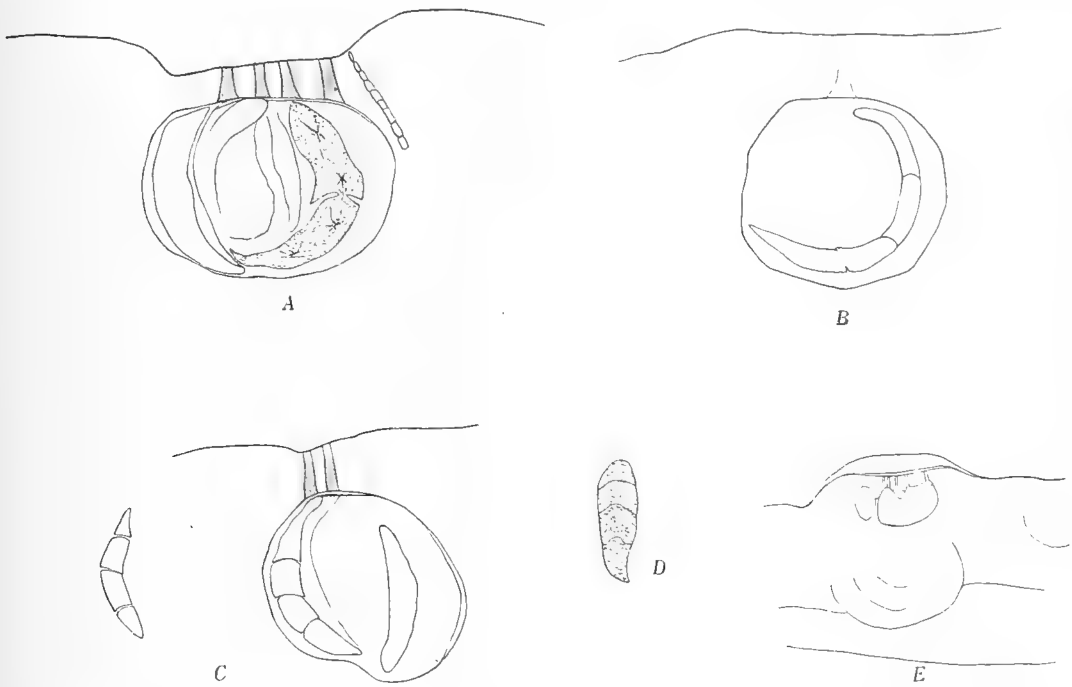


Fig. 146.
Lithothamnion polymorphum, vertical sections of sporangial conceptacles, *A*, the first division of the sporangium is not accomplished, the following not yet begun. *B*, with a very long sporangium. *C*, conceptacle with undivided and fully divided sporangia. *D*, ripe sporangium. *E*, empty sporangial conceptacle with covering tissue; below, limiting line of zones and outline of empty conceptacle filled with regenerative tissue. *A—D* 200:1; *E* 63:1.

scarcely perceivable, if at all (fig. 146). The sporangia are at least divided into 4 spores. As stated by FOSLIE, the sporangia are 80—110 μ long, 25—45 μ broad; the outermost ones, however, reach a greater length (fig. 146). After the evacuation of the sporangia, the conceptacles become sunk in the crust by continuation of the growth in thickness of the frond, but their surroundings may then behave in different manners. 1) The filaments of the roof grow upwards in accordance with those of the surrounding frond, and the conceptacle forms an empty round hole. 2) The roof falls into decay and the conceptacle is filled more or less completely by tissue growing inwards from the tissue which is developed by increase in thickness of the surrounding part of the frond and united over the conceptacle. 3) The conceptacle is completely filled by a tissue produced from the bottom of the con-

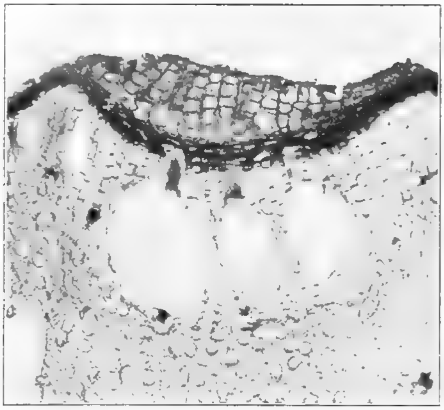


Fig. 147.
Lithothamnion polymorphum. Vertical section of emptied sporangial conceptacle, showing two muciferous canals and the covering tissue. About 350 : 1.

ceptacle. The newly evacuated conceptacles are sometimes covered by a peculiar, rather thick tissue, which is sharply marked off from the roof (fig. 146 *E*, 147, Plate III fig. 6). Its cells are frequently broader than those of the roof, (fig. 147). In a living state this covering tissue appears as a white dot. It has been mentioned by Foslie (Remarks, p. 78). A similar tissue also occurs over the sexual conceptacles. Its signification is unknown.

Antheridial conceptacles I have not seen; they have been mentioned by Heydrich (1900, p. 68, Taf. II fig. 1—3) and Foslie (1905). According to the first named author, the spermatia are produced from branched filaments given off from the inner side of the conceptacle, as it seems, in a similar manner as in *L. Lenormandi.* Thuret states (Ét. phyc., 1878, p. 91) that the spermatia resemble those of *Jania rubens.*

The cystocarpic conceptacles are, according to Foslie, at first convex, but they are not always so, for fairly young, totally immersed conceptacles may be found (fig. 148). As to the development of the cystocarp more detailed statements are given by Heydrich (l. c. p. 70) which are in several respects in discordance with those of Solms for other *Corallinaceæ.* They very much need a critical trial, but as I have had only dried specimens at my disposal I can only throw little light upon the matter. Before fertilization the concave bottom of the conceptacle is covered with numerous procarps which are two-celled, as shown by Heydrich (fig. 148, Plate III fig. 5). These filaments are intensely coloured by hæmatoxyline. The lowest cell is probably an auxiliary cell, as maintained by Heydrich, and this is also in accordance with the statements of Minder for *Choreonema* (Fruchtentw., p. 12). This cell may be rather long (fig. 148 *C*). The

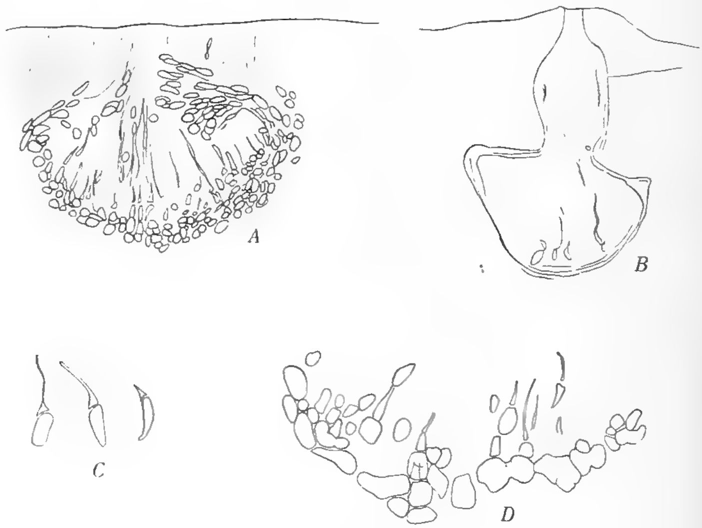


Fig. 148.
Lithothamnion polymorphum. *A*, vertical section of female conceptacle with carpogonia. *B*, similar, with a rather long neck. *C*, procarps. *D*, vertical section of the bottom of a female conceptacle, showing fusions between the cells. *A*, *B* 200 : 1. *C*, *D* 350 : 1.

wall between the two cells is more or less oblique, but a hypogynous cell is not cut off from the lowermost end of the carpogonium as in *Choreonema*. I have not been able to follow the development of the carpogonia after fertilization, but it must be said that there is nothing to support the supposition of HEYDRICH that each auxiliary cell becomes a carpospore. The only thing which might favour this view is the fact that the carpospores are produced not only at the periphery but also from the central part of the floor of the conceptacle, as shown by HEYDRICH (l. c. fig. 12), and as I have also observed it (fig. 149). But the carpospores do not arise singly; they are produced in short rows, as shown by earlier authors (SOLMS, PILGER, MINDER) for other Corallinaceæ. This is shown in fig. 149 where a smaller (younger) carpospore is situated under the most developed ones; they have undoubtedly been produced successively by the sporophyte, but the behaviour of the latter could not be stated. The low cells visible under the youngest carpospores are probably parts of the sporophyte (or of the fusion cell, if SOLMS' view is correct); or might there perhaps be more than one sporophyte? The cells situated below the procarps may show lateral fusions (fig. 148 *D*), but it is doubtful whether these fusions have any relations to those of the sporophyte with the auxiliary cells. The evacuated cystocarpic conceptacles remain empty, or become partly filled with regenerating tissue produced from above.

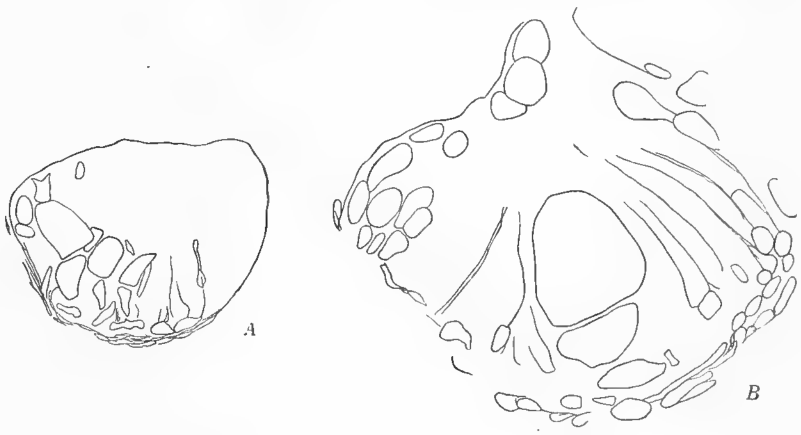


Fig. 149.
Lithothamnion polymorphum, vertical sections of cystocarpic conceptacles with carpospores. *A* 200 . 1. *B* 350 : 1.

As mentioned above, this species grows particularly on large boulders; it is therefore probably much commoner than might be supposed from the localities given below, while it does not always become loosened from the stone by the dredge. It occurs in all the three forms quoted by FOSLIE which however, as stated by this author, are "not well defined, as transitions often appear to occur". It seems to be rather common in the Danish waters to the limits of the Baltic Sea, with the exception of the Limfjord and other fjords where it is wanting. It seems most common in the Kattegat. It occurs in depths of 2 to 19 meters. Tetrasporangia have been met with in April, carpogonia in January and May, and carpospores in May.

Localities. **Sk:** ZK[10] off Lønstrup, 11,3 m; off Hirshals, 11—15 m. — **Kn:** TX, north of Græsholm (Hirsholmene); on stones picked up by Hirsholmene, about 4,5 m, large crusts; east of Deget; off

Frederikshavn; UC, TO, 18 m and FF (Trindelen) north of Læsø. — **Ke:** ZE, Fladen; IB, Store Middelgrund. — **Km:** XB and XC south of Kobbergrund. — **Ks:** HS, Briseis Grund; OU, Schultz's Grund; OO, Søborghoved Grund. — **Sa:** KK, Klørgrund, south of Hjelm; FT, Klepperne. — **Lb:** Middelfart. — **Sb:** Reef at Korsør harbour, 2 m; NN, south-west of Sprogø, 19 m. — **Su:** Off Aalsgaarde, 26 m (H. E. Petersen); TF[3], Staffans Flak, 14—18 m. — (**Bm:** Stones picked up near Stevns ?).

8. **Lithothamnion lævigatum** Foslie.

Foslie, Norweg. Forms, 1895, p. 139, pl. 19, fig. 21—23; Heydrich, Lithoth. Helgoland, 1900, p. 76.
Lithothamnion emboloides Heydrich, Lith. Helgol., p. 74, Taf. II Fig. 15 (teste Foslie).
Phymatolithon lævigatum (Fosl.) Foslie, Remarks, 1905, p. 79.

Judging from Danish specimens, this species appears to be quite distinct from *L. polymorphum*, whereas, according to Foslie (Remarks, p. 79), in more southern localities there is no distinct limit between these two species. *L. lævigatum* is characterized by a comparatively thin, smooth crust, up to 0,5 mm thick, by the roof of the sporangial conceptacles disappearing after the evacuation of the sporangia, and by the two-parted sporangia. When occurring together with *L. polymorphum*, the difference between them is evident; the two species are, however, only rarely met with in the same locality, and it must be emphasized that *L. polymorphum* does not occur in the Limfjord, where *L. lævigatum* has been met with in several localities. I therefore do not doubt that they are specifically distinct.

The anatomical structure much resembles that of *L. polymorphum*. The hypothallium is similar, but is sometimes more fully developed. Its cells were found to be 13—21 μ long, 4,5—7 μ broad. The cells of the perithallium were less variable in breadth than those of *L. polymorphum;* they were almost always 6—7 μ thick. The length was usually 6—9 μ, most frequently 7—8 μ, or only little greater than the breadth, and the rounded cells thus approach the spherical form; but cells shorter than broad are also met with (fig. 151 *A*). Transverse fusions occur here and there, in the hypothallium and the perithallium as well. Starch grains are frequently present as single grains in great numbers in most of the cells, except the uppermost. Only sporangial conceptacles were met with. They resemble those of *L. polymorphum*, and the hollow containing the roof is, as in that species, sometimes very slight or wanting, and the elevated border may also be wanting, the surface over the conceptacle thus being quite even or with

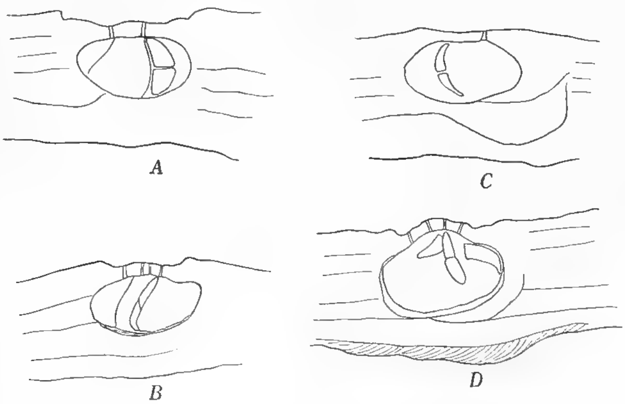


Fig. 150.
Lithothamnion lævigatum. Vertical sections of crust from Bolsaxen. **Sb**, showing sporangial conceptacles and limiting lines between the zones, fig. *D* also the hypothallium. 65 : 1.

only a feeble trace of deepening or elevation (fig. 150 *C*). The roof is sometimes convex, though inserted in the bottom of a hollow. The sporangia are, as stated by FOSLIE, always two-spored. I found them to be 95—126 μ long, (18—)37—53 μ broad, thus a little smaller than the dimensions found by FOSLIE, which might perhaps partly be caused by the fact that my measurements have mostly been made with dehydrated sections. The conceptacles are sometimes covered by a particular tissue similar to that mentioned for *L. polymorphum* (p. 230). It has also been mentioned by HEYDRICH and FOSLIE (Remarks, p. 80). According to the first named author (l. c. p. 76) it is always present in *L. emboloides* which, as shown by FOSLIE, is identical with *L. lævigatum*; it is, however, not suitable for use as a specific character, for in some specimens it covers all or nearly all the conceptacles, while in others it is almost or entirely wanting. I have only seen it on emptied conceptacles which still showed muciferous canals (fig. 151 *C*). It has a white colour.

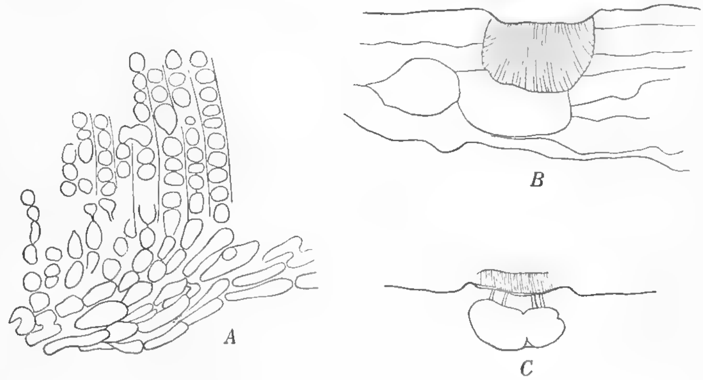


Fig. 151.
Lithothamnion lævigatum. A, vertical section of hypothallium and the under part of perithallium. *B*, vertical section of crust with emptied sporangial conceptacle filled with regenerative tissue, showing the outlines of older filled conceptacles *C*, vertical section of empty conceptacle with covering tissue. *A* 350 : 1. *B–C* 65 : 1.

After the evacuation of the sporangia, the roof falls into decay. A regenerating tissue, produced from the bottom of the conceptacle, consisting of ascending filaments, may then fill the empty cavity. A new conceptacle is frequently produced at so small distance over the first one that the base of the second is situated within the limit of the first, and the new one is thus partly produced by the regenerating tissue (fig. 150, 151). Overgrown empty conceptacles do not occur.

The species occurs in depths of 2—24,5 m, most frequently 5—20 m, growing on stones and on *Mytilus* and *Ostrea*, often in company with other *Lithothamnia*, as *L. Lenormandi*, *L. glaciale* and *L. polymorphum*. It has been found growing over *L. glaciale*, and in one case on the frond of *Chondrus crispus*. It has been found with ripe sporangia in April and May.

Localities. **Ns:** aF, N.W. of Thyborøn, 31 m. — **Sk:** 4 miles N.½E. of Svinkløv beacon, 9 m (A. C. Johansen); SY off Løkken, 13 m; ZK[6], off Lønstrup, 12 m; off Hirshals (Børgesen). — **Lf:** Sallingsund near Nykøbing (Th. Mortensen, !); LS[1], 5,5 m and aT[1], 4—5 m, east of Mors; Livø Bredning (C. H. Ostenfeld); Lendrup Røn. — **Kn:** Herthas Flak, 19—22 m; east of Deget near Frederikshavn; Trindelen, near the double broom (Børgesen). — **Ke:** IL, Fladen, 24,5 m; OO, Søborg Hoved Grund, 8,5 m. — **Ks:** RL, north of Gilleleje, 15 m; HO, N.W. of Gilleleje, 22,5 m; OS, Hastens Grund, 14 m. — **Sa:** KM, east of Øreflippen; BE, off Sletterhage; YV, east of Samsø, 15 m; north side of Refsnæs, 19 m (C. H. Ostenfeld);

DK, Bolsaxen, 13–15 m. — **Lb:** XQ, off Middelfart, north side of Lyngsodde, 19 m; north of Fænø Kalv. — **Sb:** GT, near the broom at Asnæs; GP off Halskov, 10 m; Avernakhage by Nyborg, shallow water; near Vresen, 7—9 m (Ostenfeld). — **Su:** At Ellekilde Hage 11,5 m.

Epilithon Heydrich.

Melobesiae, Ber. deut. bot. Ges. 1897, p. 408.

1. Epilithon membranaceum (Esper) Heydrich.

Heydrich, l. c.; Cotton, Mar. Alg. Clare Island, 1912, p. 150.

Corallina membranacea Esper, Pflanzenk. 1786 t. 12, fig. 1–4 (not seen).

Melobesia membranacea Rosanoff, Mélob., 1866, p. 66, pl. II figs. 13—16, pl. III fig. 1; Hauck, Meeresalg., p. 265; Guignard, Dével. et const. des anthéroz., Revue gén. de Botanique. I, 1889, p. 182, pl. VI figs. 22—23.

Melobesia corticiformis Kützing; Rosanoff, Mélob. p. 76, pl. I figs. 14—16; Solms, Corall. p. 11, Taf. III Fig. 25.

Lithothamnion membranaceum Foslie, List of spec. of the Lith., 1898, p. 7; Remarks, 1905, p. 72.

As to the morphology of this species reference may be made to the descriptions of Rosanoff and Foslie, to which I have only little to add.

The cells of the basal layer are, as pointed out by Rosanoff (l. c. p. 67), not arranged in distinct concentric zones; they are often connected through transversal fusions (fig. 152 *A*). The frond is monostromatic in its marginal part, which may be of greater or lesser extent. Otherwise the frond is often partly distromatic, and near the conceptacles it becomes gradually thicker, the cells dividing by transverse walls. There is thus no distinction between hypothallium and perithallium.

The sporangial conceptacles were often somewhat smaller than stated by Foslie, viz. 110—140 μ in diameter. Their outline is frequently oval, as mentioned by Rosanoff (l. c. p. 76) and Mme Lemoine (in Cotton, Clare Isl. Surv. p. 150). The number of the muciferous canals was also often somewhat less than that found by Foslie, namely 8—27, most frequently 16—21, while Foslie indicates 20–30. No relation was found between the number of the muciferous canals and the locality.

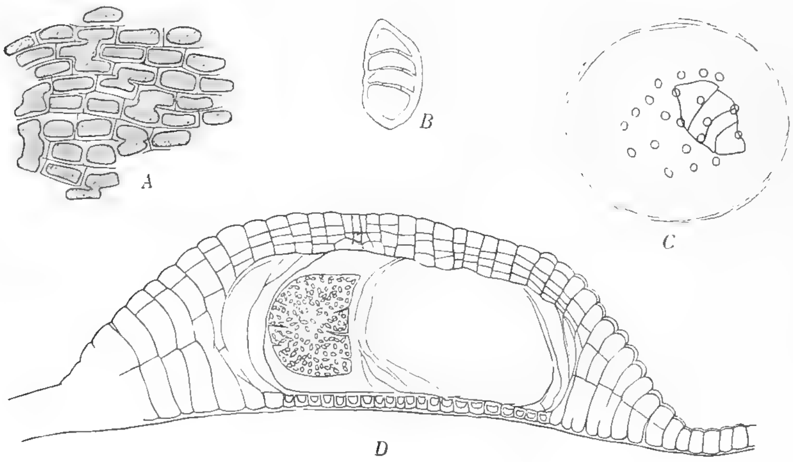


Fig. 152.
Epilithon membranaceum. *A*, frond seen from below showing several fusions. *B*, tetrasporangium not yet fully divided. *C*, sporangial conceptacle seen from above; a sporangium is seen under the roof. *D*, vertical section of sporangial conceptacle. *A,B,D* 345:1. *C* 200:1.

The sporangia apparently arise from the second cell-layer. The cells of the basal layer situated at the periphery of the conceptacle lengthen in a vertical direction, fuse laterally two or three together, and are finally disorganized, the upper part of their membrane being dissolved as far as it meets the cavity of the conceptacle. The cells of the same layer forming the central part of the floor of the conceptacle are disorganized in the same way, their contents finally disappearing, but they do not lengthen. In fig. 152 *D* the contents of these cells are still visible. In the sexual conceptacles the basal layer is exhausted in a similar way. The formation of the three dividing walls of the sporangia is almost simultaneous, the walls advancing slowly from the periphery towards the longitudinal axis of the sporangium (fig. 152 *B*, *D*).

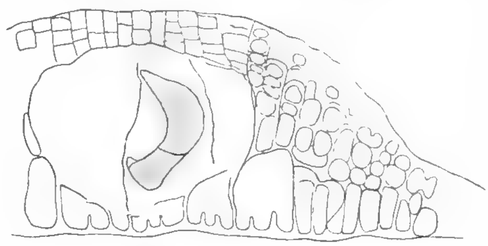


Fig. 153.
Epilithon membranaceum, vertical, somewhat excentric section of sporangial conceptacle. 345 : 1.

The antheridial conceptacles were found agreeing with the description and figure of Rosanoff (l. c. p. 59, pl. II fig. 14). The cells surrounding the orifice are elongated and directed obliquely upwards (fig. 154). The antheridia clothe the bottom of the conceptacle; their development and structure have been followed by Guignard, who found that they are seriate in densely placed short filaments. When the spermatia are to be formed, the protoplasm accumulates around the nucleus in the middle of the cell and becomes surrounded by a thin membrane, while the rest of the contents develop into two appendices, first described by Rosanoff and named "oreillettes".

The orifice of the cystocarpic conceptacles is clothed with similar elongated, hair-shaped cells like those of the antheridial conceptacles, but more numerous; they are directed inwards or downwards in the under part, upwards in the upper part of the orifice. The carpospores are only produced at the periphery of the conceptacle; in the central part of the floor carpogonia are still visible, when the carpospores are well developed (fig. 155 *B*). As to the structure of the procarps I cannot give any certain statement; they seem to resemble those of *Lithothamnion polymorphum*.

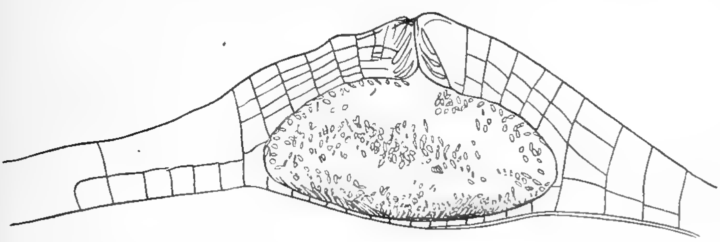


Fig. 154.
Epilithon membranaceum, vertical section of antheridial conceptacle. 500 : 1.

The species, referred by earlier authors to the genus *Melobesia*, had been transferred by Heydrich in 1897 to a new genus *Epilithon*, which was reduced in the following year by Foslie to a subgenus of *Lithothamnion*, with which it agrees by the fructification. The want of differentiation in hypothallium and perithallium seems to justify the distinction of the genus *Epilithon*. Another important generic distinction seems to exist in the position and development of the antheridia, which in the genus *Lithothamnion*, as far as known, are not seriate, and always placed on a system of branched filaments filling the cavity of the conceptacle (see above pp. 213, 218).

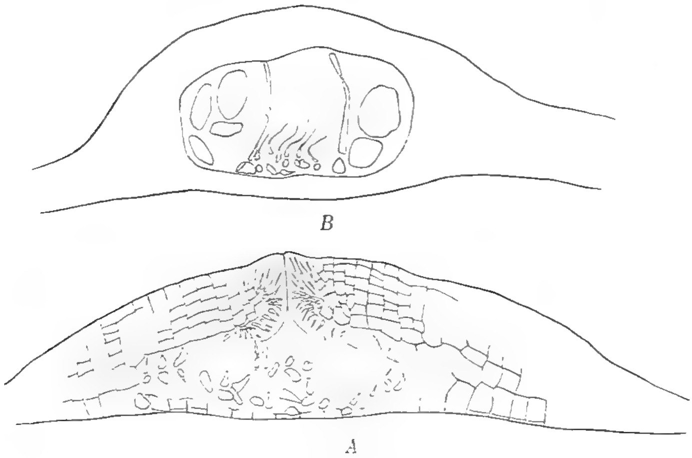


Fig. 155.
Epilithon membranaceum, vertical sections of cystocarpic conceptacles. *A*, showing the orifice. *B*, showing carpogonia at the centre and carpospores at the periphery. 350 : 1.

The species usually grows on *Furcellaria fastigiata*, but occurs in the Kattegat also on *Chondrus crispus*, and has likewise been met with on *Phyllophora rubens* and *Ph. membranifolia*. It is rather common in the Danish waters within Skagen to the western Baltic Sea, but does not occur in the Limfjord (and in other fjords), and in the Sound it has only been met with north of Helsingør. It has been found in depths between 1 and 20 meters, and there is in this respect no difference between the different waters. Its absence in the Skagerak depends probably on the want of protection in this agitated water.

Localities. **Kn:** Marens Rev, Deget a. o. locality near Frederikshavn; FF and FE, Trindelen, 9—15 m; UB and TG, north of Læsø. — **Ke:** IM, Fladen, 16 m — **Km:** XB, south of Kobbergrund; NV, off Randers Fjord. — **Ks:** FO, Havknude Flak; GG, Sjællands Rev, 4 m; D; EJ, entrance to Isefjord; RL, near Ostindiefarer Grund, 15 m; OO, Søborg Hoved Grund, 8,5 m. — **Sa:** FT, north of Samsø, 5,5 m; DK, Bolsaxen; AH and AH[1], Lillegrund north of Fyens Hoved; MQ, south of Paludans Flak; AY, Ashoved. — **Lb:** AX, Bjørnsknude, 9.5 m; north of Fænø Kalv; Fænø Sund; UX, at the north end of Ærø, 9,5 m. — **Sb:** DN, Vengeance Grund; Spodsbjerg; DT, off Magleby, Langeland. — **Sm:** Venegrund. — **Su:** BQ, off Ellekilde; off Aalsgaarde. — **Bw:** DU, off Dimesodde, 11,5 m; UL, Øjet, 20 m; KZ, off Kramnisse, 4,5 m.

Melobesia Lamour. emend.

The extent of the genus *Melobesia* has in course of time been repeatedly altered, certain species or groups of such having at various periods been detached therefrom and referred to new or other previously known genera. Thus in 1889, Schmitz removed *Melobesia Thuretii*, and gave it the name of *Choreonema Thuretii*; in 1897, *M. membranacea* was established by Heydrich as representative of a new genus, *Epilithon*, related to *Lithothamnion*. Foslie again, in 1898 (List of sp. p. 11) and 1900 (Rev. Surv. p. 21) placed *M. pustulata* and some related species under a new genus, *Dermatolithon,* characterised by having a single apical pore in the hemispherical-conical conceptacles, sporangia "with short foot rising from the almost plain disc" and developing, according to ROSANOFF, between club-shaped (?) paraphyses. In 1904 (Algol. Not. I. p. 3) however, he comes to the conclusion that these characters had not proved sufficiently constant, and did not form any distinct limit as against the genus *Lithophyllum.* He therefore no longer maintains *Dermatolithon* as a genus, but regards it as a sub-genus under the last-named genus, to which Heydrich had already previously (Corallinaceæ etc., Ber. deut. bot. Ges. 15, 1897, p. 47) reckoned *Melobesia Corallinæ* Crouan, and points out that it is further distinguished by its anatomical structure, the hypothallium being formed by a single layer of inclined cells. In 1909, (Algol. Not. VI, p. 57) however, it is again reinstated as a genus, FOSLIE now attaching greater importance to the mentioned anatomical character, and it was adopted by SVEDELIUS in 1911. M. B. NICHOLS, who has subjected some species of this relationship to closer investigation, (Univ. of California Publ. in Botany vol. 3, No. 6, 1909) discusses some of the other characters cited by FOSLIE, viz: the presence of a "plug" in the orifice of the sporangial conceptacles united at the basis by a parenchymatic tap; the position of the sporangia at the bottom of the conceptacle, which in *Melobesia* is said to be almost flat, in *Lithophyllum* over-arched; and the presence of a stalk cell under each sporangium in *Melobesia.* He adopts the standpoint which Foslie then adhered to; i. e. not maintaining *Dermatolithon* as a genus, but referring the species concerned to *Lithophyllum,* (*L. macrocarpum, pustulatum, tumidulum*). He points out, however, that in so doing, "the characters which separate *Lithophyllum* and *Melobesia* are not sufficiently well marked to warrant two separate genera" (p. 361). With regard to the structure of the conceptacles and the organs of reproduction, there is doubtless great similarity between the two genera; at any rate, no thoroughgoing differences appear to have been demonstrated up to now. The vegetative structure seems to me to present an excellent distinctive character, as in *Melobesia,* we never find transverse pits between the upright cell-series proceeding from the basal layer, whereas such are present in all *Lithophyllum* species, including the subgenus *Dermatolithon.* On the other hand, transverse fusions are of common occurrence in the *Melobesia* species, but are wanting in *Lithophyllum.* This seems, as a matter of fact, to be the best distinctive character between the two mentioned genera.

As to how far there may be reason to make further exclusions from the genus *Melobesia,* this must be left to further investigations to decide. FOSLIE, in 1900, (Rev. Surv. p. 21) established a subgenus *Heteroderma,* which he characterises as having the "thallus composed of more layers of cells" in contrast to *Eumelobesia,* which should have but one layer, except as regards the frond near the conceptacles. In 1905 however, (Remarks p. 102) a different limitation is made, and in 1909, (Alg. notes VI, p. 56) *Heteroderma* is raised to the rank of a genus, distinguished from *Melobesia* solely by the lack of hair-cells. I do not consider that we are justified in distinguishing between two genera merely by the presence or absence of hair-cells, as the occurrence and frequency of these cells seems to depend to a great extent upon external conditions. I therefore attach but little importance to the fact that such have not hitherto been found in two of the species mentioned below (*M. minutula* and *microspora*) as it must be considered highly probably that they will be found on further investigation of a greater number of specimens. Moreover, hair-cells are found in *M. Lejolisii*, noted by Foslie under the genus *Heteroderma* (see fig. 156). On the other hand, I could well imagine that it may later on be found justifiable to distinguish between those species in which the trichocytes are terminal in the horizontal cell filaments, as in *M. farinosa*, for instance, and the other, doubtless far more numerous species in which they are intercalary. Another vegetative character which might be thought to furnish grounds for generic distinction, is the lack of cortical cells shown below in the case of *M. microspora*. This point, however, still needs further investigation. As regards the cortical cells, it may also here be noted that in *M. trichostoma*, several of these were found above one another, cut off successively by the same frond cell.

Where the frond consists of more than one cell-layer, there is often but slight difference between the basal layer (hypothallium) and the upright cell filaments proceeding therefrom (perithallium). Thus the walls forming the boundary between these two tissues often lie at different heights, as for instance in *M. microspora* (figs. 176—179) and *M. trichostoma* (174—175).

The number of spores in the sporangia is in most of the present species constant. In four species, 4 spores were found, in *M. subplana* a constant 2. In *M. minutula* only specimens with 4 spores were found, whereas Foslie gives 2, and in *M. Fosliei* some conceptacles were found with 4, others with 2 spores in the sporangia. — A small stalk-cell under the sporangium was found in *M. subplana.*

With regard to the antheridia, *M. Lejolisii* was found to differ from the other species in having the spermatangia formed at the end of long sterigmata, as first shown by Mrs. Weber-van Bosse. In the other species, the spermatangia are elongated cells, situate on the flat bottom of the antheridia-conceptacles. The orifice of the antheridia-conceptacles was in four of the present species often found drawn out into a spout, as first shown by Mrs. Weber-van Bosse in the case of *M. Lejolisii.* This is, however, not a constant character, as it may frequently be lacking in all the species concerned.

The carpospores are in all the cases investigated formed only in the periphery of the conceptacle, at the margin of the flat disc-cell.

1. **Melobesia Lejolisii** Rosanoff.

Rosanoff, Rech. anat., 1866, p. 62, pl. I fig. 1—13, pl. VII fig. 9—11; Areschoug, Observ. phycolog. Part. III, 1875, p. 3; Hauck, Meeresalg., p. 264; A. Weber-van Bosse, Bijdrage tot de Algenflora van Nederland, Nederl. kruidk. archief. 2. Ser. 4. deel 4e stuk, Nijmegen 1886, p. 365; ead. in Hauck et Richter, Phykotheka univers. No. 163; Foslie, Remarks, 1905 (1906) p. 102 (f. *typica*); Mme P. Lemoine, Struct., p. 180, fig. 103; ead., Calcareous Algæ in Report on the Danish Oceanogr. Exped. 1908—10 to the Mediterranean etc. Vol. II, 1915, p. 19.

Among the distinctive characters of this species, used by ROSANOFF, in his important paper on the Melobesiaceæ, the want of "heterocysts" has been of special importance in distinguishing it from *M. farinosa*, as it permitted determination even in cases where the characters taken from the organs of reproduction could not be used. As shown by FOSLIE however, l. c. p. 103, the cells situated under the dichotomies are often larger than the others and resemble the heterocysts of *M. farinosa*. I can confirm Foslies' statement, having frequently found these cells in Danish specimens of *M. Lejolisii*. They agree indeed completely with the heterocysts of *M. farinosa*, in bearing a hair or a scar left by a shed hair, in being poorer in contents and in bearing no cortical cells as do the other cells of the monostromatic frond. But they differ from the heterocysts of the last-named species in being derived, not from end-cells of filaments, which do not develop further, but from cells situated under a ramification. I have convinced myself that this difference really exists by examining authentic specimens of *M. farinosa*. Where the included heterocysts of this species are present it is easily seen that the two cell-rows, the separating line of which goes in continuation of the heterocyst, are not given off from this, but from the adjacent cell-rows. As shown by SOLMS (Cor. p. 24), these cells produce a hair without formation of a transverse wall. The hairs are, according to the mentioned author, very short-lived, and fall off after a separation has taken place at their base by local incrassation of the longitudinal wall. This is also the case with those of *M. Lejolisii;* sometimes, however, they are more persistent, and appear as long hyaline hairs (fig. 156 *C*). Their wall is stained very intensely by hæmatoxyline, by which they become very obvious, and the same is the case with the basal part

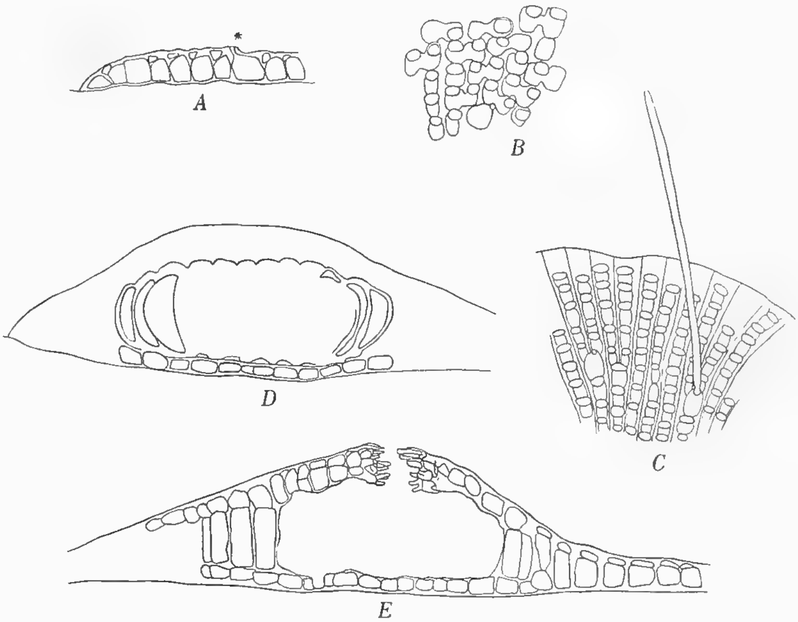


Fig. 156.

Melobesia Lejolisii, from Birkholm, **Sf**. *A*, vertical section of marginal part of frond, * trichocyte. *B*, monostromatic frond seen from above; below a trichocyte, numerous fusions. *C*, marginal part of frond seen from above; two trichocytes are visible, one with hair. *D*, vertical section, not median, through a sporangial conceptacle; only undivided sporangia present. *E*, vertical section through emptied sporangial conceptacle. 350:1.

of the cell, after the throwing off of the hair. As these cells are very different from the heterocysts of the *Cyanophyceæ*, I think it better to give them another denomination; they must be named hair-cells or trichocytes (comp. p. 213). They are somewhat larger than the other cells. Sometimes also, other intercalary cells than the branch-producing ones may develop into a trichocyte, and it may also happen that a trichocyte produces a cortical cell. These cells appear to be of normal occurrence, though varying in number[1].

In the monostromatic part of the crust the cells are 7—10(11) μ broad, and usually 1—1½ times as long. The dimensions are somewhat variable (comp. figs. 156 and 158). In specimens from the inner Danish waters (**Sf** and **Sm**) the breadth of the cells was only 7—9 μ, in specimens from **Lf** and **Kn** it was up to 11 μ; this is possibly caused by the difference in salinity of the water. These cells often contain numerous starch grains, but the trichocytes contain no starch. The cortical cells are always longer in transversal than in radial direction. Transversal fusions between the cells may occur, sometimes in great number (fig. 156 *B*). In a vertical radial section the cells are seen to be of about the same height as breadth.

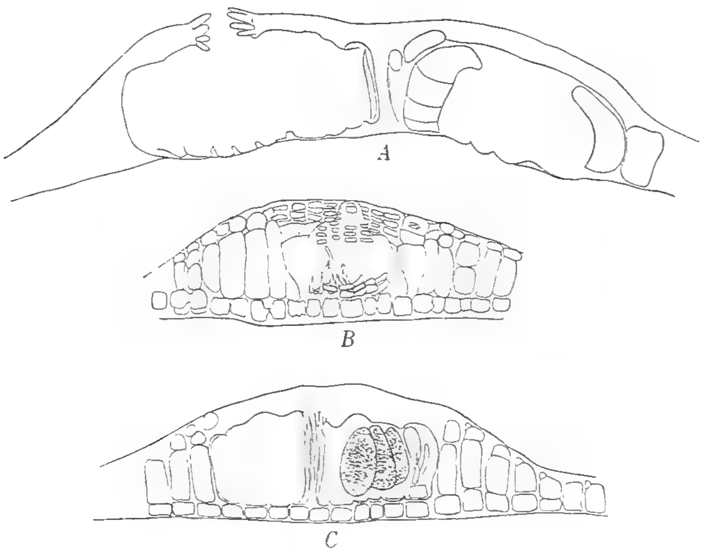


Fig. 157.
Melobesia Lejolisii. Vertical sections of conceptacles. *A*, from Stensnæs, **Kn**, sporangial conceptacles. *B* and *C* from Kragenæs, **Sm**; *B*, with carpogonia, *C*, with undivided sporangia, in the middle a columella. 350 : 1.

The marginal part of the frond remains monostromatic, the small cortical cells not taken into account. Only in the immediate vicinity of the conceptacles the frond consists of 2—3(4) layers of cells. As the conceptacles are densely placed in the greater inner part of the crust, the frond is monostromatic only in the marginal part. The statement of Mme LEMOINE (Structure, p. 180, fig. 103) that the crust of

[1] The trichocytes appear to be variable in their occurrence also in *M. farinosa*. In specimens from LE JOLIS, Alg. mar. de Cherbourg no. 194, which, as shown by FOSLIE, is a typical *M. farinosa*, I found the characteristical trichocytes quite in accordance with the descriptions of ROSANOFF and SOLMS. On the other hand, in the *Melobesia* communicated in Crouan's Exsicc. no. 244, which indeed is referred to *M. Lejolisii* by FOSLIE, I did not find any heterocysts at all. This alga agrees, however, otherwise with M. *farinosa*, by the dimensions of the cells (11—14 μ broad, about 1½—2 times as long) and by the round, not transversely elongated cortical cells. I suppose therefore that it is a form of *M. farinosa*, in which no trichocytes have been developed.

this species consists of three cell-layers, the middlemost of which is composed of high cells, must refer to the fertile part of the crust (comp. fig. 159 *D*); but the author says that she has observed three layers also at a great distance from the conceptacles. Possibly, the specimens referred to this species by Mme Lemoine do not all belong to it. In Calc. Alg. Med., 1915, p. 19, the same author mentions specimens of this species from the Mediterranean consisting only of two layers of cells, the upper being the cortical cells; these specimens thus agree with the Danish ones.

The conceptacles of sporangia are usually densely crowded. They are low conical or, when very densely placed, depressed, with almost level surface (figs. 156—158). The orifice is rather narrow, almost cylindrical, not enlarged upwards, clothed with unicellular hairs of varying length. In rare cases I found the hairs long and protruding outwards in a vertical direction (fig. 158 *D*), as drawn by Rosanoff in fig. 11, pl. I, l. c., but usually they are shorter, directed inwards horizontally and not protruding (figs. 156 *E*, 157 *A*, comp. Rosanoff's fig. 8). The last quoted figure of Rosanoff certainly represents a normal, fully developed state. Foslie, who did not find any protruding crown at all in examining numerous specimens, thought that this might perhaps be owing to the fact that he had only had dried material for examination, "or it may be that the cells of the corona have a short phase of development and are soon falling to decay". My investigations do not favour these suppositions; it must be supposed, that the development of the hairs is variable according to the various conditions. — The roof of the conceptacle is rather thin, consisting of about 2 (1—3) cell-layers, only a little thicker, if at all, near the orifice. The floor of the conceptacle consists of a single cell-layer; more rarely this cell-layer is absorbed (fig. 157 *A*). In some cases a sterile columella was observed in the centre of the conceptacle (fig. 157 *C*), but

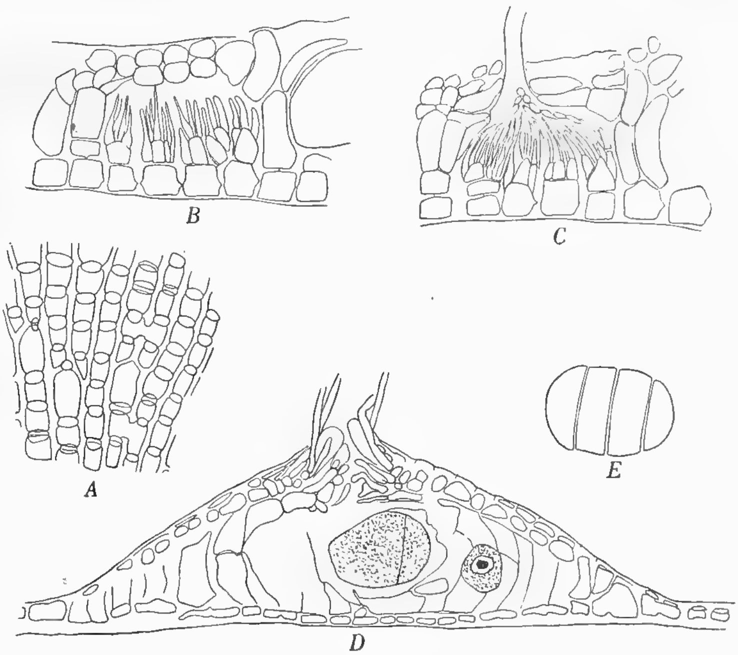


Fig. 158.

Melobesia Lejolisii, from TG, north of Læsø. *A*, frond seen from above, at left a trichocyte. *B*, vertical section of antheridial conceptacle, not yet ripe. *C*, vertical section of antheridial conceptacle provided with a spout. *D*, vertical section of sporangial conceptacle with well developed peristomial hairs. *E*, the same sporangium as seen in *D*, from a following section. *B* and *C* 650 : 1, the rest 350 : 1.

usually no such formation was to be seen. The sporangia are, when fully developed, four-parted, 45—77 μ long, 32—49 μ broad. While at first vertically placed, they may sometimes finally become horizontal, at all events when the conceptacle contains only one or two developed sporangia (fig. 158 *D—E*).

The antheridial conceptacles are small, often very small, and but little prominent if at all. As shown by Mrs. Weber-van Bosse (l. c.), the spermatia are produced at the end of long sterigmata developed from a layer of very small cells covering the basal layer (fig. 159 *A*, *C*). In some cases, however, the cells producing the sterigmata are not placed directly on the basal layer (fig. 158 *B*, *C*). In some cases the conceptacle was found provided with a long slightly curved spout agreeing exactly with that described by Mrs. Weber (fig. 158 *C*); but in most cases no such spout was to be seen. The ostiole was then a simple small hole without any peristome. The spermatia appeared sometimes as slightly elongated cells with pointed ends (fig. 159 *C*).

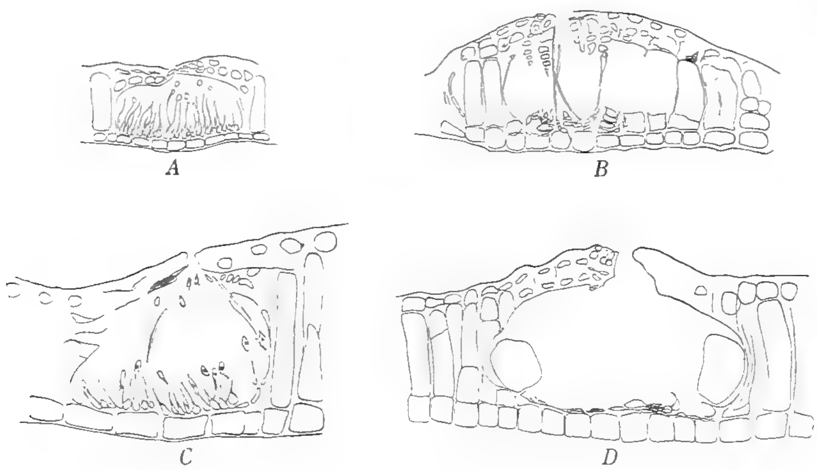


Fig. 159.
Melobesia Lejolisii. *A* and *B* from Holbæk Fjord. *A*, antheridial conceptacle. *B*, female conceptacle, showing carpogonia. *C*, antheridial conceptacle. *D*, cystocarpic conceptacle, *C* 650 : 1, the rest 350 : 1.

Well developed female conceptacles were only rarely found. The conceptacles shown in figs. 157 *B* and 159 *B* are certainly female ones, containing unfertilized carpogonia, and fig. 159 *D* represents a cystocarpic conceptacle with the carpospores placed at the periphery only. A disc-cell could not be distinguished. Peristomial hairs seem not to be developed. The diameter of female conceptacles was found to be 123—175 μ.

Ripe tetrasporangia have been found in summer (June to September), antheridia in May and September, and cystocarps (with few spores) in May.

I have referred to this species all the specimens growing on old *Zostera*-leaves and referred by Foslie to *M. Lejolisii* f. *typica*, with the exception of one sample mentioned below under *M. subplana*. The species has also been found growing on *Ruppia*. The specimens growing on Algæ, on the other hand, seem to belong to other species, which are mentioned below. The species has been found in depths of 1—11 meters.

Localities. **Lf:** Thyborøn; Nykøbing; LQ, Lendrup Røn; MK, Holmtunge Hage; F, Lunde Hage; ML, Gjøls Bredning; stone reef west of Draget; Hals. — **Kn:** TP, Tønneberg Banke; TG, near Syrodde Pynt. — **Km:** BO, Stensnæs; EZ and XC, south of Læsø. — **Ks:** NL, Isefjord; Lammefjord; Holbæk Fjord. — **Sa:** Besser Rev, Samsø, partly on Ruppia; MT, Horsens Fjord; Odense Fjord (C. Rosenberg). — **Sf:** Nakkebølle Fjord; Svendborg; U, Birkholm; EA, north of Rudkøbing. **Sb:** Munkebo, Kertinge Nor; Avernakhage by Nyborg. — **Sm:** CM, Kragenæs; CO; CR, off Dyrefoden; Guldborgsund.

2. **Melobesia subplana** sp. nov.

Crusta orbicularis, 1—2 mm diametro, in statu adulto non nisi margine angusto monostromatico, ceterum 2—6 cellulis crassa, cellulis in parte marginali c. 7—8 μ latis, cellulis corticalibus rotundatis, in sensu radiali paulo elongatis, trichocytis intercalaribus. Fila verticalia partis frondis crassioris cellulis longitudine vario, 6—9 μ crassis constituta. Conceptacula sporangifera dense posita, paulo prominula, diametro externo c. 150—200 μ, interno 70—105 μ; sub conceptaculis 1—2 strata cellularum vegetativarum; tectum subplanum, c. 2—3 cellulis crassum, ostiolo cellulis paulo horizontaliter elongatis, non erumpentibus, vestito. Columella centralis conica. Sporangia 42—60 μ longa, 26—32 μ lata, semper disporica. Conceptacula mascula parva, immersa, nonnunquam tubo longo prorumpente munita, fundo cellulis spermatogenis numerosis elongatis, leniter curvatis, e strato cellularum rotundatarum egredientibus, vestito, spermatiis longis, clavatis, leniter curvatis, c. 11 μ longis, c. 2 μ crassis. Sub conceptaculis masculis 1—3 strata cellularum vegetativarum. Conceptacula feminea parva, immersa, initio non prominula, stratis cellularum vegetativarum 1—3 suffulta. Cystocarpia non certe cognita.

The specimens which have served as base for this new species were collected near Horsens at the east coast of Jutland, growing on *Zostera*-leaves. They have been determined as *M. Lejolisii typica* by Foslie, and certainly resemble this species very much; they differ however so much from it in some respects that I have thought better to regard it as a distinct species.

The frond is polystromatic with the exception of a narrow marginal zone. It consists otherwise of vertical cell-rows composed of 2 to 5 cells, not including the small cortical cells, which are cut off by oblique walls. Near the border, the cortical cells are seen to be rounded, narrow, usually a little lengthened in a radial sense, sometimes placed not over the anterior border but over the middle of the cell (fig. 160 *A*). Hyaline hairs are sometimes numerous, given off from cells without cortical cells, also from the polystromatical part of the frond. The cells of the vertical cell-rows are of varying length. There is less contrast between the basal layer and the perithallium than in *M. Lejolisii*, the upper wall of the cells of the former falling not always at the same level, the cells thus being of somewhat varying height. While in *M. Lejolisii* the intermedial layer in thicker crusts consists only of one layer of long cells, it is in *M. subplana* usually 2—4 cells thick, its cells varying from 1 to 3 diameters in height, shorter and longer cells alternating irregularly, and the transversal walls falling at different levels in the different filaments.

Transversal pores do not occur, but transverse fusions frequently take place, most frequently in the basal layer, but also between cells at a higher level. Abundant starch-grains occur in the ordinary vegetative cells.

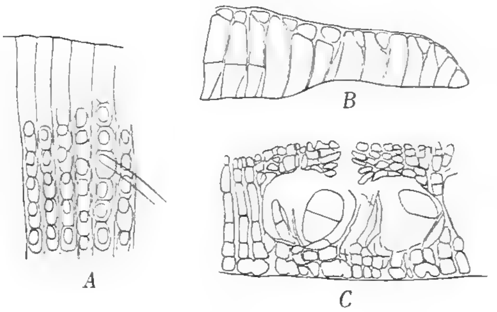


Fig. 160.
Melobesia subplana. *A*, marginal part of frond seen from the face. *B*, vertical section of border of frond. *C*, vertical section of sporangial conceptacle. *A* and *B* 350 : 1. *C* 200 : 1.

The sporangial conceptacles are numerous and densely crowded. They are only slightly prominent, but where they are very densely placed, the single conceptacles are often not prominent at all, the surface being even (fig. 160 *C*). It is therefore not always possible to indicate the outer diameter of the single conceptacles. The ostiole is lined by elongated cells radiating towards the centre of the canal. At last they assume the character of rudimentary hairs directed inwards. The middle of the conceptacle is occupied by a conical columella of sterile cells, while the sporangia are placed in the outer part of the conceptacle. A little stalk-cell was frequently seen under each sporangium. The sporangia are always two-celled. I have seen numbers of them, some preserved in alcohol, and can assert that they were really two-celled, also at maturity.

Fig. 161.
Melobesia subplana. Vertical section of antheridial conceptacle, at right presumed spermatia. 560 : 1.

I have seen only one or two male plants containing some antheridial conceptacles. These are small, completely immersed. The bottom of the conceptacle is covered by a layer of small, somewhat rounded cells, from which are given off numerous elongated slightly curved spermatia-producing cells a little incrassated upwards. I have not been able to follow the development of the spermatia, but I do not doubt that the elongated cells in question are the spermatangia, which produce long clavate, slightly curved spermatia (fig. 161). The spermatia are not formed at the end of long thin sterigmata. The ostiole of the conceptacle was in some cases provided with a long spout resembling that of *M. Lejolisii* (fig. 161), in other cases no such spout was present.

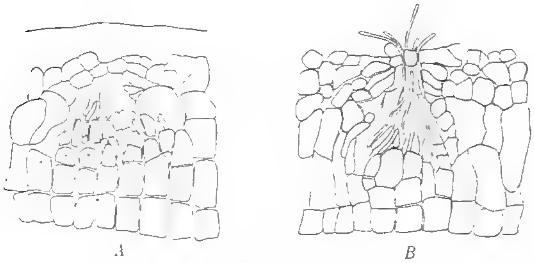


Fig. 162.
Melobesia subplana Vertical sections of carpogonial conceptacles. *A* with young, *B* with fully developed carpogonia. *B*, 485 : 1. *B* 420 : 1.

Very few conceptacles with carpogonia were seen. They were small, not prominent; the ostiole seems to be provided with a peristome similar to that of the sporangial conceptacles. Fig. 162 *B* shows fully developed carpogonia with long trichogynes penetrating through the ostiole. As to the structure of the procarps, my observations are so incomplete that I must content myself with referring to the figures without any interpretation. The bottom under the female conceptacles was composed of one to three layers of cells. Ripe cystocarps in good condition were not met with; they seem to be rather similar the tetrasporangial conceptacles.

As will be seen from the above description, this species differs from *M. Lejolisii* principally by the structure of the polystromatic frond, by the shape of the sporangial conceptacles, by the normal presence of a columella, by the two-spored sporangia, and seemingly by the formation and shape of the spermatia.

Locality. **Sa:** On *Zostera*-leaves at Horsens, September 1893.

3. **Melobesia limitata** (Foslie) K. Rosenv. sp. nov.

Melobesia Lejolisii Rosanoff f. *limitata* Fosl., Remarks 1905 (1906) p. 102.

In his valuable paper on the northern Lithothamnia (Remarks, 1905 (1906) p. 102) Foslie described a forma *limitata* of *Melobesia Lejolisii*, characterized principally by smoother and apparently more solid crusts, and by less crowded conceptacles, frequently a little higher and somewhat pointed or subhemispherical-conical, and more sharply defined. He referred to it almost all the Danish specimens noted under the species mentioned but growing on Algæ instead of on Zostera. In examining these specimens, I have found that they not only differ in the characters named by Foslie, but that they must be regarded as representing another species distinct also in several other characters.

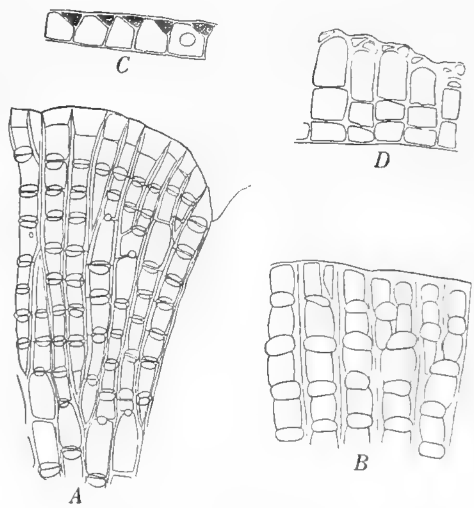


Fig. 163.
Melobesia limitata. *A–B*, marginal parts of frond, seen from the face, from M; *A*, before, *B*, after decalcification and staining. *C* and *D*, vertical sections of fronds, from I, *D* from the central part. 350 : 1.

The crusts have a diameter of 3—4 mm, sometimes they reach 5 mm or more. They are more or less irregularly orbicular with lobed margin. Frequently several crusts are confluent. The frond may be monostromatic from the border to the conceptacles, or the inner part may be distromatic (figs. 166, 167) or even thicker (fig. 163 *D*). When seen from the face, the frond presents a similar aspect to *M. Lejolisii*, but the cells are usually somewhat longer, viz. (7—)8—10,5(—12) μ broad, $1^1/_2$ to 2 times longer than broad. Transversal fusions sometimes occur. The cortical cells are longer in transversal than in radial direction. Trichocytes usually occur; they may be cells situated under a ramification or ordinary intercalary cells in the radiating filaments. They usually lack cortical cells, but such may occasionally be produced (fig. 163 *A* at left).

The conceptacles are scattered, usually not contiguous.

The sporangial conceptacles are conical or subhemispherical-conical, (170—)230—325 μ in diameter. The outer wall (the roof) is thicker than in *M. Lejolisii*, it is 3—5 cells thick and has its greatest thickness near the ostiole. It consists here of very distinct cell-filaments radiating inwards and upwards. The longest of these filaments are those directed towards the upper border of the ostiole, and which sometimes project as a crown beyond the border of the ostiole. The filaments forming the crown are given off not only from the inner face of the canal, as in *M. Lejolisii*, but also from the outer surface (fig. 165). In other cases, however, the filaments do not extent beyond the border of the ostiole and a crown is thus not developed. The ostiole has usually a constriction almost in or under the middle, and over this the ostiole is funnel-shaped or barrel-shaped, according to the development of the upper peristomial filaments (figs. 164, 165). This space is filled with a hyaline jelly. The converging filaments are easily observed when viewing the conceptacle from above. The bottom under the conceptacle consists of one or two layers of cells. The sporangia seem to be produced only in the peripheral part of the conceptacle, but there is no columella. The sporangia are four-parted, 46—77 μ long, 21—46(—61) μ broad. Un-

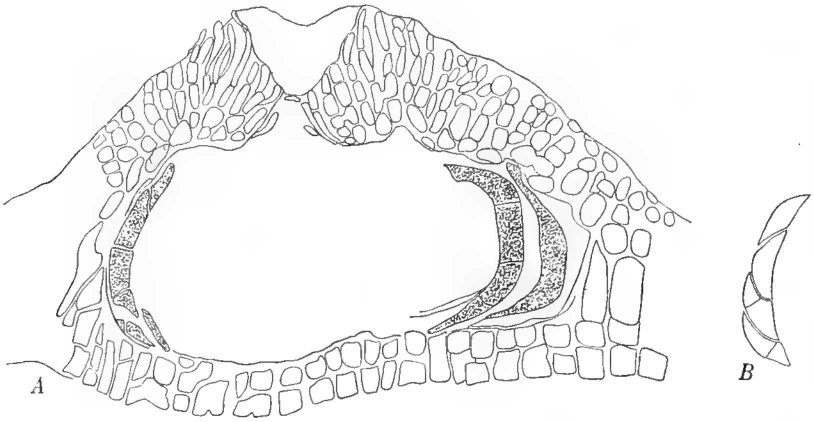


Fig. 164.
Melobesia limitata from MH. *A*, vertical section of nearly emptied sporangial conceptacle. *B*, sporangium divided into more than four cells. 350 : 1.

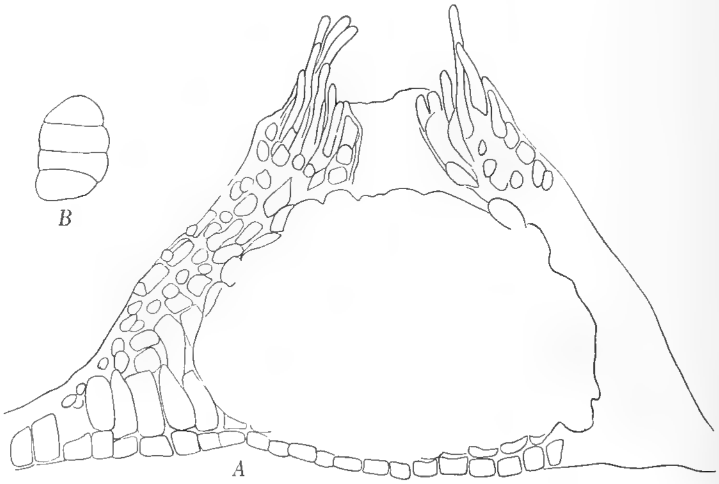


Fig. 165.
Melobesia limitata *A*, vertical section of sporangial conceptacle with well developed crown. 350 : 1. *B*, sporangium. 200 : 1.

divided and two-parted sporangia were frequently met with. In a specimen from the Limfjord, sporangia were found which were irregularly divided into more than 4 cells (fig. 164 *B*).

The antheridial conceptacles (fig. 166) occur in the same plants as the female ones. They are very small, e. g. 56 μ in inner diameter, totally immersed or only little prominent. The bottom is composed of one to two cell-layers. The cells of the roof are often partly disorganized. The ostiole is conical or conical-cylindrical, sometimes, but not always provided with a long spout resembling that in *M. Lejolisii.* The spermatangia are cylindrical and form a dense covering on the flat bottom of the conceptacle; they are produced from low cells forming a layer over the bottom. The spermatia seem to be oblong, 2—3 times as long as broad. There are no long sterigmata as in *M. Lejolisii.*

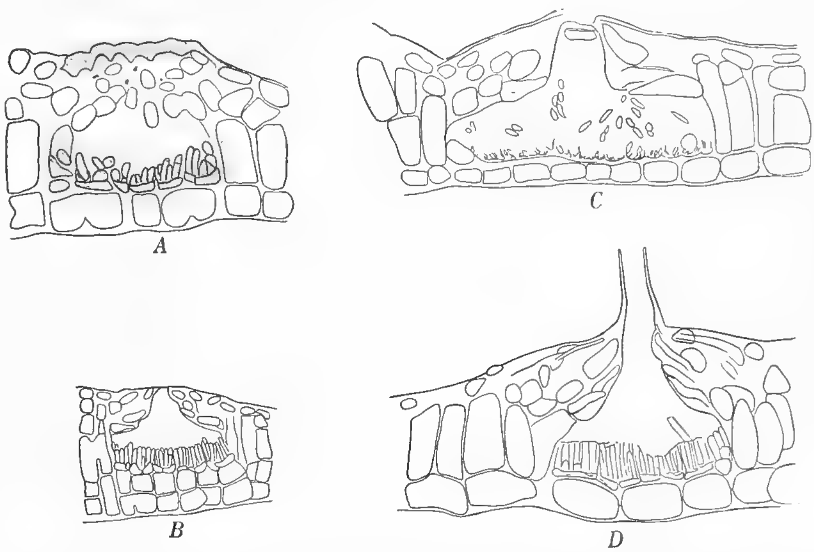


Fig. 166.
Melobesia limitata. Vertical sections of antheridial conceptacles. *A*–*C* from I, *D* from Amtoft Rev. *A* and *B*, before discharge of the spermatia. *D*, the ostiole is prolonged in a spout. *A* and *D* 650 : 1. *C* 560 : 1.

The female conceptacles resemble the sporangial ones. A young stage with unfertilized carpogonia is shown in fig. 167 *A*; a number of carpogonial branches are placed on the bottom. The short cell under the carpogonium is probably the auxiliary cell. After fertilization, the surrounding elongated cells shown in fig. 167 *A* are dissolved, the developing cystocarp increasing at the periphery. A ripe cystocarp is seen in fig. 167 *D*, showing a number of carpospores produced at the periphery of the cystocarp, while numerous unfertilized carpogonia are still visible on the middlemost part of the floor. The cystocarpic conceptacles are 210—325 μ in diameter; they are of the same shape as the sporangial ones, and the roof and the ostiole have a similar structure. The ostiole is surrounded by similar inward and upward converging filaments, which may sometimes project outwards as a crown. A well developed crown is shown in fig. 167 *C*, where the free ends of the filaments are distinctly articulated. In fig. 167 *D*, which shows another conceptacle of the same plant, the free ends of the filaments seem to have been thrown off, for the converging filaments are only one- or two-celled, and remains of the free ends of the filaments are still visible at the border of the ostiole. On the other hand it is certain that a crown is not always developed, for ripe and emptied cystocarpic conceptacles may be found in which the structure of the ostiole agrees exactly with that of the young conceptacles shown in fig. 167 *A*, and which show no trace of a shed crown.

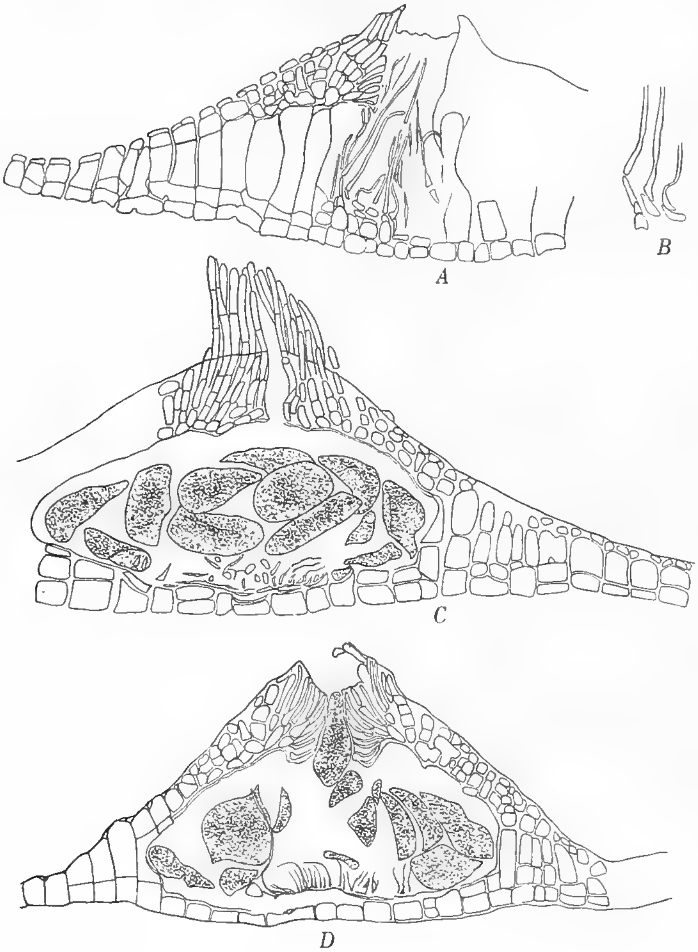


Fig. 167.

Melobesia limitata. Vertical sections of female conceptacles. *A*, young stage with unfertilized carpogonia. *B*, fully developed cystocarpic conceptacle with well developed crown consisting of articulated filaments. *C*, fully developed cystocarpic conceptacle in the stage of emptying; the crown has perhaps been thrown off. From Amtoft Rev. *A*, *C*, *D* 350 : 1. *B* 650 : 1.

As will be seen from the above, this species differs from *M. Lejolisii*, besides the characters named by Foslie, principally by the thicker roof of the sporangial and cystocarpic conceptacles, and by the central part of the roof consisting of long converging articulated filaments, sometimes projecting outwards as a crown, and further by the structure of the antheridial conceptacles, the spermatia being not produced at the end of long sterigmata.

I refer to this species the specimens from Nykøbing, Mors referred by Foslie with doubt to *Melobesia farinosa* f. *borealis* (Foslie, Remarks, p. 98). Foslie did not find any heterocysts, but I found some intercalary trichocytes with or without cortical cells, as described above, thus different from those of *M. farinosa*, in which they are terminal.

All the specimens referred to this species were growing on Algæ, particularly on *Fucus vesiculosus*, thus all the specimens found in the Limfjord, otherwise on *Chondrus crispus*, *Rhodymenia palmata* and *Laminaria digitata*. In the Limfjord it was always found growing together with *Lithophyllum macrocarpum*. Sporangia, antheridia and cystocarps were met with in August and September. The species is certainly annual.

Localities. **Lf:** Søndre Røn by Lemvig; Thisted; off Skrandrup and off Hanklit, Thisted Bredning; Venø Bugt off Nørreskov; Nykøbing; Amtoft Rev and LQ, Lendrup Røn in Løgstør Bredning. – **Kn:** Deget by Frederikshavn, on Chondrus crispus; Nordre Rønner; UB, north of Læsø; Trindelen, on Rhodymenia palmata, 19 meters. — **Sa:** AY, off Ashoved, on Laminaria digitata, 10 meters.

4. **Melobesia Fosliei** sp. n.

Frons minuta ambitu irregulari, monostromatica vel prope conceptacula polystromatica. Cellulæ partis monostromaticæ (6—)7—9(—11) μ latæ, diametro æquilongæ vel ad sesqui longiores; cellulæ corticales parvæ, ellipticæ. Trichocyti plerumque adsunt. Conceptacula sporangifera hemisphærica vel subhemisphærica, diametro 80—140—185 μ, dum dense posita confluentia. Tectum 1—2 cellulis crassum. Cellulæ ostiolum circumdantes a ceteris paulo diversæ, nonnunquam ostiolum versus paulo elongatæ, vel papillas horizontales formantes. Ostiolum interdum in rostrum breve protractum. Sporangia quadripartita et bipartita, 42—60 μ longa, 18—30 μ lata. Conceptacula mascula parva immersa, paulo prominentia; spermatia lineari-clavata, leniter curvata in fundo conceptaculi gignuntur. Conceptacula feminea eadem forma et structura ac conceptacula sporangifera.

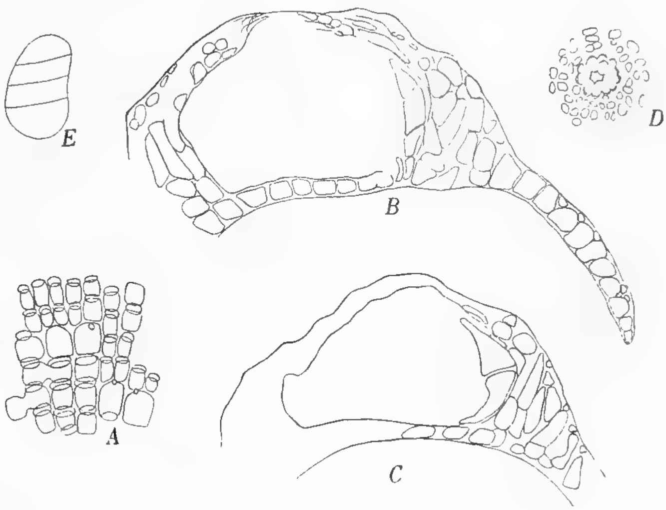


Fig. 168.
Melobesia Fosliei. *A—C*, from Deget. *A*, monostromatic frond seen from above. *B*, vertical section of a sporangial conceptacle showing one fourparted sporangium. *C*, vertical section of sporangial conceptacle showing one two-parted sporangium. The orifice has not been hit by the section. *D*-*E* from Hirsholmene. *D*, orifice of sporangial conceptacle seen from above. *E*, tetrasporangium. 350 : 1.

The specimens referred to this species were found growing on the fronds of *Polysiphonia nigrescens*, *Corallina rubens*, *C. officinalis* and on Bryozoans living in company with these Algæ. They are rather variable in several respects, but as the differences are met with not only between specimens growing on different substrata, but also in specimens growing on the same alga, I do not hesitate in referring them all to the same species.

Most of the specimens were found growing on *Corallina rubens*; these specimens may first be mentioned here. The structure of the monostromatic frond much resembles that of *M. Lejolisii*, except that the lateral walls seem to be thinner (less incrustated ?). Lateral fusions are frequent. Trichocytes were usually present, situated at the offspring of ramifications, but in some cases they were searched for in vain.

The conceptacles of sporangia are proportionally higher than in *M. Lejolisii*, hemispherical or subhemispherical, the height being frequently the half of the breadth. The cells surrounding the ostiole are usually little characteristic, forming no real peristome; they may be somewhat lengthened towards the opening, but take, as it seems, scarcely the form of papillæ, and do not as a rule protrude outside the ostiolum. In some cases, however, they are elongated, going out in a prolongation of the surroundings of the ostiole in a short spout, resembling that of the antheridial conceptacles of *M. Lejolisii* and *M. limitata*, but thicker (fig. 169 *A*). This character, however, is not constant, being met with only in some of the conceptacles but wanting in others, usually most. When seen from above, the ostiolum appears sometimes surrounded by a rosette consisting, as it seems, of very low papillæ (fig. 168 *D*), in other cases no such structure is to be seen. 4-parted sporangia were found in all the specimens examined, but 2-parted ones of the same size were found in the same specimens. As I have examined only dry specimens in which, as is well known, most of the sporangia have been emptied by the desiccation, it could not be stated whether the 2-parted sporangia were fully developed or not. I am inclined to suppose that 4-parted and 2-parted sporangia normally occur simultaneously.

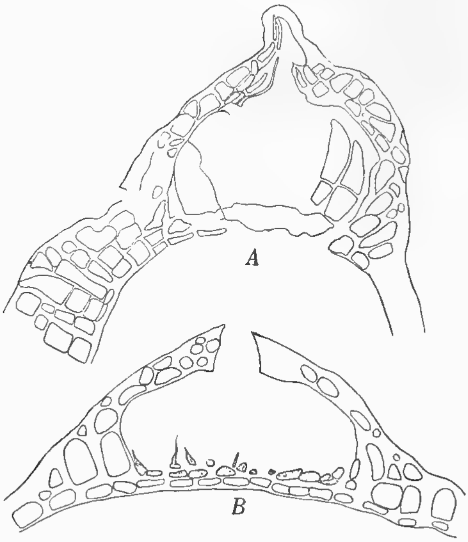


Fig. 169.
Melobesia Fosliei, from Tønneberg Banke. *A*, vertical section of sporangial conceptacle with orifice prolonged in a spout. *B*, vertical section of cystocarpic conceptacle. *A* 350 : 1. *B* 560 : 1.

The antheridial conceptacles were usually not well preserved in the dried material, but it could be seen that the spermatia were not produced at the end of long sterigmata as in *M. Lejolisii*. In one case the ostiole was found prolonged in a spout.

The conceptacles of cystocarpia were smaller than those of sporangia, and a little lower in relation to their breadth; the ostiole was similar in structure to these.

The specimens growing on *Polysiphonia nigrescens* agree in all essential points with the others; the cells of the monostromatic frond were only a little broader, 9—13 μ. A number of the conceptacles were provided with a well developed spout, containing elongated cells, the rest were without any projection. It appeared

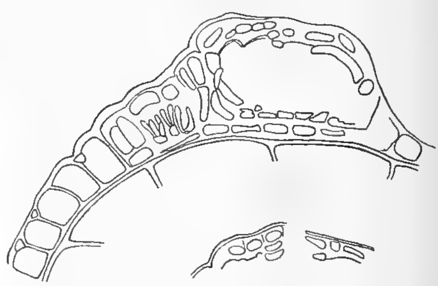


Fig. 170.
Melobesia Fosliei, from Bragerne. Vertical section of frond with antheridial and cystocarpic conceptacle. Below another section of the latter showing the orifice. 560 : 1.

to me that some of the first were cystocarpic ones. As shown in fig. 170 the antheridial conceptacles occur in the same fronds as the cystocarpic ones. The latter were rather small in these specimens.

The specimens growing on *Corallina officinalis*, collected north of Læsø (ZC[1], 7658a, fig. 171), are more vigorous than the specimens previously mentioned. The structure of the frond is the same, but the conceptacles reach greater dimensions. They may be hemispherical, 160—185 μ in diameter, or they may be lower, frequently fusing together, when the conceptacles are densely placed. The ostiole was provided with small papillæ directed inwards in the conical space of the orifice. When seen from above, the ostiole appeared surrounded by a rosette exactly like that shown in fig. 168 *D*. The remains of a columella were found in the case represented in fig. 171 *A*. The sporangia were always tetrasporic, 44—50 μ long, 11—16 μ broad. — The antheridial conceptacles are slightly prominent; the spermatangia are produced on the flat bottom of the conceptacle from small cup-shaped cells; they (or the spermatia) are linear-clavate, slightly curved, measuring 7 μ in length, about 2 μ in their broader end. — The cystocarpic conceptacles have the same shape and size as the sporangial ones and are, as those, provided with short horizontal papillæ in the ostiole, principally in its under part.

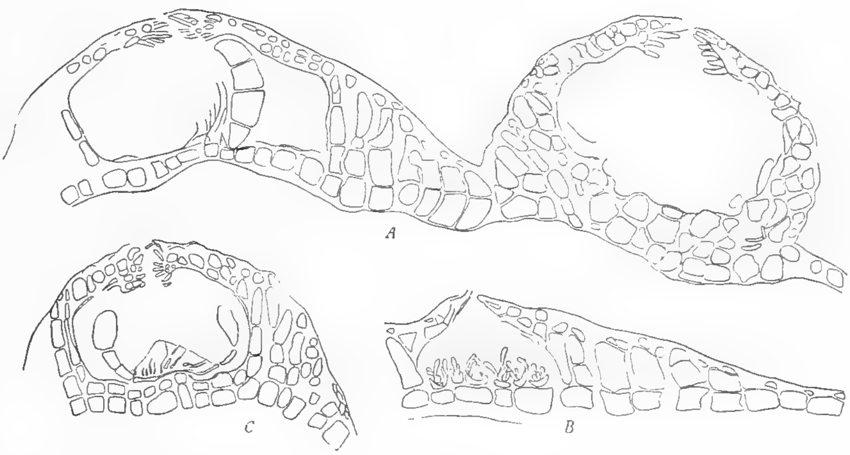


Fig. 171.
Melobesia Fosliei growing on Corallina officinalis from ZC[1], north of Læsø *A*, vertical section of frond with two conceptacles, one hemispherical, the other depressed. *B*, vertical section of frond with antheridial conceptacle. *C*, vertical section of cystocarpic conceptacle. *A* and *C* 260 : 1. *B* 420 : 1.

I have been much in doubt in determining the specimens referred to this species. Some of them, those from Bragerne, Skagerak, have been referred to *M. Lejolisii* by Foslie (Remarks, p. 106) and I have also been much inclined to consider them as a more or less reduced form of this species. However, I have judged it better to describe it as a new species, considering, besides other characters, especially the higher conceptacles of sporangia, the formation of the spermatia taking place in our species at the bottom of the conceptacle from short cells, while in *M. Lejolisii* they are produced at the end of long sterigmata, and the long curved spermatia, while those of *M. Lejolisii* are much shorter. The antheridial conceptacles more resemble those of *M. limitata*, but this species is more different principally by the stronger development of the filaments surrounding the ostiole. It much resembles *M. minutula* Fosl. (comp. Foslie Remarks p. 107) from which it differs by its more incrusted frond and by the usual presence of trichocytes. Whether it can be kept distinct from it must be decided by further investigations.

Localities. **Sk:** YN², south-east of Bragerne, on *Polysiphonia nigrescens* and *violacea*, July; Lønstrup, on *Corallina rubens*, washed ashore, June (C. H. Ostenfeld). — **Kn:** Within Deget near Frederikshavn, on *Cor. rub.* (C. H. Ostenf.); north-east of Hirsholmene, 6—7,5 meters, August, (C. H. Ostenf.); TL, north of Læsø, on *Cor. rubens*, Sept.; ZL¹, north of Læsø, 9,5 meters, on *Corallina officinalis*, July; TP, Tønneberg Banke, 16 met., on *Cor. rubens*, Sept.

5. **Melobesia minutula** Foslie.

Foslie, Algolog. Notiser, 1904, p. 8; Remarks, 1905, p. 107.
Lithocystis Allmanni Harvey, Phyc. Brit. Vol. II, plate 166, 1849 (?).
Melobesia inæquilatera Solms, Corall., 1881, p. 12, Taf. III fig. 13—18 (?).
Non *Epilithon Van Heurckii* F. Heydrich in J. Chalon, Liste des Algues mar. obs. jusqu'à ce jour entre l'embouchure de l'Escaut et la Corogne, 1905, p. 207, fig. 1—5.

Foslie has referred to this species some specimens growing on Bryozoans attached to *Polysiphonia elongata* collected by me in the northern Kattegat (comp. Remarks p. 109). They form small, scarcely incrusted fronds consisting of a single layer of low cells, irregular in outline but not lacunose, wherefore it has been referred to f. *typica*. The frond is monostromatic in its whole extent to the border of the conceptacles. When seen from above, the cells are usually 7—10 μ broad, of the same length or a little longer. Very small hyaline cortical cells are as a rule present, covering the pericline walls. According to Foslie, they "mostly seem to be wanting", which statement is probably founded on the fact that they are only discernible by rather high magnifying powers, owing to their small size and transparence. They are narrower than in the other Melobesiæ examined by me. They were also found over the periclinal walls situated under the pseudodichotomies (fig. 172), a fact in accordance with the complete absence of trichocytes.

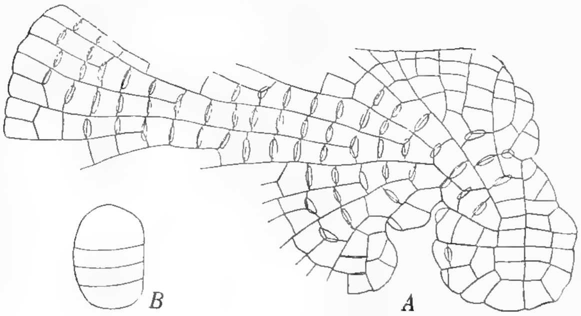


Fig. 172.
Melobesia minutula. *A*, part of a frond seen from above, at right the primary disc. The cortical cells have not been drawn in the upper and under part of the figure. *B*, a tetrasporangium. 350:1.

The sporangial conceptacles are conical-hemispherical with a small orifice surrounded by a whorl of cells radiating towards it. I found them about 90 μ in diameter (fig. 173). The sporangia were found to be tetrasporic (fig. 172 *B*), 43—54 μ long, 24—31 μ broad. Foslie found them only disporic. —

Further statements as to this species cannot be given owing to the very scarce material at hand.

The synonyms given are all dubious, as also mentioned by FOSLIE. The species described by HEYDRICH resembles FOSLIE's species by the structure of the frond, but if his description is correct, it cannot be identical with it, and must even belong to another genus, as the conceptacle is said to have as many openings as it contains sporangia. HEYDRICH's description of the cortical cells also does not agree with those of *M. minutula*, as they are said to cover the half of the cells of the disc; in *M. minutula* they are very narrow, covering only a small part of the underlying cells. It must therefore be concluded that HEYDRICH's species cannot be identified with *M. minutula*.

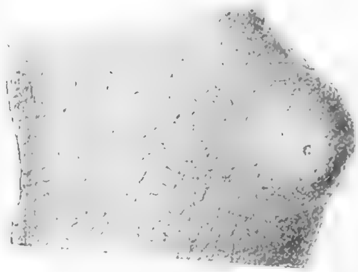


Fig. 173.
Melobesia minutula. Part of frond with conceptacle. 200 : 1.

The plant was found growing not only on the Bryozoan but also on *Ceramium tenuissimum* attached to the same *Polysiphonia*.

Locality. **Kn:** TP, Tønneberg Banke, 16 meters, September.

6. **Melobesia trichostoma** sp. n.

Frons primo monostromatica, dein, saltim maxima ex parte, polystromatica, usque ad 8 cellulis crassa, plerumque tamen e pluribus lobis vel frondibus secundariis minoribus, partim sese invicem obtegentibus composita, lobis plerumque usque ad marginem polystromaticis. Cellulæ frondis monostromaticæ vulgo 7—8 μ crassæ, latitudine plerumque paulo longiores, cellulis corticalibus transverse ellipticis munitæ. Frons adulta e filis verticalibus composita, cellulis longitudine vario, latitudine 1—3-plo longioribus. — Conceptacula sporangifera verruciformia, parum elevata, superne applanata, diametro 160 – 280 μ. Tectum planum, crassum, c. 5 cellulis crassum. Ostiolum pilis numerosis, sursum longioribus, superioribus ex ostiolo prominentibus ornatum. Sporangia tetraspora, 42—63 μ longa, 17—29 μ lata. Conceptacula mascula non prominula, ostiolo in tubo longo, sæpe curvato, protracto. Spermatangia lineari-clavata in fundo plano conceptaculi e cellulis depressis procreata, dense stipata. — Conceptacula cystocarpifera eadem forma magnitudineque ac sporangifera et peristomio simili ornata.

The specimens on which this species is founded formed dull rose-coloured crusts on the shells of living *Trochus cinerarius* collected in the Limfjord. They were referred to *Lithothamnion Lenormandi* by FOSLIE in 1905 and are also rather like old specimens of that species, especially the forma *squamulosa*. The frond is at first monostromatic, and the marginal part may remain so, much resembling that of *M. Lejolisii*, with well developed cortical cells, which seen from above are elliptical. A parietal body, situated closely at the outer wall in these cells is very intensely stained by hæmatoxyline (fig. 174 *A*). Trichocytes may occur. The greater part of the crust is polystromatic, being composed of vertical cell-rows, up to 8 cells high or more. The older parts of the crusts are very irregular, being composed of several smaller crusts or lobes growing partly over each other. These partial fronds or lobes are usually polystromatic to the very margin. The compound crusts may be composed of lobes of the same frond or of different fronds growing together; it is therefore impossible to state the diameter of the single frond. In the thicker fronds, the upper ordinary frond-cell may bear more than one cortical cell, frequently one over the other (fig. 174 *A*, *D*). In the last-named figure the three undermost cells at right bear each a cortical cell, the explanation of which must be that they represent the monostromatic border of the frond, which has been overgrown by tissue produced by the neighbouring thicker part of the same frond. A similar process often takes place in various parts of the frond and gives rise to the complicated structure of the old crusts, new lobes developing from certain parts of the frond, and growing over the neighbouring parts. — The length of the cells of the vertical cell-rows is highly variable, usually one to three times as long as the breadth, and irregularly varying in the same filament. The undermost cell-layer is not distinct from the others, its cells being of variable height. The cells contain often numerous starch-grains. Transversal pores between the cells of different cell-filaments never occur, but transversal fusions are frequently met with, between the cells of the basal layer and between cells of the upper parts of the vertical cell-rows as well (figs. 174, 175).

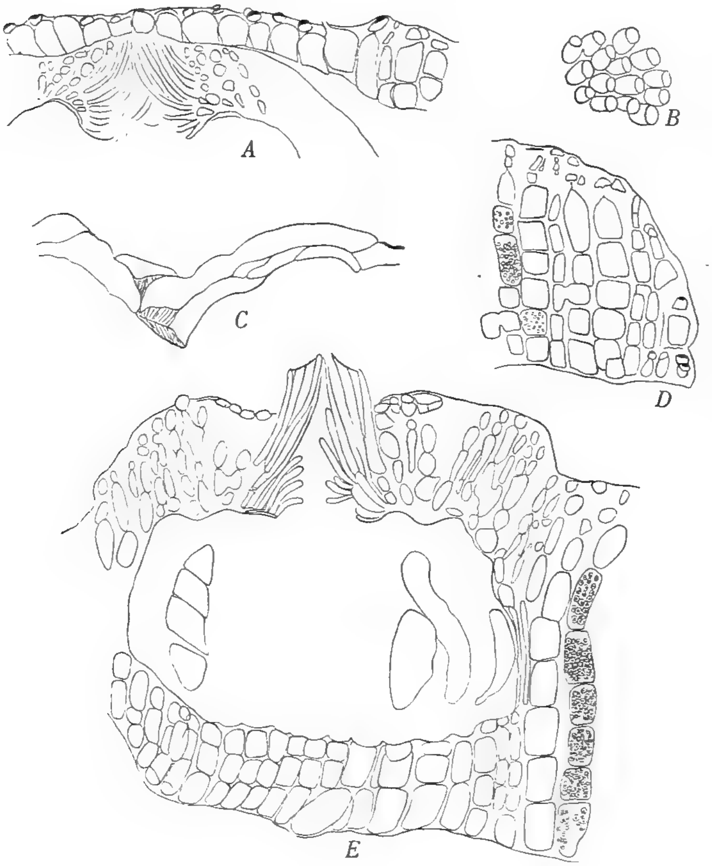


Fig. 174.
Melobesia trichostoma. *A*, vertical section of the monostromatic part of a frond growing over the conceptacle of another frond of the same species. *B*, monostromatic frond seen from above. *C*, vertical section of older, compound crust. *D*, vertical section of a thick lobe of frond. *E*, vertical section of sporangial conceptacle. *C*, 65 : 1, the rest 350 : 1.

The outer part of the sporangial conceptacles (fig. 174 *E*) is low, wart-like, with plane upper face. The outer diameter of the conceptacle is often difficult to state, as it is usually for a great part sunk in the frond, and the outer delimitation often indefinite. One to three layers of cells are present under the conceptacle. The roof is flat, thick, about 5 cells thick. The ostiole is clothed with numerous well-developed unicellular hairs, the uppermost of which are long, and protruding outside the ostiole; the undermost ones are shorter and more oblique or horizontal. They are all intensely stained by hæmatoxyline. The sporangia do not occupy the central portion of the conceptacle, where a small columella of sterile cells is sometimes to be found. The ripe sporangia are always tetrasporic. A small stalk-cell is present under the sporangia (not shown in the figure).

The antheridial conceptacles (fig. 175 *A*) much resemble those of *M. subplana* (comp. fig. 161), being provided with a similar tube, and the antheridia having the same shape and position as in that species.

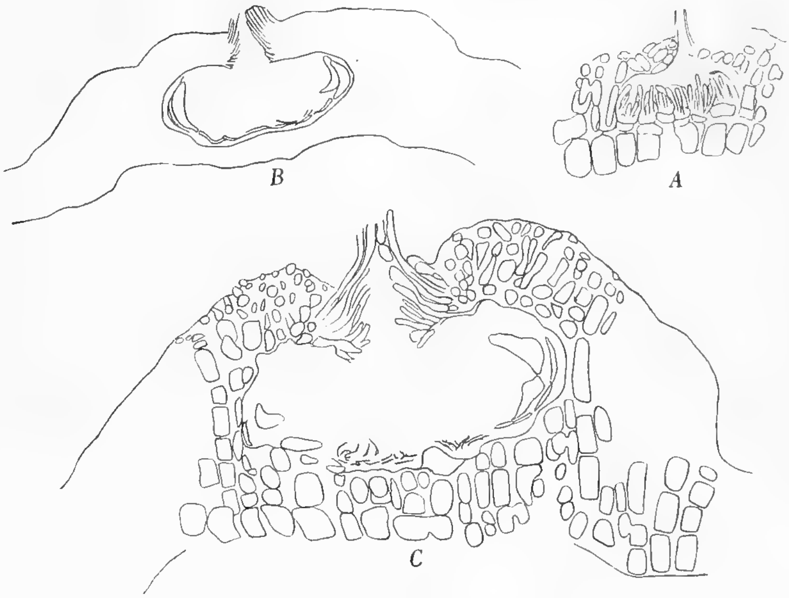


Fig. 175.
Melobesia trichostoma. *A*, vertical section of antheridial conceptacle. *B* and *C*, vertical sections of cystocarpic conceptacles. *A* and *C* 350 : 1. *B* 65 : 1.

The cystocarpic conceptacles (fig. 175 *B*, *C*) have the same shape and size as the sporangial ones, and the ostiole is endowed with a similar peristome. The thick roof is plane, or a little depressed near the ostiole. The carpospores are, as usually, produced seriately at the periphery of the conceptacle.

The species appears fairly distinct from all hitherto described species of the genus *Melobesia*. The low conceptacles with the thick, flat or a little deepened roof distinguish it from other species of the genus having a well developed peristome (e. gr. *M. Lejolisii*, *coronata*). Its occurrence on mollusc shells, unusual for the genus *Melobesia*, might seem grounds for placing it in the genus *Lithophyllum*; the want of transversal pores between the frond cells and the fact that these cells are not arranged in transversal rows, however, preclude its adoption in that genus.

Locality. **Lf:** Søndre Røn by Lemvig, near the surface of the water, September.

7. **Melobesia microspora** sp. n.

Frondes suborbiculares, sæpe confluentes, 1—2 mm diametro, excepta parte marginali polystromaticæ, e filis verticalibus usque ad 7-cellularibus compositæ; cellulis filorum 6—8 μ latis, diametro vulgo 1—2-plo longioribus, cellulis strati basalis plerumque brevioribus. Cellulæ corticales desunt. — Conceptacula numerosa contigua vel subcontigua. — Conceptacula sporangifera depresso-hemisphærica vel conica, diametro 120—140 μ, ostiolo vix papilloso, medio nonnunquam columella munita. Sporangia parva, 17—24 μ longa, (9—)11—12(—16) μ lata, semper 4-partita. Sub conceptaculis 1—4 strata cellularum vegetativarum. — Conceptacula mascula parva, paulo prominula vel omnino immersa. Spermatangia elongata vel clavata, fundum planum conceptaculi investientia. Spermatia lineari-clavata, nonnunquam leniter curvata, c. 6 μ longa, 2 μ lata. — Conceptacula feminea ut videtur forma structuraque conc. sporangiferis similia. — Hab. in fronde *Furcellariæ fastigiatæ*.

The species here described has only been met with once, viz. on a specimen dredged in the bay of Aarhus. The specimens were determined by Foslie as *Melobesia Lejolisii* Rosan. *forma*, but as will be seen from the description given here, it is very different from that species, particularly in the structure of the frond and the small dimensions of the sporangia.

The greater part of the frond is polystromatic; only the marginal part is monostromatic, but it is early divided by horizontal walls, and the frond is then composed of vertical filaments composed of from two to seven or eight cells. These filaments are usually 6—8 μ broad and consist of cells of varying length, usually 1 to 2 times as long as broad. The cells of the basal layer are rather varying in height, but they are usually lower than broad. There is thus no contrast between the basal layer and the perithallium. Seen from above, the cells of the basal layer show a breadth of 5—8 μ, about the same length or a little more, and appear to be frequently connected by lateral fusions (fig. 176 *C*). Such fusions may also occur between cells above the basal layer, but transversal pores (secondary) nowhere occur. It is remarkable that cortical cells as those characteristic of the other *Melobesia* species do not occur. When seen from above, the superficial cells present themselves as nearly quadratic cells arranged in rows, but no small cells cut off from them appear, not even after staining with hæmatoxyline, by which treatment the walls of all the outer cells and the cuticle are very intensely stained. Hair-cells were not observed.

The conceptacles are numerous, occupying most part of the crust, frequently contiguous, giving the frond a verrucose aspect. The sporangial conceptacles are depressed hemispherical or more rarely low conical. A more or less developed central narrow columella is not infrequently present. The sporangia which do not occupy the centre of the conceptacle are remarkably small; they are always fourparted, the three septa approaching each other in the middle of the sporangium (fig. 177 *A*). When seen from above, the small ostiole is seen to be surrounded by small-celled filaments radiating towards the centre. In a vertical section these filaments are only little conspicuous, and there are only feeble rudiments of papillæ in the conical orificium (fig. 177). One to four layers of vegetative cells are to be found under the conceptacles.

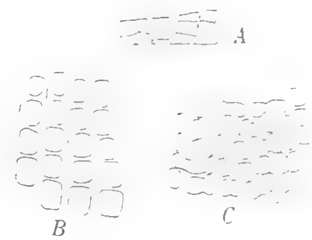


Fig. 176.
Melobesia microspora. A, vertical section of thin crust. *B,* surface view of crust near the border. *C,* basal layer seen from the face, showing numerous fusions. 350 : 1.

The antheridial conceptacles are small, sometimes entirely immersed, usually, however, more or less prominent. The inner cavity has a flat bottom, and may be about 40 μ in diameter. The ostiole is not prolonged in a spout. The spermatangia form a covering on the bottom of the conceptacle; they are produced from small squarish or trapezoid cells, and are lengthened, upwards incrassated, sometimes a little curved cells. Sometimes the spermatangia are produced not directly from the small squarish cells but from cells of the same shape as themselves (fig. 178 *C* at left). The spermatia are clavate, broadest in the upper end, sometimes slightly curved, about 6 μ long, and 2 μ broad at their broadest end, (fig. 178 *C*). Under the bottom of the conceptacles up to 5 layers of vegetative cells may be found.

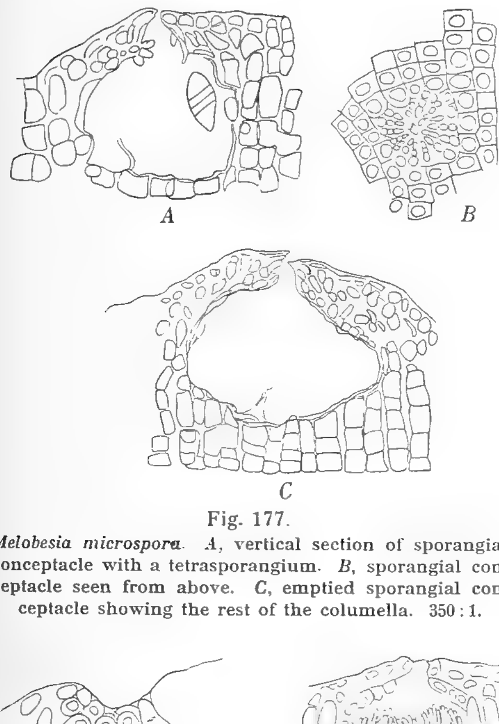


Fig. 177.
Melobesia microspora. A, vertical section of sporangial conceptacle with a tetrasporangium. *B,* sporangial conceptacle seen from above. *C,* emptied sporangial conceptacle showing the rest of the columella. 350 : 1.

Of female conceptacles I have only met with very few, which gave no clear idea of their structure. They seem to be similar in shape and structure to the sporangial ones. Fig. 179 shows a conceptacle containing carpogonia and trichogynes; at left is shown a carpogonium from another section of the same conceptacle.

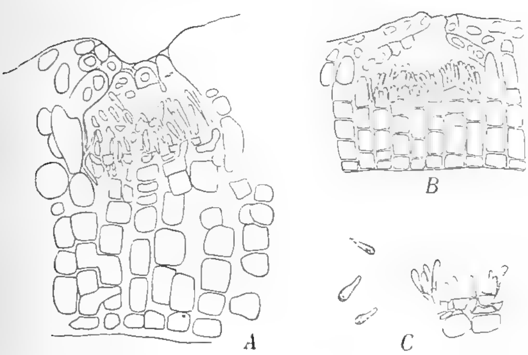


Fig. 178.
Melobesia microspora. A and *B,* vertical sections of frond with antheridial conceptacles. *C,* spermatangia and spermatia. *A* and *C* 560 : 1, *B* 350 : 1.

This species seems to be quite distinct from all well known species of the genus. The want of cortical cells is indeed so remarkable as possibly to suggest that it should be referred to another genus: but as other characters justifying its removal from the genus *Melobesia* are not known. I prefer to retain it under the genus provisionally. The small size of the tetrasporangia seems to be a significant mark distinguishing it from other species. The want of transversal pores between the cells of the vertical filaments, and the fact that these cells are not disposed in transversal rows, exclude it from the genus *Lithophyllum*.

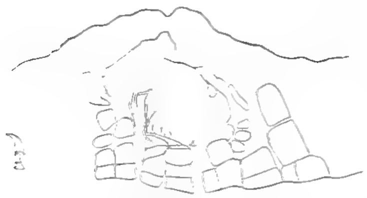


Fig. 179.
Melobesia microspora. Vertical section of female conceptacle; at left a carpogonium from another section of the same conceptacle. 420 : 1.

Only found once, growing on the frond of *Furcellaria fastigiata*, with ripe sporangia, ripe antheridia and carpogonia in April.

Locality: **Sa:** PP, Ryes Flak, 5 meters (no: 4670).

Choreonema Schmitz.

1. **Choreonema Thuretii** (Bornet) Schmitz.

Fr. Schmitz. Uebersicht. Flora 1889, p. 21 (reprint); id. in Engler u. Prantl. Nat. Pflfam. I p. 541; Fr. Minder. Die Fruchtentwicklung von Choreonema Thur. Diss. Freiburg, s. a.

Melobesia Thuretii Bornet in Thuret, Etudes phycolog., 1878, p. 96, pl. 50, fig. 1—8; Solms-Laubach, Corallinenalgen d. G. v. Neapel. 1881, p. 12, 54, Taf. III fig. 1, 4—10.

Endosiphonia Thuretii Ardissone. Phycologia mediterranea. I. Varese, 1883, p. 451.

This interesting Alga, parasitic in *Corallina rubens*, has been met with in a few localities in the Northern Kattegat and perhaps also in the Skagerak. Unfortunately, the collected material was lost, except that from a single locality near Frederikshavn; I must therefore content myself with referring to the quoted publications.

Minder has in his important paper given a thorough description of the development of the cystocarp, which in essential points modifies the statements of Solms-Laubach. After fertilization, the zygote gives off short sporogenous filaments, which gradually fuse with the auxiliary cells, but none of the numerous sporogenous nuclei enter into these cells. From the marginal lobes of the resulting great sporophytic cell (which is not produced by mutual fusion of the auxiliary cells, but has been nourished by them) the carpospores are produced, becoming cut off by watch-glass-formed walls.

As I have had very few specimens at my disposal, I cannot give any statement as to the fructification in the Danish waters,

Localities. **Sk** (?). — **Kn:** Within Deget near Frederikshavn (C. H. Ostenfeld), and perhaps a few other localities.

Lithophyllum Phil.

Subgenus ***Eulithophyllum.***

1. **Lithophyllum orbiculatum** (Foslie) Foslie.

Foslie. Rev. survey (1900) p. 19 (without mention): Remarks (1906) p. 112.

Lithothamnion orbiculatum Foslie. Norw. Lithoth. (1895), p. 143, pl. 22 fig. 10—11.

The crust is generally orbicular, scarcely exceeding 2 cm in diameter. In one locality only I found larger crusts expanded over stones; as these crusts also in other respects differred from the others, they will be mentioned separately below. The crusts are 1 to 1,5 mm thick.

According to Foslie, the hypothallic layer mainly resembles that of *Lithoth. læve*, being rather feebly developed (Remarks p. 112). I found it, however, always consisting of one layer only, the upright filaments springing out from it in a vertical or nearly vertical direction. The thickness of the perithallic cells varies between 6 and 9 μ; the height is generally greater than the breadth, often about double (about 13 μ), but it may be of the same size or even smaller. Foslie describes these cells as squarish; I found them generally more or less roundish, frequently approaching the ellipsoid or globe. They are connected with the cells of the neighbouring filaments through transversal pits situated about in the middle of the cells; in transverse sections 3 to 5 such pits are seen in each cell (fig. 180 *C*). The crust is traversed by horizontal limiting lines which are stained intensely blue by hæmatoxyline; they are often seen crossing the middle of the cells (fig. 180 *A*). Mme Lemoine did not find such limiting lines in any species of *Lithophyllum* (Struct. p. 28). The cells of the perithallium are frequently filled with starch grains, particularly in the under part of the crust. The surface of the frond is frequently much inclined towards the border, which in vertical section shows a great marginal cell (fig. 180 *D*).

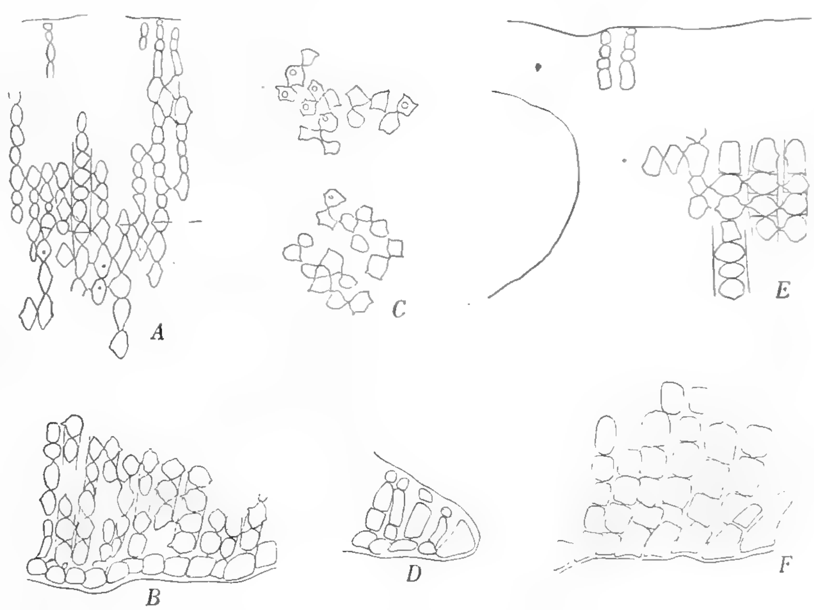


Fig. 180.
Lithophyllum orbiculatum. *A*, vertical section of crust; *B*, under part of the same crust. *C*, horizontal section of crust showing the tranverse pits. *D*, vertical section of margin of frond. *E* and *F*, vertical sections of aberrant specimen (no. 5341), *F*, showing the hypothallium. 350 : 1.

The conceptacles of sporangia are completely immersed; they had in the specimens examined a transverse inner diameter of 92—116 μ; they are generally almost globular in a vertical section. They have a single pore in the middle of the roof which is not surrounded by peculiarly shaped cell-rows. The sporangia are four-parted: I found them 70 μ long, 24—35 μ broad, thus somewhat smaller than indicated by Foslie. However, I have only met with a small number of well developed sporangia; I am therefore also unable to state whether they are placed over the whole conceptacle or only in its periphery. A group of sterile filaments in the middle of the floor was not observed. The emptied conceptacles are limited by a sharp inner contour.

Supposed antheridial conceptacles are shown in fig. 182. They had a transverse diameter of 60—77 μ and the slightly prominent pore surrounded by a number of

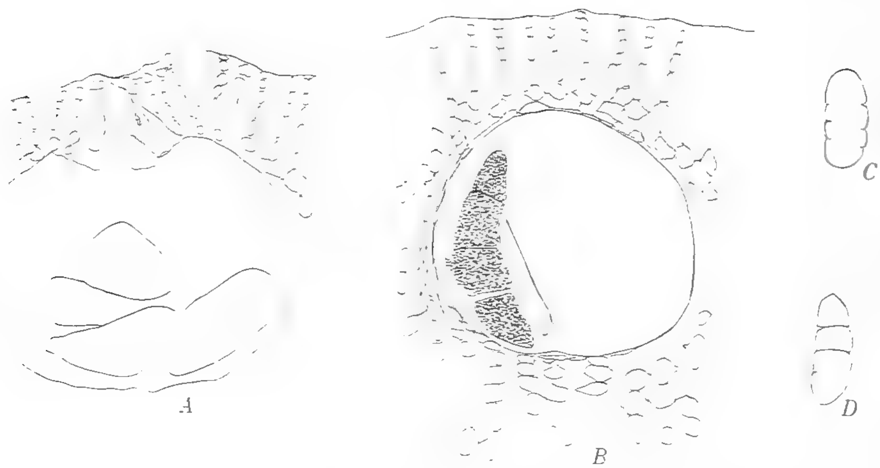


Fig. 181.
Lithophyllum orbiculatum. *A*, vertical section of tetrasporic conceptacle showing the pore. *B*, similar, but somewhat excentric section. *C* and *D*, feebly developed, not yet fully divided sporangia 350 : 1.

peculiarly formed narrow, obliquely upwardly directed filaments, forming the central part of the roof. The rather plain floor was in some cases covered by a very small-celled layer which had probably supported the spermatangia. In some of these conceptacles small bodies were seen which were supposed to be spermatia.

The conceptacles of cystocarps are entirely immersed (fig. 183); they have an inner diameter of 112—142 μ. (According to Foslie it is 200—300 μ, but it is not stated if it is the inner or the outer diameter). The pore is surrounded above by obliquely upward directed filaments resembling those of the antheridial conceptacles; but below them is situated an inner crown composed of obliquely downward directed cells. Fig. 183 *A* shows a number of carpogonia in the central part of the floor, those situated nearest the centre having the longest trichogynes. The carpospores are produced from the margin of the disc-cell at the base of the conceptacle (fig. 183 *B*). The inner crown of the peristome keeps for a long time in the overgrown conceptacles.

According to Foslie (Remarks p. 113) "the conceptacles do not become gradually overgrown, as far as hitherto seen". It may happen that the emptied conceptacles are filled with filaments growing out from the bottom of the conceptacle, but it also not unfrequently occurs that they are overgrown without being filled, and empty conceptacles are thus found at various depths in the thicker crusts. This was observed with all kinds of conceptacles.

As mentioned above, I found in one locality (TL, north-west of N. Rønners Rev, 4—5,5 m, Sept. 1894, nº 5341) some specimens somewhat different from the ones just mentioned. They form much more expanded crusts, up to 10 cm or more in diameter, and the cells of the perithallium are thicker, 9—12 μ broad, 7—16(25) μ long. These measurements, however, are only little different from those given by Foslie, who has also determined these specimens as *Lith. orbiculatum forma*. The hypothallium consists, as in the other specimens, of a single cell layer, but the cells are frequently elongated obliquely upwards, in the same direction as the perithallic filaments, and they are similar to the cells of these filaments (fig. 180 *E*, *F*). The examined crust contained sporangial conceptacles 77—122 μ in diameter, with a single pore; in an old conceptacle a few not exhausted two-parted sporangia were still present. It must be left to further investigations to determine whether these specimens really belong to *L. orbiculatum*.

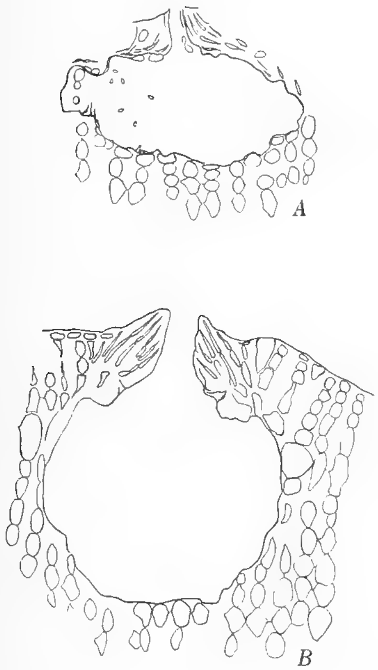


Fig. 182.
Lithophyllum orbiculatum Supposed antheridial conceptacles. In *A* small bodies are seen which are probably spermatia. 350 : 1.

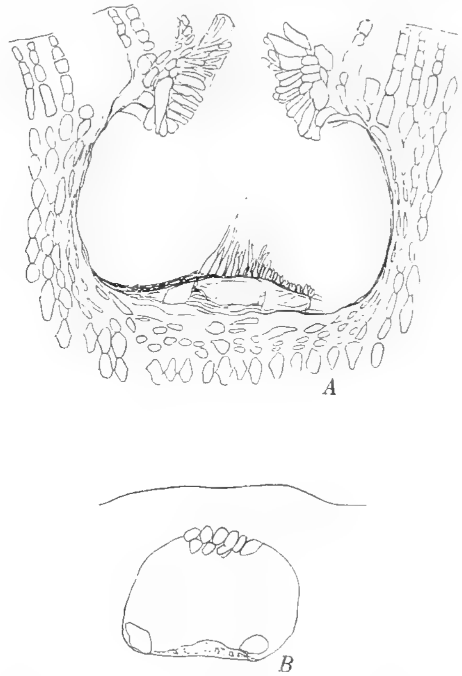


Fig. 183.
Lithophyllum orbiculatum. Cystocarpic conceptacles, *A*, showing the pore and the carpogonia. 350 : 1. *B*, excentric section showing the inner crown and two carpospores at the periphery of the disc. 200 : 1.

Foslie discusses (Remarks p. 113) the question, whether this species might possibly be a northern form of *Lithophyllum incrustans*. This supposition would not agree with the fact that the last named species, according to Mme Lemoine (Struct. anat. pl. IV fig. 1), has a much developed hypothallium. On the other hand, a specimen collected by me at Cherbourg and determined by Foslie as *Lithophyllum incrustans,* showed a one-layered basal layer and on the whole the same anatomical structure as *L. orbiculatum*. The question as to mutual relation of the two species must therefore be left undecided.

The species has in the Danish waters only been found in the northern, eastern and southern Kattegat and in the Sound. It has been met with in depths from 16,5 to 24,5 meters. The aberrant specimens were dredged in a depth of 4—5,5 m.

Localities. **Kn:** TL, N.W. of Læsø, 4—5,5 meters, large crusts, Sept., nº 5341 (see above). — **Ke:** IR, Groves Flak, 24,5 meters; IK and IH, Lille Middelgrund; IA, Store Middelgrund. — **Ks:** HO, east of Hesselø. — **Su:** bM, south of Hveen, 12,5 meters.

Subgenus ***Dermatolithon*** Foslie.

As mentioned above, p. 236, the genus *Dermatolithon* was established by Foslie in 1898 (List of Spec., p. 11), only however as a *nomen nudum,* and the following species of *Melobesia* were referred to it: *M. pustulata, Lejolisii* and *hapalidioides.* In 1900 (Rev. syst. Surv., p. 21) the genus was described and *M. macrocarpa* was further referred to it, besides two uncertain species, while *M. Lejolisii* was removed from it. It was founded on characters of the sporangial conceptacles (comp. p 237). Later on (Algol. Not. I, 1904, p. 3), Foslie judged that these characters were of small systematic value, he pointed out the relations of these species to the genus *Lithophyllum,* and transferred *Dermatolithon* as a subgenus under *Lithophyllum,* characterized by having the hypothallium formed by a single layer of inclined cells, in contradiction to *Eulithophyllum* and *Lepidomorphum,* the hypothallium of which always consists of several cell-layers. Three years later (Algol. Not. VI, 1909, p. 58) Foslie raised it again to a distinct genus characterized only by the last-named character. As mentioned above, the species of *Dermatolithon* agree with *Lithophyllum* in the presence of transversal pits between the vertical cell-rows. A difference is certainly said to exist in the hypothallium being in *Dermatolithon* monostromatical, while it is polystromatical in *Lithophyllum;* but Foslie admits himself that the hypothallium may sometimes be partly polystromatical in *Dermatolithon,* (1909, p. 57). And in *Lithophyllum orbiculatum* mentioned above there is evidently a monostromatical hypothallium (fig. 180). Further, in *Dermatolithon,* the cells of the hypothallium are usually long and oblique, but they may also be rather short and only little inclined (fig. 189), which may likewise be met with in *Lithophyllum,* e. g. in *L. orbiculatum,* fig. 180 *F.* It must therefore be concluded that *Dermatolithon* cannot be kept distinct from *Lithophyllum* as a separate genus, at all events on the basis of the anatomical structure, but must be regarded only as a subgenus.

Lithophyllum Corallinæ (Crouan), which was already in 1897 transferred from the genus *Melobesia* to *Lithophyllum*, seems particularly to be a connecting link between *Dermatolithon* and the typical *Lithophyllum*.

2. **Lithophyllum macrocarpum** (Rosan.) Foslie.

Foslie, Remarks, 1905 (1906), p. 128; M. B. Nichols, Contribut. to the knowledge of the Californ. spec. of crustaceous Corallines. II. University of California Publ. in Botany. Vol. 3, No. 6, 1909, p. 352, figs. 12, 15, 16, 17; Foslie, Algol. Notiser VI, 1909, p. 47.
Melobesia macrocarpa Rosanoff, Recherches, 1866, p. 74, pl. IV, figs. 4—8, 11—20.
Dermatolithon macrocarpum Foslie, Rev. Surv., 1900, p. 21; Algol. Not. VI, 1909, p. 58.

f. *typica* Foslie.

L. pustulatum (Lamour.) Foslie f. *macrocarpa* (Rosan.) Fosl., Remarks, p. 117.

It seems that only the specimens from one locality growing on *Phyllophora membranifolia* are with certainty referable to the typical form which, according to Foslie, differs from the following form by the frond attaining a greater thickness and by the sporangial conceptacles being up to 600 μ in diameter but a little lower proportionally to the diameter. The frond of the named specimens, however, attains only a thickness of 200 μ; the sporangial conceptacles measured over 500 μ, and under them were 3—4 layers of cells. The other specimens referred by Foslie to this variety are partly sterile and only determined with doubt, or they seem not to possess the characters named.

Localities. **Kn:** Trindelen, 15 meters, on *Phyllophora membranifolia*, July, with ripe sporangia. — Further recorded with doubt from the following localities. **Lf:** Nykøbing, on *Chorda Filum*, (Th. Mortensen). — **Kn:** Hirsholmene, on *Fucus vesiculosus*; Nordre Rønner, on *Fucus vesiculosus*; TG, north of Læsø, 9,5 m, on *Phyllophora membranifolia*, sterile.

f. *intermedia* Foslie.

Foslie, Remarks, 1905, p. 117; Nichols, Crustaceous Corallines, II, 1909, p. 352, plate 11 fig. 12, pl. 12 figs. 15—17.
L. pustulatum (Lamour.) Foslie f. *intermedia* Foslie, Remarks, p. 128.

Most of the specimens of this species have been referred by Foslie to the f. *intermedia*, which has later been carefully described by Nichols, l. c. I have nothing to object against the determinations of Foslie, and I shall not enter into the question as to whether the species can be kept distinct from *L. pustulatum*, but will merely remark that I have always found two-parted sporangia. In referring to the quoted descriptions and figures however, some remarks on the Danish species may be added.

These are almost all growing on *Fucus vesiculosus*, where they form crusts measuring 4—7,5 mm in diameter, frequently confluent. The border of the frond, which is not always adherent to the substratum, consists of a single layer of long oblique cells, each bearing a cortical cell cut off by an oblique wall. Later on, the long cells are divided by a transversal wall, the crust thus being composed of two layers of cells, not including the cortical cells, and further transversal divisions frequently do not occur except in the immediate vicinity of the conceptacles; it may even happen that the frond is monostromatic in almost its whole extent. The long cells in the upper layers are always connected with transversal pits (fig. 184). The thickness of the frond is rather variable. Monostromatic fronds were 25—42 μ thick, fronds consisting of two layers of cells 67—105 μ and fronds containing three layers were 91—123 μ thick. The fronds are frequently growing over each other. It also frequently happens that new growing edges are produced from certain parts of the frond, growing over the neighbouring parts the growth of which has ceased. The long cells contain a small nucleus in the upper part of the cell, and a number of small chromatophores spread in the cell. The cortical cells are produced early, immediately after the formation of the long cells by the division of the marginal cell. But at some distance from the margin a new cortical cell may be cut off under the primary one by a horizontal or inclined wall (fig. 184 *B*), and this process may be repeated several times. Hyaline hairs may be produced from long cells seemingly not different from the others, and provided, like these, with a cortical cell (fig. 184 *B*). The length of the long cells of the frond varies greatly; when the crust is polystromatic, the cells of the undermost layer are often rather short. When these cells or those of the monostromatic frond are long, their undermost part is usually more inclined than their upper part (fig. 184 *B*, comp. NICHOLS, l. c. fig. 12, 15).

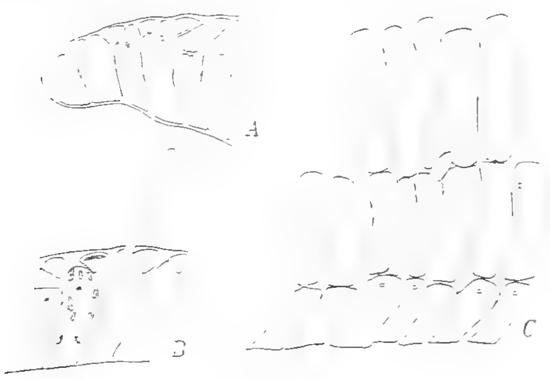


Fig. 184.
Lithophyllum macrocarpum f. *intermedia*. Vertical sections of fronds. *A*, margin of frond. *B*, part of monostromatic frond showing a hair-cell and two cortical cells cut off from one cell. *C*, part of thicker crust; transversal pits between the cells of the two upper layers. 350 : 1

The sporangial conceptacles are very prominent, conical with rounded or applanated top, 300—500 μ in diameter. Under the conceptacle 1—3 layers of sterile cells are present. Papillæ projecting inward and upward, lining the pore, as described and figured by NICHOLS, may be found in the under part of the pore, but they are usually slightly developed. Seen from above, the superficial cells surrounding the pore appear scarcely different from the others, the nearest being only a little smaller (fig. 185 *B*). The sporangia are only placed in the peripheral part of the conceptacle, the central part being occupied by sterile cells forming a conical columella. NICHOLS found also sporangia in the central part, though less numerous there than at the periphery. As shown by this author, each sporangium is born by a stalk cell. A "plug" was found in some rare cases in the ostiole, forming a continuation of the central sterile cells (fig. 185 *A*), but it seems to be usually wanting, and was not found by NICHOLS. The sporangia are disporic; they were found to be 105—140 μ long, 35—60 μ broad; the smallest ones, however, were perhaps not ripe.

Antheridial conceptacles were not observed.

Cystocarpic conceptacles were only found in specimens from one locality (Kalö). They are of the same shape and size (about 400 μ in diameter) as the sporangial ones, and the ostiole is of the same structure, being without or only with poorly developed papillæ in the under part. The carpospores are only produced at the periphery.

This variety has only been found growing on *Fucus vesiculosus* and *Fucus serratus* a little below low-water mark. It is particularly abundant in the Limfjord, probably owing to the high salinity and the high summer temperature of this

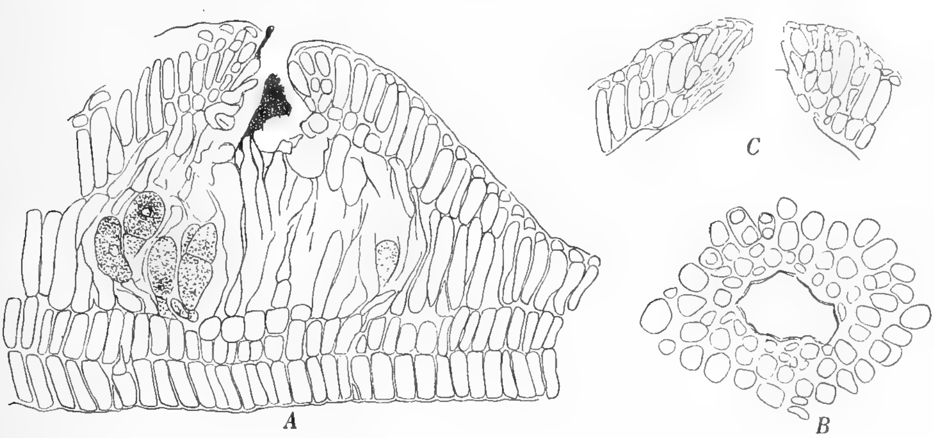


Fig. 185.
Lithophyllum macrocarpum f. *intermedia*. *A*, vertical section of not quite ripe sporangial conceptacle. *B*, orifice of sporangial conceptacle seen from above. *C*, vertical section of orifice of cystocarpic conceptacle. *A* and *C* 200 : 1. *B* 350 : 1.

water. Ripe sporangia have been met with in summer, June to September. In April two-parted sporangia were found, but not fully ripe, and in the same month cystocarpia were found.

Localities. **Lf:** Søndre Røn by Lemvig; Oddesund; MH, bank of Skrandrup, MG. off Hanklit, and Thisted in Thisted Bredning; I, Venø Bugt; Nykøbing; Sallingsund, pier; Amtoft Rev; LQ, Lendrup Røn; Løgstør. — **Kn:** Hirsholm and Kølpen near Frederikshavn. — **Ks:** Isefjord: on the beach near Frederiksværk (Th. Mortensen); Lammefjord; Holbæk Fjord. — **Sa:** Reef near Kalø; Æbelø. — **Sf:** near Birkholm.

3. Lithophyllum Corallinæ (Crouan) Heydr.

F. Heydrich, Corallineae, insbes. Melobesieae. Ber. deut. bot. Ges. Bd. 15, 1897, p. 47.
Melobesia Corallinæ Crouan, Florule du Finist., 1867, p. 150, pl. 20, genre 133 bis, fig. 6—11.
Lithophyllum pustulatum (Lamour.) Fosl., f. *Corallinæ* (Crn.) Foslie, Remarks, 1905, p. 118.

In two localities in the Skagerak a few specimens of a calcareous alga were found growing on *Corallina officinalis* and agreeing with the short description and the figures of *Melobesia Corallinæ* Crouan (l. c.). These specimens have not been examined by Foslie, but as this author regarded Crouan's species as being only a form of *Lithophyllum pustulatum*, he would probably have referred our plant "as a denominated form" to *L. macrocarpum*, whereas it has disporic sporangia. A closer examination of my specimens, some of which were preserved in alcohol, showed me, however, such differences from the named species that they cannot, in my opinion, be referred to it, but must be regarded as representing a different species bearing Crouan's name.

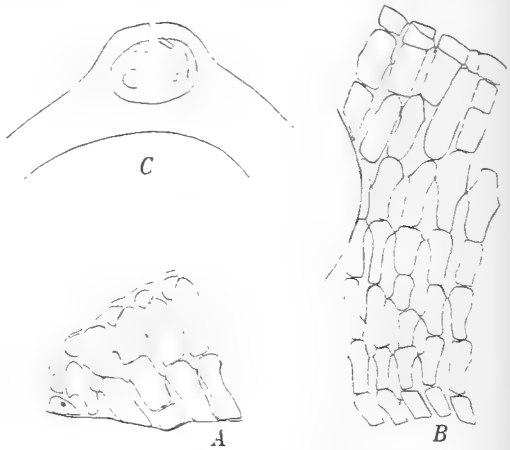


Fig. 186.
Lithophyllum Corallinæ, from Hirshals. *A*, vertical section of edge of frond. 560 : 1. *B*, vertical section of frond near a conceptacle. 350 : 1. *C*, section of frond with sporangial conceptacle. 65 : 1.

The crust is in some cases surrounding the *Corallina*-frond, being attached to it in its whole extent and fusing together where the borders meet. In other cases it is only attached by its central thicker portion, while the thinner edges of the orbicular, peltate frond are free (fig. 187, comp. Crouan, l. c. fig. 6, 7). In the first case the frond was up to 105 μ (over 12 cells) thick, in the latter the central part was about 250 μ thick, the inner edge 70—105 μ thick. The diameter of the peltate fronds is 2—2,5 mm. The edge of the frond is thick, polystromatic to the very margin or nearly so, the cells cut off from the marginal cell dividing early by transversal walls. The marginal cell is much smaller than in *L. macrocarpum* (fig. 186 *A*). The undermost cell in the vertical or ascending cell-rows constituting the frond is not longer than the others, frequently even shorter, being only 1—3 times as long as broad; these cells are usually inclined. The cells of the upper cell-layers are frequently much longer; the transversal pits of these cells are always distinct; they are shown in fig. 186.

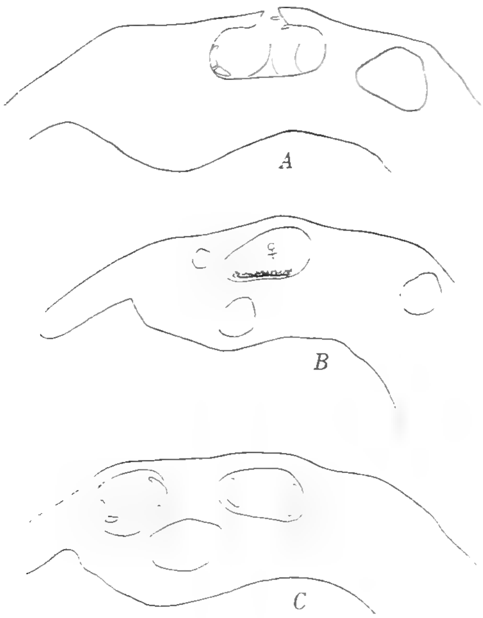


Fig. 187.
Lithophyllum Corallinæ, from Hanstholm, vertical sections of scutate fronds with free edges. Sporangial conceptacles in *A* and *C*. cystocarpic conceptacles in *B*. Overgrown conceptacles in *B* and *C*. 65 : 1.

The sporangial conceptacles are only little prominent, forming low warts with a more or less plane upper face, the cavity being entirely or for the most part sunk in the frond. Their outer diameter is therefore often difficult to state, but it reaches at least 350 μ. The cavity is nearly globular or usually more or less flattened. The ostiole is without or provided with poorly developed papillæ in its under part. In some cases the ostiole was found to be excentric. The sporangia are only placed at the periphery of the conceptacle, the central part being occupied by a conical columella. The sporangia are always disporic, 50—88 μ long, 18—32 μ broad. The number of sterile cell-layers under the conceptacle varies greatly according to the thickness

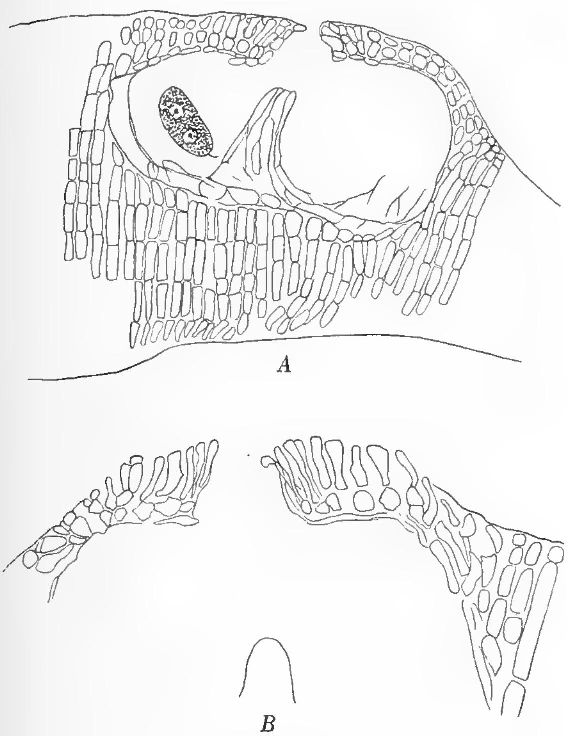


Fig. 188.
Lithophyllum Corallinæ. *A*, vertical section of sporangial conceptacle. 205:1. *B*, vertical section of upper part of a similar one. 350:1.

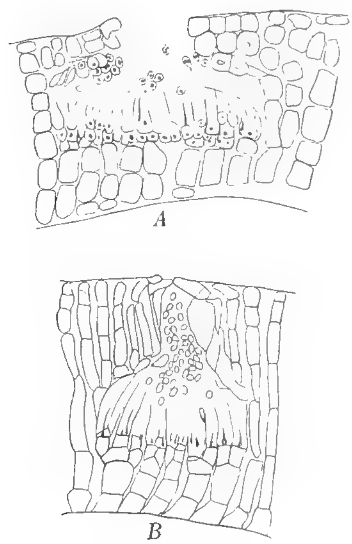


Fig. 189.
Lithophyllum Corallinæ. *A*, Vertical sections of antheridial conceptacles. In *A* some spermatia show two nuclei. *A* 350:1. *B* 370:1

and age of the frond. In thicker, older fronds the first produced conceptacula after evacuation become overgrown by the continued growth of the surrounding tissue and are later found as empty cavities in the under part of the crust, while new conceptacula are formed at a higher level (fig. 187).

The antheridial conceptacles are entirely sunk in the frond, not prominent, rather low, with a flat bottom and a shorter or longer orifice. The spermatia are produced at the end of long sterigmata given off from small cells covering the bottom of the conceptacle. The ripe spermatia are globular-ovoid, at one end (the basal one) drawn out in a short point. Two nuclei were distinctly visible in isolated spermatia (fig. 189 *A*).

The cystocarpic conceptacles have the same shape and size as the sporangial ones. The papillæ lining the ostiole were found more developed than in the sporangial conceptacles. The structure of the cystocarp rather resembles that of *Corallina*, a large disc-shaped cell occupying the bottom of the conceptacle giving off at the periphery seriate carpospores and covered with numerous closely placed oblong cells filled with protoplasmatic contents, the morphological character of which could not be determined, as trichogynes were in no cases observed (fig. 190). The cystocarpic conceptacles become overgrown and sunk in the crust as also the sporangial conceptacles.

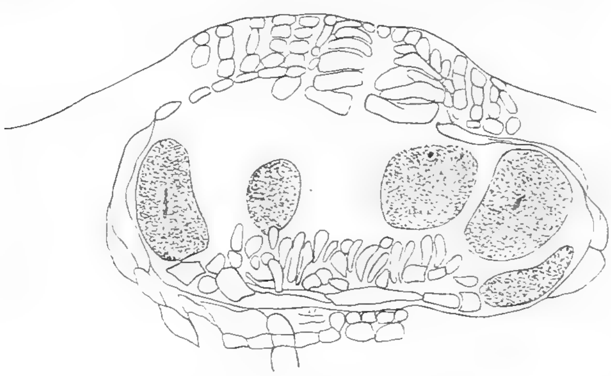


Fig. 190.
Lithophyllum Corallinæ. Vertical section of cystocarpic conceptacle. 350 : 1.

The structure of the frond, being polystromatic to the margin, and the slightly prominent conceptacles being sometimes overgrown and deeply sunk in the frond, are the principal characters distinguishing this species from the foregoing, with which it agrees in its disporic, though smaller sporangia. It is apparently not identical with *Melobesia Corallinæ* Solms (Corall. p. 9, Taf. II, fig. 25, III fig. 21—24) which differs, to judge from the figures, by tetrasporic sporangia, occupying the central part of the conceptacle, by the want of columella, and apparently by the structure of the frond, the basal cell-layer being very low.

Found with sporangia and cystocarps in July and August.

Localities. **Sk:** YT, YU, Hanstholm, 2—6 meters; Hirshals, on the mole.

4. Lithophyllum pustulatum (Lamour.) Foslie *forma*?

Mention may be made here of an alga recorded once growing on *Corallina officinalis* but which could not be identified with certainty on account of the incomplete state of the present material. It forms thin red crusts, the peripheral part of which is monostromatic with cortical cells, only 14—20 μ thick, while the central portion, consisting of 2—3 cell-layers, besides the cortical cells, has a thickness of up to 80 μ.

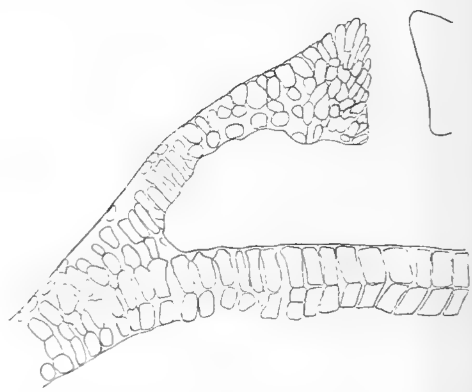


Fig. 191.
Lithophyllum pustulatum forma?. Vertical section of one half of an empty conceptacle. 205 : 1.

The cells of the vertical cell-rows are proportionally short, and connected with transversal pits. Only empty conceptacles were found. They are about 420—500 μ in diameter, conical-subhemispherical, somewhat lower in proportion to the breadth than in *L. macrocarpum*. The roof is of solid structure and is very thick near the ostiole. The cells surrounding the upper part of the ostiole are elongated but not projecting as free papillæ. Our alga reminds one of *L. pustulatum* f. *australis* Foslie (Remarks, p. 117, NICHOLS, Contrib. II, 1909, p. 356, fig. 21—24) from which it differs, however, to judge from NICHOLS' description, by the want of papillæ surrounding the ostiole. As the conceptacles were empty, their nature could not be determined.

Locality: **Ke:** Store Middelgrund 19 meters, May.

Corallina L.

1. Corallina officinalis L.

Linné, Fauna Suecica 1761, p. 539; Kützing, Phyc. gener., 1843 p. 388, Taf. 79, Fig. 1; Harvey, Phyc. Brit. II, 1849, pl. 222; J. E. Areschoug in J. Agardh, Spec. II, 2, 1851–52, p. 562; Kützing, Tab. phyc. Vol. 8, 1858, Tab. 66—68; Kny und Magnus, Ueber ächte und falsche Dichotomie im Pflanzenreich. Botan. Zeit. 1872 Sp. 708; Thuret, Études phycologiques, 1878, p. 93 pl. 49; Solms, Corallinenalg., 1881 (Corallina mediterranea); Hauck, Meeresalg., p. 281; Guignard, Dév. et const. des anthérozoïdes. Revue gén. T. I, 1889, extrait, p. 50, pl. VI fig. 24—26 (spermatia); B. M. Davis, Kerntheilung in der Tetrasporenmutterzelle bei Corallina offic. Ber. deut. bot. Ges. 1898, Bd. 16 Heft 8, p. 266; K. Yendo, Corallinæ veræ japonicæ. Journ. Coll. of Science. Imp. Univ. Tokyo. Vol. XVI. Art. 3, 1902, p. 28, pl. III fig. 11—13, pl. VII, fig. 10—13; id., Study of the genicula of Corallinæ. Ibid., Vol. XIX, Art. 14. 1904; id., A revised list of Corallinæ. Ibid., Vol. XX, 1905, p. 29; Oltmanns, Morph. u. Biol. d. Algen, I, 1904, p. 562.

The articulated fronds are given off from a basal crust much resembling some crustaceous *Lithothamnia* (comp. HARVEY, l. c.). In some cases it is rather small and gives off numerous closely placed fronds from almost its whole surface. In other cases it is widely extended, up to 2,4 cm. in diameter or more, and bears only a small number of erect fronds (fig. 192). The border is lobed, the lobes being now broad, now narrow. In the latter case the lobes are more or less branched and often keep their independence, being separated by deep furrows when meeting, but it also happens that they grow partly over each other; in other cases, however, they are confluent. Concentric zones are sometimes very distinct. In the anatomical structure they resemble the crustaceous *Lithothamnia*, showing a hypothallium consisting of long cells running in a horizontal direction and a perithallium composed of ascending filaments of shorter cells. The last cell of the latter is very short, the penultimate proportionally long. There seems to be a continuous layer of non-

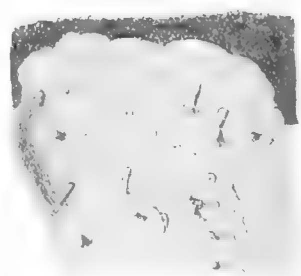


Fig. 192.
Corallina officinalis. Basal crust with scattered articulated fronds or scars after them; at right it meets with a crust of a Lithothamnion. 4:1.

dividing cover cells similar to that pointed out for the articulated fronds and for *Lithothamnion* by Solms (Corall., p. 27 and 29). The cells of the hypothallium and those of the inner perithallium were, in a specimen collected in July, filled with starch grains, while the cells of the outer perithallium showed numerous disc-shaped chromatophores and a single nucleus.

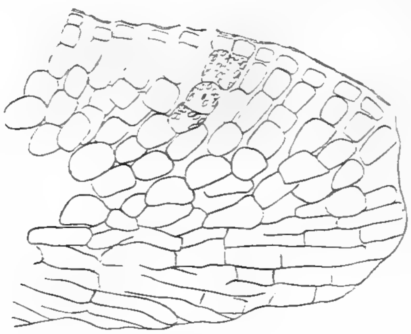


Fig. 193.
Corallina officinalis. Border of basal crust in vertical section. 390 : 1.

The articulated fronds are connected with the crust by a geniculum. The ramification is monopodial, in the typical form pinnate. The branches usually arise near the growing point. At an early stage three (or more) small protuberances are seen at the upper end of the last joint, the middlemost of which develops in continuation of the axis. This has been interpreted as trichotomy, or polychotomy (Kny 1872, Sp. 704, Solms 1881, p. 30); I think, however, with Magnus 1872, p. 721, that there is no reason for this interpretation, and that the middlemost outgrowth must be regarded as the principal axis, the others as lateral branches. In f. *typica* each joint bears two opposite branches, all in the same plane, having for the most part a limited growth, being "pinnulæ", but there is no distinct difference between the pinnulæ and the longer branches with continual growth. It frequently happens, however, that some joints produce more than two branches; 6 branches are not rarely met with and I have found up to 10 lateral branches placed in the same plane on the upper border of a much flattened joint (fig. 194 *A*). More rarely the supernumerary branches are given off in different directions at the same level, being thus verticillate (fig. 194 *B*, Plate IV fig. 5); in a specimen from Frederikshavn, a whorl of 8 pinnulæ was found on a joint. It may happen also otherwise, that normal branches are exceptionally given off in a direction diverging from the ordinary plane of ramification. The joints bearing a great number of branches occur principally in the upper part of the shoots produced in a period of growth. Besides the normal branches, adventitious ones occur, though rather rarely (Comp. Solms l, c. p. 29). Their position is less regular than that of the normal branches, and they are usually given off from the under part of the joints.

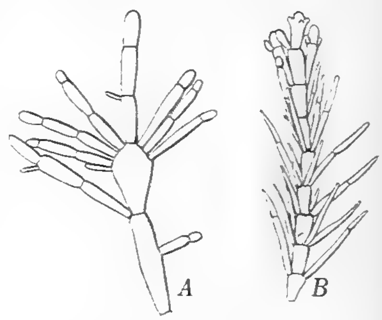


Fig. 194.
Corallina officinalis. *A*, seriate branches placed on the border of a joint. *B*, upper part of frond with verticillate branchlets. 3 : 1.

While in the f. *typica* every joint bears usually two opposite branches, other specimens, especially those growing in deeper water, are less branched, a greater or lesser number of joints bearing no branches, or only one. In these specimens the joints are cylindrical or nearly so, while the joints of the much branched forms are usually more complanated, especially in the upper end of the shoots (Plate IV fig. 6). In specimens from deeper water it sometimes happens that some of the branches assume a special character, growing out as slender, unbranched, irregularly curved organs taking not the upward direction but growing in a transversal direction or more downwards. They resemble either rhizomes or tendrils but have usually not the function of either of these organs (Plate IV fig. 7). It may however happen that the end of such a branch fixes itself on any solid substratum, f. inst. molluscs, *Furcellaria*, *Zostera*, developing an adhesive disc similar to the primary crustaceous frond. It is connected with the ultimate joint by a genicle. Such adhesive discs may also develop at the end of ordinary fronds coming accidentally in contact with any solid body (fig. 195). These discs have the power of producing new articulated fronds, in a similar manner to the primary ones (fig. 195 *B*).

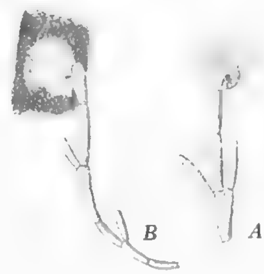


Fig. 195.
Corallina officinalis. *A*, adhesive disc developed at the end of an ordinary shoot on coming in contact with a shell. *B*, adhesive disc developed from the ultimate joint of a shoot coming in contact with a rhizome of Zostera: scars after articulated fronds developed from the disc but fallen off are visible. 3:1.

The age of the articulated fronds is not known. They reach a length of up to 16 cm, usually however only 10 cm. Supposing that a long pinnated shoot is produced every year, it seems probable that the age of the erect fronds does not exceed 3 or 4 years.

The joints consist of a central tissue of elongated cells and a cortex not sharply limited from it, the cell-rows at the periphery of the central tissue bending outwards and consisting of cells becoming gradually shorter outwards. The cells of the central tissue are usually 5—8 times as long as broad; they are disposed in transversal zones, their end-walls being situated about at the same level, the limiting lines being, however, convex upwards (comp. Mrs. WEBER, Siboga pl. XVI fig. 15, 1904). The cells are as usual connected with primary pits at the end walls, while secondary pits do not occur[1]), but lateral fusions between the cells of the central strand are very numerous and more than two cells frequently fuse together. As mentioned above, p. 211, I found these fusions followed by a fusion of the nuclei in a tetraspore-bearing plant.

In a female specimen with ripe cystocarps collected in winter at Frederikshavn similar cell-fusions were found, but the behaviour of the nuclei was different, those of the central tissue having divided in two to four, while such divisions were not observed in the tetraspore-bearing plants. It was therefore not easy to decide whether fusion of the nuclei took place in the female plant. It should be of much interest to decide whether there is such a constant difference between the tetraspore-bearing and the sexual plants.

The cortex of the joints is covered with a continuous layer of low cover-cells (comp. Solms, Corall. p. 29).

[1]) PILGER states, however, that the longitudinal walls in the central tissue of *Corallina* are provided with pits (1908. p. 252).

The nodes (genicula) consist of a single layer of very long cylindrical cells with attenuated ends continuing into the joints connected by the node. The statement of SOLMS (l. c. p. 28) that these cells are later on divided by a number of thin transversal walls has not been confirmed by YENDO (Genicula, 1904, p. 30), neither have I found these walls. The longitudinal walls of the genicular cells are not incrustated with calcium carbonate, while the attenuated ends (their extragenicular portions, YENDO) are incrustated as the cells of the joints between which they are inserted. For further information on the chemical qualities of the walls of the genicular cells comp. YENDO (l. c.). The node is more or less covered by a cortex which is interrupted in the middle (comp. KÜTZING, Phyc. gen. pl. 79, I).

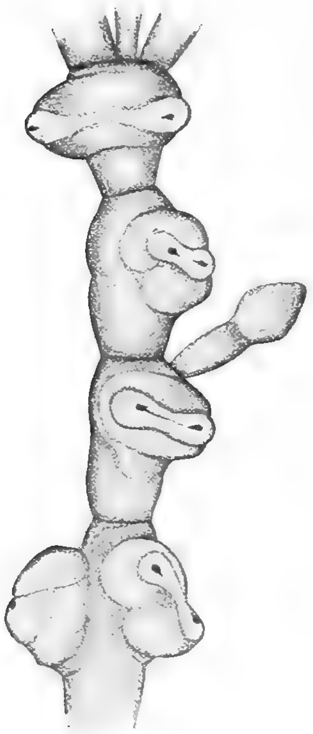


Fig. 196.
Corallina officinalis. Part of frond with fused male conceptacles. 18:1.

Hyaline hairs were not observed in the Danish specimens of this species, but as they have been figured by THURET in *C. mediterranea* (Ét. phyc. pl. 49 fig. 2 and 4) they will probably also be found in the typical *C. officinalis*.

The three kinds of conceptacula occur, as far as known, always on different individuals (comp. THURET, l. c. p. 93). They are either terminal in the ends of shorter and longer branches, or lateral, sessile on the joints, and the three kinds of conceptacula may all be apical or lateral as well (comp. SOLMS, l. c. p. 5). The lateral conceptacula are frequently placed on the edges of the joints, but their position may also be more irregular on various sides of the branches. In a male specimen which was very densely beset with conceptacles, many of them were fused together. Two or three of them were frequently placed at the same level, forming an incomplete ring at the upper end of the joint, with the ostioles more or less drawn out in a horizontal slit (fig. 196).

As to the structure and development of the conceptacles, reference may be made to the repeatedly quoted papers of THURET and SOLMS on *Corallina mediterranea*, which must be supposed to agree with the typical *C. officinalis* in this respect.

As shown by THURET (l. c. p. 93, pl. 49 fig. 6), the antheridial conceptacles differ from the others in having a conical prolongation containing the ostiole. I found the same in the Danish specimens. The development and structure of the spermatia have been studied by THURET (l. c. p. 95, pl. 49 fig. 7—9), SOLMS (l. c. p. 36, Taf. II fig. 21—23) and GUIGNARD (l. c.).

The development of the cystocarp has been thorough described by SOLMS and I must content myself with referring to his paper, remarking however, that the subject needs further examination after the important paper by MINDER on *Choreo-*

nema Thuretii. I have only examined a few fully developed cystocarps on slides made by microtome, and they showed that the formation of carpospores is not always limited to the periphery of the conceptacle, but may also take place from the inner part of the great disc-shaped cell at the bottom of the conceptacle, perhaps only because the border of this cell is lobed.

Referring for the structure and development of the conceptacles of sporangia to Thuret (l. c. p. 94, pl. 49 fig. 4—5) and Solms (l. c. p. 31, Taf. I, fig. 6—7), I shall as to the sporangia only mention that, after the division of the primary sporangial nucleus into four, a fairly long time elapses before the cell-division begins. A great number of sporangia with four nuclei situated about (not exactly) in a vertical series are therefore to be found (fig. 197 *B*). This was already observed by Thuret, who remarks (l. c. p. 95): "La formation des cloisons est précédée de l'apparition d'espaces clairs qui occupent le centre des futurs spores (fig. 5)".

As elsewhere (comp. Thuret, l. c. p. 95, Solms, l. c. p. 5), the sporangia-bearing specimens seem to be more frequent than the sexual ones also in the Danish waters, but I have not sufficient observations to affirm this with certainty.

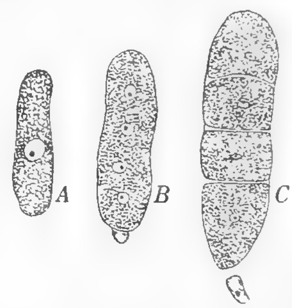


Fig. 197.
Corallina officinalis. *A*, with undivided nucleus; *B*, with four nuclei but yet undivided; C, with completed divisions. 230 : 1.

The species is, as elsewhere, rather variable, but cannot be divided into well defined varieties. When growing at low-water mark or in shallow water it is markedly pinnate, almost every joint bearing a pair of branches, and must be referred to f. *vulgaris* Kützing (Tab. phyc. VIII, p. 32, Tab. 66 fig. 2; *C. officinalis* α, Areschoug l. c. p. 562; *C. offic.* f. *typica* Kjellman, Alg. Arct. Sea p. 86 (114); *C. offic.* γ, Yendo 1902, p. 29, pl. VII, fig. 12, comp. Plate IV figs. 5—6). The specimens growing in deeper water are sometimes not much different from the ones just named, but are usually less branched and have longer joints. In f. *vulgaris*, the length of these does not reach 2 mm, while in the specimens from deeper water it not rarely reaches 3,5 mm, and even a length of 4,5 mm has been met with. In the extreme forms, the ramification is scarce and irregular, not pinnate, and the branches are often given off at various sides, though a tendency to branching in one plane is to a certain degree pronounced. Such forms may be named f. *profunda* Farlow (Mar. Alg. New. Engl., 1881, p. 179). In the Kattegat and the Samsø waters they are frequently coarser than the typical form, the joints being cylindrical, about 1 mm thick, and agree then fully with the description of f. *robusta* Kjellm. (l. c. p. 86 (114)). This form has been collected in several places in the named waters in depths from 10 to 19 meters (Plate IV fig. 8).

The species is commonly spread in all the Danish waters with proportionally high salinity, including the Samsø waters, where it is very common. It grows usually on stones, but may also be fixed to shells of molluscs (*Purpura, Littorina, Buccinum*, bivalves), on wood, and more rarely on Algæ (*Furcellaria*). It often forms associations from ordinary low-water mark to two or four meters depth on moles and boulders in Skagerak, the northern Kattegat and the Limfjord, and it does not avoid exposed places. In summer, a narrow belt of dead *Corallina* may be found at low-water mark when the upper part of the *Corallina*-association has been exposed to the air during a long period of low-water. It can also occur abundantly and form associations in deeper water, on gravelly or stony bottom, e. g. in the eastern Kattegat, but it is then frequently associated with *Lithothamnia*. In the sublittoral region it descends frequently to 19 meters depth, but it has been met with at a depth of 29 meters in the northern Kattegat. As to the vegetative development of the frond during the year I have no personal observations, but it must be supposed that the growth begins in the last part of the winter and ceases in summer, and that old fronds are thrown off in autumn. Nelson and Duncan (Histology of cert. spec. of Corallinaceæ. Trans. Linn. Soc. Bot. Ser. 2 Vol. I. 1876 p. 203) indicate that there is not much carbonate of lime in the frond in spring. Old fronds are often corroded by various organisms. Ripe tetrasporangia were repeatedly met with in the months of May to July, unripe in March. Ripe antheridia were found in May, ripe cystocarpia in May and December.

Localities. **Ns:** ZQ, jydske Rev, 24,5 m; groin at Thyborøn; Klitmøller, 2 m. — **Sk:** Hanstholm, various places, 4—15 m; YM, YN, Bragerne, 1—10 m; Bulbjerg and Svinkløv, washed ashore; SZ, Løkken, ZK[1], ZK[7], Lønstrup; Hirshals, mole and boulders near land, and 2 miles N.W. of Hirshals, 11 m; Højen, c. 5 m. — **Lf:** Lemvig; Ydre Røn by Lemvig; ZY; Oddesund; MD; MF, MG, MH, Thisted in Thisted Bredning; harbour of Struer; I; various places in Sallingsund; LS[1]; MI; Ejerslev Røn; Holmtunge Hage; Amtoft Rev; LQ. — **Kn:** Harbour of Skagen; KC, TV, Krageskovs Rev; Hirsholmene; Kølpen; Deget; Frederikshavn; Marens Rev, Borrebjergs Rev; Nordre Rønner; TJ; TL; TH; UC; UB; ZL; Jegens Odde; Trindelen; FF, FE; IX; ZB, 29 m; TG. — **Ke:** IM, VY, IP, Fladen; XA, Lille Middelgrund: EU, ET, II, IK, f. *robusta*, dominant, at 14 meters depth. Store Middelgrund: ID, (f. *robusta*, 19 m), IB, HX, IA, 11—19 m; OO, Søborg Hoved Grund, 8,5 m. — **Km:** XF, Læsø Rende; ZC, Kobbergrund; XB; XD; XC; TS; bK; FM; FN (f. *robusta*); ND. — **Ks:** Pakhusbugt, Anholt (loose); EM and EJ, Lysegrund; HS, Briseis Grund; OS, Hastens Grund; OU, Schultz's Grund; D, Grønne Revle north of Isefjord; aU, off Lumbsaas; GF, Sjællands Rev; FO, off Havknude; NB; FP, Jessens Grund. — **Sa:** MZ; KK and KJ, south of Hjelm; KM; BE and BF, off Sletterhage, f. robusta, 10 m; MY; PL; Begtrup Vig; Kalø Rev; harbour of Aarhus; PK; FS, Vejrø Sund N.E. of Samsø (f. robusta); MP; DK, Bolsaxen (f. robusta, 14 m); MQ; AH[1]; Korshavn; Hofmansgave (Car. Rosenberg); NZ; PK, Norsminde Flak; BC; aX, south Side of Endelave; AI[1] and DJ, by Æbelø; FY, off Bjørnsknude, 5,5 m. — **Lb:** Only found at the harbour of Bogense and at FZ, Kasser Odde, the north side of the reef, 6,5 m. Never met with in the neighbourhood of Middelfart and Fænø, where numerous dredgings have been made. — **Sb:** Harbour of Kerteminde; NR, at the entrance to the harbour of Korsør, only 1,5 m high, on stones picked up in the belt (Nyborg). — In the German part of the western Baltic Sea Reinke records the species from the isle of Als and from Neukirchner Grund in Flensborg Fjord. At Kullen on the west coast of Sweden I have not met with it.

2. Corallina rubens L.

Linné Syst. nat. Ed. 12. Vol. I. p. 1305. Kützing, Tab. phyc. 8. Band, 1858, p. 38, Taf. 80; Solms, Corall., p. 42; Hauck, Meeresalg. p. 278.

Jania rubens Lamour.; Kützing, Phyc. gener., 1843, p. 389, Taf. 79 II; Harvey, Phyc. Brit. pl. 252, 1851; Areschoug, in J. Agardh, Sp. g. o. Vol. II 1852, p. 557; Kny, Bot. Zeit. 1872, p. 350; Thuret, Études phyc. 1878, p. 99, pl. L, LI.

This species is usually classed under the genus *Jania*, established by LAMOUROUX. This genus, however, is, as shown by ARESCHOUG (l. c. p. 554), scarcely different from *Corallina* by other characters than the normally forked frond. Mrs. WEBER has later (Siboga, p. 85) stated that there is also an anatomical difference, the cells of the central tissue in the joints being of almost the same length as those of the genicula, while they are much shorter in the true *Corallina*. I prefer, however, to regard *Jania* as a subgenus of *Corallina*.

The articulated fronds are given off from a small thick crust with lobed outline, resembling that of *C. officinalis* but of smaller size. From the crusts examined by me only a small number of fronds, usually 1—3, were given off. The fronds are connected with the crust by a geniculum which may be rather broad (high) (fig. 198 *A*). The fronds are normally forked, the point of vegetation producing by the ramification no shoot in continuation of the axis, but two diverging equally from its direction. The bifurcations occur in greatly varying frequency, the number of interjacent joints varying from 1 to 10 or more. The planes of ramification of the successive bifurcations do not coïncide, but cross each other under various angles (comp. KNY, 1872 p. 707). In most of the Danish specimens this is the only ramification existing; but pinnate ramification may also occur. A greater or smaller nûmber of the joints may be complanated, obsagittate and bearing on the upwardly directed points two opposed simple articulated pinnulæ consisting of a small number of joints. When these pinnulæ are produced in a greater number, on several successive joints, we have the f. *corniculata*, which has been regarded as a distinct species, but which cannot be kept distinct from the typical species. The joints at the base of the bifurcations may also bear pinnulæ, under the forking branches. The pinnulæ, no doubt, usually arise later than the branches of the bifurcations, and may then perhaps be regarded as adventitious organs; but it seems that opposite lateral pinnulæ or pinnæ may sometimes arise at the growing point, for according to KNY (l. c. sp. 707) "trichotomies" may also occur. This must take place when the ramification is pinnate. In such cases the middlemost shoot certainly represents the continuation of the axis, and the two lateral ones correspond to the branches of an ordinary bifurcation; I have not, however, examined such ramifications. In rare cases the lateral shoots showed a more vigorous development, and were bifurcate as the ordinary shoots. Supernumerary adventitious pinnulæ may

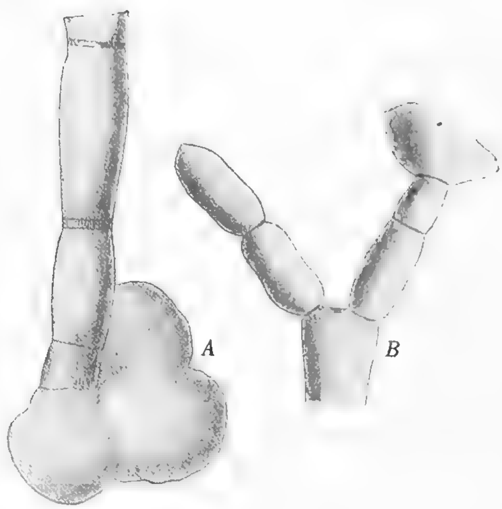


Fig. 198.
Corallina rubens. *A*, basal part of an articulated frond springing off from the basal disc. *B*, adhesive disc developed at the end of a branch. 65 : 1.

sometimes occur under the normal ones. — Hyaline unicellular hairs covering the surface of the frond have been mentioned and figured by THURET (Ét. phyc. p. 96, pl. L, LI, fig. 1, 9, 15, 18). Their occurrence seems to be dependent upon the season, as I found them in specimens collected in July while they were wanting in specimens from August.

The cortical layer consists of two or three cell-layers. It is covered by a continuous layer of low cover cells. The cells of the central tissue are, as mentioned above, almost of the same length as those of the genicula (fig. 199). Lateral fusions take place between the cells of the cortical layer and of the central tissue as well.

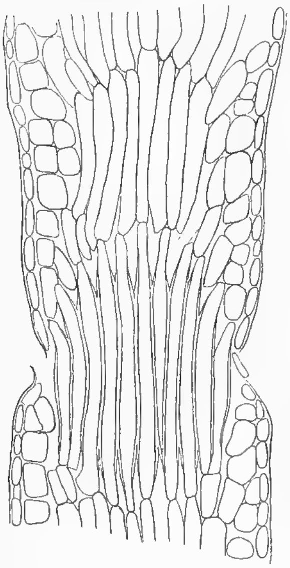


Fig. 199.
Corallina rubens, longitudinal section of joint. 350 : 1.

Adhesive discs are not seldom produced at the end of branches which accidentally come in contact with any solid body, e. g. an Alga or a shell of a bivalve. They are, as in *Cor. officinalis*, connected with the frond by a geniculum (fig. 198 *B*).

As to the organs of reproduction and the germination, reference may be made to the splendid work of THURET (l. c. p. 99, plates L, LI); it should only be mentioned that there are but two kinds of individuals, the sexual plants being monoecious. In the Danish waters only tetrasporangia-bearing plants were found.

The species has been met with in several places at the shore of the Skagerak and in the northern Kattegat. In the Skagerak it occurred partly as f. *corniculata* or a transitional form; in Kattegat it occurred only as f. *typica*. It was found growing on several Algæ, in particular *Ahnfeltia plicata*, further *Chondrus crispus*, *Phyllophora rubens*, *Delesseria* and *Corallina rubens*. It grows partly in small depth, about 1 meter, near the coast, partly deeper, up to 23,5 m depth. It reaches a length of 2—3 cm or a little more. It has been met with both in summer and winter, with ripe tetrasporangia in June to August.

Localities. **Sk:** YM[1], Bragerne, 1—2 m; Lønstrup, washed ashore, partly f. *corniculata*, (C. H. Ostenfeld); Hirshals, 2 m and washed ashore, partly f. corniculata. — **Lf:** ZY, Nissum Bredning, a small specimen between loose Algæ. — **Kn:** Hirsholm, about 2 m; N.E. of Hirsholm, c. 7 m (C. H. Ostenfeld); Deget; GM, Engelskmands Banke, 6 m; TP, Tønneberg Banke, 15,5 m; FF, Trindelen, 15 m; TR, near Trindelen, 23,5 m; UB, east af Nordre Rønner; TL and ZL[1] E. of Nordre Rønner.

Fam. 10. Gloiosiphoniaceæ.

Gloiosiphonia Carmichael.

1. **Gloiosiphonia capillaris** Huds. (Carm.)

Carmichael in Berkeley, Gleanings of British Algæ, 1833, p. 45, Tab. 17 fig. 3; Harvey, Phyc. Brit. plate 57, 1846; J. Agardh, Spec., II, p. 161, 1851; Flora Danica, tab. 2574, 1852; Ekman, Bidrag till känned.

af Skand. hafsalger. Stockh. 1857, p. 8; Nägeli, Morph. u. Syst. d. Ceram., Sitzber. Münch. Akad. 1861, II, p. 387; J. Areschoug, Observ. phycol. III, Upsal. 1875, p. 10, Tab. I, fig. 4; Bornet et Thuret, Notes algologiques, I, 1876, p. 41, pl. 13; Schmitz, Untersuch. Befr. Florid., Berlin 1883, p. 224, 230, etc., Taf. V fig. 8–15; Oltmanns, Z. Entwickl. d. Florid., Botan. Zeit. 1898, p. 109, Taf. V; Oltmanns, Morph. u. Biol. d. Algen I, 1904, p. 572, 698; Kolderup Rosenvinge, Hyaline unicell. hairs, Biol. Arb. til. E. Warming, 1911, p. 205, fig. 1—2.

Fucus capillaris Hudson, Fl. Angl. 1762, p. 591.

Gigartina lubrica Lyngbye, Hydroph., p. 45, Tab. 12 A (teste specim.).

The structure of the frond has been described by Nægeli (1861), Bornet and Thuret (1876) and Oltmanns (1904); reference may be made to the quoted works. The outer cells of the frond contain narrow branched chromatophores; the number of the latter could not be determined. The Danish specimens, collected in June to August, were always provided with numerous hyaline hairs, at least on the young parts of the frond, but sometimes also on the older parts (comp. Kolderup Rosenvinge l. c.). Strange to say, they have not been mentioned and figured by Bornet (l. c.) who examined plants collected at St. Malo in June. On the other hand, Kuckuck has found hairs terminal on the erect filaments given off from the germ-disc (fig. 356 in Oltmanns' Morph., p. 572).

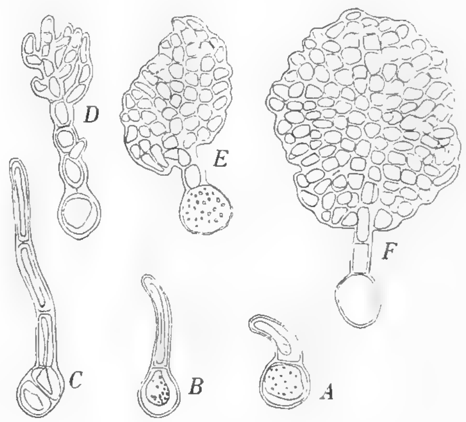


Fig. 200.
Gloiosiphonia capillaris. Sporelings. *A* and *B* two days old, *C* three days, *D* 6 days, *E* 10 days and *F* 29 days old. 350 : 1.

As shown by Kuckuck in the figure quoted, several fronds are given off from a monostromatic basal disc bearing on its upper face numerous short simple or slightly branched cell-filaments. The fronds arise by transformation of some of these filaments; one of the fronds shown in the figure mentioned arises from a branch of a cell-filament. The fronds are divided by transversal walls in low segments, early producing verticillate branches, and afterwards dividing by vertical walls. — The earlier stages of development have been studied in July 1914 at Hirshals, where the carpospores were brought to germinate (fig. 200). The globular spores after having been fixed to the substratum, e. g. a slide or a cover-glass, surround themselves with a membrane, and frequently show the first signs of germination within 24 hours, a germinating tube being produced at one side and separated from it by a wall. The circular spore-body is frequently divided by a wall, the orientation of which to the germinating tube is not constant. After 2 days the germinating filament was 3—4 times as long as the spore-body, usually two-celled, the ultimate cell being densely filled with protoplasm, while the undermost were almost empty, and the spore-cell as well. Sometimes two germinating tubes are given off from the same spore, either diametrically opposed or diverging under an obtuse angle. After four days the first germinating spores had produced long germinating filaments which commenced to branch, producing usually alternating branches at their distal end. The following day a great number of the sporelings had produced a multicellular monostromatic disc arising by further branching and fusing together of the branches, and being terminal on a shorter or longer filament. After ten days the germ discs were larger, some of the cells were divided by transversal walls, and several hairs were given off from the upper surface. Some sporelings continued growing as long unbranched filaments, but producing no disc; they were growing obliquely upwards against the light. It is probably the want of contact with any solid substratum which has caused the absence of a disc. The cultures were continued during up to a month. The sporelings showed at the end of that time no essential differences; they were only somewhat larger, having increased by marginal growth and cell-divisions, and most of the cells were divided by a horizontal wall, which may signify that the upper cell formed may be the mother-cell of a vertical filament as described by KUCKUCK, but these filaments were not yet formed in their definite shape. Numerous hairs were frequently produced by the disc. Fronds emerging from the discs were not observed; they are probably only produced in the following year, the plant wintering probably in the disc-shaped stage. The outline of the discs is nearly orbicular. The number of the cells in the basal germ filament is rather variable; usually it is small, and the filament may be wanting, the branches continuing to the spore-cell. — A similar formation of the germ disc, not from the spore-cell but from the germ-tube produced by it, is known also for other Florideæ, e. g. *Dudresnaya* (KILLIAN, Entw. ein. Florid. Zeitschr. f. Botanik. VI, 1914, p. 237).

Fig. 201.
Gloiosiphonia capillaris. Part of transversal section of frond with antheridia. 670 : 1.

The antheridia are, as shown by BORNET and THURET (l. c. p. 42) found in spots scattered on the plants which bear the carpogonia. They are oblong or obovate, and are produced by transversal divisions of narrow cells covering the surface of the plant. These cells branch, being divided by oblique walls (fig. 201).

Regarding the development and structure of the cystocarps, reference may be made to the important paper by OLTMANNS in 1898 (see also 1904) where it was proved that the double fertilization, presumed by SCHMITZ for this plant, do not take place.

The tetrasporangia were unknown to J. AGARDH, as late as in 1876 (Epicrisis p.115) although they were described by EKMAN in 1856 and by ARESCHOUG in 1875. They are, according to the named authors, cruciately divided, though often very irregularly; the sporangia-bearing specimens are much branched above, bearing dense bushes of branches. Such specimens were found at Christianssund on the west coast of Norway in August, later on the coast of Bohuslän in June by KYLIN. On the Danish shores, sporangia-bearing specimens have never been found. All the specimens examined (nearly 200) were sexual plants.

The species occurs on stones in exposed places in small depths (1—5 meters).

It can support a strong surf and is then living in much polluted water. It attains a length of 15 cm in the Skagerak, 8 cm in the Limfjord. It has only been collected in June to August. Nearly all the specimens bore cystocarpia. It has only been found in the saltest waters.

Localities. **Sk:** YN, within Bragerne, 5 m; washed ashore on Grønhøj Strand (Miss Ellen Møller); Hirshals, mole and reefs, 1—5 m. — **Lf:** Sallingsund, near Nykøbing, east side of Odden (Th. Mortensen, !) and off Grønnerup. In the herbarium of the Botan. Museum at Copenhagen a specimen is to be found, labelled Limfjorden Aug. 1869, probably collected by J. P. Jacobsen.

Some general remarks on the Cryptonemiales.

1. **Intercalary cell-divisions.** The species belonging to this order appear as a rule to follow with great regularity the rule pointed out by SCHMITZ[1]) for cell-division in Florideæ: that only the terminal cells in the filaments, of which the frond is composed, divide by transverse walls. Some cases occur, however, where transverse divisions of the segment cells have been noted. Thus, according to BREBNER, intercalary transverse divisions take place in *Dumontia incrassata* in the short-celled filaments, which grow out from the basal disc and form the upright fronds (see above p. 156). Another instance I have noticed in *Hildenbrandia prototypus*, where intercalary divisions may occur in the radiating filaments forming the basal layer, which makes itself apparent in the fact that the cells are shorter at some distance from the margin than at the margin itself (p. 203 fig. 121). It should further be mentioned, that the filaments in several Melobesieæ (*Lithothamnion*, *Corallina*) terminate in a covering cell, which does not divide, and which forms, together with the covering cells of the adjacent filaments, an outer layer, incapable of development, the penultimate cell in the filament taking over the function of the terminal cell as an initial one. A deviation from the order of succession in cell division as noted by SCHMITZ may also be found in some species of *Melobesia* and *Lithophyllum*, where two or more cortical cells, likewise incapable of division, are cut off one below the other at the end of the same mother cell (p. 254 fig. 174 and p. 264 fig. 184 *B*)[2]).

2. **Cell-fusions.** Secondary pits, which are commonly found in the Rhodomelaceæ and several other families of the Florideæ[3]) appear to be altogether lacking in most Cryptonemiales. I have only found them in the genus *Lithophyllum*. As

[1]) FR. SCHMITZ, Untersuch. über die Befrucht. d. Florideen. Sitzungsber. d. Ak. d. Wiss. Berlin 1883, p. 216.

[2]) Intercalary divisions appear to occur throughout the whole of the frond, at any rate in the perithallium in the genus *Porolithon*, to judge from the drawings of Mme LEMOINE in BØRGESEN, The Marine Algæ of the Danish West Indies, III Rhodophyceæ. Dansk Botanisk Arkiv. II p. 177 and p. 179.

[3]) Comp. L. KOLDERUP ROSENVINGE, Sur la formation des pores secondaires chez les Polysiphonia. Botan. Tidsskr. 17. Bind. Kjøbenhavn, 1888, p. 10.

mentioned on p. 210, this genus is characterised by the fact that the cells in the upright filaments, of which the frond (the perithallium) is composed, are connected by transverse pits, the origin of which must be of a secondary nature. I have not, however, been able to follow their development, and particularly did not succeed in ascertaining the co-operation of the nuclei in their formation. In the remaining members of the family of Corallinaceæ, on the other hand, there is a different method by which the cells in various filaments may enter into direct communication one with another, to wit, by dissolution of the separating wall, whereby an open connection is established between the cells. This feature has already been referred to above (p. 210) where it was also pointed out that more than two cells may fuse together, and that the cell-fusions may involve fusion of the nuclei (cf. figs. 136, 139, 156 and many others). Only in two of the Danish Corallinaceæ have the fusions hitherto not been shown (*Melobesia minutula* and *Choreonema Thuretii*).

Entirely similar cell-fusions were demonstrated in various Squamariaceæ, viz, *Cruoriopsis danica* (p. 185 fig. 107), *Cruoriopsis gracilis* (p. 188 fig. 111), *Rhododermis elegans* (p. 198 fig. 118) and *Rhododermis Georgii* (p. 199 fig. 119). In *Hildenbrandia*, on the other hand, they were not found.

That cell-fusions are important as facilitating connection between cells and cell-filaments not directly in communication by plasma-continuity can hardly be doubted. We find them also particularly numerous in the "roof" above the conceptacle (in the Corallinaceæ, i. e. between cells whose indirect connection below has been interrupted by the formation of the conceptacle. Comparison with *Hildenbrandia*, which lacks cell fusions, supports this view, as the roof of a conceptacle, which grows in extent through the continued sporangia formation, consists of dead and more or less disorganised cells, save at the margin, undoubtedly owing to the fact that the connections below have been interrupted, and those to the sides are wanting (cf. p. 204 and figs. 125, 126.).

3. **Alternation of generations and alternation of nuclear phases.** As we know, there has in several Florideæ been shown to exist a regular alternation between a haplophase, consisting of the sexual generation, and a diplophase, consisting of two generations, viz: the cystocarp or gonimoblast, and the tetraspore-bearing plant[1]). A like course of development must be presumed to take place in all Florideæ with normal fertilisation, and having tetrasporangia. SVEDELIUS has called these Florideæ diplobiontic, in contrast to the haplobiontic, which lack tetraspores, and in which the chromosome reduction takes place by division of the zygote nucleus[2]). Here then, we have but two generations, the sexed plant and the cystocarpium, both

[1]) Comp. H. KYLIN, Die Entwick. u. syst. Stell. von Bonnemaisonia asparagoides etc. Zeitschr. f. Botanik. 8. Jahrg., 1916. p. 570. — J. BUDER, Zur Frage des Generationswechsels im Pflanzenreiche. Ber. deut. bot. Ges. Bd. 34. 1916, Heft 8. — O. RENNER, Zur Terminologie des pflanzlichen Generationswechsels. Biolog. Centralblatt. Bd. 36. 1916, p. 337.

[2]) N. SVEDELIUS, Zytolog.-entwickelungsgesch. Stud. über Scinaia furcellata. N. Acta reg. soc. sc. Upsal. Ser. IV. vol. 4 no. 4. Upsala 1915, p. 42.

haploid, and the diploid phase is restricted to the undivided zygote cell. To these Florideæ belongs, among the species mentioned in the present paper, *Halarachnion ligulatum*. *Gloiosiphonia capillaris* must also be haplobiontic on the coasts of Denmark, where, as on those of France, tetrasporangia-bearing plants have never been found, though they have been met with on the coasts of Norway and Sweden (see p. 278).

On the other hand, there are species which only propagate by tetraspores, not sexually. This applies first of all to the *Hildenbrandia* species, which are extremely common with tetraspores, but have never been found with sexual organs. In *Cruoriopsis gracilis* also, and *Rhododermis Georgii*, sexual organs are quite unknown. *Rhododermis elegans* again, has always been found with tetrasporangia only, save for the case of some specimens from North-east Greenland, which bore antheridia. There are moreover some Corallinaceæ which have hitherto been found in Danish waters only with tetrasporangia (*Lithothamnion læve*, *glaciale*, *Sonderi*, *norvegicum*, and *lævigatum*). In all these, at any rate those first named, tetraspore formation must be supposed to take place without reduction of the chromosomes.

It should further be noted that in some species, albeit possessing both kinds of spores, the two kinds do not occur with like frequency. This is probably the case with several of the *Lithothamnion* species just referred to, the sexual plants being presumably not altogether lacking, but merely rarer than those bearing tetraspores, and have therefore not hitherto been found. On the other hand, sexed plants of *Polyides rotundus* seem to be far more common than the tetraspore plants in the Danish waters. All this might seem to suggest that these species have no regular alternation of generations, such as takes place in the typical diplobiontic Florideæ, in which sexual plants and those bearing tetraspores are nearly alike in point of frequency.

Parthenogenesis has been shown with certainty in *Platoma Bairdii* by KUCKUCK. In the Little Belt, it appeared in the same manner as at Helgoland, the antheridia lacking, whereas cystocarpia and tetrasporangia were found. Here also the tetrasporangia must be formed without reduction of the chromosomes. Possibly parthenogenesis may also occur in other Cryptonemiales. Some observations would seem to suggest that this may be the case in *Furcellaria fastigiata*. The fact that I did not find the spermatia attached to the trichogynes I do not consider as of great importance; more significant, however, is the finding of an unfertilised carpogonium with a short trichogyne, but which had nevertheless formed an outgrowth which could only be regarded as a sporogenous filament (cf. p. 169, fig. 85 *D*). -- In *Petrocelis Hennedyi* I found, in some instances, sporogenous filaments growing out from carpogonia which showed no interruption of the plasmatic connection with the trichogyne (fig. 98 *E*, 99 *E*) and here also, no spermatia were found attached to the trichogynes.

Finally, some cases have been noted where tetraspores and sexual organs appeared in one and the same individual. This has occasionally been found in

Petrocelis Hennedyi and *Cruoria pellita*. Here also it must be presumed that the tetrasporangia are formed without reduction of chromosomes.

There are thus a considerable number of Cryptonemiales which differ with regard to the course of development from the typical diplobiontic forms.

Svedelius [1]), referring to the simultaneous occurrence of monospores and tetraspores in one and the same individual of *Chantransia efflorescens*, considers it not altogether impossible that future investigation of the cruciate tetrasporangia may show them to have been produced without reduction of chromosomes. Up to the present, however, no Floridea with such sporangia has been subjected to closer cytological investigation. The Swedish writer points out in this connection, that such sporangia are first divided by a transverse wall, and thereafter by two perpendicular partitions, which he considers would hardly fit in with a reduction division. It should nevertheless be borne in mind that we find, both in Archegoniates and in flowering plants, cruciate sporangia as well as zonate sporangia, — though the latter, it is true, are more rare — and it seems not to be apparent that the formation of a cell-wall on the first division would preclude the reduction of chromosomes. As regards the zonate division, it has in several of the Corallinaceæ been demonstrated with certainty that the three cell-divisions take place almost simultaneously, and that the nuclear divisions are completed before the cell-division sets in (see p. 273). It is hardly likely that there should be any difference in principle between the cruciate and the zonate division; among other reasons, because we find both occurring in the species of the genus *Hildenbrandia*, — which are doubtless very closely related — where the sporangia must also be presumed to divide without reduction of chromosomes (cf. also *Lithothamnion Sonderi*, fig. 137). If Svedelius' supposition were correct, it would involve either that the reduction division must take place by the division of the zygote nucleus, in spite of the presence of tetrasporangia, or that it never occurred among Cryptonemiales, since the tetrasporangia, as far as we know, here never divide tetrahedrically, but always by parallel or cruciate walls, often markedly inclined. The latter alternative would further imply that the cystocarpia were throughout developed by parthenogenesis, which is not in accordance with the actual facts, as, though fertilization has not, it is true, been cytologically demonstrated in any of these algæ, which are furnished with tetraspores [2]), yet spermatia have at any rate been found attached to the trichogynes in *Dumontia incrassata* (see above p. 158), *Polyides rotundus* (Thuret, Et. phyc. Pl. 38 figs. 14—18) and in certain Corallinaceæ (*Choreonema Thuretii*, Solms, Corall. Taf. III, fig. 4, *Corallina mediterranea*, Solms, l. c. Taf. III, fig. 19).

On the other hand, it must be presumed that reduction division may also be lacking in tetrahedrically divided sporangia, as cases are also known where such

[1]) N. Svedelius, l. c. p. 50.

[2]) The fertilization has been cytologically demonstrated in *Gloiosiphonia capillaris* by Oltmanns; but this Alga has usually no tetrasporangia.

sporangia occur in the same plant as sexual organs, (e. g. *Callithamnion corymbosum*, cf. THURET in LE JOLIS' Liste d. Alg. mar. de Cherbourg, p. 112).

As will be seen from the above, there are many features in the Cryptonemiales which call for further cytological investigation, especially with regard to the presence of a fertilisation process and the manner in which nuclear division takes place in the tetrasporangia. The latter point will doubtless be the easier to decide, as the tetrasporangia are in many species easily found, and contain large nuclei.

EXPLANATION OF PLATES.

Plate III.

All the figures are microphotographs after microtome-sections taken by Mr. A. HESSELBO.

1. *Lithothamnion læve* Strömf. Tetraspore (dispore), showing the nucleus with nucleolus (fallen out) and the structure of the protoplasm. (Specimen from Aalsgaarde). About 225:1.
2. *Lithothamnion Lenormandi* (Aresch.) Foslie. Vertical section of antheridial conceptacle. (Specimen from TF[1]). About 200:1.
3. *Lithothamnion Lenormandi* (Aresch.) Foslie. Vertical section of conceptacle of cystocarp. (Specimen from XQ). About 200:1.
4. *Lithothamnion glaciale* Kjellm. f. *Granii* Fosl. Section of crustaceous frond with conceptacles of sporangia. Specimen from Læsø Rende). About 180:1.
5. *Lithothamnion polymorphum* (L.) Aresch. Vertical section of female conceptacle showing procarps. (Specimen from Store Middelgrund, May).
6. *Lithothamnion polymorphum* (L.) Aresch. Vertical section of emptied conceptacles of sporangia with covering tissue. (Specimen from reef near Korsør).

Plate IV.

All figures from photopraphs in natural size.

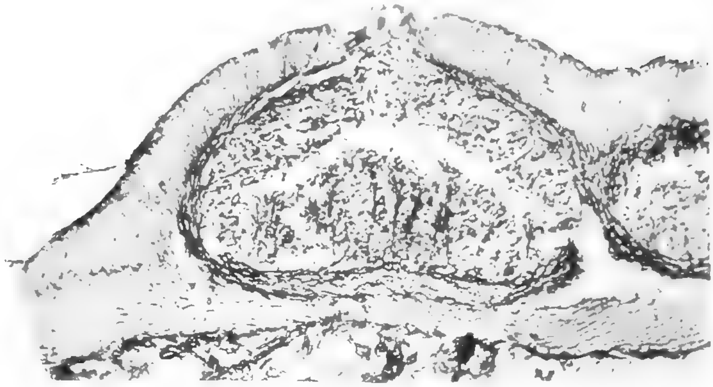
1—4. *Lithothamnion glaciale* Kjellm. f. *Granii* Fosl. 1 and 2 attached to stones, 3 free, 4 similar one being on the point of dividing. (Specimens from IH, 3375).

5—6. *Corallina officinalis* L., f. *robusta* Kjellm. (Specimen from YU, Hanstholm. 7286). In fig. 5 the branchlets are partly verticillate.

7. *Corallina officinalis* L., slender, slightly branched form with some stoloniform branches growing out in a transversal direction. (Specimen from UC, north of Læsø, 5625).

8. *Corallina officinalis* L. f. *robusta* Kjellm. With lateral conceptacles. (Specimen from MZ. 4058).

1



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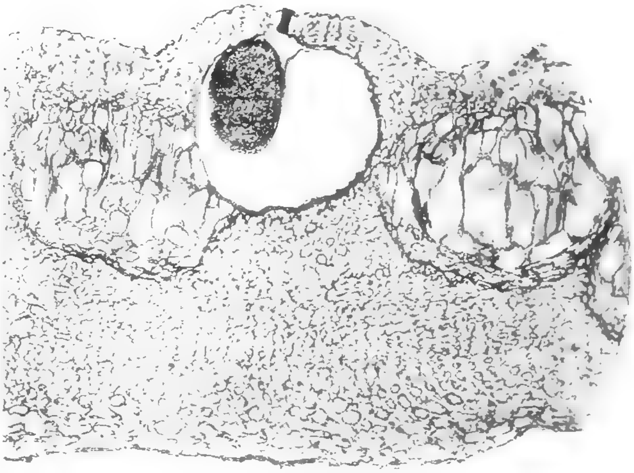

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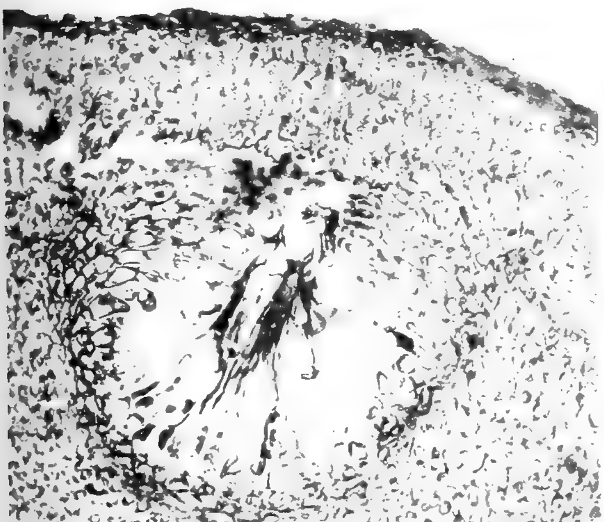

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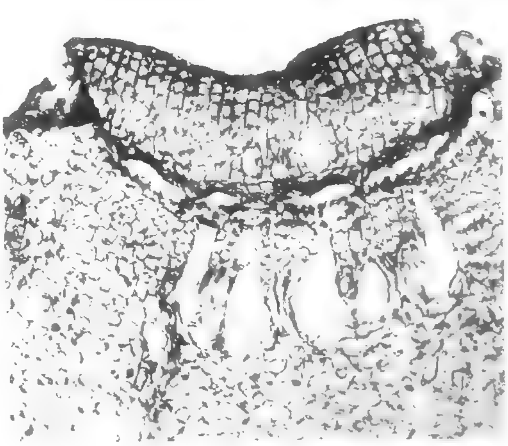

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Phot. by A. Hesselbo

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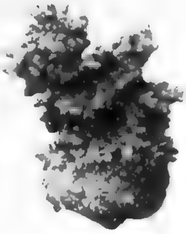

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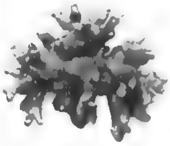

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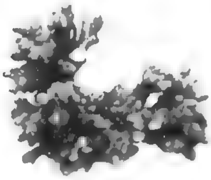

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THE MARINE ALGÆ OF DENMARK

CONTRIBUTIONS TO THEIR NATURAL HISTORY

PART III

RHODOPHYCEÆ III.

(CERAMIALES)

BY

L. KOLDERUP ROSENVINGE

WITH THREE PLATES

D. Kgl. Danske Vidensk. Selsk. Skrifter, 7. Række, naturvidensk. og mathem. Afd., VII. 3

KØBENHAVN

BIANCO LUNOS BOGTRYKKERI

1923 – 24

INTRODUCTION

Since the first part of this publication was issued I have studied the marine Algæ on the Danish coasts almost every summer. During the last two years my investigations have been more extensive. This is chiefly due to the addition made to the area of the Danish flora in consequence of the reunion of North Slesvig with Denmark in 1920. The boundary on the eastern side of Slesvig having been removed from Heilsminde to Krusaa in the interior of Flensborg Fiord, the Little Belt area (**Lb**) has been augmented by the waters between Heilsminde in the north, and Sønderborg and Pøl at the south-eastern extremity of Als, while the line bounding the Danish part of the Baltic (**Bw**) on the south must now be drawn from Krusaa through the middle of Flensborg Fiord and thence south of Bredgrund south of Als. Though these waters have formerly been examined by Professor Reinke, and their flora and vegetation dealt with in his well-known work Algenflora der westlichen Ostsee Deutschen Anteils, 1889, I have considered it necessary to study the same waters myself. By the kindness of the fisheries director, Mr. F. V. Mortensen, I have been enabled, with the assistance of the fishery control motor-boat, to make investigations and collections in the waters round Sønderborg in June 1921, and in June 1922 to make similar investigations while onboard the control steamer S. S. Falken (fisheries supervisor Trolle Thomsen), along the entire eastern coast of South Jutland and likewise in the waters surrounding Funen. In both cases the material was collected partly, by means of a boat, from stone reefs and in other localities such as breakwaters near land, partly by dredgings from ship at a greater distance from land. In the autumn of 1922 there further occurred an exceptional opportunity to make dredgings in the North Sea and the Skagerak in places otherwise very difficult of access, since the marine research ship S. S. Dana was to make fishery investigations in these waters, and especially in places where one might expect to find Algæ. The Marine Research Committee very readily granted me room onboard, and the leader of the cruise, Dr. A. C. Johansen, did everything in his power to further my investigations. As I was obliged to break off my stay onboard on October 7th, mag. sc. Mr. C. A. Jørgensen was deputed to carry on my investigations of the flora of the Skagerak and the northern and central parts of the Kattegat until the cruise came to an end on October 19th. Mag. Jørgensen has later, in June 1923, made investigations onboard the Dana in the waters around Bornholm and left the collected Algæ at my disposal.

In continuation of the list given on p. 22 et seq. I give below a list of the new dredging stations arranged on the same principles as the one already mentioned.

Most of the new dredging places are marked on the charts given on pp. 288 and 290. In the later those places at the shores where investigations and collections have been made are likewise indicated by a mark together with the name of the place concerned. In deep waters the collections have always been made with a dredge where nothing else is indicated. In most other places an otter trawl has been employed.

As the markings on the charts and in the list show, there was no vegetation at all in the southern part of the North Sea area even where the bottom was stony. This agrees with what earlier German investigations have shown[1] and what I myself found in 1905 at Horns Reef (Part I p. 22, Chart II). Further it was in accordance with what Dr. Johansen had found immediately before my arrival onboard the Dana. In thirty localities between 6°07′ and 8°16′ E. and between 55°00′ and 56°08′ N. on fishing with otter trawl no vegetation at all was found. It was confirmed, then, by these investigations that this part of the North Sea is a veritable desert as regards bottom vegetation. In the northern part of the North Sea area, where there were stones or at any rate gravel in nearly all the localities examined, the bottom was almost equally bare, being either entirely destitute of vegetation or showing only very sparse vegetation. This result may, however, be partly due to the late season (the latter part of September) for I have formerly found a fairly abundant flora in some parts of this area at the close of July. In the Skagerak, too, the vegetation is on the whole very poor even on stony bottom, and only in a few places, mostly near land, do we find spots with continuous vegetation, especially at Hirshals, but also at Hanstholm, Bragerne and Lønstrup. On the other hand, in the Skagerak one often comes across loose, drifting Algæ carried along by the strong current.

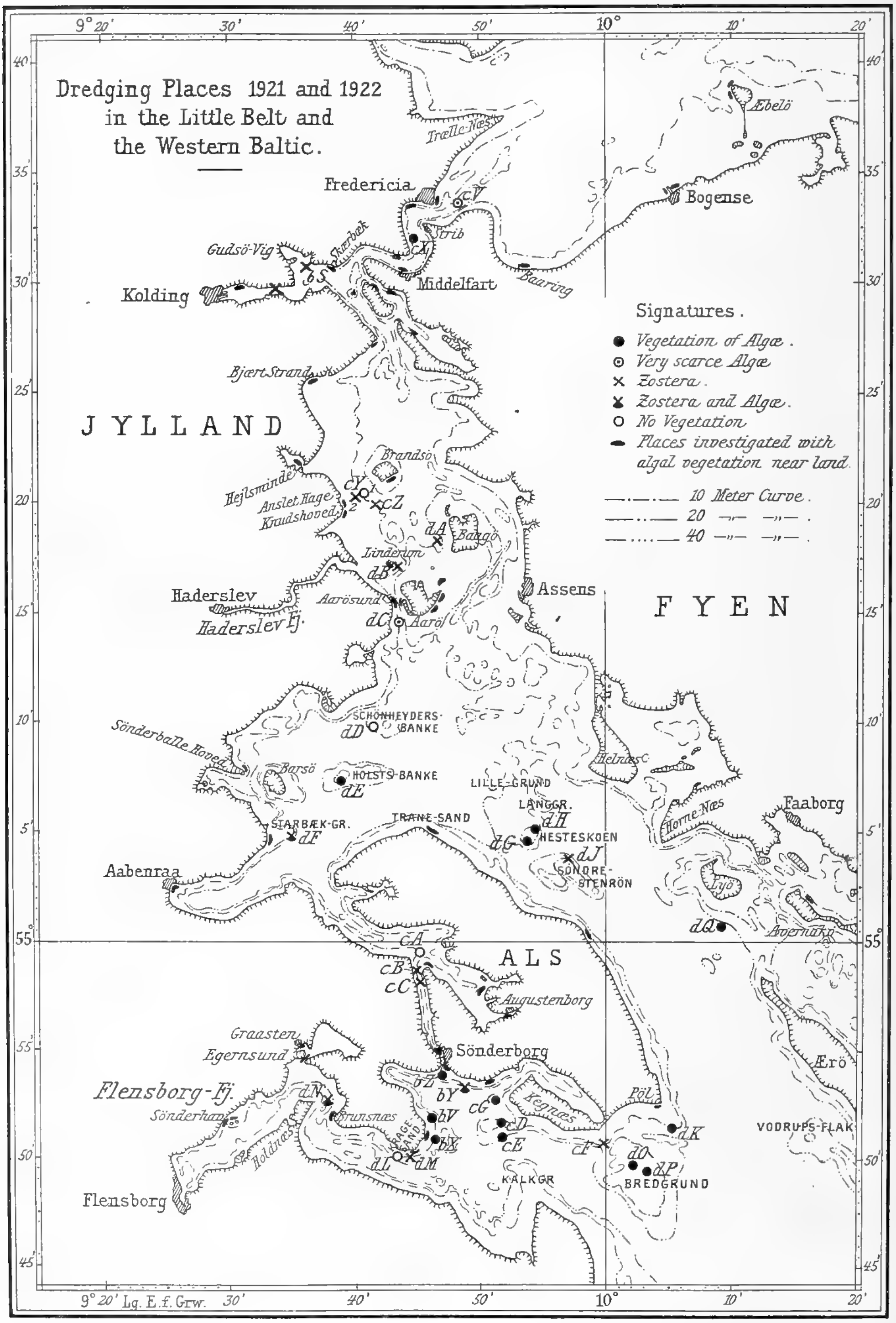
On groins and breakwaters in the northern part of the North Sea area there is an abundant and fairly varied vegetation. At Fanø and Esbjerg the corresponding vegetation is poor in species and, according to Reinbold[2] and Jaap,[3] the same is the case with the Algæ vegetation on the coasts of Rømø and on the west coasts of North Slesvig; I myself had no opportunity to examine Rømø until August 1923. In the shallow sea between North Slesvig and the islands *Zostera marina* and *Z. nana* grow in low water, but there seem to be no Algæ. Mag. R. Spärck who made dredgings along the east coast of Fanø at a depth of 4—5 m. has kindly informed me that he got numerous oyster shells and mussel shells and not a few stones in the dredge, but that there was no Algæ vegetation. Only a little loose *Fucus vesiculosus* without vesicles and some *Zostera* got into the dredge.

The waters washing the eastern coast of North Slesvig are so similar in character to the adjoining parts of the Little Belt and the western part of the Baltic dealt with in Part I, that they do not require further mention here, the more so since they have been treated in Reinke's above cited work. The depth conditions are shown on Chart II and in map p. 290.

[1] J. Reinke, Notiz über die Vegetationsverhältnisse in der deutschen Bucht der Nordsee. Bericht deut. bot. Ges. 1889 p. 367. Th. Reinbold, Untersuchung des Borkum-Riffgrundes. Sechster Bericht d. Komm. z. wiss. Unters. d. deutsch. Meere. III Heft.

[2] Th. Reinbold, Bericht über die im Juni 1892 ausgeführte botan. Untersuch. einiger Distrikte der Schleswig-Holsteinischen Nordseeküste. Sechster Bericht d. Komm. z. wiss. Unters. d. deutsch. Meere. III Heft.

[3] O. Jaap, Zur Kryptogamenflora d. nordfriesischen Insel Röm. Schrift. d. Naturv. Vereins d. Prov. Schleswig-Holstein Bd. 12. 1902.


Dredging Places 1921 and 1922
in the Little Belt and
the Western Baltic.
Signatures.
Vegetation of Algæ.
Very scarce Algæ
Zostera.
Zostera and Algæ.
No Vegetation
Places investigated with algal vegetation near land.
10 Meter Curve.
20
40
JYLLAND
FYEN
ALS
Fredericia
Kolding
Middelfart
Bogense
Æbelö
Trælle-Næs
Strib
Baaring
Gudsö-Vig
Skærbæk
Bjært Strand
Brandsö
Hejlsminde
Anslet Hage
Knudshoved
Baagö
Linderum
Aarösund
Aarö
Haderslev
Haderslev Fj.
Assens
Sönderballe Hoved
Barsö
SCHÖNHEYDERS-BANKE
HOLSTS-BANKE
LILLE-GRUND
LANGGR.
HESTESKOEN
SÖNDRE-STENRÖN
TRANE-SAND
STARBÆK-GR.
Aabenraa
Helnæs
Horne-Næs
Faaborg
Lyö
Avernakø
Augustenborg
Graasten
Egernsund
Sönderborg
Flensborg-Fj.
Sönderhav
Holdnæs
Brunsnæs
Kegnæs
Pöl
Ærö
VODRUPS-FLAK
KALKGR
BREDGRUND
Flensborg
9° 20' Lg. E.f. Grw.
30'
40'
50'
10°
20'
55°

List of new dredging stations arranged according to the different waters.

The localities are designated by letters like the foregoing ones (comp. pp. 22—54). Some of the dredgings of the later years have been made by Dr. Henning Petersen, Mag. P. Kramp or Mr. J. Boye Petersen while I have examined the collected material of Algæ. The dredging stations of Mag. Jørgensen in October 1922 have been designed with the station figures of the S. S. Dana.

North Sea. (Ns)

dU. (Dana St. 2835). 27/9 22. 4 miles N. 3/4 E. of Blaavandshuk light-house. 8 m. — Fine sand. — No vegetation. (Otter trawl).

dV. (Dana St. 2836). 11 miles S. by W. of Lyngvig light-house. 15 m. — Fine sand. — No vegetation.

eG. (Dana St. 2846). 30/9 22. 9 miles S.W. 1/2 N. of Bovbjerg light-house. 24 m. — Gravel, stones. — No Algæ, only a fragment of *Desmar. acul.*

eH. (Dana St. 2848). 30/9 22. 14 miles W. by S. 1/4 S. of Bovbjerg light-house. 27 m. — Sand with few stones. — No vegetation.

eI. (Dana St. 2849). 30/9 22. 21 miles W. of Bovbjerg light-house. 34 m. — Clay with stones, shells. — No Algæ.

eK. (Dana St. 2850). 1/10 22. Lille Fiskebanke. 46 miles W. by N. of Bovbjerg light-house. 37 m. — Clay, large stones. Scarce *Hildenbrandia prototypus.*

eL. (Dana St. 2851). 1/10 22. Lille Fiskebanke. 53 miles W.N.W. 1/4 W. of Bovbjerg light-house. 37 m. — Coarse sand mixed with ooze, with shells. — No Algæ.

eF. (Dana St. 2845). 30/9 22. 2,5 miles W. by N. of Bovbjerg light-house. 18—22 m. — Sand, stones, clay. — No vegetation; only *Rhodochorton membranaceum* in Hydrallmannia falcata.

eE. (Dana St. 2844). 29/9 22. 12 miles N.W. by N. of Bovbjerg light-house. 26 m. — Gravel, stones. — Scarce *Desmarestia aculeata,* otherwise only incrusting Algæ (*Lithoderma*).

dY. (Dana St. 2838). 28/9 22. 10 miles S.W. 1/4 S. of Lodbjerg light-house. 18 m. — Clay with single stones. — No vegetation.

dX. (Dana St. 2837). 28/9 22. 11 miles W.S.W. 1/2 W. of Lodbjerg light-house. 28 m. — Fine sand. — No vegetation.

eD. (Dana St. 2843). 29/9 22. S.E. of Jydske Rev. 22 miles W. of Lodbjerg light-house. 41 m. — Sand, gravel, stones. — No vegetation; only single specimens of *Desmarestia aculeata* and fragments of a few other Algæ.

eN. (Dana St. 2853). 1/10 22. Between Lille Fiskebanke and Jydske Rev. 45 miles W. by N. of Lodbjerg light-house. 34 m. — Sand, few animals. — No Algæ.

eM. (Dana St. 2852). 1/10 22. Lille Fiskebanke. 55 miles N.W. by W. 1/2 W. of Bovbjerg light-house. 48 m. — Gravel, shells. — No Algæ.

eA. (Dana St. 2840). 28/9 22. 27 miles W. 3/4 N. of Lodbjerg light-house. 25—28 m. — Coarse gravel. — Very scarce vegetation: single specimens of *Desmarestia aculeata, D. viridis, Corallina offic., Trailliella intricata, Chætopteris, Laminaria* (young).

eO. (Dana St. 2854). 2/10 22. 4 1/2 miles W. 1/2 S. of Lodbjerg light-house. 23 m. — Large stones and gravel. — Scarce *Phyllophora rubens, Lithoderma* and *Lithothamnion.*

dZ. (Dana St. 2839). 28/9 22. 17 miles W. 3/4 N. of Lodbjerg light-house. 36 m. — Stones. — Scarce *Desmarestia aculeata* and incrusting Algæ (*Cruoria pellita, Lithothamnion lævigatum, Lithoderma*).

eP. (Dana St. 2855). 2/10 22. 8 miles W. by N. of Lodbjerg light-house. 24 m. — Gravel and small stones. — Scarce *Desmarestia aculeata,* single specimens of *Phyllophora rubens* and *Ph. membranifolia.*

eQ. (Dana St. 2856). 2/10 22. 8 miles N.W. by W. 1/2 W. of Lodbjerg light-house. 27 m. — Large and smaller stones. — Mostly incrusting Algæ (*Lithoderma, Lithothamnion, Rhododermis elegans*).

eC. (Dana St. 2842). $^{29}/_{9}$ 22. Jydske Rev. 23 miles W.N.W. of Lodbjerg light-house. 26 m. — Gravel, sand. — In four dredgings only single specimens of *Desmarestia acul., Furcellaria, Phylloph. rubens* and *Corallina off.*

eB. (Dana St. 2841). $^{29}/_{9}$ 22. 21 miles N.W. $^{3}/_{4}$ W. of Lodbjerg light-house. 22 m. — Gravel with small stones. — Two loose specimens of *Laminaria saccharina.*

eR. (Dana St. 2857). $^{2}/_{10}$ 22. 9 miles N.W. $^{1}/_{2}$ N. of Lodbjerg light-house. 27 m. — Gravel with stones. — Scarce *Desmarestia aculeata*, otherwise only few fragments (*Phyll. rubens, membran., Trailliella, Plocamium coccineum*); stones mostly bare.

eS. (Dana St. 2858). $^{2}/_{10}$ 22. 8 miles N. by W. of Lodbjerg light-house. 25 m. — Gravel with small stones. — No vegetation. (Single small specimens of *Desmar. acul., Phylloph. Brod., Rhodomela*).

eT. (Dana St. 2859). $^{2}/_{10}$ 22. 15 miles W. by N. of Hanstholm light-house. 34 m. — Gravel, stones. — Scarce vegetation: *Laminaria hyperborea* and *digitata, Phyllophora rubens* . . .

eU. (Dana St. 2860). $^{2}/_{10}$ 22. 24 miles W.N.W. of Hanstholm light-house. 50 m. — Gravel, small stones (Alcyonidium gelatinosum in abundance). — No Algæ.

Skagerak. (Sk)

eV. (Dana St. 2864). $^{3}/_{10}$ 22. 6 miles N. by E. of Hanstholm light-house. 22—24 m. — Stones, sand with shells and clay. — Scarce *Desmarestia aculeata.*

eX. (Dana St. 2865). $^{3}/_{10}$ 22. 10 miles E.N.E. $^{1}/_{2}$ E. of Hanstholm light-house; N. of Bragerne. 16 m. — Gravel, stones. — Mostly incrusting Algæ, rather scarce however, further *Laminaria hyperborea* (scarce) and *Phyllophora membranifol.*

Dana St. 2904. $^{13}/_{10}$ 22. 13$^{1}/_{2}$ miles N.E. $^{1}/_{2}$ E. of Hanstholm light-house. 23 m. — Stones, shells. — Very few Algæ. (*Chætopteris, Sphacelaria, Cystoclon., Polys. urceolata, Antithamnion cruciatum, Lithoderma*).

Dana St. 2902. $^{13}/_{10}$ 22. 12 miles E. by N. $^{1}/_{4}$ N. of Hanstholm light-house. E. side of Bragerne. 15 m. — Sand. — Various Algæ, probably all loose (*Laminaria sacch.* and *digit., Fuc. serr., Dilsea, Deless. etc.*). (Young-fish trawl).

Dana St. 2903. $^{13}/_{10}$ 22. 12 miles E. $^{3}/_{4}$ N. of Hanstholm light-house. Near Bragerne. 7 m. — Sand, shells. — No Algæ.

Dana St. 2907. $^{14}/_{10}$ 22. 26 miles N.W. by W. of Rubjerg Knude light-house. 45 m. — No Algæ. —

Dana St. 2906. $^{14}/_{10}$ 22. 26 miles N.W. $^{1}/_{4}$ W. of Rubjerg Knude light-house. — 70 m. — Soft bottom. — No Algæ.

fA. (Dana St. 2868). $^{3}/_{10}$ 22. E.N.E. of Hanstholm light-house. 18 m. — Gravel, shells. — Single loose fragments of various Algæ (*Fucus vesiculosus, Halidrys, Furcellaria* etc.) and loose *Zostera* (with rhizomes).

eY. (Dana St. 2866). $^{3}/_{10}$ 22. 18 miles E.N.E. $^{1}/_{2}$ E. of Hanstholm light-house. 15 m. — Sand, stones. — Very scarce Algæ: *Halidrys, Delesseria alata, Rhodomela, Furcellaria* a. o. and loose *Zostera* with narrow leaves.

eZ. (Dana St. 2867). $^{3}/_{10}$ 22. 21 miles E.N.E. of Hanstholm light-house. 15—17 m. — Gravel, sand. — One specimen of *Halidrys*, single small specimens or fragments of *Dilsea edulis, Deless. sinuosa* a. o.; loose narrow-leaved *Zostera.*

Dana St. 2900. $^{13}/_{10}$ 22. 21 miles S.W. $^{3}/_{4}$ W. of Rubjerg Knude light-house. 9 m. — Sand. — Drifting Algæ (*Dilsea edulis, Fucus serratus, Laminaria sacch.* and *digit., Desmar. acul.* etc.). (Otter trawl).

Dana St. 2899. $^{13}/_{10}$ 22. 13 miles S.W. by W. $^{1}/_{2}$ W. of Rubjerg Knude light-house. 14 m. — Sand. — Few Algæ (*Furcellaria, Ahnfeltia, Desmarestia acul.* a. o.), mostly loose probably.

fB. (Dana St. 2869). $^{3}/_{10}$ 22. 22 miles N.W. $^{1}/_{2}$ N. of Rubjerg Knude light-house. 47 m. — Sand, shells.— Loose Algæ (*Desmarestia aculeata, Laminaria sacch., Chorda Filum* a.o.) and *Zostera.*

Dana St. 2912. $^{15}/_{10}$ 22. 5$^{1}/_{2}$ miles W. $^{1}/_{2}$ S. of Højen light-house. 25 m. — Stones, small shells. — Incrusting Algæ (*Lithothamnion Sonderi*) mostly on Modiola modiolus.

cK. $^{26}/_{7}$ 21. North of Skagen; the life-boat station in line with the old church. 28 m.—Soft bottom.— A fragment of *Laminaria digitata*, otherwise no Algæ. — Farther North. 97 m. — Soft bottom. — Some loose Algæ.

Limfjord. (Lf)

bU. $^{27}/_{7}$ 20. Ejerslev-Næse, E. coast of Mors. 3—8 meters. — Farthest out oysters and stones with very few Algæ. Nearer land *Zostera*.

bT³. $^{27}/_{7}$ 20. West of Ejerslev Røn. 7 meters. — Firm clay with stones, Mytilus and oysters. — Very few Algæ, mostly *Polysiphonia elongata* and *Trailliella intricata*.

bT¹. $^{23}/_{7}$ 20. At the broom, Sæbygaards Hage (Fursund). 2 meters. — Stones. — *Fucus vesiculosus, Corallina officinalis.*

bT². $^{23}/_{7}$ 20. Knudshoved, at the N.W. end of Fur. 5,5 meters. — Great stones. — *Fucus vesiculosus, Zostera.* — North side of the same point, within the broom. 4 meters. — *Zostera* and stones with *Fucus vesiculosus.*

Kattegat, Northern part. (Kn)

bQ. $^{28}/_{7}$ 11. Skagen, under the land from the lazaretto to the light-house. — 2 to 3 meters. — Sand and small stones. — *Enteromorpha* or *Chorda Filum*.

cI. $^{23}/_{7}$ 21. South of Skagen light-house (P. Kramp). 7,5 and 5,5 meters. — Sand and small stones. — *Ectocarpus siliculosus* abundant, further *Polysiphonia elongata*, and in smaller depth *Chorda Filum*.

cI². $^{30}/_{7}$ 21. South of Skagens Gren (Kramp). 9,5 meters. — Sand with *Zostera*. — 13—15 meters. — Clayey sand. — *Antithamnion Plumula* abundantly on Buccinum and Turritella.

cI¹. $^{23}/_{7}$ 21. South side Skagens Gren (Kramp). 9,5 meters. — Soft bottom. — Some Algæ on the claws of Pagurus and on mollusc shells.

cH. $^{20}/_{7}$ 21. Off Skagens harbour (Boye Petersen). — Soft bottom with molluscs. — *Halorhiza vaga, Arthrocladia villosa.*

cH¹. $^{22}/_{7}$ 21. Off Klitgaarden, Skagen (Boye Petersen). 4 meters. — Soft bottom. — Brown Algæ, in particular *Ectocarpus siliculosus* and *Halorhiza vaga*, further *Polysiphonia elongata*. — 2 meters. — Sand with stones. — *Kjellmania striarioides* and *Delamarea attenuata*.

fC. (Dana St. 2870). 3 miles S.W. by S. of Skagen light-house. 15 m. — Ooze with molluscs (mostly Turritella terebra). — *Polysiphonia elongata* and *atrorubescens, Chætopteris* on *Turritella; Zostera* with fruit.

fD. (Dana St. 2871). $^{4}/_{10}$ 22. Off Aalbæk. 8 miles S. $^{3}/_{4}$ W. of Skagen light-house. 22 m. — Soft bottom (seine), Pecten islandicus. — *Lithothamnion lævigatum* and *L. glaciale* on coal, Buccinum undatum o. a.

fE. (Dana St. 2872). $^{4}/_{10}$ 22. E. side of Krageskov Rev. 7 m. — Sand with *Zostera*, and various intermingled Algæ.

Dana St. 2917. $^{15}/_{10}$ 22. Hirsholm Nordost Rev, just outside the broom. — Stones. — Rich algal vegetation; *Laminariæ* predominant with *Desmarestia aculeata* and various *Florideæ*.

fF. (Dana St. 2873). $^{6}/_{10}$ 22. 4 miles E.S.E. $^{3}/_{4}$ E. of Nordre Rønner light-house. 8 m. — Sand with stones. — *Fucus serratus* and *Furcellaria* dominant, further *Polyides, Brongniartella, Halidrys* a. o.

dR. $^{2}/_{8}$ 22. The light-ship at Læsø Trindel S.S.E. 1$^{1}/_{2}$ miles. 21 m. — Stones with *Lithothamnion læve*, other Algæ scarce.

fG. (Dana St. 2874). $^{6}/_{10}$ 22. 3 miles W. of Læsø Trindel light-ship. 15 m. — Sand, gravel, stones. —*Laminaria saccharina, L.hyperborea, Halidrys, Lithothamnia (L.calcareum, glaciale)* a.m.o.

dS. $^{3}/_{8}$ 22. Læsø Trindel; midway between the light-ship and the broom. — Soft bottom (Pennatula). — No Algæ.

dT. $^{3}/_{8}$ 22. S. of Læsø Trindel. 20 m. — Soft bottom. — No vegetation.

dT[1]. $^{3}/_{8}$ 22. Nearer the broom. 11 m. — Stones. — *Halidrys, Laminaria saccharina, Furcellaria, Brongniartella, Desmarestia viridis.* (Abundant vegetation).

dT[2]. $^{3}/_{8}$ 22. S. of the broom. 26 m. — Shells, stones. — *Fucus serratus, Laminaria digitata, Halidrys.*

Dana St. 2891. $^{10}/_{10}$ 22. 6$^{1}/_{2}$ miles S.W. by W. $^{1}/_{2}$ W. of Læsø Trindel light-ship. 8 m. — Sand, stones. — *Fucus serratus* and *Furcellaria* dominant, scarce *Halidrys.* Further various Algæ; *Trailliella* abundant, with tetraspores.

Kattegat, eastern part. (Ke)

fK. (Dana St. 2875). $^{6}/_{10}$ 22. 4 miles W. by N. of Fladens light-ship. 39 m. — Sand, shells. — No Algæ.

fI. (Dana St. 2877). $^{6}/_{10}$ 22. 3$^{1}/_{2}$ miles W. by N. of Fladens light-ship. 30 m. — Sand, stones, shells. — Few Algæ: *Laminaria hyperborea* and incrusting Algæ (*Cruoria, Cruoriella Dubyi, Lithothamnia, Lithoderma* etc.)

fH. (Dana St. 2876). $^{6}/_{10}$ 22. 1 mile W. by N. of Fladens light-ship. 17 m. — Stones, sand. — *Laminaria digitata, hyperborea, saccharina, Dilsea edulis, Furcellaria* etc.

Dana St. 2922. $^{18}/_{10}$ 22. 4$^{1}/_{2}$ miles S.W. $^{3}/_{4}$ W. of Fladens light-ship. 30 m. — Stones, shells. — *Laminaria saccharina* and *hyperborea* predominant, further *Halidrys, Desmar. acul., Furcellaria, Dilsea edulis, Deless. sanguinea, Brongniartella, Lithothamnion læve, glaciale,* various other incrusting Algæ etc.

fM. (Dana St. 2881). $^{7}/_{10}$ 22. 10 miles W.S.W. $^{1}/_{4}$ W. of Fladens light-ship. 23 m. — Sand, stones. — 1) Incrusting Algæ (*Cruoria, Cruoriella Dub., Lithoderma, Lithothamnion glaciale* a. o. 2) *Halidrys, Desmarestia aculeata.*

fL. (Dana St. 2880). $^{7}/_{10}$ 22. 11 miles W. by S. of Fladens light-ship. 33 m. — Ooze, sand with small stones. — No Algæ (a small spec. of *Phylloph. membr.*, also one of *Corallina off.*)

Dana St. 2925. $^{19}/_{10}$ 22. Store Middelgrund. 14$^{1}/_{2}$ miles S.S.E. of Anholt Knob light-ship. Lat. N. 56° 33′, Long. E. 12° 05′. 10 m. — Stones. — *Furcellaria* predominant, with *Laminaria hyperb., digit., sacchar., Fucus serratus* and various other Algæ.

Kattegat, central part. (Km)

Dana St. 2919. $^{17}/_{10}$ 22. 6 miles S.S.W. $^{1}/_{2}$ W. of Læsø Rende light-ship. Lat. N. 57° 07′, Long E. 10° 37′. 8 m. — Stones. — *Halidrys* abundant, *Polys. nigrescens* and *elongata* and various other Algæ.

Dana St. 2884. $^{8}/_{10}$ 22. 5$^{1}/_{2}$ miles N. by E. $^{3}/_{4}$ E. of Østre Flak light-ship. 9 m. — Sand, stones. — *Zostera* in abundance with *Furcellaria,* further *Halidrys, Fuc. serratus* a. o. Algæ.

Kattegat, southern part. (Ks)

bR. $^{15}/_{8}$ 13. Vesterlandsgrund by Gilleleje. — 7,5 meters. — Stones and gravel. — Vegetation partly continuous, partly interrupted by bare spots: *Fucus serratus, Furcellaria, Brongniartella, Phyllophora Brodiæi* a. o.

Samsø area. (Sa)

cU. $^{9}/_{6}$ 22. North of Fyn, 55° 35′ N, 10° 28,5′ E. 9 m. — *Zostera* with *Furcellaria* a. o. entangled Algæ. — 7 m. — The same and *Fucus serratus.*

Little Belt. (Lb)

cV. $^{10}/_{6}$ 22. Abreast of Røgle, Røgle Klint S. by W. 19—30 m. — At 30 m clay, at higher level small stones. — Few Algæ, *Rhodomela, Desmarestia aculeata, Furcellaria, Chorda tomentosa.*

cX. $^{13}/_{6}$ 22. Between Strib and Nederballe. 35—44 m. — Firm clay. — Florideæ (*Cystoclonium, Polysiphonia nigrescens, Furcellaria*), *Desmarestia aculeata* and *Stictyosiphon tortilis.*

bS. $^{21}/_{8}$ 1917. Outer part of Kolding Fjord, off Ellidshøj. C. 4 meters. — Soft bottom. — Broad-leaved *Zostera*-vegetation with loose *Furcellaria* and single *Fucus vesiculosus* and *F. serratus.*

cY[1]. $^{14}/_{6}$ 22. Outside the broom at Anslet Hage. 12,5—14 m. — Mud. — Dead *Zostera* leaves.

cY[2]. $^{14}/_{6}$ 22. The broom at Anslet Hage N.E. $^{2}/_{5}$ mile. 5–8 m. — Dense vegetation of broad-leaved Zostera (flowering), a little loose *Furcellaria (f ægagropila), Rhodomela* and *Polysiphonia nigrescens.*

cZ. $^{15}/_{6}$ 22. Knudshoved Grund (North of Haderslev Fjord), across the bank. 5,5—7 m. — 1) plain bottom with single stones, a little *Zostera.* 2) East border: *Zostera*-vegetation, a little *Furcellaria.*

dA. $^{15}/_{6}$ 22. The bank E. of the broom Fyrrenden N. 6,5—8 m. — *Zostera*-vegetation with single stones; *Furcellaria, Laminaria saccharina.*

dB. $^{15}/_{6}$ 22. South of Linderum. C. 5 m. — Dense *Zostera*-vegetation vith *Laminaria saccharina.*

dC. $^{16}/_{6}$ 22. South end of Aarø Sund, S. of the broom on the W. side. 8—10 m. — Dead *Zostera,* a little *Furcellaria, Rhodomela* and *Polysiphonia nigrescens.* — A little further South. 18—19 m. — Bare sand.

dD. $^{16}/_{6}$ 22. W. of Schønheyders Flak, 21 m. — Soft bottom. (Cyprina). — No vegetation.

dE. $^{16}/_{6}$ 22. Holsts Banke. 8–12,5 m. — Sand with stones. — Abundant vegetation: *Furcellaria, Chætopteris, Phyllophora Brodiæi, Rhodomela, Laminaria digitata, Zostera* etc.

dF. $^{16}/_{6}$ 22. Starbæk Rev. 1) 5—25 m. — Sand. — *Zostera* with Algæ, in particular *Desmotrichum undulatum* and *Chorda Filum;* further *Fucus vesiculosus, Ahnfeltia, Furcellaria, Polysiphonia nigrescens.* — 2) 10 m. — Sand with single stones. — *Zostera,* few Algæ.

cA. $^{4}/_{6}$ 21. Outside the beacon at Snogebæk, at the N. end of Alssund. C. 10 meters. — Mud with dead *Zostera*-leaves.

cB. $^{4}/_{6}$ 21. W. side of Arnkilsøre, Als, at the beacon. — Mud. — *Zostera* with broad leaves.

cC. $^{4}/_{6}$ 21. Alssund, a small bank, south of cB. — *Zostera* with *Desmotrichum undulatum.*

dH. $^{17}/_{6}$ 22. Just E. of Hesteskoen. c. 15 m. — Sand with stones. — *Laminaria digitata, Fucus serratus, Delesseria sanguinea, Furcellaria, Rhodomela.*

dH[1]. — Same place. 18—19 m. — *Laminaria saccharina, L. digitata, Delesseria sanguinea, Phyllophora Brodiæi.*

dG. $^{17}/_{6}$ 22. Hesteskoen. (Alssten). 1—2 m. — Narrow shoal, consisting of small stones. — At the top no vegetation. From 1,5 m. downwards vegetation of *Chorda Filum* and *Ectocarpus,* further single bushes of *Fucus serratus.*

dJ. $^{17}/_{6}$ 22. Søndre Stenrøn, by the triple broom. 6–7,5 m. — Sand with stones. — *Zostera,* a little *Rhodomela.*

dQ. $^{20}/_{6}$ 22. Bank S. of Lyø, $1^{1}/_{2}$ miles south of the S. end. 22 m. — Stones (small). — *Laminaria digitata* and *L. saccharina,* Florideæ, (*Phyllophora Brodiæi, Polysiphonia nigrescens, P. elongata* f., *Rhodomela subfusca* f.)

Great Belt. (Sb)

cT. $^{9}/_{6}$ 22. West of Ryggen, 55° 37′ N., 10° 41′ E. C. 20 m. — In a seine: *Laminaria digitata, Delesseria sanguinea, Dilsea edulis* (loose).

cS. $^{9}/_{6}$ 22. Ryggen, 55° 37′ N., 10° 43,5′ E. 18,5—23 m. — Gravel. — No vegetation.

cR. $^{9}/_{6}$ 22. Ryggen, 55° 37′ N., 10° 44,5′ E. 13—13,5 m. — Gravel, stones. — No vegetation.

cQ. $^{9}/_{6}$ 22. N. of Romsø, 55° 36,5′ N., 10° 47′ E. 22 m. — Soft bottom. — No vegetation.

cP. $^{9}/_{6}$ 22. N. of Romsø, 55° 34,5′ N., 10° 48′ E. 25 m. — Soft bottom, Ophiuræ. — No vegetation.

cO. $^{9}/_{6}$ 22. N. of Romsø, 55° 33′ N., 10° 48′ E. c. 15 m. — Soft bottom. — No vegetation (a fragment of *Dilsea edulis*).

cN. $^{8}/_{6}$ 22. S.W. of Musholm, 55° 26,3′ N., 11° 2,3′ E. 18 m. — Stones. — *Laminaria saccharina, Deless. sinuosa, D. sanguinea* in abundance.

cM. $^{8}/_{6}$ 22. N.E. of Sprogø, 55° 23′ N., 11° 0,5′ E. 25 m. — Mud, stones. — No Algæ.

cL. $^{8}/_{6}$ 22. N.E. of Sprogø, 55° 21,5′ N., 11° 1,5′ E. 25—27 m. — Stones. — *Delesseria sanguinea, D. sinuosa, Furcellaria* a. o.

Baltic, western part. (Bw)

bZ. $^3/_6$ 21. At the beacon south of Sønderborg, at the side of Sundeved. C. 11 m. — Coarse sand with stones. — *Laminaria saccharina, L. digitata* a. o. Algæ.

bV. $^3/_6$ 21. N.E. of the N. end of Kobbel Skov (Sundeved), off the point. 6,5—13 meters. — Stones. — *Furcellaria, Laminaria digitata,* several Florideæ *(Polysiphonia nigrescens, Rhodomela, Phyllophora membranifolia* a. o.)

bX. $^3/_6$ 21. Off the S. end of Kobbel Skov. 5,5—6,5 meters. — Gravel with stones. — The same species as in bV and further *Fucus vesiculosus* and *F. serratus.*

dL. $^{19}/_6$ 22. W. of the broom at Kragesand. 14 m. — Clayey sand without vegetation.

dM. $^{19}/_6$ 22. Same place, E. of the broom. 14 m. — Clayey sand with *Zostera.*

dN. $^{19}/_6$ 22. Flensborg Fjord. Bank between Holdnæs and Brunsnæs. 9 m. — *Laminaria saccharina, Zostera.*

bY. $^3/_6$ 21. Off Sønderskov. 11,3 meters. — First clay with Ophiuræ, then *Zostera* with Algæ, in particular *Furcellaria* and *Phyllophora.*

cG. $^6/_6$ 21. Trindelen, reef from the W. point of Kegnæs. 9,5—11,3 meters. — Stones. — Several Algæ, *Zostera.* — 11—19 meters. Stones. *Laminaria saccharina.*

cD. $^6/_6$ 21. Middelgrund (Hans Madsens Grund) south of Als, E. side of the bank, by the triple broom. 7,5—11,5 meters. — Sand with stones. — Various Algæ, *Laminaria digitata, Delesseria sanguinea* a. o.

cE. $^6/_6$ 21. The same bank, a little further south, 13—15 meters. — Sand (with stones). — Various Algæ.

cF. $^6/_6$ 21. 1 mile S. of Kegnæs light-house. In the channel 19 meters, soft bottom, no vegetation. — 8,5 meters, sand with *Zostera* and Algæ (*Phyllophora Bangii*).

dK. $^{17}/_6$ 22. Pøls Rev, near the bell buoy. 6—7 m. — Stones. — Abundant vegetation of *Halidrys, Furcellaria* etc.

dO. $^{20}/_6$ 22. North side of Bredgrund south of Als. 5 m. — Bare sand, single spots with stones. — *Fucus vesiculosus* and *F. serratus,* scarce *Zostera.*

dP. $^{20}/_6$ 22. E. side of Bredgrund. $7^1/_2$ m. — Large stony spots covered with vegetation. — *Fucus vesiculosus,* Florideæ (*Rhodomela, Polysiph. nigrescens, Furcellaria*), scarce *Laminaria digitata* and *Zostera.*

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Herpothamnion Turneri (Mert.) Nägeli, 1861, p. 348, figs. 14—16 and 18—19.
Herpothamnion hermaphroditum Nägeli, ibid. p. 352, figs. 28—29.
Spermothamnion hermaphroditum (Näg.) Janczewski, Développement du cystocarpe d. l. Floridées. Mém. Soc. sc. nat. de Cherbourg. Vol. XX. 1877, p. 115, pl. 3, figs. 7—14.

α, *Turneri* (Mertens).

Branches generally opposite, the tetrasporangia usually in corymbiform clusters. Sexual organs usually present.

β, *roseolum* (Agardh).

Branches generally alternate, the tetrasporangia single or in pairs (small clusters). Sexual organs frequently wanting.

Various opinions as to the denomination and the limitation of this species are still maintained. British authors mention *Spermothamnion Turneri* as common on the British shores but do not mention *Sp. roseolum* as a distinct species occurring there. On the other hand, C. Agardh and J. Agardh designate by this latter name the species occurring on the western coast of Sweden which they consider different from *S. Turneri*, a species which they do not record from the Swedish coast. Kylin follows them in 1907 (Stud. Algenfl. schwed. Westk., p. 149). J. Agardh (Spec. g. ord. II, 1, 1851, p. 24) quotes the characters by which *Callithamnion roseolum* differs from *C. Turneri*, viz. the ramification which is more rarely opposite, the sporangia which are single or placed in pairs while they are aggregate in *C. Turneri*, the looser and often longer tufts and the longer cells. These characters are, however, very variable, of which one is easily convinced by examination of a greater number of specimens.[1] I can therefore only approve that J. Areschoug in 1850 referred *Call. roseolum* as a variety under *Spermothamnion Turneri*, and it must also be considered that he is justified in referring *Conferva repens* Dillw. to the same species.

[1] Comp. Schmitz in Hauck et Richter, Phycotheca universalis No. 657, 1895.

This species of DILLWYN is the first described plant of this form series. It must be granted that the description only comprises sterile plants, but there is no doubt

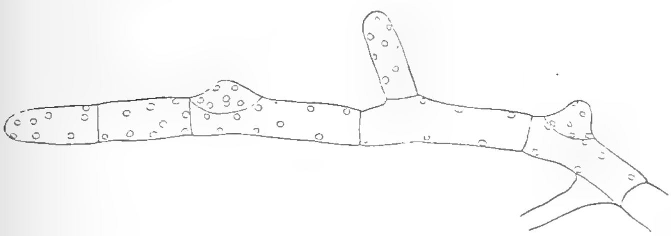


Fig. 202.
Spermothamnion repens. Filament showing the nuclei and the formation of the branches.

Fig. 203.
Spermothamnion repens. Upper end of thin filament. 300 : 1.

Fig. 204.
Spermothamnion repens. Two-celled hapter. 158 : 1.

that it refers to incompletely developed specimens of *C. Turneri.* Its occurrence on *Furcellaria fastigiata* which is a favourite substratum of *S. Turneri* speaks decidedly in favour of it. It must therefore be most correct to give the plant DILLWYN's specific name which is 4 years earlier than that of MERTENS.

The Danish specimens may be referred to two forms: f. *Turneri* and f. *roseola,* which are shortly characterized above. The first-named form has only been found in the North Sea, the Skagerak and the northern Kattegat, while in the specimens from the inner Danish waters the branches are rarely or never opposite and the sporangia are placed singly or in pairs on short pedicels. No distinct line of demarcation between the two forms can however be drawn, the characters varying considerably even on the same plant.

As shown by NÄGELI (l. c. p. 346), there is a distinct morphological difference between the horizontal filaments, which constantly grow in a transversal direction, and the erect filaments given off from their upper side. New creeping filaments are given off from the flanks of the first named filaments while rhizoids are produced from the under face.

The cells contain numerous nuclei, not only the older cells but also the apical ones which contain a considerable number in thicker filaments. They appear in the apical cells as hyaline globular bodies dispersed in the peripheral part of the dense

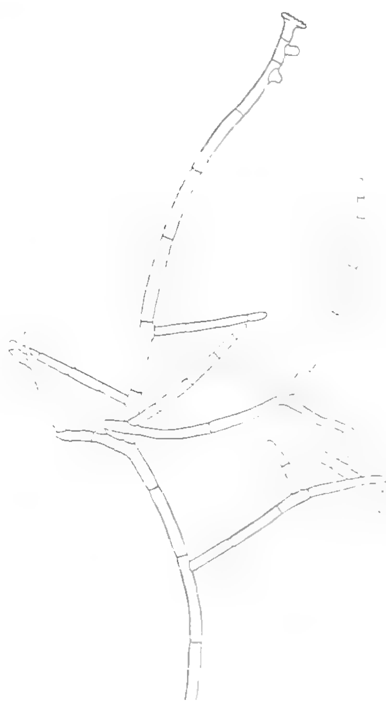


Fig. 205.
Spermothamnion repens. Normal and terminal hapters. 50 : 1.

protoplasm filling out the cell and not covered by chromatophores. In the other cells the nuclei are smaller and less conspicuous in a living state. In the thinner branches which sometimes occur in f. *Turneri* the number of nuclei may decrease to 3 or 4 (fig. 203) and the same may be the case with the sterile cells supporting the reproductive organs. The branches arise as small lenticular cells cut off by a concave wall at the upper end of the cell and containing from the first a number of nuclei (fig. 202).

Fig. 206.
Spermothamnion repens. Hair-cell with several nuclei and numerous small chromatophores. 220 : 1.

The hapters are numerous; they are frequently produced from a number of consecutive cells of the creeping filaments (comp. Dillwyn l. c., Lyngbye Plate 40 *C*). They spring normally from the basiscopic end of these filaments and are as a rule unicellular. When meeting the substratum the cell is expanded in an adhesive disc composed of densely joined dichotomous ramifications of the cell (fig. 204). The hapters may exceptionally be two-celled (fig. 204), and it may also occur that a hapter is produced at the end of a shorter or longer filament (fig. 205).

According to Pringsheim (1862, p. 17, Taf. IV fig. 1 and Taf. VI figs. 1—2) the erect filaments may terminate in a feebly coloured hair and the same may be the case with the involucral branches of the cystocarps. The occurrence of these hairs is however, according to my observations, not normal but a comparatively rare phenomenon which I have observed only in a few specimens. They arise from terminal cells of shorter or longer filaments, these cells becoming much longer, upwards a little thinner. The nuclei persist and become distincter while the chromatophores vanish and appear only as small feebly coloured grains (Comp. Kolderup Rosenvinge, Hyaline hairs. Biol. Arb. tilegn. E. Warming. 1911, p. 210). Transitional forms between hairs and hapters may occur (comp. Pringsheim and K. Rosenvinge ll. cc.).

The tetrasporangia are in the simplest case solitary and borne on a stalk-cell. This occurs particularly in the f. *roseola*; but a second sporangium is here frequently present, terminal on a lateral stalk-cell given off under the first. In the specimens from the North Sea, the Skagerak and the Northern Kattegat, which are in great part referable to f. *Turneri*, the sporangia are placed in cymoid clusters, the ramification continuing in various degree. These clusters may be opposite or secund. In the f. *Turneri* verticillate clusters, in ternate whorls, may occur beside the opposite ones. The sporangia contain from the first one nucleus only, while the supporting cell contains several nuclei (fig. 207 *B*). This comes in existence, as far as I have observed, in the way that the sporangium only receives one nucleus by the division by which it is separated from the stalk-cell. Any disorganization of supernumerary nuclei as in

Martensia a. o. (comp. N. Svedelius, Bau, Entw. d. Florideengatt. Martensia, K. Sv. Vet. Ak. Handl. Bd. 43, no. 7, 1908) could not be observed. The spores, which arise by tetrahedrical division, contain each one nucleus (fig. 208 *A*). A cell-wall separating the spores is shown in fig. 207 *D*. A small number of sporangia containing more than 4 spores, up to 8, was met with on a plant from the North Sea (aF, fig. 207 *E*). They had the same shape and size as the normal sporangia or were only a little longer. The spores produced seem to be somewhat smaller than the normal ones.

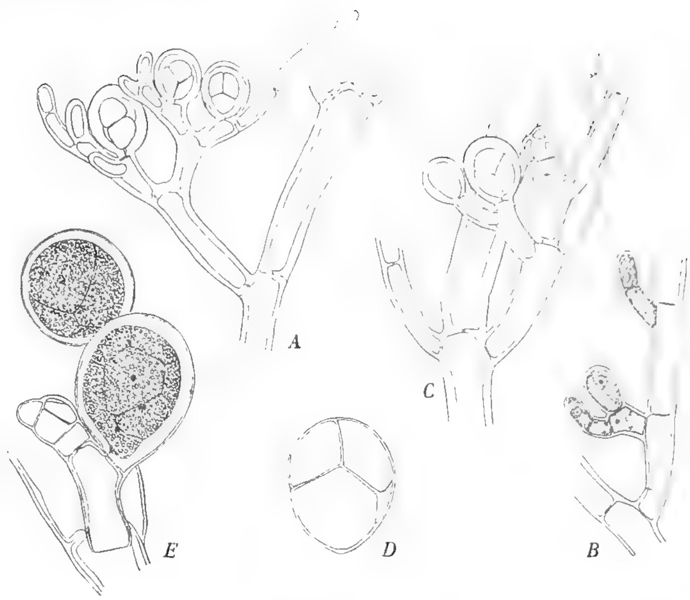


Fig. 207.
Spermothamnion repens. Tetrasporangia. *A* (Hirsholm), sporangia in cymoid cluster. *B*, young sporangia with one nucleus. *C—D* (North Sea). *C*, sporangia in company with a procarp. *D*, sporangium without the outer sporangial wall. *E*, two sporangia and a young procarp; the one sporangium with 8 spores. *A—C*, 150 : 1. *D—E*, 260 : 1.

The antheridia form irregularly ovate stipitate or sessile bodies which may appear on particular plants or branches but more frequently occur in company with the procarps. In the first case they are frequently seriate on the inner side of shorter branches. The antheridia-producing branchlets are divided by transversal walls in a number of segments which remain short except the undermost segment which usually develops into a stalk-cell. The other segments divide by vertical and oblique walls in a number of smaller cells all containing one nucleus only, the outer-

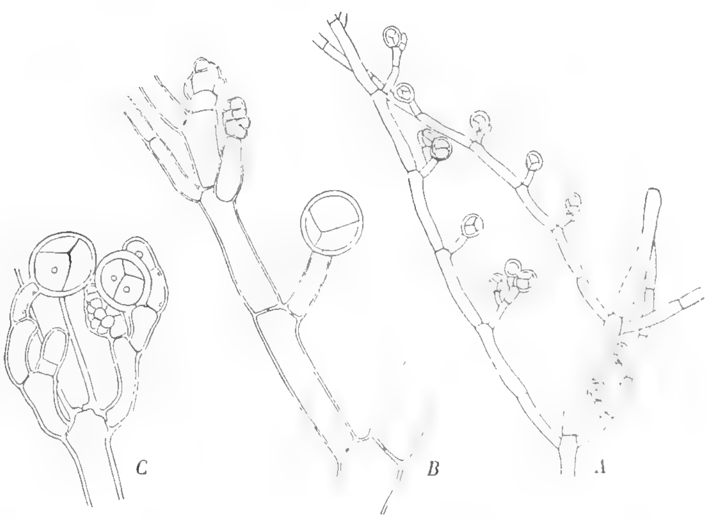


Fig. 208.
Spermothamnion repens. Sporangia. *A* (Hirsholm). *B*, *C* (North Sea), in company with antheridia and procarps. *B*, *C* 150 : 1.

most of which are smaller and become the antheridia. An axile cell as those figured by NÄGELI (l. c. fig. 28) may be present, but only in the under part of the antheridial cluster. The upper segments divide by anticlinal walls in a number of cells, meeting almost in the axis of the segment and producing at the periphery a number of smaller cells, the antheridia (fig. 209). The stalk-cell, which usually contains a number of nuclei, produces also by peripheral divisions a number of unicellular antheridia-producing cells (SVEDELIUS' "Spermatangienmutterzellen").

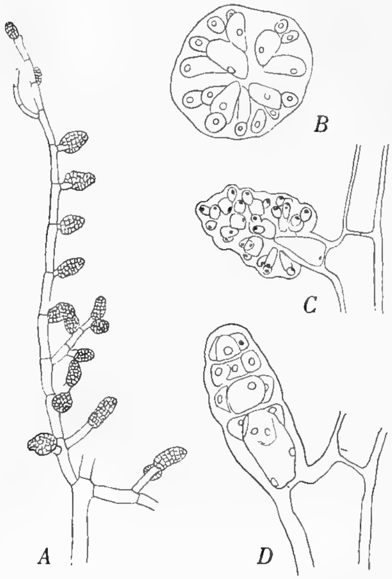


Fig. 209.
Spermothamnion repens. (Hirsholm) Antheridia. *B*, transverse section of antheridial body. *A* 63:1. *C* 350:1. *B*, *D* 560:1.

The procarps are situated at the end of short branches, The apical cell of such a branch produces by two transverse divisions two short segments, the uppermost of which undergoes further divisions, giving rise to the procarp, while the undermost and the apical cell remain undivided. By the first of these divisions the upper cell receives only one nucleus while the segment cell, becoming the stalk cell, contains several nuclei (fig. 210 to the left). Only rarely is the stalk cell also uninucleated (fig. 211 *A*). By division of the uninucleated apical cells two cells, each containing one nucleus only, result, the undermost of which is the mother-cell of the procarp.

The development of the procarp has been described by NÄGELI (1861), PRINGSHEIM (1862), BORNET and THURET (1876), JANCZEWSKI (1877) and recently more thoroughly by KYLIN (1923 p. 53—55), to whose description we may here refer. As shown by this author, the cell next to the top divides by longitudinal walls in a central cell and three pericentral ones the middlemost of which does not divide further. One of the lateral cells gives rise to a peripheral sterile cell (figs. 211 *B*, *C*, *G*, I^1) and to the carpogonial branch which becomes opposite to the median pericentral cell. The undermost cell-wall of the carpogonial branch is often oblique (fig. *B*, *E*, comp. JANCZEWSKI p. 115), the undermost cell being nearer to the lateral cell from which the carpogonial branch is given off. All the cells of the procarp are uninucleated from the first. The nucleus of the young carpogonium divides into two, the upper of which enters into the trichogyne where it appears as a rather hyaline body with a distinct nucleolus (figs. *D*, *E*). As shown by KYLIN, two small sporogenous cells are cut off from the fertilised carpogonium and these cells fuse with the two auxiliary cells which are cut off from the two lateral peri-

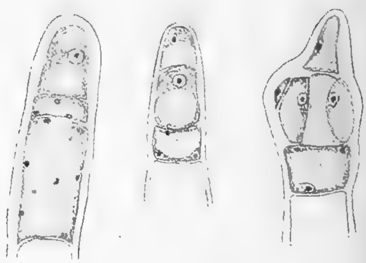


Fig. 210.
Spermothamnion repens. Young procarps bearing branches showing the first divisions and the nuclei. 500:1.

central cells; one of these sporogenous cells is seen in fig. *F*. The cells of the carpogonial branch were often found fused together after fertilisation, most frequently so that they all took part in the fusion (figs. *F*, *G*). The interpretation of the case represented in fig. I^2 is somewhat uncertain. A fusion cell is seen under the carpogonium and on either side of the fusion cell a small cell has been cut off. It has the appearance that the sporogenous cells have been cut off not from the fertilized carpogonium but from the upper sterile cell of the carpogonial branch. It seems however that this case must be interpreted in another way. The cell situated to the left of the carpogonial branch in fig. I^2 is evidently the first cell of this branch, being attached to the pericentral cell to the left in fig. I^1. The fusion cell has undoubtedly arisen by fusion of three cells. The upper of these cells must have been the carpogonium or more exactly a part of the carpogonium, undoubtedly containing the sporogenous nucleus, while the small cell situated over the fusion cell must be the rest of the carpogonium, probably without any nucleus. If this interpretation is true, the two small lateral cells must be true sporogenous cells, on the way to fusion with the auxiliary cells just cut off from the peripheral cells (comp. fig. I^1).

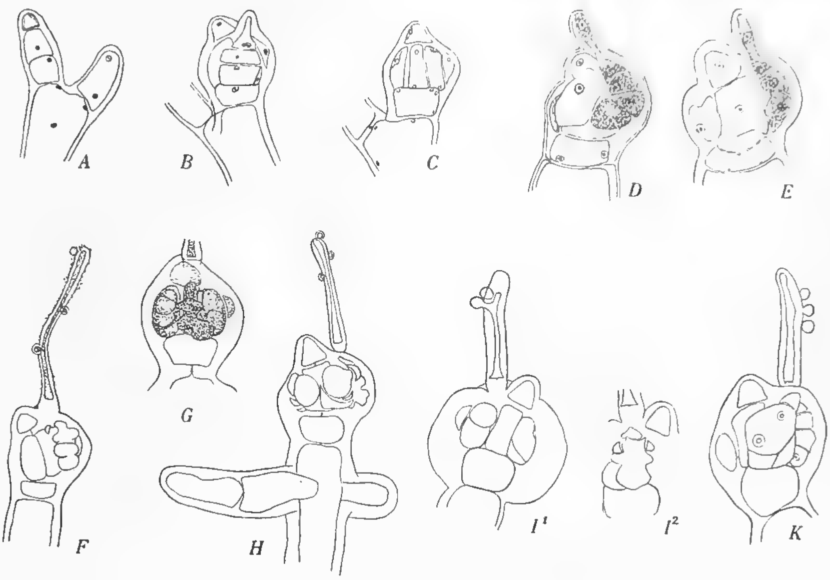


Fig. 211.

Spermothamnion repens. Development of procarps. *A*, young procarp-bearing filament; the stalk-cell is uninucleated. *B*, the carpogonial branch is formed; its first cell is partly hidden behind the second one. *C*, procarp seen from the dorsal side; *D*, *E*, lateral view; the trichogyne nucleus is visible. *F*—*K* after fertilisation. *F*, a sporogenous cell is visible. *G*, the cells of the carpogonial branch fused together; young gonimoblasts. *I* procarp seen from the ventral side, I^1 at a lower, I^2 at a higher level of the same procarp. The pericentral cell to the left has produced a sterile cell and an auxiliary cell, for the rest see text. *K*, lateral view; the auxiliary cell in beginning division. *D*, *E* 455 : 1, the other 284 : 1.

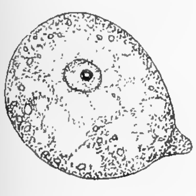


Fig. 212.
Spermothamnion repens. Carpospore. 350 : 1.

The upper sterile cell in the procarps may sometimes divide and grow out in a sterile filament. Janczewski (l. c. p. 117) found it sometimes replaced by a cluster of antheridia. The statement of Pringsheim (l. c. p. 19) that it may sometimes develop into a "Sporenmutterzelle" (carpospore), is certainly erroneus. I once observed two procarpia situated one over the other, originating without doubt in the following way: the first uninucleated apical cell (comp. fig. 210) has produced two uninucleated segments each developing into a procarp. The procarp of the undermost procarp protruded obliquely at the side.

The development of the gonimoblasts has been described by KYLIN (l. c.). The ripe carpospores contain one large nucleus (fig. 212). During the development of the cystocarp a number of involucral branches grow out under its base; there are usually 3 or 4, more rarely up to 8.

When sexual organs are present, they almost always occur on the same plant and further in combination with sporangia; the three kinds of reproductive organs are as a rule to be found in the immediate neighbourhood of each other on the same system of branches or branchlets, in various combinations. Usually the procarps are terminal in such complexes of branches, and branchlets bearing antheridia or sporangia are given off under them. A cytological study of such plants is much needed (comp. KYLIN 1916).

The species is widely distributed in the Danish waters except those with slightest salinity (the Baltic around Møen and Bornholm and the Sound south of Helsingør). It occurs scantily in the Limfjord but has otherwise not been met with in the fjords except the Isefjord where it has been found in the entrance. It attains its greatest development in the North Sea and the Skagerak where it has been found in almost all the places investigated and frequently in great abundance. It occurs here in dense tufts up to 5 cm high and may be referred to f. *Turneri*; it is usually fructiferous in summer and frequently bears sexual organs together with sporangia. Similar specimens are found in the Northern Kattegat, scarcely however exceeding 3 cm in height, and transitions to f. *roseola* are frequently met with, the sporangia-bearing branchlets bearing only a very small number of sporangia. In the more southern waters the species is usually sterile, even in summer; in some places, however. it has been found with tetraspores, but nowhere with sex organs (except once at Helsingør), The branches are rarely or not at all opposite and the sporangia are placed singly or in pairs on the pedicels. Also in the southern waters transitional forms may be met with; e. g. specimens collected at Lohals in **Sb** have partly numerous opposite branches and well developed corymbiform sporangial clusters.

Spermothamnion repens grows epiphytically on various Algæ, principally on *Furcellaria fastigiata*, also frequently on *Phyllophora membranifolia, Ahnfeltia plicata* and *Corallina officinalis*, further on several other Florideæ, on *Fucus serratus* and *Laminaria hyperborea* and *digitata*, and finally it has been met with growing on *Buccinum undatum*. It is perennial, but most of the upright filaments perish in the autumn, and the tufts are therefore only 2—10 mm high in winter. It is fructiferous only in summer, June to September (October). Ripe sporangia have been found in all these months, ripe cystocarps only in July to September. The species has been met with from low-water mark to 31 meters' depth (North Sea); in the Kattegat it has been observed down to 25 meters', in the more southern waters only to 13 meters' depth.

Localities. **Ns:** ZQ, jyske Rev, 24,5 met., ♂ ◯ +[1]; aF, 31 m. ♂ ◯ +; Klitmøller (Hornemann); XR, off Ørhage and within Ørhage, on stony bottom with Mytilus edulis, sterile (fixed to the pebbles or loose?). — **Sk:** YT and YU at Hanstholm, 2—13 m, ♂ ◯ +; eY, 18 miles E.N.E. $^1/_2$ E. of Hanstholm light-house, 15 miles N. of Bragerne 16 m; YN[2], S.E. of Bragerne, 10,5 m ♂ ◯ +; Bulbjerg (J. P. Jacobsen); SZ and SY, N. of Løkken, 13 m +; washed ashore at Løkken, ♂ ◯ +; ZK off Lønstrup, several places, 1—19 m, ♂ ◯ +, or only +; XO and VJ and several other places near Hirshals, 1—15 m, ♂ ◯ +, or only +; Tannisbugt, washed ashore (V. Schmidt); Højen, between first and second shoal. — **Lf:** LZ, Nissum Bredning; Oddesund, 6,5 met.; MH, Thisted Bredning; I, Venø Bugt; in all places sterile. — **Kn:** Harbour of Skagen; Krageskov Rev; Hirsholmene, ♂ ◯ +; Frederikshavn, harbour and several places in the neighbourhood, e. g. Deget; YP and UD, ♂ ◯ +; VT, +, ZP, UC, TL, +, near Nordre Rønner; Vesterø Havn; GM, near Engelskmands Banke, +; Tønneberg Banke, 15,5 m, +; FE, Trindelen, 10 m, +. — **Ke:** FD, E. of Læsø; VY and ZE[2], Fladen 15—18 m; XA, S.E. of Kobbergrund; E. end of Anholt; 14$^1/_2$ miles S.S.E. of Anholt Knob lightsh. 10 m (C. A. J.); HZ, Store Middelgrund; GI, Ostindiefarer Grund; off Gilleleje, +; Nakkehoved (Lyngbye), +. — **Km:** 6 miles S.S.W. $^1/_2$ W. of Læsø Rende light-ship, 8 m; 5$^1/_2$ miles N. to E. $^3/_4$ E. of Østre Flak light-ship, 9 m (C. A. J); BO, Stensnæs; BN, W. of Asaa; YY, ZC[1] and ZD Kobbergrund; XD, S. of Læsø; XB, S. of Kobbergrund; VN, S.E. of mouth of Randers Fjord; Gjerrild (Lyngbye); BJ, Gjerrild Flak; BH, off Gjerrild Klint. — **Ks:** EP, Pakhusbugt Anholt; OP, EM and EJ, Lysegrund; HP, S. of Lysegrund; Hesselø (Lyngbye); OS[1], Hastens Grund; FP, Jessens Grund, 4 m, +; GG and GF, Sjællands Rev; D, N. of Grønne Revle, 11,5 m, +; EH, W. of Lynæs. — **Sa:** Begtrup Rev, +; FT, N. of Samsø; FX, off Dyngby Hage; MP, Falske Bolsax; MQ, S. of Paludans Flak; AJ[1], N. of Æbelø, +; AH[1], N. of Fyns Hoved; Hofmansgave (Lyngbye, Hofm. Bang., C. Rosenberg). — **Lb:** AX, Bjørnsknude; Linderum; DB, Lillegrund (Reinke, !); CD, Helnæs Hoved Flak; DA, off Bøjgden; CC, Hornenæs, +; LG, off Vidsø, Ærø; DX, Vodrups Flak. Does not occur in the middlemost part of the Belt between AX and Linderum. — **Sf:** UV, N of Ærø. — **Sb:** AG, W of Romsø; AF, Møllegrund off Kerteminde; harbour and bay of Kerteminde; NU, off the Strandskov by Bogense, 11,5 m; reef at Korsør; Lohals, harbour, +; UU, Snøde Rev. — **Sm:** CQ, N.N.E. of Kogrund: Q off Vesterskovs Flak. — **Su:** BQ, off Ellekilde, 5,5 m; Hellebæk; near Helsingør (Liebman), ♂ ◯ +; Kronborg (Lyngbye). — **Bw:** cF, south of Kegnæs, Als, 8,5 m; dK, Pøls Rev; DU, off Dimes Odde; LC, off Gulstav, 11,5 m; KZ, of Kramnisse.

Trailliella Batters.

1. **Trailliella intricata** Batters.

E. A. L. Batters, Some new Brit. mar. Algæ. Journ. of Bot. Vol. 34, 1896, p. 10; id. in Journ. of Botany, Vol. 38, 1900, Tab. 414, fig. 14. H. Kylin, Über Spermothamnion roseolum (Ag.) Pringsh. und Trailliella intricata Batters. Botan. Notiser, Lund, 1916, p. 87. Kolderup Rosenvinge, Om nogle i nyere Tid indvandrede Havalger. Bot. Tids. **37**, 1920, p. 127. Kylin, Bot. Notiser 1922 p. 346.
Spermothamnion Turneri f. *intricata* Holmes et Batters, Annals of Botany, Vol. 5, 1890, p. 96.
Spermothamnion roseolum Kylin, 1915, p. 4.
non *Callithamnion intricata* Ag. Syst. Alg. 1824, p. 132, id. 1828, p. 182, Kützing, Tab. phyc. Vol. 11 pl. 62.

It is remarkable that this species which now occurs abundantly in several places has not been observed, as it seems, before 1890 and has been described for the first time in 1896. In mode of growth, it somewhat resembles *Spermothamnion Turneri*, but differs by smaller dimensions, by the want of opposite branches, by the presence of gland cells and by the structure of the hapters.

There is no essential difference between the horizontal and the vertical filaments. The cells contain a single nucleus, which is easily pointed out by fixing and

[1] ♂ designates antheridia, ◯ cystocarps, + tetrasporangia.

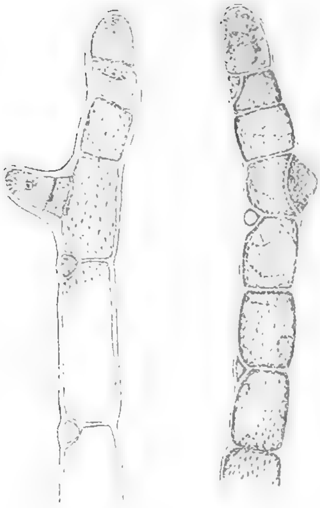


Fig. 213.
Trailliella intricata. Upper ends of filaments. 300 : 1.

staining agents in the apical cell and the young segment cells (fig. 213). As shown by Batters and Kylin, the cells contain numerous disc-shaped, or elongated chromatophores. The fully developed cells contain numerous starch-grains. The pits connecting the cells are very distinct. Most of the articular cells bear at their upper end a small gland cell, in optical section triangular, seen from the face roundish. As shown by Kylin (ll. cc.) they contain a substance which by addition of hydrochloric acid produces iodine.

The horizontal filaments are fixed to the substratum through pluricellular hapters, consisting of a downward tapering cell which at its under end bears a whorl of repeatedly branched filaments closely connate in a conical attachment disc (fig. 214). The rhizomes are frequently curved a little upwards between the hapters; they usually bear near the hapters a number of branches which are partly horizontal partly upright.

Fig. 214.
Trailliella intricata. Creeping filament with hapter. 260 : 1.

The upright filaments are sparsely and irregularly branched; there may be two generations of branches. The branches are scattered; they arise a little below the upper end of the filaments and are cut off by a watch-glas-shaped wall (fig. 213). The filaments are of almost equal thickness in their whole length, only a little tapering at their upper end; the diameter is 25—38 μ, the length of the cells 1—2,5 times as long as the diameter, more rarely up to 3 times as long. The long cells are a little constricted at the transversal walls. Hapters may exceptionally be found terminal on the filaments (fig. 215).

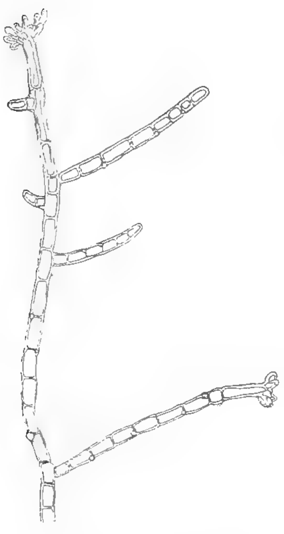


Fig. 215.
Trailliella intricata. Terminal hapters. 82 : 1.

The arrangement of the gland cells is irregular; in the horizontal filaments they are particularly produced on the upper convex side. In the upright filaments they have a tendency to be alternating, but no regularity exists and some cells bear no gland cell (comp. Kylin 1915).

The plant has always been found sterile in the Danish waters till October 1922 when Mr. C. A. Jørgensen found tetrasporiferous specimens in two localities in the Skagerak and the northern Kattegat. The tetrasporangia are formed, as shown by BATTERS, in the upright filaments by longitudinal division of a somewhat swollen cell into two parts of unequal size, the larger forming the tetrasporangium, the other part remaining sterile. The longitudinal wall is often somewhat inclined, the lower end of the sterile cell being broader than the upper. While the sterile cells contain numerous coarse starch grains, the developing tetrasporangium becomes dark-red and with more fine-granular contents. The tetrasporangium is first divided by a horizontal, slightly inclined wall and then by two nearly vertical walls. The ripe sporangium is much swollen; it opens by a split opposite to the sterile cell. As shown in fig. 215 bis the sporangium is connected with the sterile cell through a pit in the middle of the longitudinal wall. The sporangia may be solitary or 2 to 6 together and then variously orientated, always separated from the apex of the filament by a varying number of sterile cells. The sex-organs are unknown.[1]

BATTERS thought that this Alga was identical with *Callithamnion intricatum* J. Agardh. If he has founded this supposition only on the short descriptions of C. AGARDH (Syst. Alg., 1824, p. 132) and J. G. AGARDH (Spec. g. ord. II pars I, p. 19), it must be said that these descriptions are too incomplete to allow of an identification, and the plant represented in KÜTZING's Tab. phyc. 11. Band, Tab. 62, II is evidently another species, being much coarser and showing no gland cells. Two specimens in the herbarium of the Botan. Museum of Copenhagen from J. AGARDH, determined as *Callithamnion intricatum* and collected at Koster Bahusiæ and at Kullaberg, turned out to be *Spermothamnion repens*.

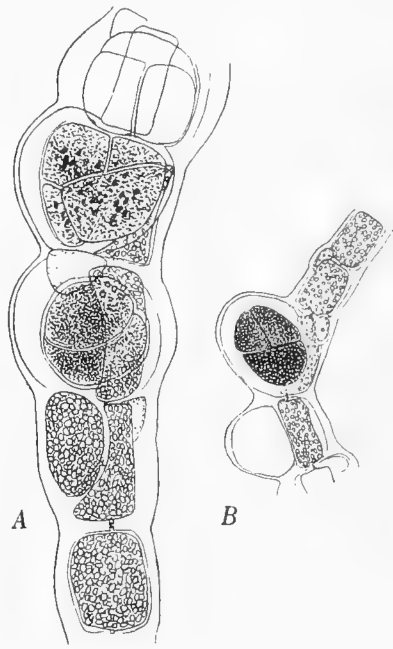


Fig. 215 bis.
Trailliella intricata Batt. Parts of filaments with tetrasporangia. *A* 390 : 1. *B* 230 : 1.

As long as the sex-organs are unknown the systematical position of the genus remains uncertain. The position and development of the tetrasporangia remove it from the other genera of *Ceramiaceæ*; the genus in this respect somewhat reminds one of the *Rhodomelaceæ*.

The species has been found more or less abundantly in numerous places in the Limfjord and the northern part of Kattegat, and recently in several places in the North Sea and Skagerak. It was first met with in the Western part of the Limfjord in 1901 but has not been observed there before that year, although numerous

[1] KYLIN has recently (Botan. Notiser 1922 p. 346) given a drawing of a tetrasporiferous plant after a slide from BATTERS kept in the herb. AGARDH in Lund, not being acquainted with the drawing given by BATTERS in Journ. of Botany 1900.

dredgings have been made in the same part of the fjord in 1890, 1893 and 1899. In the Kattegat it was not observed till 1909, when it was met with in the neighbourhood of Frederikshavn, although these waters were very carefully explored after 1889. It is therefore very probable that the species has immigrated into the Danish water about the year 1900, a supposition which is in accordance with the observations of Kylin on the west coast of Sweden (1916, p. 91), where *Trailliella* was found in three localities on the coast of Bohuslän in 1902—1906, while it was not met with by the earlier investigators, e. g. by Strömfelt who made large collections (of *Spermothamnion*) on the same coast in 1885—1887. At Helgoland it has also been recorded in later years (comp. Kuckuck, Zeitschr. f. Bot. 8 p. 135). In July 1907 I found *Trailliella intricata* abundantly on various Algæ and Ascidia at Arendal on the south-eastern coast of Norway, and in July 1916 at Anuglen on the West coast of Norway, near Bergen.

Trailliella intricata is almost always epiphytic, growing on various algæ, e. g. *Furcellaria, Corallina officinalis, Phyllophora* etc. but it also grows on *Mytilus, Trochus, Hydroids* and on pebbles, from low-water mark to 28 meters depth.

Localities. **Ns:** eA and eR, off Thyborøn, 28 and 27 meters. — **Sk:** eY and eZ, east of Hanstholm, 15—17 meters; 13 miles S.W. by W. $^1/_2$ W. of Rubjerg Knude light-house, 14 meters, with tetraspores, Oct. (C. A. Jørgensen); ($2^1/_2$ miles N.E. by N. of Skagens reef light-ship, 90 meters, loose, C. A. J.) — **Lf:** Nissum Bredning: Harbour of Thyborøn; Rønnen near Lem Vig (1901); ZU, near the latter, 4 meters; XV, N. of Rønnen (1901); off Hesdal, Kobberød; ZT, off Østerbol, 4 m, abundantly on loose Furcellaria; ZV, 5 m: ZY, 4,5 m; XU, 4 m; Nissum Bredning 1908 (Th. Mortensen); Oddesund. XT, south side of Jegindø Tap, 5 m; Sallingsund, various places, abundantly; aT^1, off Alsted, Mors, 5 m; Knudshoved, Fur; N. side of Fur; W. of Eierslev Røn, 7 m; off Feggeklit, 4 m. — **Kn:** Harbour of Skagen; fE, E. side of Krageskov Rev, 7 m; various places at Hirsholm, c. 11 m (1909 H. E. P.); near Kølpen, 4 m (H. E. P.); Laurs Rev; harbour of Frederikshavn; E. of Nordre Rønner; ZA, Tønneberg Banke, 12—18 m (1904); fG, 3 miles W. of Læsø Trindels light-ship; various places near the same 11—21 m; $6^1/_2$ miles S.W. by W. $^1/_2$ W. of Læsø Trindels light-ship, 15 m, abundantly, with tetraspores, October (C. A. J.) — **Ke:** ZE^2, near Fladens light-ship, 15 m (1904); 1 mile W. by N. of Fladens light-ship, 17 m, abundantly, Octob.; $14^1/_2$ miles S.S.E. of Anholt Knob, light-ship, 10 m (C. A. J.). — **Km:** $5^1/_2$ miles N. by E. $^3/_4$ E. of østre Flak light-ship, 9 m (C. A. J.).

Callithamnion Lyngbye emend.

Key to the Danish species of Callithamnion.

1. All cells uninucleate.
   2. Branches generally biseriate; hairs wanting; heaps of paraspores on the upper side of the pinnulæ .... *C. Hookeri.*
   2. Branches generally spirally arranged; no paraspores.
      3. Pinnulæ with terminal hairs .... *C. Brodiæi.*
      3. Pinnulæ usually without terminal hairs.
         4. Main axes vigorous, corticated; cystocarps round .... *C. roseum.*
         4. Main axes feeble, usually not corticated; cystocarps lobed .... *C. Furcellariæ.*
1. The older cells contain several nuclei.
   2. Branching pseudodichotomous; pinnulæ blunt, usually with terminal hairs .... *C. corymbosum.*
   2. Branches generally spirally arranged; pinnulæ pointed, never with hairs *C. tetragonum.*

1. Callithamnion Hookeri (Dillw.) Agardh.

C. Agardh, 1828, p. 178; Harvey, Manual Brit. Alg. 1841, p. 106; J. Areschoug, 1850, p. 103, tab. IV F (forma *a*); J. Agardh, 1851, p. 51; Harvey, Phyc. Brit. Vol. III, 1851, pl. 279; Kützing, Tab. phycol. XI tab. 94 a, 1861; Kylin, 1907, p. 150.

f. *Areschougii* nob.

Areschoug, l. c. forma *a*, Alg. scand. exsicc. No. 311; Kylin, l. c. f. *typica*.

Callithamnion pyramidatum Liebman, Bemærkn. o. Tillæg, Krøyers Tidsskrift II, 1839, p. 479, Tab. VI fig. 1, ex parte.

In several places in the Danish waters a *Callithamnion* has been met with which agrees exactly with *Callithamnion Hookeri a* Aresch., as described by ARE-

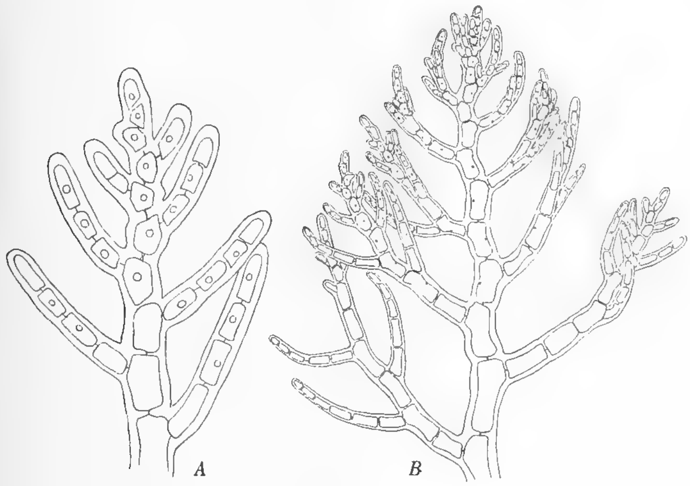


Fig. 216.
Callithamnion Hookeri. Upper end of sterile shoots. *A* 150:1. *B* 70:1.

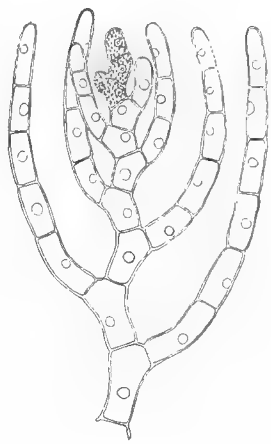


Fig. 217.
Callithamnion Hookeri. After a living plant. 160:1.

SCHOUG and KYLIN, ll. cc., and bearing, like the Swedish plants, heaps of paraspores but no or scarce tetrasporangia and never sexual organs. The Scandinavian specimens have certainly justly been referred to *C. Hookeri* Harvey; but as they differ from the British specimens by the presence of paraspores and by the absence of sexual organs they might be regarded as representing a particular form of the species.

The Danish specimens ordinarily reach only a length of 1,5—2 cm; but they may become up to 3 cm high (Skærbæk). The stem and the main branches are very distinct, not bent in zigzag, covered with down-growing cortical filaments. The ramification is mainly pinnate, the consecutive cells bearing each a branch alternating with the foregoing. Vigorous branches generally show a pinnate ramification, the pinnulæ lying all in the same plane, and being rather diverging. The lateral branches do not generally reach the level of the top of the main axis, and the outline of the shoot is therefore lanceolate, pointed above (comp. fig. 216). Exceptions may how-

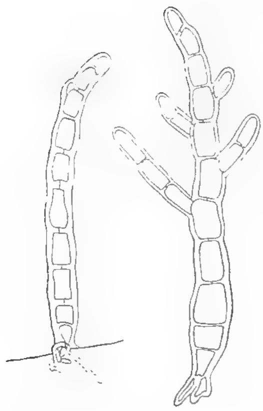


Fig. 218.
Callithamnion Hookeri.
Young plants. 145 : 1.

ever be met with (fig. 217). The pinnulæ become thinner towards the end, but they are not pointed.

In growing fronds with pinnate ramification, the dividing walls are inclined and alternating (figs. 216, 217, comp. Kylin, l. c. fig. 30 *c*); in the pinnulæ they are transversal. The lateral branches, the pinnæ, are branched in the same way as the main axis, from the base or so that the first lateral branch of the second order is placed on the 2[d] or 3[d] article or even higher (fig. 216). According to Kylin (l. c. p. 151), the branches of the second order are, when developed, orientated in the same plane as the lateral branch and the mother axis, but, when arising, they are placed in a plane perpendicular on the named plane, thus to the right and to the left, and the later position is arrived at by the turning of the lateral branch. My observations are not sufficient to warrant or disprove with certainty this statement, but at all events it must be said that its validity is not general. The case represented in fig. 216 *B* is in general favourable to the supposition of Kylin, however, it will be seen that there are some irregularities, e. g. in the 5[th] and the 10[th] branch from the base; and in other cases the plane of ramification of the youngest branched lateral branches coincided with that of the mother branch. Deviations from the pinnate ramification

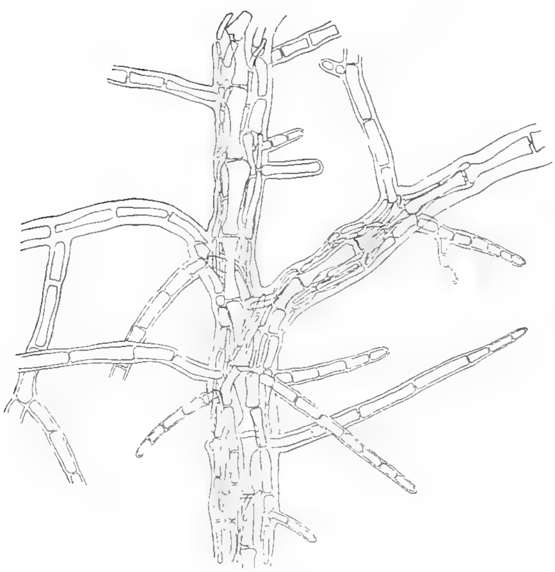


Fig. 219.
Callithamnion Hookeri. Part of mains axis with cortication. 70 : 1.

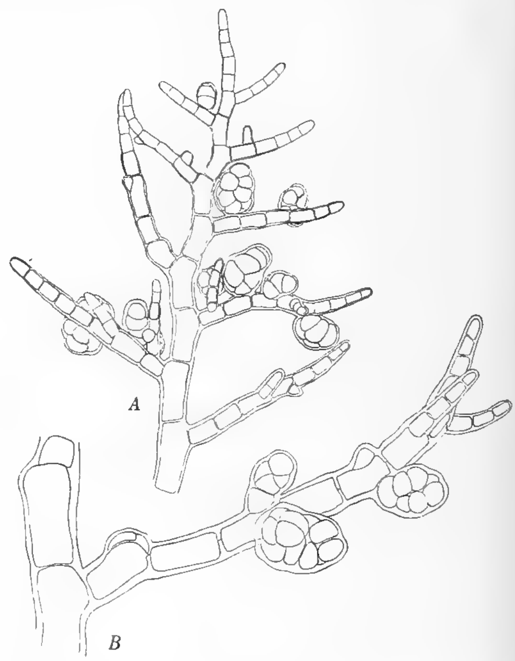


Fig. 220.
Callithamnion Hookeri. With paraspores. (Frederikshavn). *A* 70 : 1. *B* 145 : 1.

occur rather frequently, in branches of different order (fig. 216 *B*), principally in the most vigorous main axes, which may bear branches on all sides. J. Agardh states that the lower branches are given off on all sides, and that I have also found in some cases; but in other cases, the main stem was pinnate from the base, and the same was found in a young plant (fig. 218).

The descending filaments constituting the cortex of the stem and the main branches are produced from the base of the cells of the axes and from the base of the branches given off from them; they may completely hide the original cell-filament of these axes. Here and there adventitious filaments are given off from the descending filaments, principally from the base of the branches (fig. 219).

All cells contain a single nucleus and numerous chromatophores which in the young cells are small lengthened discs (fig. 217), in the older ones long bended, partly branched ribbons.

All the fructiferous specimens bear heaps of paraspores agreeing with the description of Kylin, l. c. They are more or less obliquely ovate and contain an indefinite number of spores, e. g. 10—12, resembling the tetraspores; they are placed on the upper pinnæ or pinnulæ, usually on their upper side in a number of one or two on the first or on the first and the second joint, more rarely in a number of three or four. In the latter case they are not always placed on the upper side of the branch but partly on the flanks or on the under side, and not rarely it happens that two heaps are placed on the same joint and then one under the other (fig. 221 *B*) or beside the other (fig. 220 *B*) or in oblique direction under the other, or they may be opposite, on the upper and under side of the cell (fig. 220). One of the heaps may be replaced by a vegetative branch. The position of the heaps of paraspores is the same as that of the tetrasporangia which in the plants from the Atlantic shores are placed not only on the upper side of the pinnules but also "utroque latere inordinatæ" (J. Agardh, l. c. p. 52, comp. Harvey l. c. pl. 279, fig. 4, Kützing l. c. pl. 94 fig. b).

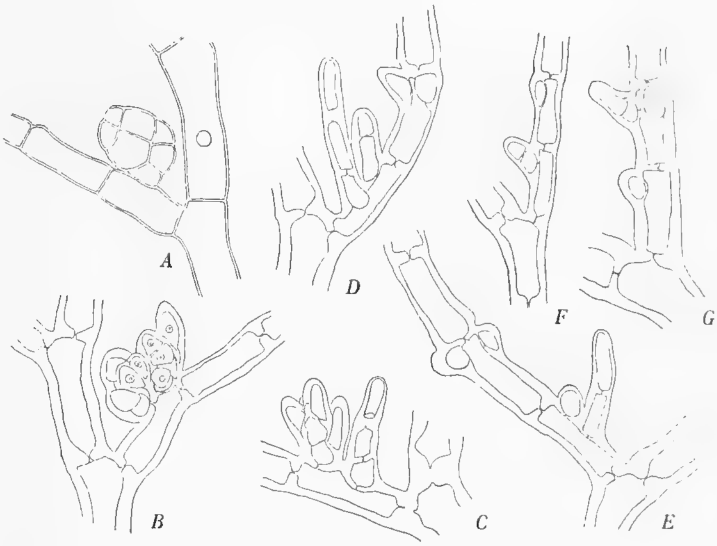


Fig. 221.
Callithamnion Hookeri. With heaps of paraspores. (Kerteminde). *A*, nearly ripe heap. *B*, younger stage. *C—G*, still younger stages, the heaps of paraspores partly replaced by vegetative branches. 200 : 1.

The fact that the heaps of paraspores have a position similar to that of the tetrasporangia might suggest that they are transformed tetrasporangia which have been divided in a greater and indistinct number of cells. This supposition, however, is only little probable; at all events the transformation might then be supposed to begin at so early a moment that it was impossible to decide whether the young organ were really a sporangium. The sporangia are early distinguished by their regular outline and by the double firm membrane (fig. 222). The heaps of paraspores are a special form of vegetative propagative organs, more related to the vegetative cells than the sporangia. This conception is confirmed by the fact that transitional stages between the named organs and vegetative shoots frequently occur (fig. 221) and that they may, as named above, be replaced by vegetative shoots (fig. 221 *C*—*E*).

Fig. 222.
Callithamnion Hookeri. Parts of plants with tetrasporangia. In *C* the same branch bears a tetrasporangium and a heap of paraspores. *D* and *E*, intercalary sporangia. *A*, *B* 145 : 1. *C*–*E* 200 : 1.

Tetrasporangia were found in some cases in paraspore-bearing plants, but in small number (Hirsholm, Frederikshavn, Grenaa, Kerteminde, Skærbæk). They are usually placed on the first or on the first and the second joint of a pinnula. Curiously enough, intercalary sporangia may sometimes be met with, arising from an intercalary cell in a pinnula (fig. 222 *D*). In such cases one of the spores is connected with the underlying cell by a pit, another spore with the cell above. Intercalary sporangia are hitherto unknown as a normal occurrence in the *Ceramiaceæ*, as far as I know.

The specimens from all the localities with one exception, occurring in depths from 0 to 30 meters, most frequently from 0 to 10 m, agree with Kylin's f. *typica*, having proportionally short cells, 2—3—4 times as long as broad, and well developed cortex on the principal axes. Specimens from YV in the Samsø area, 15 meters depth, remind one of f. *elongata* Kylin, l. c. by its longer cells, 5—6 times as long as broad; but the pinnulæ are scarcely less diverging than in the typical form. The frond is more slender and the cortex is very feeble or almost wanting. These characters are perhaps caused by the greater depth at which the plant was found growing. The heaps of paraspores were not more lengthened than in the other specimens but frequently bilobate (fig. 223).

The species has been found repeatedly sterile in April and May, frequently growing on *Furcellaria*, further on *Fucus serratus*, *Delesseria sanguinea* and *Rhomela subfusca*. Twice it has been found with paraspores in May, but otherwise with paraspores in the summer months (June to August) and in November. Tetrasporangia were met with in June, August and September.

Localities. **Kn:** Hirsholmene, littoral region and 9 meters (Henn. Petersen, !); Frederikshavn, harbour and Bussserev (!, Henn. Petersen); Østerø harbour, Læsø. — **Ke:** fO, Fladen, 10—11 meters; fI, Fladen, 30 meters, small specimen (C. A. J.); OO, Søborghoved Grund, 8,5 m. — **Ks:** Harbour of Grenaa; OT, Hastens Grund, 9,5 m. — **Sa:** YV; the light-buoy at Hatterbarn N. $2^1/_2$ miles, 15 meters (slender form, see above). — **Lb:** Skærbæk harbour off Kolding Fjord, with paraspores and tetraspores; DB, Lillegrund, (slender form, sterile). — **Sb:** Kerteminde, harbour. — **Su:** Ellekilde Hage (Boye Petersen); Hellebæk, washed ashore; near Helsingør (Liebman, *Call. pyramidatum*). — **Bw:** dK, Pøls Rev, 6—7 m.

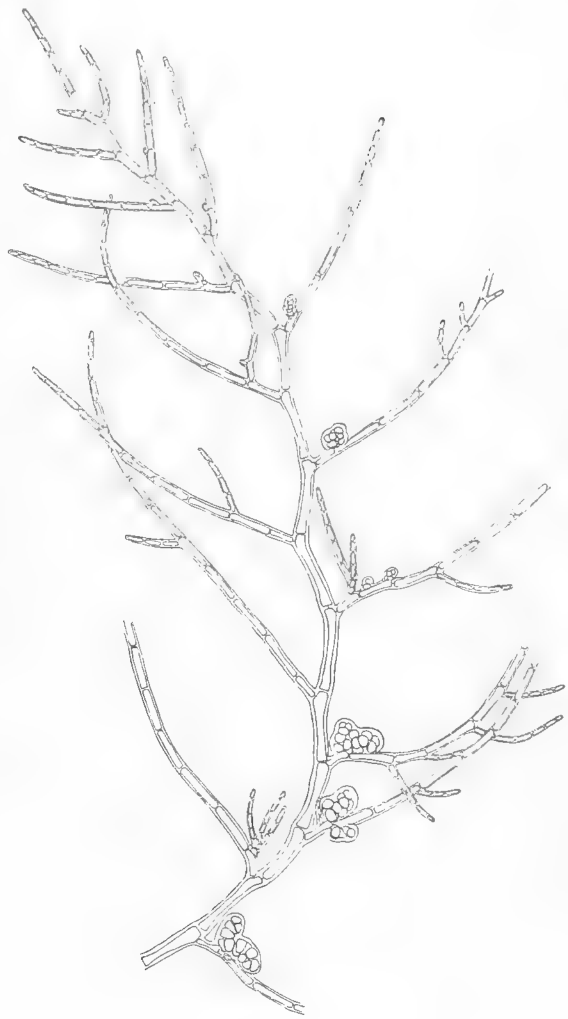


Fig. 223.
Callithamnion Hookeri. Slender form from 15 meters depth (YV). 47 : 1.

2. Callithamnion Brodiæi Harv.

Harvey in Hooker, English Flora, Vol. V part 1, 1833, p. 340; Manual, 1841, p. 105, Phyc. Brit. Pl. 129, 1849. J. Agardh, 1851, p. 57, III, 1876, p. 34. Kylin, 1907, p. 162.
Phlebothamnion Brodiæi Kützing, Spec. alg. 1849, p. 655, Tab. phyc., 11. Band, Tab. 100_{II}, 1861.

Only some few specimens of the species here mentioned have been met with, growing on *Furcellaria fastigiata* collected on the Nordvestrev by Hirsholmene, in company with four other species of Callithamnion, Spermothamnion repens and others. They agree perfectly with the quoted figures and descriptions of Agardh, Kützing and Kylin, and it is probably justly that the name of Harvey has been assigned to them though it is not excluded that two species might have been confounded under that name. Referring especially to the paper of Kylin, a description of the Danish specimens may be given here.

The specimens reach only a length of 1,5 cm at most. The main axes are very distinct, straight, not bent in zigzag, corticated below. The thickness is 130—150 μ below, over the cortication about 75 μ. The cells are $1^1/_2$—5 times as long as broad. From the cells of the cortical filaments growing down in the outer walls small adventitious filaments are given off (fig. 224), probably more numerous in larger specimens. The lateral branches are as a rule much shorter than the main axes the result being that the outline of the main branches become narrow, hastate or pyramidate.

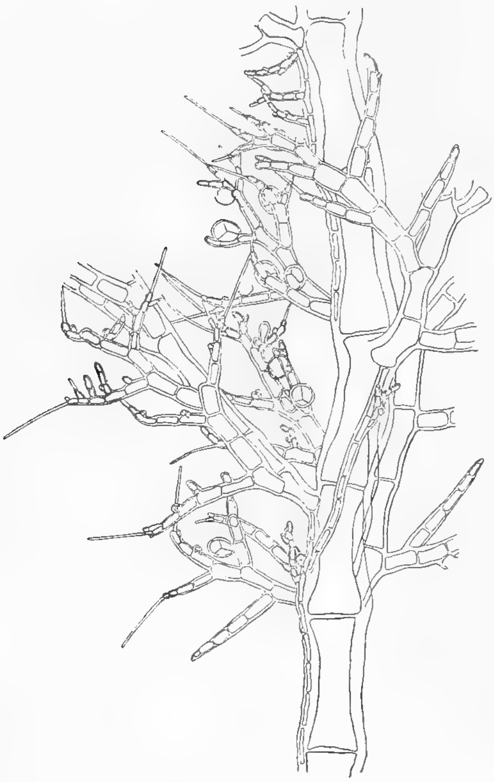


Fig. 224.
Callithamnion Brodiæi. Part of tetrasporiferous plant. 62:1.

The branches are given off on all sides, as a rule one from each joint; they are usually placed in a spiral line, however not in the whole length of the shoot, the angle of divergence is about $^1/_3$ or $^1/_4$, the spiral turning to the right or to the left in different shoots (fig. 227). In a long branch the branches were arranged from the base in a spiral turning to the right with an angle of divergence of $^1/_3$, then irregularly, after that in a spiral to the right with an angle of divergence of $^1/_3$ and finally secundate. The ramification of the lateral branches is usually similar to that of the main branches. The first branches of the second order are frequently alternating to the right and to the left or irregularly arranged, and it is only at a higher level that the regular spiral arrangement commences. In the main branches this ramification may be repeated several times, but the branches become gradually feebler and the later branches have limited growth, are divaricate and more irregularly branched, often secundate, bearing only branches on the upper side (fig. 228). As will be seen, this description agrees with that of Kylin. Secundate pinnulæ are also mentioned and figured by Harvey (Phyc. Brit. Pl. 129), but as many and as regularly arranged secundate pinnulæ as in Harvey's figs. 2 and 3 I have never seen in the Danish specimens.

In the main branches dividing walls of the apical cell are inclined, and the axis is at first bent in zigzag but later it becomes straight. In the unbranched or feebly branched pinnulæ the dividing walls are transversal.

The cells contain a single nucleus in the young and the later age, and numerous long ribbon-like, more or less branched chromatophores.

Characteristic of the species is the great development of hyaline hairs at the tip of the branchlets, as already figured by Kützing and Kylin. The hairs are rather short (7—9 μ thick, 160—290 μ long). The pit connecting the hair with the bearing cell is very distinct. The hair-bearing cell cannot function as apical cell but it may produce a branch which sometimes grows out approximately in the same

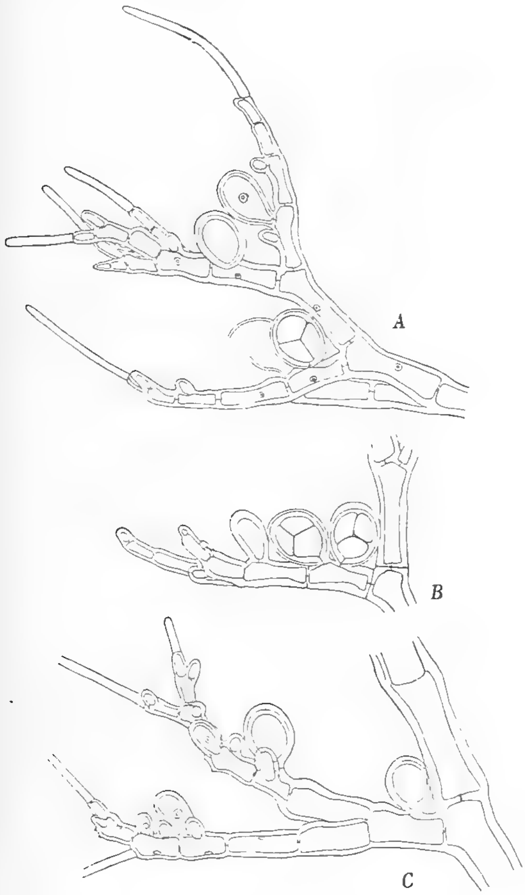


Fig. 225.
Callithamnion Brodiæi. Parts of tetrasporiferous plant. 158:1.

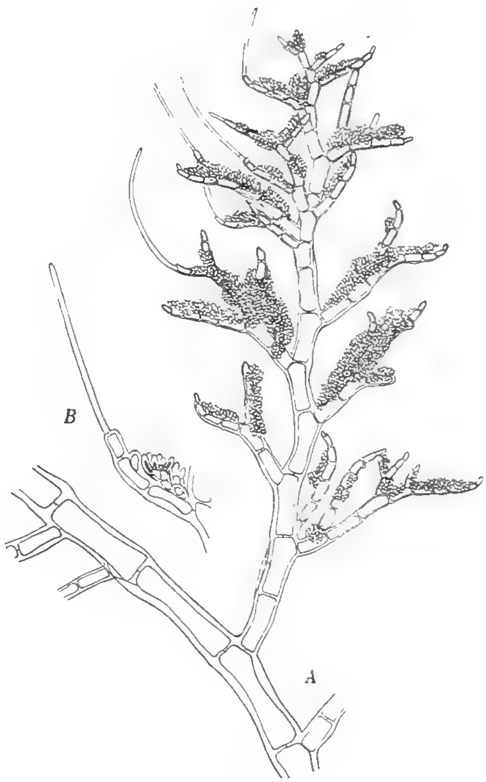


Fig. 226.
Callithamnion Brodiæi. Parts of male plant. A 77:1. *B* 220:1.

direction as the mother axis, the hair being pushed aside (fig. 225 *C*). In the observed cases the hair was pushed towards the dorsal side of the filament. The process may be repeated in the same filament.

The tetrasporangia are placed on the branches of higher order, principally on the upper side of the branchlets, on the first joint, on two or three consecutive ones or more irregularly. There are frequently two on the same joint and then the younger below the older or obliquely beside and below it (fig. 225). The undermost sporangium may be placed on the middle of the joint which may also be the case with a single sporangium (225 *C*). A seriate arrangement as regular as in Harvey's figs. 3

and 4 is only met with exceptionally in the Danish specimens (fig. 225 *B*). The sporangia were 70—76 μ long, 61—65 μ broad; they are discharged through a transversal split above.

The antheridia are produced on the surface of long cushions on the upper side of the branchlets which are much divaricate in the male specimens. The cushions are composed of two or more small bushes on each joint fused with each other and with those of the neighbouring joints. The outer cells only of these bushes produce spermatia while the under cells remain sterile.

The procarps are placed on a branch-bearing cell opposite to the branch. They have the same structure as in *Call. corymbosum*. In an unfertilised carpogonium the trichogyne was feebly swollen at the base (fig. 227). There are two nearly globular gonimoblasts and under each of them a smaller one which may produce carpospores as well developed as the large ones. The cell bearing the cystocarp is frequently shorter than the other cells in the same filament.

As pointed out by Nägeli (Morph. Ceram., 1861, p. 372), *Call. Brodiæi* Crouan (Alg. mar. du Finistère, no. 154, Florule du Finistère, p. 138) is not identical with Harvey's and Kützing's species. In the specimen of the Exsicc. I found the ramification generally pinnate in the pinnæ and the pinnulæ as well, the cells much shorter and thicker and hairs totally wanting. Crouan's plant has been described as *Maschalosporium gallicum* (*Call. gallicum* Sauvageau, Alg. mar. Golf. Gascogne, Journ. de Botanique t. XI 1897, p. 63). It is probable that Harvey's description included also this species (comp. Phyc. Brit. pl. 129 fig. 3—4), but it seems to have been worked out principally after specimens of the species mentioned here under Harvey's name. I have had no occasion to examine authentical specimens.

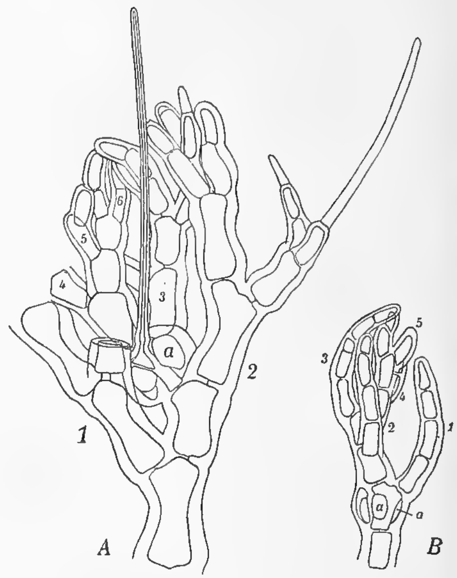


Fig. 227.
Callithamnion Brodiæi. Upper ends of female plants; *A*, with fully developed, *B*, with young procarp. *a* auxiliary mother-cells; the first cell of the carpogonial branch is not visible. *A* 270:1. *B* 200:1.

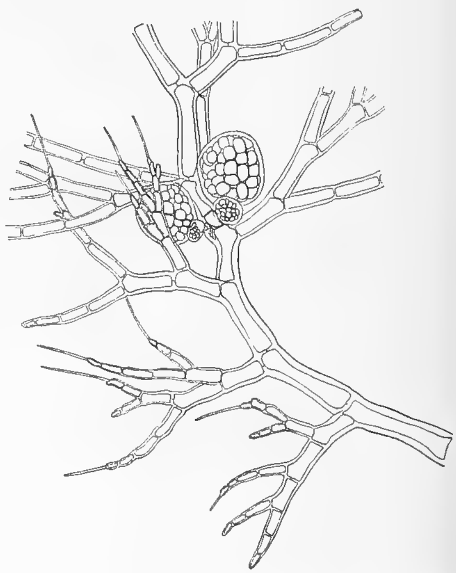


Fig. 228.
Callithamnion Brodiæi. Part of cystocarp-bearing plant. 70:1.

C. Brodiæi cannot be confounded with any of the species found at the Danish shores. *C. corymbosum* is the only species bearing equally numerous hairs but these hairs are much longer than in *C. Brodiæi.*

Localities. **Kn:** Nordostrev by Hirsholm, 7—9 meters depth, on Furcellaria fastigiata, July 1904; one specimen with cystocarps met with at the same place in August 1922 (C. A. Jørgensen).

3. Callithamnion tetragonum (With.) Ag.

C. A. Agardh, Spec. Alg. Vol. II sect. I 1828, p. 176; J. Agardh, 1851, p. 53; Harvey, Phyc. Brit. pl. 136, 1849; Kylin, 1907, p. 158.
Conferva tetragona Withering, Arrang. Brit. Pl., 3d edit. Vol. IV, 1796, p. 405.
Dorythamnion tetragonum Nägeli, 1861 p. 344—345.
Callithamnion brachiatum Bonnem., Harvey, Phyc. Brit. p. 137, 1849.

This species is here taken in a somewhat wider sense than generally accepted. The typical, first described *C. tetragonum* is characterized by its thick pinnulæ, having

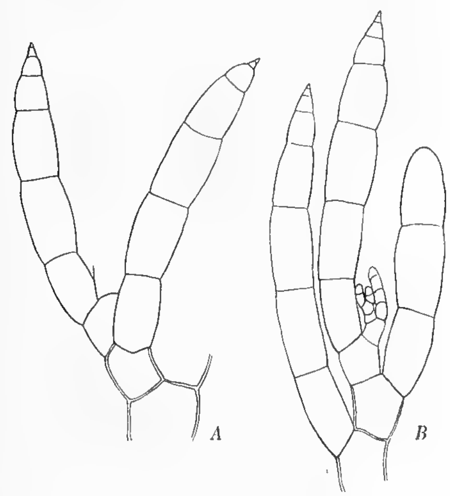


Fig. 229.
Callithamnion tetragonum Ag. From Devonshire, ex herb. J. G. Agardh. 47:1.

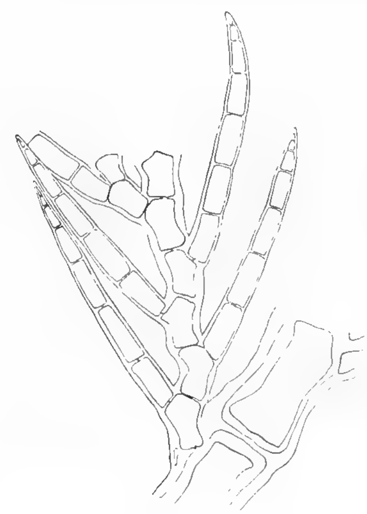


Fig. 230.
Callithamnion tetragonum (f. *brachiata*). From Cherbourg. 47:1.

their greatest thickness above the base (80—140 μ according to Hauck, 75—100 μ after Kylin), consisting of barrel-shaped cells and suddenly acuminate. In the very nearly related *C. brachiatum* the pinnulæ are thinner (40—80 μ) and consist of cylindrical cells 2—3 times as long as broad. This form is, certainly rightly, regarded as a form of *C. tetragonum* by several authors (J. Agardh, l. c.; Hauck Meeresalg., p. 83; Gran, Kristianiafjord, p. 26); it forms further a transition to *C. fruticulosum* Ag., as principally known from the Scandinavian coasts. J. Agardh has already stated that the latter is related to *C. tetragonum*, and Gran (l. c.) declares that the Norwegian specimens determined by him as *C. tetragonum β, brachiatum*, show much resemblance to *C. fruticulosum.* Kylin (1907, pp. 154—162) points out the accordance in the morphological structure existing between these three forms which he considers as distinct species, and he further describes a new, fourth species, *C. spiniferum* characterized principally by thinner pinnulæ, 25—40 μ thick, and consisting of longer cells, 5—8 times as long as broad, while in *C. fruticulosum* the pinnulæ, according to Kylin, are 40—60 μ thick and consist of cells 3—5 times as long as broad.

I cannot acknowledge the right of distinguishing these four forms as species, at all events not with the delimitation given by Kylin. The specimens found at the

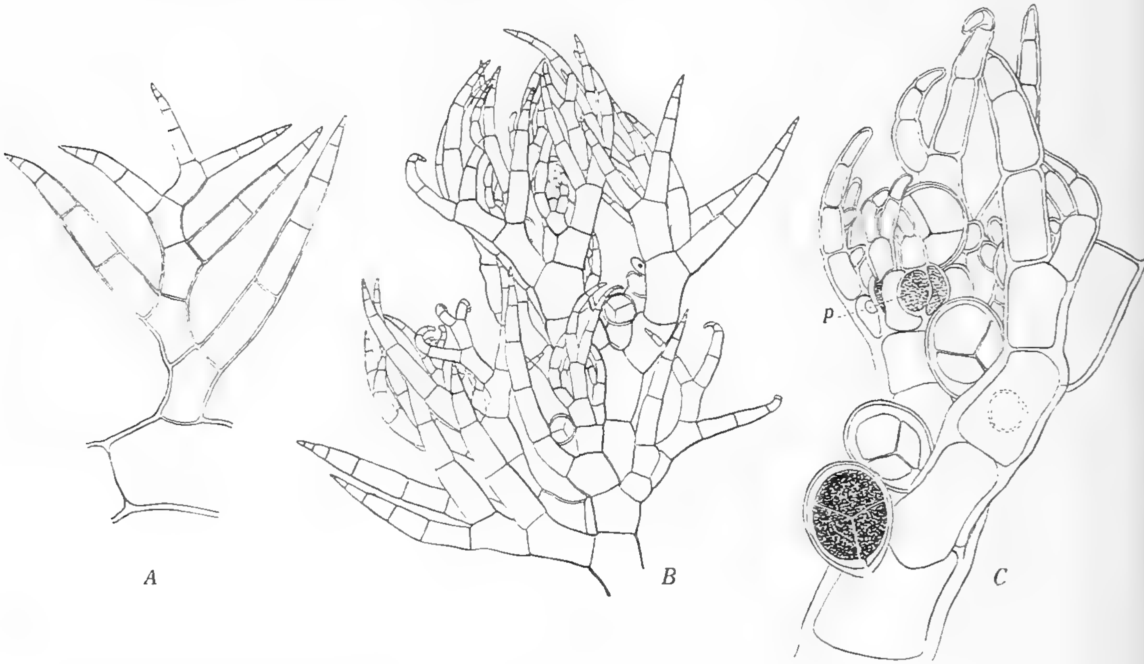


Fig. 231.
Callithamnion tetragonum var. *divaricata.* *A*, pinna. *B*, branch-system with tetrasporangia. *C*, branch with tetrasporangia and an arrested procarp *p*. *A*, *B* 70:1. *C* 200:1.

North coast of Sealand agree perfectly with J. Agardh's description of *C. fruticulosum* and with specimens from Agardh (from Kullaberg), and the dimensions of the cells in the pinnulæ correspond also with those attributed to this species by Kylin, viz. 3—5,5 times as long as broad; but the thickness of the pinnulæ is the same as that attributed to *C. spiniferum*, viz. 23—42 μ. In specimens found in the Northern Kattegat, the pinnulæ are thicker and of a structure more resembling that of *C. brachiatum*, but in some of the specimens the pinnulæ were up to 123 μ thick and consisted of cells only 1,2—2,7 times as long as broad, thus resembling those of the typical *C. tetragonum*; the cells were, however, not barrel-shaped and the pinnulæ were thickest at the base. My investigations have led me to consider all these supposed species as forms of one species which must bear the name of the first described form, the typical, Atlantic *C. tetragonum* (With.). This apparently rather variable species may very likely comprise a number of elementary species, but as it is impossible for me to distinguish them, it is preferable to distinguish varieties or forms within the larger species.

The typical *C. tetragonum* has not been found at the shores of Denmark. But plants that must be regarded as forms of this species have been met with in two distinct groups of localities, the one in the neighbourhood of Frederikshavn and Hirsholmene in the Northern Kattegat, the other at the North coast of Sealand

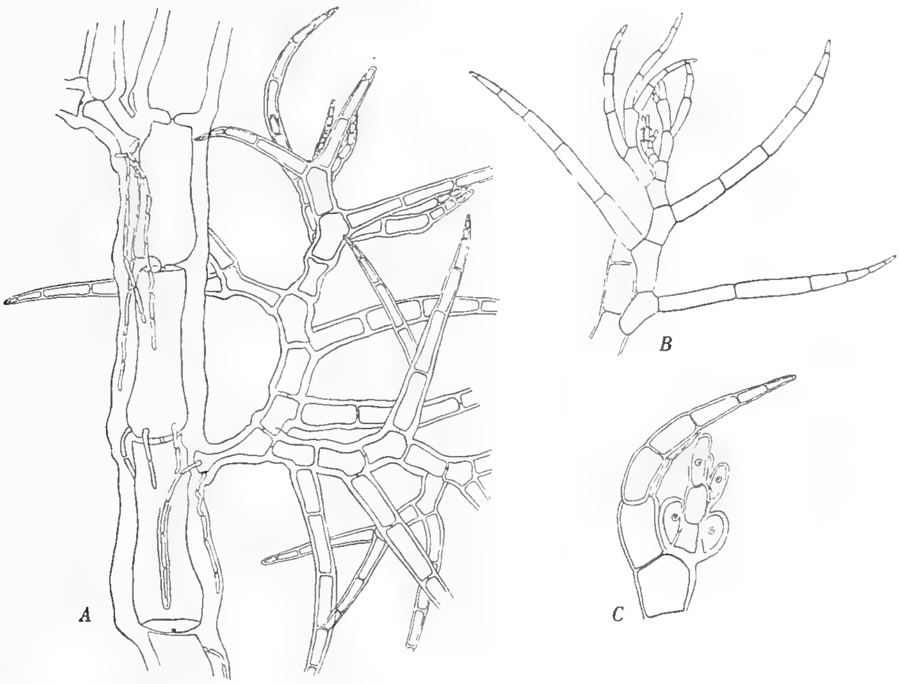


Fig. 232.
Callithamnion tetragonum var. *divaricata*. From Hirsholmene. *A*, part of stem with branches. *B*, branch. *C*, branch with procarp; the two auxiliary mother-cells are visible. *A* 50 : 1. *B* 47 : 1. *C* 260 : 1.

from Gilleleje to a place a little north of Helsingør. As the specimens from these two groups of localities are different from each other, they may be mentioned particularly.

The species is easily distinguished from the other Danish species by its pointed pinnulæ which never terminate in a hair and by the cells being multinucleated to the top or with the exception of a few of the uppermost cells.

Var. *divaricata*.

The species has been found several times in the neighbourhood of Frederikshavn and at Hirsholmene but only in a few and small specimens, 1,5—2,5 cm high. They pretty much agree with var. *brachiata* in the structure of the pinnulæ, but these are more divaricate than in that variety. The pinnulæ have their greatest thickness at the base and gradually taper upwards. Their greatest thickness is somewhat variable; it was greatest in a specimen met with in November in Busserev at Frederikshavn, viz. 50—124 μ, frequently over 100 μ. In small specimens found in the same locality in July it was only 49—63 μ. The length of the cells was in the first case 1,25—2,7, in the latter case 2,5—3 times the breadth, and similar dimensions of the pinnulæ were found in specimens from Marens Rev (January) and Hirsholmene (July). In the pinnæ with arrested growth, the last pinnulæ were more or less divaricate (figs. 231—232).

The tetrasporangia are placed on the inner side of the pinnæ, usually beside and at a lower level than the branches. Tetrasporiferous pinnæ with arrested growth may form corymbiform clusters. The sporangia are nearly globular, 62—70 μ long, 51—59 μ broad. In sporangiferous specimens, undeveloped procarps may be found in the same pinnæ as the sporangia (fig. 231 *C*).

Found with ripe tetrasporangia in July and November, with ripe cystocarps in July.

Localities. Nordostrev by Hirsholm, in *Furcellaria*, 7,5—9,5 m; Busserev and Marens Rev by Frederikshavn.

Var. *fruticulosa* J. Agardh.

Kolderup Rosenvinge 1920, p. 7.

Callithamnion fruticulosum J. Agardh, Symbolæ, Linnæa, 15. Bd. 1841, p. 46, Spec. gen. ord. Alg. II p. 56, 1851; Kylin, Algenfl., 1907, p. 154. Non Roth, Catalecta II, 1800, p. 183, nec Lyngbye, Hydr., 1819, p. 124.

Callithamnion Hookeri (Dillw.) b. Areschoug, Phyc. scand. 1850, p. 104.

Phlebothamnion fruticulosum Kützing, Tab. Phyc. 11, 1850, pl. 95.

Callithamnion Baileyi Harv., Ner. Bor. Amer. II. 1853, p. 231, pl. 35 B; Farlow Mar. Alg, N. Engl., 1881, p. 127, pl. XI, figs. 1—2.

Phlebothamnion Baileyi (Harv.) Kützing, Tab. phyc. 11, 1850, pl. 95.

Callithamnion spiniferum Kylin, l. c. p. 159.

When J. Agardh has named this plant *C. fruticulosum*, it might be observed that it is not identical with the plants which have formerly been designated by this name. J. Agardh has himself identified Roth's species with *C. versicolor* Draparn., and *C. fruticulosum* Lyngbye is at all events also a different species. I do not doubt that our plant is identical with *C. Baileyi* or with one of the forms of this variable species of which Harvey declares, l. c. p. 232 that "the most robust forms, with shortest joints, approach *inconveniently* near to *C. tetragonum*, from which species the more delicate ones appear widely different." In North American specimens from Farlow and Saunders I found cystocarps and antheridial-cushions resembling those in the European species.

As mentioned above, I cannot regard *C. spiniferum* as a species distinct from *C. fruticulosum*, the dimensions of the pinnulæ offering no distinctive characters. According to Kylin (l. c. pp. 157—162), the dimensions of the gonimoblasts and the tetrasporangia should in *C. spiniferum* be greater than in the last named species; in the Danish specimens, these organs reach the dimensions stated for *C. spiniferum*, the gonimoblasts being 130—227 μ in diameter, and the sporangia being 74—81 μ long, 46—61 μ broad.

As stated by KYLIN, l. c., all the forms referred here to *C. tetragonum* agree with each other in branching and all morphological characters. Referring to KYLIN's descriptions, I shall here describe the specimens occurring at the North coast of Sealand, all referable, in my opinion, to the variety that J. AGARDH designated by the name of *fruticulosum*.

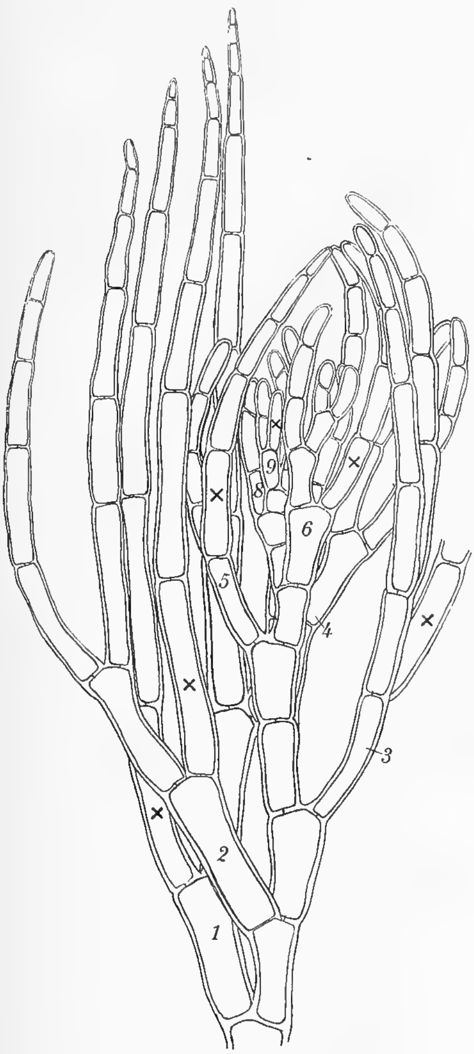


Fig. 233.
Callithamnion tetragonum var. *fruticulosa*. From Hellebæk. Upper part of sterile branch. The first branch of the second order is marked with ×. 200 : 1.

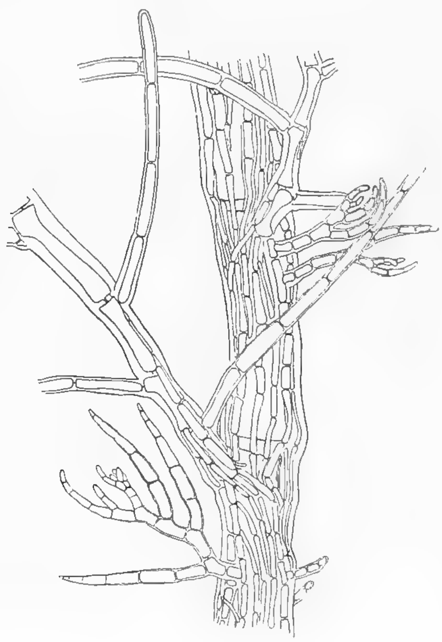


Fig. 234.
Callithamnion tetragonum var. *fruticulosa*. Part of stem showing cortication and adventitious branches. 50 : 1.

The plants reach a length of up to 7 cm; in aspect they resemble the typical *C. tetragonum* and have the same brownish red colour. The main branches have a pyramidal outline. The main axes are vigorous, straight and covered with a cortex of decurrent filaments, from which here and there adventitious shoots are given off without any distinct order; young and older shoots may arise intermingled with each other. The branches of the main axes are spirally disposed with an angle of divergence of about $^1/_4$ or between $^1/_3$ and $^1/_4$. The branches of the second and higher orders are arranged in a spiral as those of the first order, except the first 1—5 which are alternate, biseriate and arranged in a transversal plane. The ultimate short branches bear only biseriate pinnulæ. A sympodial ramification does not occur. The branching designated with this term by Nägeli (1861, p. 305—306) is really monopodial, the end of the growing axes being only bent by the developing branches. For further details of the arrangement of the branches reference may be made to my above quoted paper (1920 p. 7).

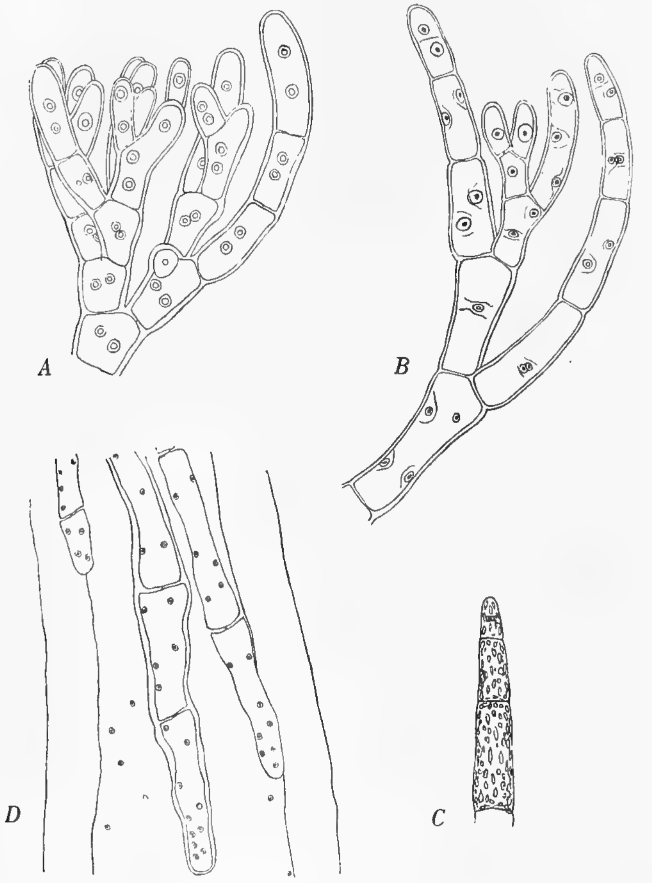


Fig. 235.
Callithamnion tetragonum var. *fruticulosa*. *A* and *B*, upper ends of growing plants showing the nuclei. *C*, upper end of branchlet with arresting growth. *D*, part of stem cell with corticating filaments showing the nuclei. *A*, *B*, *C* 350 : 1. *D* 203 : 1.

The pinnulæ are all acuminate when their growth is arrested. Only exceptionally a feebly developed obtuse pinnula may be met with (fig. 234). The lower cells are 3—5,5 (6) times as long as broad, usually 4—5 times as long. Hairs do not occur.

The older cells contain a great number of nuclei, but also the younger cells are polynucleate and this stage is not unfrequently primitive, the apical cell and the youngest segments containing each two nuclei (fig. 235). But in other cases the uppermost cells are uninucleate; this is particularly the case in the pinnulæ when the growth has arrested, but it is also frequently met with in growing axes (fig. 238). In such cases the 4th or 5th cell from the top usually contained more than one nucleus. In the decurrent filaments, the apical cell may contain numerous nuclei (fig. 235 *D*). The chromatophores are numerous, in the young cells they are rounded or oblong discs, in the older they are longer and irregularly bent.

The tetrasporangia are obovate, 74—81 μ long, 46—61 μ broad, placed on the inner face of the pinnæ, in their under part[1], sometimes only on the undermost cell, in

[1] According to Harvey, l. c. p. 232, pl. 35 fig. 5, *C. Baileyi* appears to differ from our plant in

other cases on two or more consecutive cells. Most of the sporangia are placed on the branched part of the pinnæ, but they may also be placed on the unbranched parts (the pinnulæ). As the pinnæ are pinnate below with transverse branches the sporangia are usually placed beside a branch but at a lower level; but the sporangia may also be opposite to the branches (fig. 236). The sporangia are usually placed singly near the upper end of the cell, but a second, younger sporangium may be produced under the first one or in an oblique direction from it and then sometimes under the branch given off from the same cell. In sporangiferous individuals procarps are frequently found; thus in a such specimen with numerous sporangia a branch was met with bearing a great number of procarps above but sporangia below.

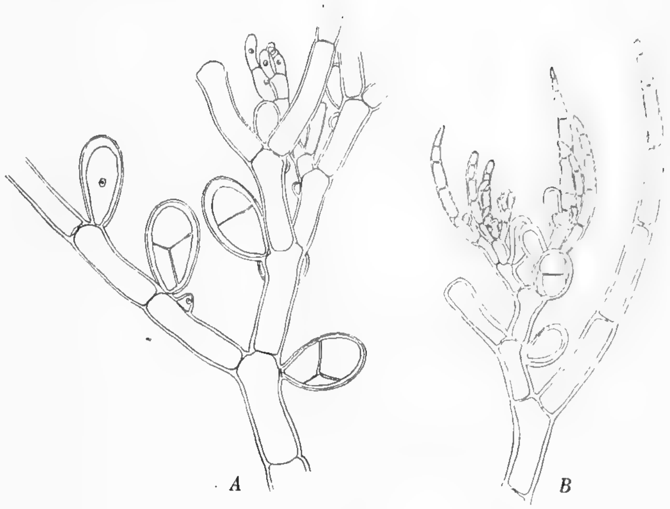


Fig. 236.
Callithamnion tetragonum var. *fruticulosa*. Branches with tetrasporangia. *A* 150 : 1. *B* c. 100 : 1.

The antheridia are placed in hemispherical cushions, as described by Nägeli for *C. tetragonum* (l. c. p. 345, fig. 30) and Kylin for *C. fruticulosum* and *C. spiniferum* (l. c. pp. 155—161, figs. 32—33). Comp. our fig. 237. These cushions have the same position as the tetrasporangia; they are placed singly or two in the same cell. The antheridia are usually found on the same individuals as the procarps.

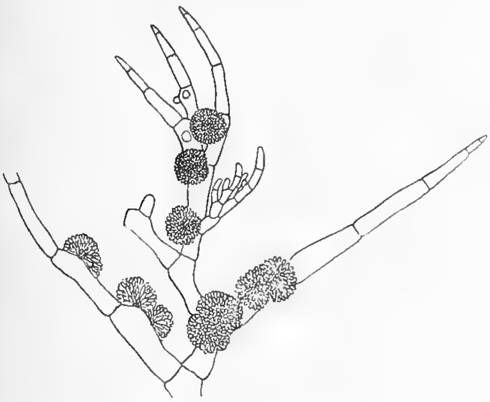


Fig. 237.
Callithamnion tetragonum var. *fruticulosa*. Part of plant with antheridial clusters. 215 : 1.

The procarps always arise in a branch-bearing cell and in such position that the carpogonium is opposite to the branch, the two auxiliar-mothercells lateral. The carpogonial branch is composed of 4 cells the two outermost of which are superposed while the first cells of the branch form a horizontal row. Spermatia were repeatedly found attached to the trichogyne, what

the sporangia being placed "near the middle of the ramuli"; in the quoted figure, the undermost cell in the pinnulæ bears no sporangium.

makes it probable that fertilisation really takes place. However, it must be said that trichogynes with attached spermatia but with undeveloped auxiliary mother-cells

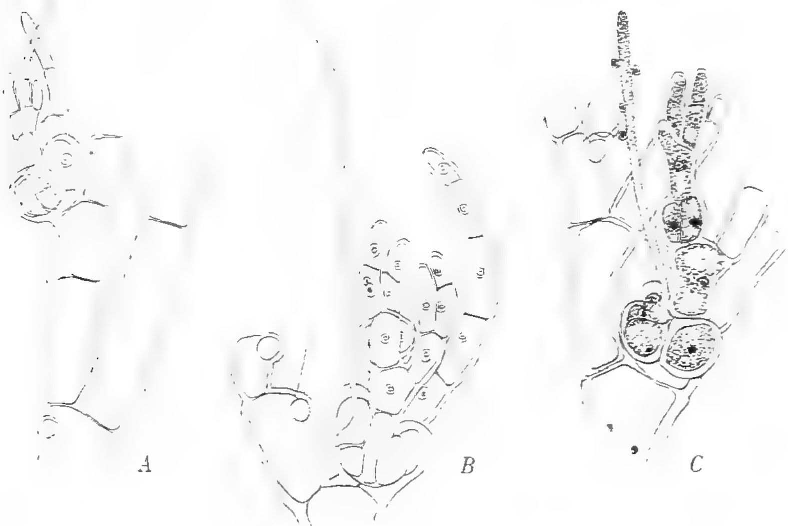


Fig. 238.
Callithamnion tetragonum var. *fruticulosa*. Procarps. To the right in *B* the auxiliary mother-cell which supports the carpogonial branch. *A*, *B* 270 : 1. *C* 350 : 1.

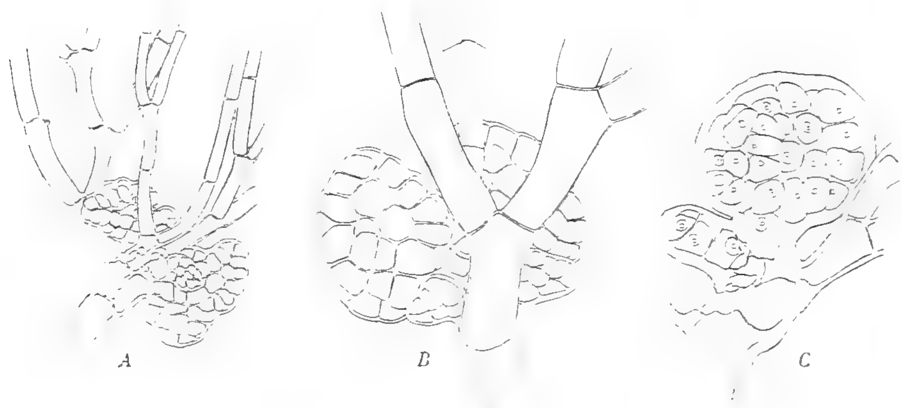


Fig. 239.
Callithamnion tetragonum var. *fruticulosa*. Ripe cystocarps. *A* 70 : 1. *B* 145 : 1. *C* 200 : 1.

though of rather advanced age were in some cases observed. (These observations are communicated here because sporangia frequently occur on the same plants as the sexual organs). Each of the auxiliary cells produces a glomerulus which is ovoid-globular or a little irregular. Usually a smaller conical lobe is seen at the base of the glomerulus. As shown in fig. 239 *C* the glomerulus is supported by a large sterile cell, the "Centralzelle" of OLTMANNS, while the small lobe is given off from the stalk-cell of the auxiliary cell (the "Basalzelle" of OLTMANNS and KYLIN 1923). The conical body cannot therefore belong to the gonimoblast and it must be concluded that it is unable to produce normal carpospores. A similar smaller lobe developed under the primary glomerulus has first been mentioned by JANCZEWSKI (1877, p. 119) in *Call. tetricum* and later by OLTMANNS in *C. corymbosum* (1898, p. 118) and KYLIN (1907) in *C. fruticulosum*, *C. spiniferum* and *C. Brodiæi*, comp. above p. 316. In the cases described by JANCZEWSKI and OLTMANNS, however, the smaller lobe arises from the same cell, the central cell, which has produced the glomerulus and is therefore a part of the gonimoblast. — The cystocarp-bearing cells remain shorter than the sterile cells of the filaments.

This variety has been found growing on various Algæ, e. g. *Furcellaria* and *Cladophora rupestris*, in 1 to 8 meters depth, with sexual organs and ripe sporangia in May to September, with cystocarps in July to October.

Localities. **Kn:** 6½ miles S.W. by W. ½ W. of Læsø Trindel light-ship, 8 m (C. A. J.) — **Ke:** Gilleleje; on the shore at Nakkehoved (?) (Lyngbye). — **Su:** off Ellekilde; Hellebæk; Blokhus Grund (Henn. Petersen).

4. **Callithamnion corymbosum** (Engl. Bot.) Lyngbye.

Lyngbye, 1819, p. 125, tab. 38 C; J. Agardh, 1851, p. 41; Harvey, Phyc. Brit. III, 1851, pl. 272; Thuret, Ét. phyc., 1878, p. 67, pll. 33—35; Reinke Algenfl. 1889, p. 24; Oltmanns, Bot. Zeit. 1898, p. 114, Taf. VI—VII; Kylin, 1907, p. 165; Kolderup Rosenvinge, 1911, p. 25; 1920, p. 25.
Conferva corymbosa Engl. Bot., pl. 2352, 1812.
Ceramium pedicellatum Lyngbye, Flora Dan. tab. 1596, 2, 1818.[1]
Phlebothamnion corymbosum Kützing, Spec. Alg. 1849, p. 657, Tab. phyc. XII Taf. 9.
Poecilothamnion corymbosum Nägeli, 1861, p. 360.
Callithamnion hiemale Kjellman in Kylin 1907, p. 170, ex parte.

Referring the reader, for the ramification, to the papers of NÄGELI, KYLIN and myself (1920), I shall only mention that the branches are usually arranged in a spiral with an angle of divergence varying between $^1/_5$ and $^1/_3$, the spiral turning with equal

[1] In the herbarium of the Botanical Museum of Copenhagen a number of specimens of this species from Hofmansgave are to be found together with a leaf with drawings of the same species by LYNGBYE with the following remark in LYNGBYE's handwriting: *Ceramium roseum* Var.? Nov. 1815 Hofmansgave, and signed with the letters A—D. The three last of these figures have been reproduced in Fl. Dan. Tab. 1596, 2 (under the name *Ceramium pedicellatum*). Fig. *A* which represents the habit of the species in feeble magnification and shows the corymbous ramification is in Fl. Dan. replaced by another figure which agrees fairly well with the fig. 38 *C* 1 of LYNGBYE's Hydr. but does not give a good idea of the ramification of the species. Confusion with another species has perhaps taken place. The fig. *C* (the undermost, to the left) which shows antheridial bushes has also been rightly interpreted, for LYNGBYE has marked it: "C mas?". Fig. *D* shows the upper sporangium opened with a split in the original drawing, but that has not been reproduced in the engraving.

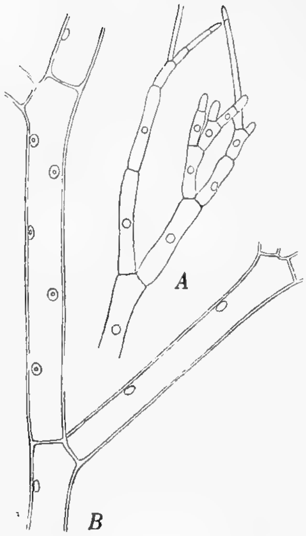


Fig. 240.
Callithamnion corymbosum. A, upper end of shoot. *B*, somewhat older cells. 210 : 1.

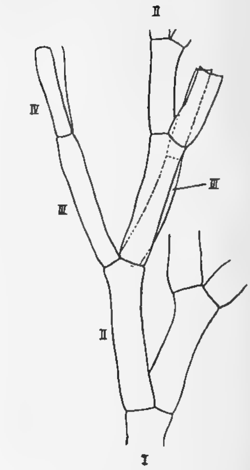


Fig. 241.
Callithamnion corymbosum. A joint bears two branches (III) at the upper end. 200 : 1.

frequency to the right and to the left. The ramification of the branches begins from the very base but the first branches are not as a rule included in the spiral arrangement. Most frequently the first two or three branches are biseriate in a transverse plane. The ramification is often pseudodichomous (camptopodial Nägeli), in particular in the upper part of the plants, the branches reaching the same size as the mother axis and diverging almost equally with this from the original direction of the mother axis, for which reason it is often difficult to decide which of the rays is the main axis and which the branch. When the pseudodichotomous ramification is very pronounced, the greater sections of the frond may get a semicircular outline; when the main axes are more vigorous than the others, the outline becomes pyramidal. In other cases the outline is more indistinct, the greater complexes of shoots being dissolved in smaller corymbous bunches. Very rarely two branches were found on the same joint; they were not opposite but diverging with an obtuse angle from one another (fig. 241).

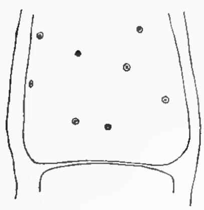


Fig. 242.
Callithamnion corymbosum: Lower part of older cell showing the nuclei. 200 : 1.

The young cells contain a single nucleus; later on it divides and as a consequence of continued divisions the older cells contain a great number of nuclei equally distributed over the cell (fig. 242). They are distinctly visible in the figures of THURET (1878, pll. 33—35).

Hyaline hairs normally occur. They have been mentioned and partly figured by KÜTZING, NÄGELI, THURET, KYLIN and myself (1911). They are present in the whole season of vegetative development, but are wanting in winter (December, January). No specimens have been collected in February and March, but all the specimens collected in April to October were provided with hairs. Only in very rare cases were the specimens collected in summer devoid of hairs; thus, some large specimens from Herthas Flak in 20 to 23 meters depth had only very few

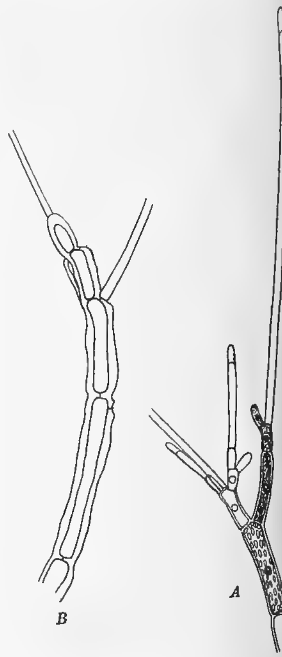


Fig. 243.
Callithamnion corymbosum. A, Upper end of branch with terminal hairs. *B*, the hairs are pushed aside by the sympodial development of the branch. Two hairs are shed but their basal pits are still visible. *A* 240 : 1. *B* 300 : 1.

poorly developed hairs and some scars after hairs which had fallen off. Similar specimens were found in the harbour of Skagen in July, but the ends of the branches showed sympodial development and sometimes a pit in the end wall at the point where the hair had been inserted. The hairs are terminal on the branches the development of which is stopped by the formation of the hair, but the hair is often pushed aside by a lateral branch formed under it, and such a sympodial development may repeatedly occur on the same branch (fig. 243, comp. L. K. R. 1911, p. 212). Not rarely two hairs are to be found on the same terminal cell; the one is then terminal, the other lateral (comp. Thuret 1878, pl. 33 and 35). The shoots in full

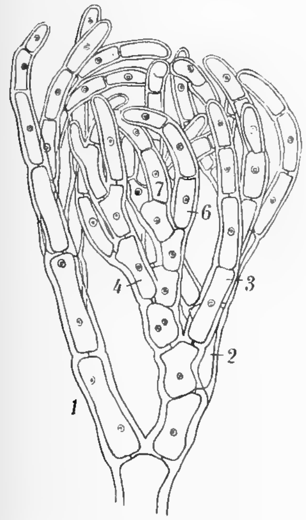


Fig. 244.
Callithamnion corymbosum. Upper end of shoot of plant collected in December; the young branches are hairless and incurved over the top. 270 : 1.

Fig. 245.
Callithamnion corymbosum. *A*, cortical filaments with adventitious shoots, *B*, part of plant with stoloniform filaments partly ending with hapters. *B* 50 : 1.

growth do not terminate with a hair but only the shoots with feebler or ceasing intensity of growth. In autumn the hairs are shed, and in the specimens found in December and January the hairless branches are curved in over the summit of the shoot (fig. 244).

The main axes increase gradually in thickness downwards and are in the lower part provided with a cortex of decurrent filaments. The cells issuing from the bases of the branches and growing in the outer wall of the joint cells of these filaments contain several nuclei. Small adventitious shoots may issue from them (fig. 245 *A*).

In specimens from the harbour of Kerteminde numerous free filaments were found issuing from the lower end of the cells of the erect filaments and growing out in a direction perpendicular to these filaments; they consisted of long cells and might attain a considerable length without branching, but on meeting a solid body they had fixed themselves to it and produced numerous branches partly adhering to the same body (fig. 245 *B*).

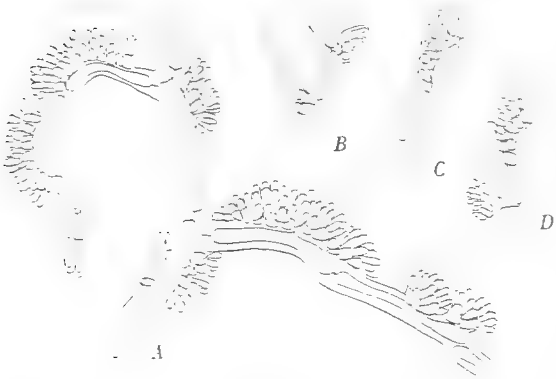


Fig. 246.
Callithamnion corymbosum. Antheridial cushions. 260 : 1.

The antheridia always occur on particular male specimens. They form small, often hemispherical cushions on the upper branchlets; they are usually seated, in analogy with the sporangia, on the upper side of the lower joint of the branchlets, near its upper end, but, as shown by Thuret, two or three cushions are frequently seated under one another and these may be fused together. The joint may thus be occupied in its whole length or nearly so by a long compound antheridial cushion, and the joint is then usually more or less recurved by epinastic growth and bears no vegetative branch. When the production of antheridia is very abundant, they occupy not only the branchlets but also the mother axes. The cushions consist of much branched short branch-systems, the upper cells of which are the antheridia (spermatangia) (fig. 246).

With regard to the position and the development of the procarps and the cystocarps reference may be made to the quoted papers of Thuret (1878, pl. 34 and 35), Oltmanns (1898) and Kylin (1907, p. 166).

As mentioned by earlier observers, the tetrasporangia are seated on the inner side of the upper branchlets, on the lower joint, usually at its upper end. The first branch of the second order having a transversal position, the sporangium then forms a right angle with this branch. The sporangia are single or a younger sporangium appears under the first formed, sometimes in an oblique direction under it or nearly beside it (fig. 247 *A*). A third sporangium may rarely be found under the second. In rare cases the sporangium is inserted in the middle of the joint (fig. 247 *B*, *C*); in the case shown in fig. 247 *C*, a second sporangium is seated over the first formed. — As shown by Thuret (1878, plate 35 fig. 14), the sporangia open by a transversal split near the upper end of the sporangium; the upper part of the wall then forms a lid fixed by a hinge. At the discharge, which was once

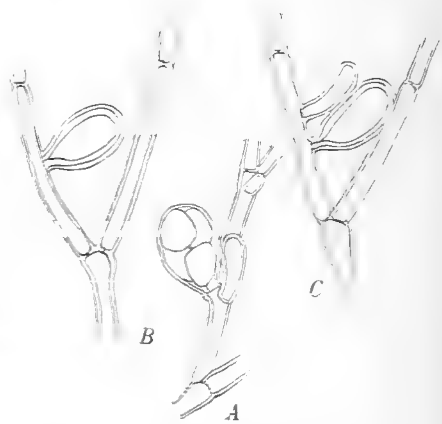


Fig. 247.
Callithamnion corymbosum. Tetrasporangia. 210 : 1.

observed, the two upper spores first escaped almost simultaneously and shortly after a third. During the liberation, the spores changed form when squeezing through the narrow split and afterwards regained the globular form. A liberated spore was seen to move between some filaments of the same species, likewise changing form when squeezing through the narrow interstice between the filaments.

Germination of tetraspores and carpospores is easily realized in cultures, as shown by THURET (1878 p. 71, pl. 35 fig. 15), who obtained, however, only very young stages consisting of few cells. The seedlings in my cultures reached a greater size and began to branch (fig. 248). As mentioned by THURET, the seedlings resulting from the two kinds of spores are alike. The germinating spore gives off two opposite germinating tubes, the one becoming the primary axis of the plant, the other growing out to a long articulate rhizine. The original spore-cell remains for a long time distinguishable by its greater thickness, at least in the cultures. The branching of the primary axis may begin immediately over it or at a higher level.

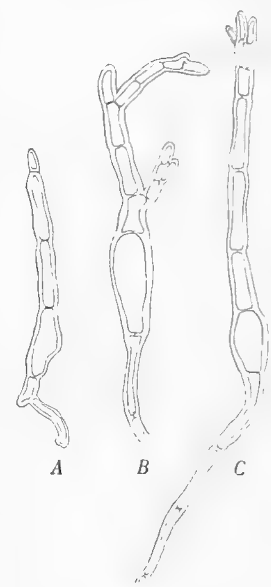


Fig. 248.
Callithamnion corymbosum. Sporelings from Frederikshavn. *A*, 3 weeks, *B*, *C*, 4 weeks old. 150 : 1.

Antheridia have been met with in April to September, cystocarps in June to October, tetrasporangia in June to December and in January, but not in the spring. The cystocarp-bearing specimens are often smaller than the tetraspore-bearing ones. Sterile specimens are not rarely found in considerable number between the fertile ones, and they are then often larger than these. In the Smaaland Sea, in the Sound south of Hveen and in the Baltic Sea, thus in the innermost localities, only sterile specimens were found.

The species has been met with at all seasons; that it has not been observed in the months of February and March is certainly due to the fact that only very few collections have been made in these months. It can without doubt continue alive from one season to the next, but it can also accomplish its life-cycle during a short time, being thus ephemerous, and perhaps produce more than one generation in the season. The duration of life must at all events be short when it is epiphytical on Algæ or parts of Algæ which die in the autumn. It may be met with in well developed specimens at all seasons; it occurs, however, in the greatest quantity in summer and autumn, when it also attains its greatest development. Most of the specimens certainly die in the autumn. The specimens found in winter are not in growth and without hairs (fig. 244) but may still bear tetrasporangia. *Callithamnion hiemale* Kjellm., Kylin seems at least in part to be such a winter-form of *C. corymbosum*, for a specimen of the named species kindly sent me by dr. KYLIN agreed with my winter specimens of the latter by its structure and its corymbous ramification; the number of the nuclei could not, however, be ascertained in the dried state. A few hairs were still present.[1] — The growth of the species apparently begins at the end of the winter. As the germination of the spores takes place immediately after the dissemination of the spores, it is probable, that the species usually passes through the winter as small plants having reached only a small size at the beginning of the winter. — It grows on stones, wood, leaves of *Zostera* and numerous Algæ as f. inst. *Furcellaria fastigiata, Ahnfeltia plicata, Fucus vesiculosus, Polysiphonia* spp., *Phyllophora* spp. and many others.

The species varies in the length of the cells and the different degree of contraction of the branches thereon dependent, apparently owing to the various conditions of the environment; further, as mentioned above, in the relation of the longitudinal growth of the branches to that of the mother axis. When the ramification is decidedly pseudodichotomous the outline of the sections of the frond becomes semicircular or nearly circular. The branches are then often more divaricate than usual, thus in the f. *intricata* Lyngbye (Hydr. p. 125), which occurs in sunny localities in shallow water.

The species is spread from the North Sea to the south end of the Sound and to the western part of the Baltic. In the North Sea it has only been met with in two localities very remote from land at greater depths (24,5—31 m) and further in the harbour of Thyborøn; in the Skagerak it has been collected in several places, mostly at small depths near land, and in the inner waters it is commonly spread from low-water mark to 20 meters depth (in the Limfjord only to 6 m). In the Sound south of Helsingør it does not occur at depths smaller than 9,5 m, and in the Smaaland Sea not at depths smaller than 4,5 m. It usually reaches only a length of 5 cm; it may, however, attain 7,5 cm (f. inst. in one of the innermost localities, south of Langeland at 11,5 meters depth) and specimens up to 9 cm high were found once, in Grenaa harbour.

Localities. **Ns:** aF, Thyborøn beacon S.E. 1/2 E., 19,5 miles, 31 m ○ Aug.; ZQ jydske Rev, 24,5 m; harbour of Thyborøn. — **Sk:** YU, Roshage, Hanstholm, near land, 1—2 m; YM[1], Bragerne; YN, within Bragerne; ZK, off Lønstrup; Lønstrup, near land, 1 m; Hirshals, mole and boulders near land; N.W. of Hirshals, 15 m; Skiveren, on wreck; north Side of Skagens Gren. — **Lf:** ZS, Kobberød; Ydre Røn by Lemvig; MC[1]; south side of Jegindø Tap, 6 m; east of Jegindø; MH, off Skrandrup, Thisted Bredning; Nykøbing (Th. Mortensen); Glyngøre; off Knudshoved, Fur; north coast of Fur; MK, Holmtunge Hage; LQ, Lendrup Røn; Løgstør Kanal; Løgstør; near Marbjerg Tange (Boye Petersen). — **Kn:** Harbour of Skagen; south of Fyrbakken, 4 m and south of Skagens Gren, 13—15 m; off Hulsig, 7,5 m (B. P.); Herthas Flak, 19 m; TV, Krageskovs Rev; various places around Hirsholmene; Frederikshavn, harbour and various places in the neighbourhood; BP, off Sæby, VT and TK near Nordre Rønner; north end of Nordre Rønner; NH, north of Læsø, 15 m, + in Sept.; Vesterø harbour, Østerø harbour; TP and ZA, Tønneberg Banke, about 16 m; 6 1/2 miles S.W. by W. 1/2 W. of Læsø Trindel light-ship, 8 m (C. A. J.). — **Ke:** FD, east of Læsø; VY, Fladen, 18 m, sterile in July; XA, S.E. of Kobbergrundene; east end of Anholt; 14 1/2 miles S.S.E. of Anholt Knob lightsh., 10 m, + Oct. (C. A. J.); Gilleleje. — **Km:** 6 miles S.S.W. 1/2 W. of Læsø Rende lightsh., 8 m (C. A. J.); 5 1/2 miles N. by E. 3/4 E. of Østre Flak lightsh., 9 m. (C. A. J); BO, Stensnæs; Asaa, mole; EZ, south of Læsø; ZC[1], Kobbergrundene; BK, Tan-

[1] Dr. Kylin has later arrived at the opinion that *C. hiemale* is a winter-form of *C. Furcellariæ* (Botan. Notiser 1916, p. 65), as he has found specimens with lobed gonimoblasts. It appears therefore that two species have been confounded under this name.

gen; NC, east of Tangen. — **Ks:** Pakhusbugt, Anholt, 19 m; Grenaa harbour; NB, Havknudeflak; MZ, north of Hjelm; D, north of Grønne Revle; RL; EH and NL, off Lynæs, Isefjord. — **Sa:** BF, off Sletterhage; Kalø Rev; Aarhus; PC, between Sejerø and Ordrups Næs; PK, Norsminde Flak; YV, east of Samsø, 15 m (+ and ♂ in June); MX, at Tunø Rev; BC, off Hov Røn; BB, Søby Rev; aV, east of Endelave; DK, Bolsaxen; MQ, Paludans Flak; entrance to Korshavn; north coast of Æbelø; Hofmansgave (Lyngbye, Hofman Bang, J. Vahl, C. Rosenberg). — **Lb:** Horsens Fjord west of Alderø; AX, Bjørnsknude; FZ, Kasser Odde; Fænø Sund; cZ, Knudshoved Grund; Aarøsund (Reinke, !); CD, Helnæshoved Flak; Sønderborg. — **Sf:** CC, south side of Hornenæs; banks off Nakkebølle Fjord; UX and UV, north of Ærø; CV, Billes Grunde; BX, Svendborgsund; Svendborg. — **Sb:** South side of Refsnæs; MN, north of Asnæs; GU, S.W. of Asnæs; AG, Romsø; Reersø; GQ, west side of Slettings Grund; Kerteminde; Korsør; GY, west of Gjellegrund; Z, off Skagbo Huse; NS, BS near Nyborg; GZ, north of Egholm; Lohals harbour, near low-water mark; Snøde Rev, west of Langeland, 4 m, st.; T, Staalgrund, 9,5 m, ♀; LB, Langelandsbelt, 17 m, ♀. — **Sm:** CK, 9,5 m; CQ, 4,5 m, st. — **Su:** Hellebæk (Børgesen, !); north of Helsingør; PZ, east of Hveen, 10—19 m, ♀; TF[1], Staffans Flak, 11—13 m, st.; RH, Knollen, 9,5 m, st. — **Bw:** Flensborg Fjord (Suhr, Hansen): Egernsund, Graasten; cX, off the South end of Kobbel Skov; bZ, south of Sønderborg; DV, south of Marstal 9,5—11 m, st; LC, south of Gulstav, 11,3 m, st; KZ, off Kramnisse, 4,5 m, st.

5. Callithamnion roseum Harvey.

Harvey in Hooker, The English Flora, Vol. V, part I. 1833, p. 341; Manual Brit. Alg. 1841, p. 106; Phycol. Brit. pl. 230, 1849; Wyatt, Algæ Danmonienses No. 44. J. Agardh, 1851, p. 36; Bornet in Børgesen, Mar. Alg. Fær. 1902, p. 377; Le Jolis, Alg. mar. de Cherbourg, no. 162; Kolderup Rosenvinge 1920, p. 44.

Phlebothamnion roseum Kützing, Tab. phyc. Vol. XI, tab. 97, 1861.

Callithamnion byssoides K. Rosenvinge, 1911, p. 209.

This species grows in certain localities in the harbour of Frederikshavn where it has been met with repeatedly during the last 27 years. Otherwise it is seldom found in the Danish waters. The Danish specimens agree with the species as described by Harvey and as understood in the above citations. They are up to 10 cm high.

The filaments are branched on all sides, sometimes, however, the branches are alternate biseriate, in particular in the undermost part of the upper branches, and then usually placed in a transversal plane, as pointed out by Bornet (l. c.). The main axes are distinct, scarcely bent in zigzag. When the branching is regular and the plant is in active growth the segments are cut off by inclined walls. The young segments are only a little longer than broad (fig. 249). The branches are never branched from the base. The number of joints below the first branch varies from 2 to many, at least 25; as a rule, it is greatest at the base of the older branches.

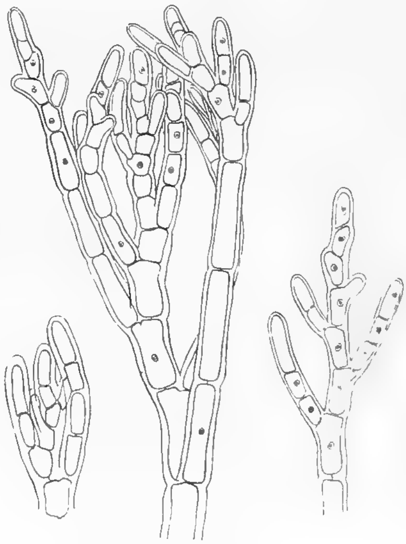


Fig. 249.
Callithamnion roseum. Upper ends of shoots. In that on the left and in the middlemost the branches are arranged in a spiral, in the shoot on the right they are biseriate. 290:1.

A number of branches remain unbranched, though consisting of a rather large number of cells; such branches occur frequently at the base of the longer axes but also near the top (fig. 250). When the ramification has begun, it usually continues uninterrupted, each joint bearing a branch. It happens, however, that one or two consecutive branchless articles may occur here and there, in particular in the lowermost part of the main axis and the branches. The branches of the long shoots are always arranged in a spiral, at all events in the upper part of the shoots, and here

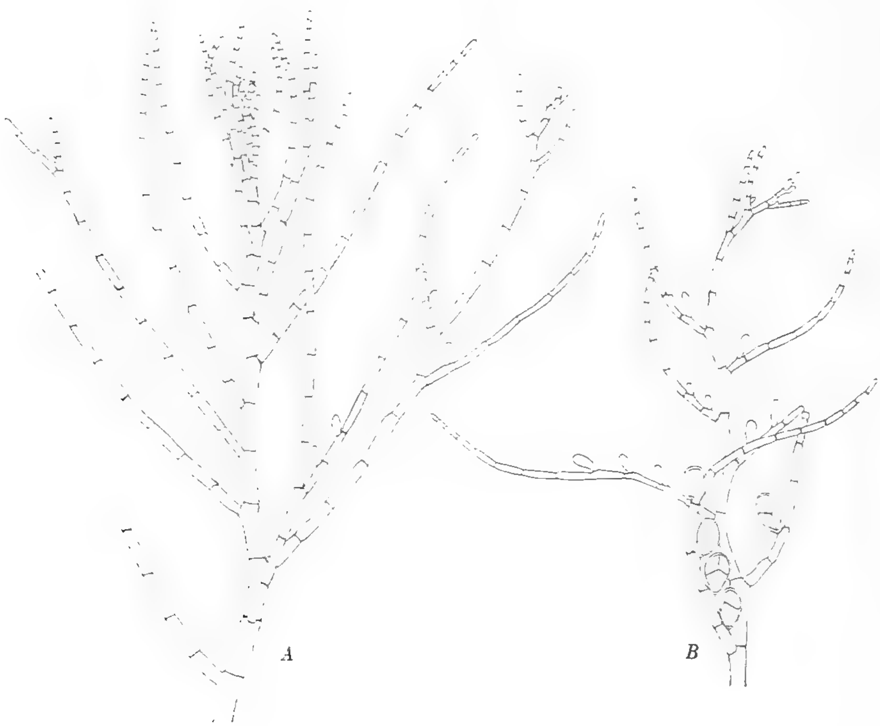


Fig. 250.
Callithamnion roseum. A, upper end of long shoot. *B*, shoot with tetrasporangia. 70 : 1.

the angle of divergence is usually $^{1}/_{4}$; the arrangement of the lowermost branches, however, is irregular or alternate biseriate. (Comp. L. K. R. 1920). It very rarely happens that one joint bears two branches. The filaments are 10,5—14 μ broad right under the apical cell. They are not usually terminated by a hair, such organs may, however, occur sometimes (fig. 251, comp. L. K. R. 1911 p. 209); the hairs are rather short; they are a little thinner than the end of the filament, about 7 μ thick.

The cells contain one nucleus and numerous irregular lengthened chromatophores; numerous starch grains may occur (fig. 252).

The lower part of the principal filaments is corticated with descending filaments given off from the lowermost cell of the branches, sometimes also from the second and following cells. They are frequently formed in a number of three from the basal cell; they grow in the outer membrane of the filaments but become partly free at the base of the principal axis, here forming free, pluricellular, branched filaments which fix the plant to the substratum. The cortical layer may be so much developed that the cells of the filament are scarcely distinguishable. Adventitious shoots do not occur or only exceptionally.

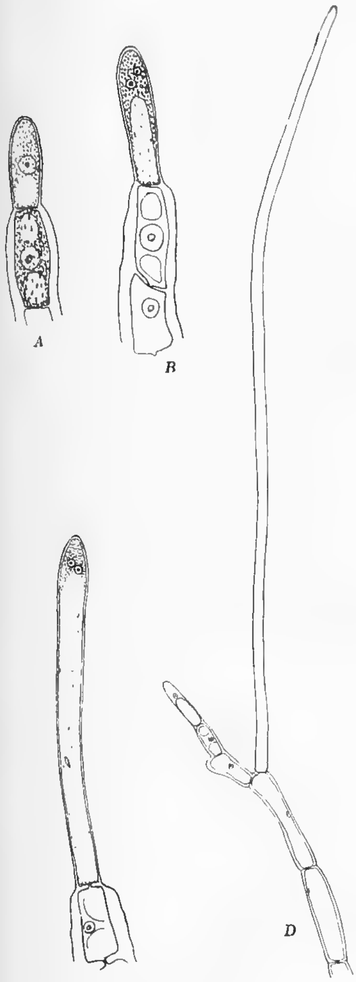


Fig. 251.
Callithamnion roseum. A—C, development of the hairs. *D*, Fully developed hair pushed aside by a branch from the subterminal cell. *A—C* 700 : 1. *D* 300 : 1.

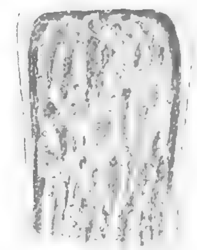


Fig. 252.
Callithamnion roseum. Part of cell with chromatophores and Floridean starch.

The tetrasporangia are usually placed in a row on the upper (inner) side of the branches of the last order. The tetraspore-bearing branchlets are thus, as a rule, unbranched, but fertile branchlets more or less branched above not unfrequently occur. The tetrasporangia-bearing branchlets are frequently alternate biseriate. The sporangia usually form a short row of 1—4 or 5 on the lowermost cells, one on each cell (figs. 250 *B*, 254, comp. Harvey, Phyc. Brit. l. c. fig. 2—3), but the row is frequently interrupted, by single cells bearing no sporangium. Sometimes, the undermost articles are bare, and the formation of sporangia begins only at a higher level. The sporangia placed at some distance from the base are not always situated on the upper side but frequently on the flanks or even on the outer (under) side of the branch (fig. 254). The number of sporangia on a branch is often only 1 or 2. Cells bearing more than one sporangium have never been met with. The ripe sporangia are (60—) 70—80 (—84) μ long, 45—55 (—70) μ broad. Once I found an unusually large sporangium measuring 98×74 μ. The sporangia open by a transversal slit above.

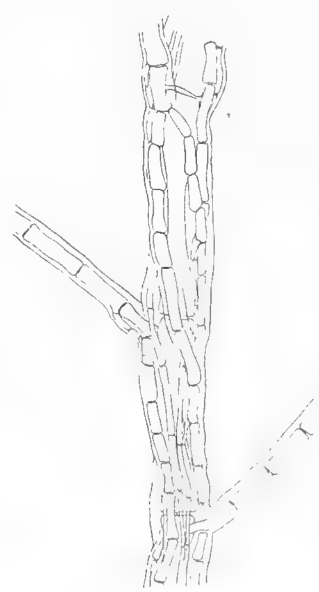


Fig. 253.
Callithamnion roseum. Part of stem with corticating filaments. 50 : 1.

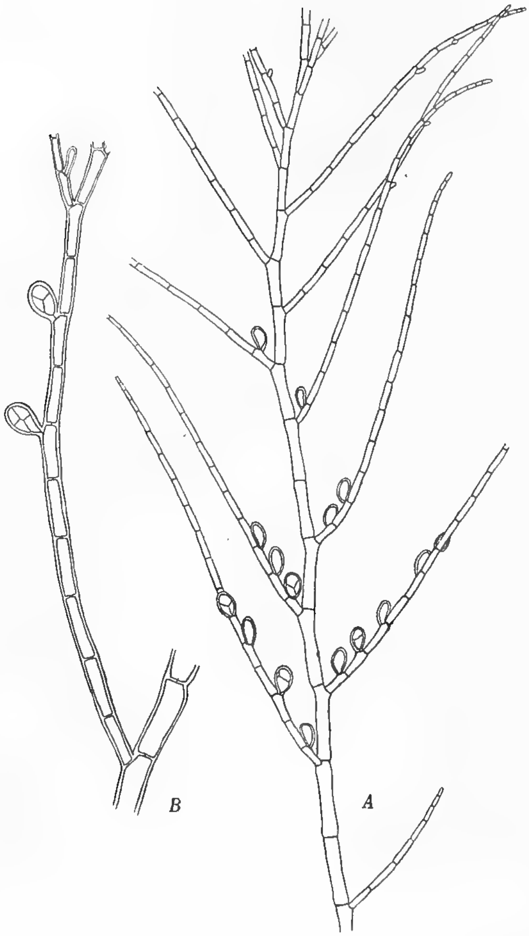


Fig. 254.
Callithamnion roseum. *A*, sporangia-bearing branch. *B*, sporangia situated on the outer side of the branch. *A*, 52 : 1. *B*, 80 : 1.

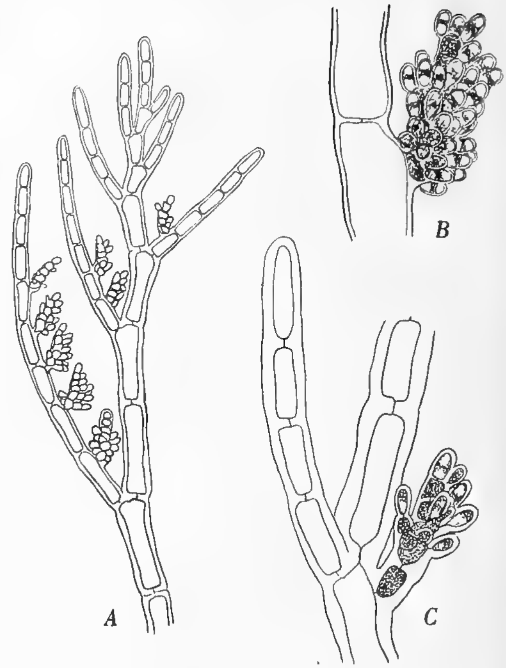


Fig. 255.
Callithamnion roseum. Antheridial clusters. *A* 205 : 1. *B*, *C* 560 : 1.

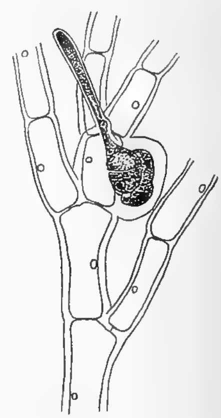


Fig. 256.
Callithamnion roseum. Procarp before fertilisation. Only one auxiliary mother-cell is present, a^1, situated behind the carpogonial branch. 350 : 1.

The antheridial clusters have a similar position to that of the sporangia, namely in a row of 1 to 6 on the upper side of the pinnulæ, usually one on each cell, rarely two, one over the other. Sometimes, the undermost cell or cells bear no antheridial clusters, the formation of these beginning only at a higher level, or the row is interrupted by joints bearing no antheridial bush. The branchlets bearing these organs are usually unbranched, but it occurs sometimes that they are branched above and the case may also be met with that a cell of a branchlet bears a branchlet and an antheridial bush as well (fig. 255 *C*). The main axis of the antheridial cluster consists of five or six cells, which are usually shorter than their breadth. It is slightly curved towards the top of the branch and bears a number of

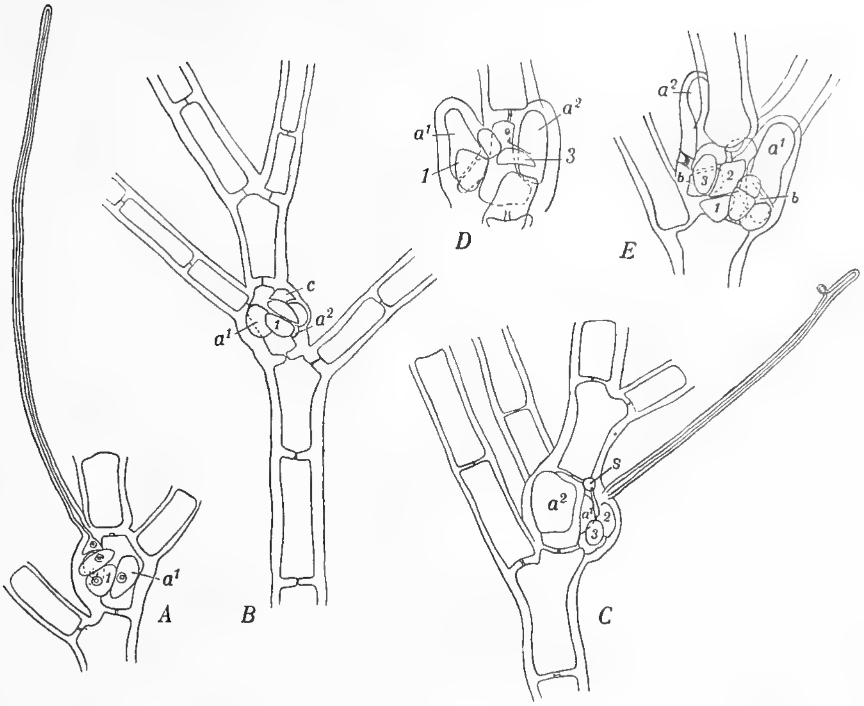


Fig. 257.

Callithamnion roseum. Procarps before and after fertilisation. a^1 and a^2 auxiliary mother-cells, or in *D* and *E* auxiliary cells. a^1 that from which the carpogonial branch is given off. *1, 2, 3, c,* the cells of the carpogonial branch. In *A* a^2 is wanting. In *C* fertilisation has taken place; *s* sporogenous cell before fusion with the auxiliary cell; under it the rest of the carpogonium. In *D* and *E* the auxiliary cells have been cut off, except a^2 in *D*; *b* the stalk cells of the auxiliary cells. The three cells under a^1 seem to be the young gonimoblast. *B* 270 : 1, the others 350 : 1.

short branches principally on its convex side, but on the flanks and the upper side too, consisting of one or few cells and producing numerous antheridia which organs may also project directly from the cells of the main axis.

The procarps are nearly opposite to the branch projecting from the same cell. The auxiliary mother-cell (a^1) from which the carpogonial branch is produced is situated very near the branch, the other one (a^2) is somewhat removed from its other side (fig. 257). The carpogonial branch consists of four cells, the second of which is situated obliquely over the first, the carpogonium exactly over the third (fig. 257). The one auxiliary mother-cell (a^2) may sometimes be wanting (fig. 256). The cystocarps are composed of two ovate gonimoblasts; their outline may be more or less irre-

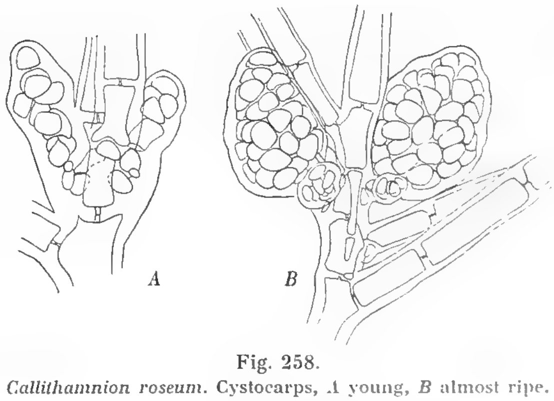


Fig. 258.

Callithamnion roseum. Cystocarps, *A* young, *B* almost ripe. *A* 260 : 1. *B* 150 : 1.

gular, but not lobed. A few gonimoblasts on the same specimens were, however, more irregular and lobed, much as in *C. Furcellariæ*. A little special lobe is developed at the base of the gonimoblast, as in other species (fig. 258). In Phyc. Brit. pl. 230 fig. 5 HARVEY figures a cystocarp consisting of a small number of cells; perhaps it represents a young stage. I have not seen anything corresponding to the 'cluster of favellæ' figured in Harvey's fig. 4. The vegetative cells in the neighbourhood of the cystocarps usually produce rudimentary or more developed decurrent filaments which undoubtedly serve to strengthen the parts of the filaments bearing these heavy organs (fig. 258 *B*).

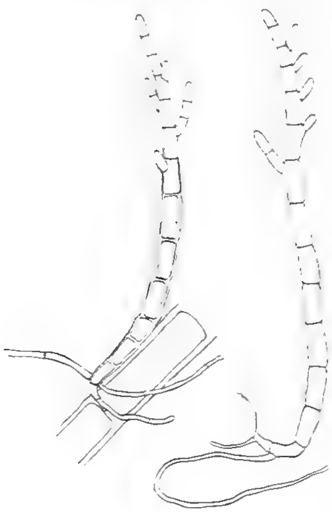


Fig. 259.
Callithamnion roseum. Sporelings found on a tetraspore-bearing specimen of C. roseum. 204 : 1.

On a tetraspore-bearing plant were found a number of sporelings apparently of the same species. Some of them were unbranched, others were branched, the ramification being irregular, alternate or secund.

The species is nearly related to *C. Furcellariæ* from which it differs in particular by its robuster filaments, by the principal axes being corticated in their lower part, and by the ovate, not lobed gonimoblasts.

The above description is founded on numerous living and preserved specimens from Frederikshavn. Elsewhere the species has only been met with in two other places in a sterile state.

The basal part of the plants is usually enveloped by dense masses of detritus. In one case, the lowermost part of the main axis had no cortex while the next following part had a well developed cortex. The species has been observed with sexual organs and with ripe cystocarps and tetrasporangia in the months of July and August, the only months in which it has been collected at Frederikshavn. In this locality it has been met with only in the harbour from low-water mark to about one meter's depth. In the Smaaland Sea it has been found in 11,5 meters' depth.

Localities. **Lf:** Fuur "apportavit Kjølbye", Herb. LYNGBYE, determined by Lyngbye as *C. roseum*. A specimen from Limfjorden communicated by HORNEMANN to Lyngbye in the same year (1826) probably originates from the same locality. All the specimens are well developed but sterile. — **Kn:** Frederikshavn, in the harbour for boats at the end of the north mole (1891—1923), on the head of the northern transverse mole and at the harbour of the pilots. Vesterø Havn, Læsø. — **Sm:** (?) Agersøsund, 11,5 m, sterile.

6. Callithamnion Furcellariæ J. Agardh.

J. Agardh, 1851, p. 57; Kylin 1907, p. 167; Kolderup Rosenvinge 1920, p. 49; Kylin 1923, p. 56.
Callithamnion byssoides Areschoug, 1850, p. 107, Tab. V, B; Svedelius, Östersj. hafsalgfl., 1901, p. 126.
Callithamnion hiemale Kjellm., Kylin, 1907, p. 170, teste Kylin, Botan. Notiser 1916, p. 65, ex parte.[1]

[1] As mentioned above, p. 330, a specimen of *C. hiemale* communicated to me by prof. KYLIN has turned out to be a *C. corymbosum*; but as the said author has found lobed gonimoblasts in other specimens, it seems that two species have been confounded under the name of *C. hiemale* Kjellm.

The Alga here treated has been mentioned for a long time in my annotations under the name of *Call. byssoides.* As, however, it is doubtful whether it is warranted to refer it to the species of ARNOTT and HARVEY and as the limitation of this species in regard to related forms is uncertain, I prefer to give to the species of the Danish waters the name of *C. Furcellariæ*, because it is at all events identical with this species of AGARDH. It must then be left undecided whether it can be identified with the British species wholly or in part; I must content myself with referring to SCHMITZ's remarks on the synonymy of *C. byssoides* and related forms in his paper: Die Gattung Microthamnion in Ber. d. deut. bot. Ges. 1893 pp. 280 and 283.

The species occurs in all the Danish waters; it usually reaches only a length of 2 cm or a little more, in the inner waters Sf and Sb, however, it becomes 3 cm and at Bornholm up to 4 cm high.

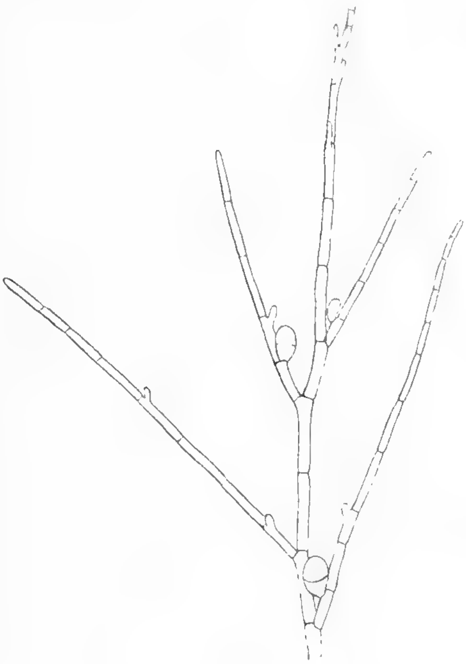


Fig. 260.
Callithamnion Furcellariæ. Upper end of plant from Fænø Sund, with irregularly arranged branches and dispores. 70 : 1.

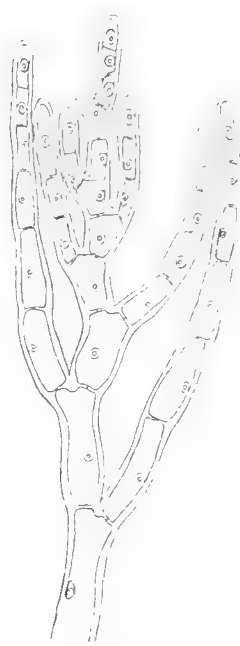


Fig. 261.
Callithamnion Furcellariæ. Upper end of plant from Bornholm, with biseriate branches. 270 : 1.

The ramification has been treated at length by KYLIN (1907, p. 167) and by me (1920, p. 49). It is less regular than in the other Danish species. The branches are, however, usually arranged in a spiral, but in several shoots the branches were irregularly arranged or more rarely biseriate (specimens from Bornholm). When the branches are arranged in a spiral, the angle of divergence is more variable than in the other species; the angle of divergence varied in the examined shoots from 67° to 131°. Not rarely did the direction of the spiral change in the same shoot. The branches are usually branched from the base, the first joint normally bearing a branch; but it happens now and then that the first joint is branchless, and in specimens from Bornholm several joints at the base of the branches were branchless. The spiral arrangement as a rule begins at a certain distance from the base, the first branches being irregularly arranged, sometimes, however, partly biseriate in a transverse or oblique plane. In several cases two branches of unequal size were found inserted

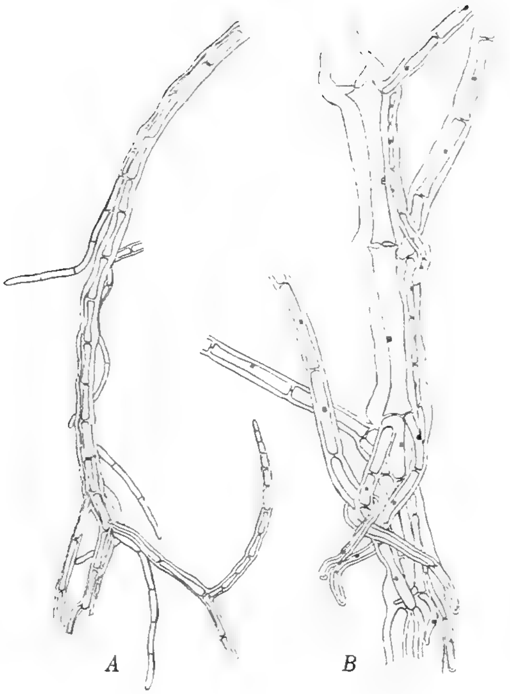


Fig. 262.
Callithamnion Furcellariæ. Bases of plants with intramatrical and extramatrical descending filaments. *A* 45 : 1. *B* 95 : 1.

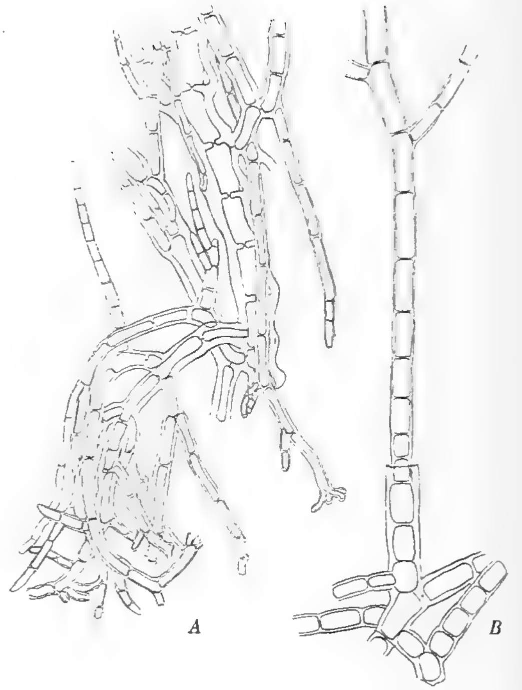


Fig. 263.
Callithamnion Furcellariæ. A, basal part of plant. *B,* creeping filaments from the foregoing year. A new erect shoot has broken forth from the remains of an erect shoot from the foregoing year. *A* 70 : 1. *B* 80 : 1.

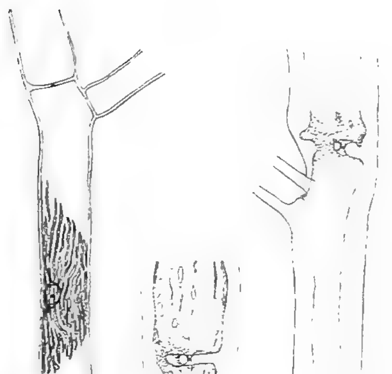


Fig. 264.
Callithamnion Furcellariæ. A, cell showing the nucleus and a number of the chromatophores. *B* and *C,* cells connected by a broad bridge of protoplasma at the periphery. *A* 195:1. *B, C* 270:1.

on the same joint, diverging from one another at an angle of a little over or a little under 90°; the larger one entered into the spiral. For more details see my paper (1920 pp. 49—58).

The principal axes are distinct and straight or only a little bent in zigzag. The ramification is thus distinctly monopodial but sometimes it may be somewhat corymbose, thus reminding of that of *C. corymbosum.* The length of the cells in proportion to the breadth is rather variable but usually considerable, varying from 4 to 12, rarely up to 17, but in the lower part of the main axis the cells are shorter.

In the lower part of the principal shoot single descending filaments occur, being partly intramatrical, partly extramatrical, but in the first case not forming a continuous cortical layer. The intramatrical ones may be free before reaching the base (fig. 262). Moreover, free horizontal shoots arise from the lowermost part of the principal axes, usually given off from the lower end of the cells. They have the character of rhizomes producing new erect filaments. Fig. 263 shows such much-branched rhizomes growing in a bow towards the substratum. In the seedlings, too, such horizontal filaments are to be found (fig. 271).

The filaments as a rule terminate without hyaline hairs. This character is so constant that it can be used to distinguish this species from *Call. corymbosum*. It must, however, be admitted that hairs may occur in rare cases in genuine specimens of *C. Furcellariæ* (YV, Hatterbarn, **Sa** (Fig. 266); D, **Ks** and UV, **Sf**). The hairs were much less numerous and feebler developed than in *C. corymbosum*, only 12—140 μ long and 3,5 μ broad in no. 7380 (YV). The specimens in question were collected in May to June in depths of 11–15 meters.

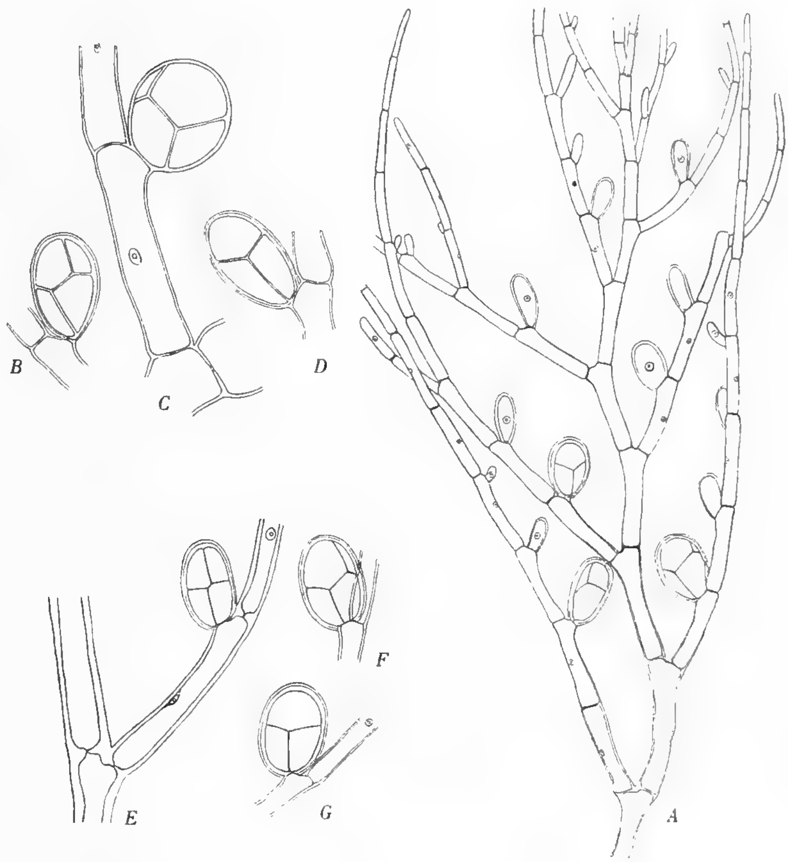


Fig. 265.
Callithamnion Furcellariæ. Tetrasporangia. *A*, showing their arrangement, plant from northern Kattegat (TP). *B—G* showing the varying arrangement of the spores in the sporangium. *A* 160:1. *B—G* 220:1.

The cells always contain a single nucleus and numerous long, narrow, more or less curved chromatophores (fig. 264).

In specimens conserved in alcohol curious fusions between cells in the older parts of the plants were observed (fig. 264). The transverse wall was dissolved to a greater extent in the periphery and the two cells thus connected by a broad bridge of protoplasma, much broader than the central pit connecting the two cells. This fusion is not followed by any formation of pit-membrane and may be compared with the cell-fusions by the *Corallinaceæ* and *Squamariaceæ*, but they take place between cells which were before-hand connected by a pit. The process is not accompanied by a migration of nuclei; the two cells fusing with each other contain each one central nucleus like the other cells.

The sporangia are borne on the inner side of the branches of the last or penultimate order. They are 4-parted or 2-parted, most frequently the first, but there is always one sort of sporangia only on the same plant. They form a short row on the inner side of the branches, frequently in a number of 3 or 4, but sometimes there is only one, on the first joint. When the number is greater, they are not always all placed on the inner side but some of them on the flanks of the branches (fig. 265). There is usually one sporangium only on each joint but a young sporangium may sometimes be found under the normal one, more rarely over it. Such small, incompletely developed sporangia were met with in plants with four-parted and with two-parted sporangia as well, most frequently in the latter. The sporangia-bearing branches may be simple but are frequently branched and the branches then issue over the sporangia-bearing part (fig. 266). It is very rare to find a cell bearing at the same time a sporangium and a branch (fig. 273).

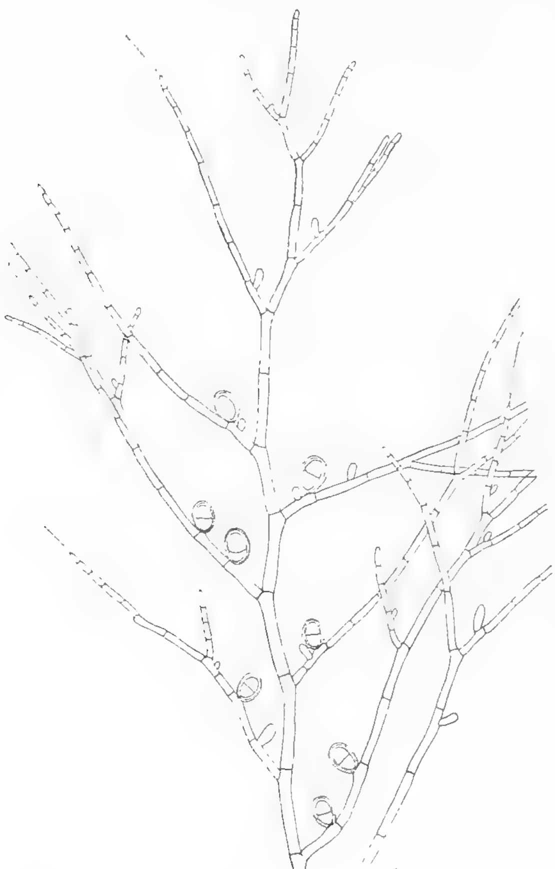


Fig. 266.
Callithamnion Furcellariæ. Part of plant with disporangia. From YV. 200 : 1.

The sporangia are ovate or obovate or broadly ellipsoid. The tetrasporangia are tetrahedrically divided, but the spores are sometimes so arranged that the sporangia seem to have been cruciately divided (fig. 265), a fact to which Hauck has already paid attention in the species mentioned by him under the name of *C. byssoides* (Österr. bot. Zeitschr. 1878 p. 288, Taf. 3 Fig. 9). The tetrasporangia are (44—) 53—79 μ long, 33—51 μ broad. When the specimens from the waters within Skagen only are taken into account, the size is a little smaller, viz. (44—) 53—65 (—67) μ long, 33—42 μ broad, which quite agrees with the dimensions stated by Kylin. The specimens from the Skagerak, some of which were not with certainty referable to this species, had larger sporangia, 66—79 μ long, (38—) 42—53 μ broad.

The disporangia are of the same size as the tetrasporangia, or, when only the specimens within Skagen are taken into account, generally larger than the tetrasporangia, viz. 56—78 μ long, 43—65 μ broad. The size was rather variable in specimens from different localities. Thus in specimens from Fænø Sund gathered in June the disporangia were 56—60 μ long, 43—47 μ broad, while in specimens from a locality north of Ærø gathered in May, they were 67—78 μ long, 53—63 μ broad. The disporangia were formerly mentioned by KYLIN (1907, p. 169) who raises the question whether they might possibly be young stages of tetrasporangia. He arrives at the conclusion that they are fully developed, partly on account of the fact that he found some of them emptied, which conclusion I can fully confirm.

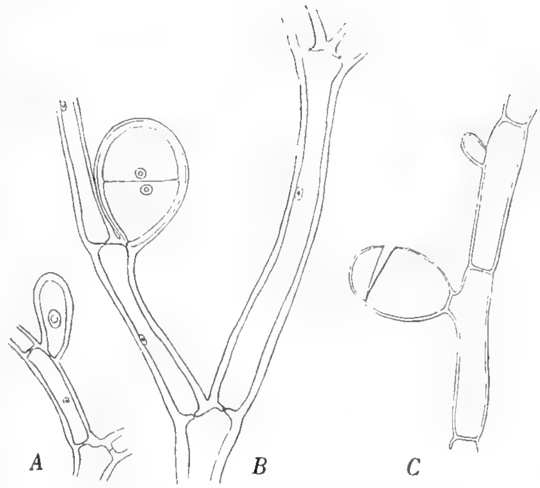


Fig. 267.
Callithamnion Furcellariæ. Disporangia. *A* young, *B* ripe, *C* emptied. *A*, *B* 270 : 1. *C* 195 : 1.

The disporangia-bearing specimens in all other respects fully agree with the tetrasporangia-bearing ones so there seems to be no sufficient reason to consider them as a special variety. They occur more rarely than the others; in Fænø Sund both kinds of individuals have been met with. The disporangia are divided by a horizontal wall on each side of which a large nucleus is situated. A finer cytological investigation of the disporangia is much needed.

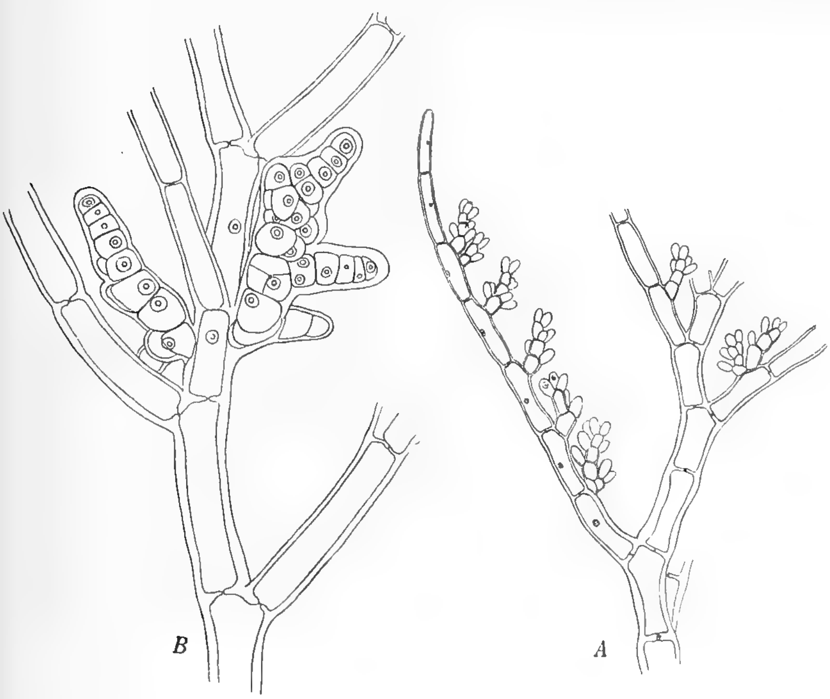


Fig. 268.
Callithamnion Furcellariæ. *A*, antheridial clusters. *B*, cystocarps. From Tonneberg Banke. *A* 270 : 1. *B* 195 : 1.

Both kinds of

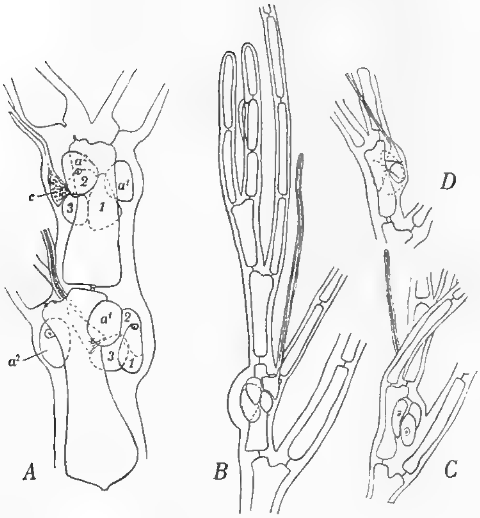


Fig. 269.
Callithamnion Furcellariæ. Procarps. In *A* a^1 and a^2 the two auxiliary mother-cells; *1, 2, 3, c*, the cells of the carpogonial filament. The lowermost trichogyne was very long. *B—D*, the auxiliary mother-cells a^2 is wanting. *A* 350 : 1. *B* 270 : 1.

sporangia open by a transversal slit in the upper part of the sporangium. The disporangia have been met with in May to July, the tetrasporangia in June to October.

The antheridial clusters have been described and figured by KYLIN (1907, p. 169, fig. 35 b). They are usually arranged in a row on the upper side of the upper pinnulæ, often on the lowermost 4—6 joints, but they may also be borne on branches of penultimate order. On each joint one to three clusters are to be found. Even when seated very densely they are never fused together as in certain other species. The clusters consist in a usually somewhat curved axis composed of 3 or 4 cells which are almost isodiametrical and bear each a number of antheridia mostly on the convex side turning downwards. The antheridia are 7—7,5 μ long, 4,5—5 μ broad. They were met with in July and September.

Buffham has described and figured the antheridial clusters in *Call. byssoideum* (1884, p. 341, pl. X figs. 4, 5); they agree with those of *C. Furcellariæ* by the position and the structure of the axes, but they seem to differ, according to BATTERS, by the antheridia being developed equally on all sides of the cluster and by being "very elongated". — According to KÜTZING (Tab. phyc. Vol. 12 pl. 8), the antheridial clusters of *C. byssoides* are, at any rate in great part, axillary. The species of KÜTZING seems, however, to be very different not only from our species but also from HARVEY's by its much corticated main axes. — The antheridial clusters of *C. byssoides* Börgs. from the Danish West Indies (F. BØRGESEN, Mar. Alg. Dan. W. Ind. 1917 (Dansk Bot. Ark. III, p. 218, Fig. 207) are also different, being cushions consisting "of a system of short (branched) branchlets in which the uppermost cells are the antheridia". They may some-

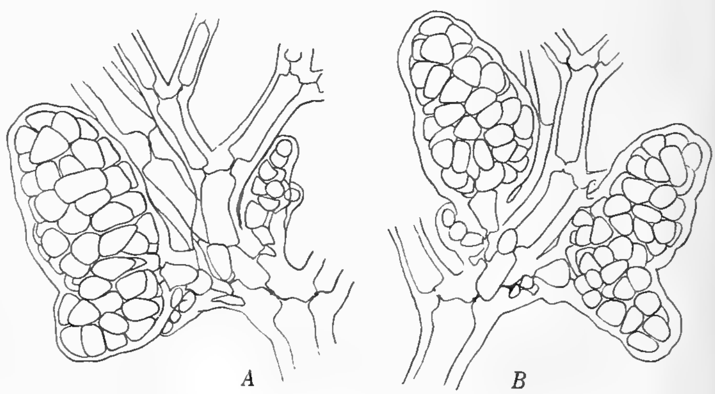


Fig. 270.
Callithamnion Furcellariæ. Ripe cystocarps. From Hirsholm. 200 : 1.

times occupy nearly the whole upper side of the cell of the branch. — The quoted differences in the structure of the antheridial clusters of the various plants referred to *C. byssoides* suggest that different species have been confounded under this name.

The carpogonial filaments are borne on the upper end of joints bearing a branch on the opposite side. They are, as in the other species, composed of four cells arranged in a zigzag line. There are usually two auxiliary mother cells, but sometimes there is only one, a_1, from which the carpogonial branch is given off, while a_2 is wanting (fig. 269). The growth of the procarp-bearing cell is arrested during the development of the cystocarp and this cell is therefore much shorter than the other cells in the filament, when the cystocarp reaches its definite size, but it has often more protoplasmic contents. The fertilisation and the development of the gonimoblast has quite recently been described by KYLIN (1923 p. 56) and found to be as in *C. corymbosum* as described by OLTMANNS. The gonimoblasts are lobed; the lobes are at first cylindrical, then conical (fig. 268), and finally rounded, ovate (fig. 270). At maturity there is usually a longer end-lobe and a shorter side-lobe, both issuing from a large cell, and sometimes furthermore a small supplementary lobe derived, as shown by KYLIN, from the auxiliary cell. In some cases the lateral lobe is not developed, and the gonimoblast is then much like that of *C. roseum*. The procarps were met with in June to September, the cystocarps in July to October.

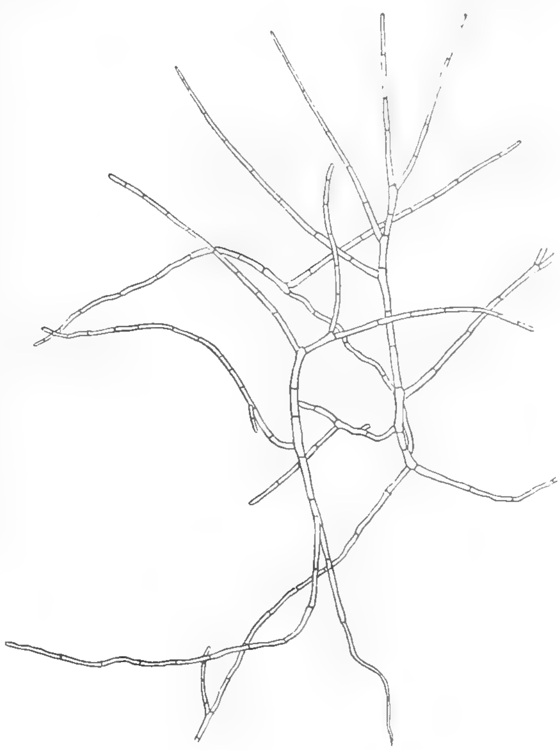


Fig. 271.
Callithamnion Furcellariæ. Two sporelings from sown tetraspores, 4 weeks old. 47:1.

Tetraspores sown in July at Frederikshavn immediately germinated. 4 days later the sporelings were partly unbranched, about 10- to 13-celled, partly more or less branched. After four weeks they had grown much longer and variously branched but sterile (fig. 271). Filaments having the character of rhizomes were frequently given off from the basiscopic end of the cells, and these rhizomes produced erect filaments. In fig. 271 to the right one rhizome is given off from the basiscopic end, another from the acroscopic end of the same cell, but this cell is perhaps the original spore cell.

C. Furcellariæ has been met with in the months of May to October. The spores produced in summer and autumn are able to germinate immediately and give rise to plants which in part probably only reach a small size before winter. It must be supposed that the plants die in autumn or winter, entirely or with the exception of the basal portion which may survive the winter. New erect shoots may then grow out in spring from the basal remains of the erect shoots from the foregoing year (fig. 263 *B*). The species occurs in all the Danish waters except the North Sea where hitherto it has not been met with, and it has been found in depths from 7,5 to 24,5 meters, rarely in slighter depths. It grows on various Algæ e. g. *Furcellaria* and *Polysiphonia elongata*, further on *Zostera*, *Flustra foliacea* etc. The three kinds of organs of reproduction occur in different individuals. Once only a disporangium-bearing individual was found bearing at the same time some few procarps (fig. 272). A general difference in size of the three kinds of individuals as that stated by ARESCHOUG (1850, p. 107), could not be ascertained. As a rule the plants are less branched in the inner Danish waters with feebler salinity, which is in accordance with the observations of KYLIN at the west coast of Sweden. But, with decreasing salinity the size of the plants rather increases, for while in the Skagerak and Kattegat it reaches only a little over 2 cm, it is up to 3 and 4 cm in Store Belt and the Baltic Sea, greatest near Bornholm. Specimens with procarps and cystocarps were frequently met with in the Kattegat together with sporangia-bearing ones, but in the inner waters south of the Samsø area sex organs were not found, while sporangia were frequently present. The sporangia were in most cases four-parted; disporangia have only been recorded from three localities in **Sa**, **Lb** and **Sf**.

Fig. 272.
Callithamnion Furcellariæ. From YV, June. Part of plant with disporangia. Above a procarp. 70 : 1.

Some specimens from Skagerak are dubious. That is particularly the case with a specimen from Hirshals (no. 7077, Hirshals lighthouse in S.E., $2^1/_2$ miles), differing by the cells not quite young containing more than one nucleus; in other respects it agrees with *C. Furcellariæ*, but fully developed cystocarps were not present. The plant might possibly be of hybrid origin. The number of nuclei in the cells is otherwise, according to my experience, a very constant character. Other specimens were, as mentioned above, different in having bigger sporangia, up to 79 μ long, so

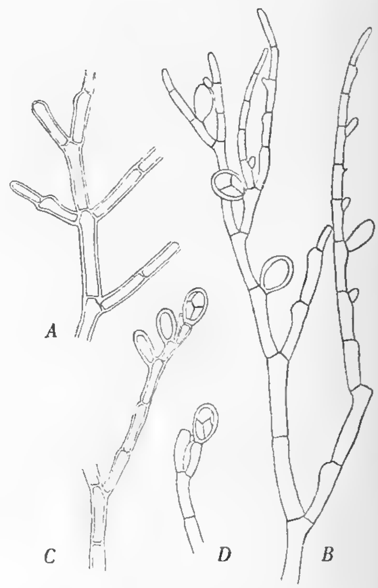


Fig. 273.
Callithamnion Furcellariæ. Aberrant specimens from Løkken. *A*, a joint bears two opposite branches. *B–D*, tetrasporangiferous branches. 70 : 1.

in specimens from SY, north of Løkken. These specimens were more vigorous than the typical *C. Furcellariæ* and partly showed another arrangement of the tetrasporangia, these being partly terminal on short branchlets (fig. 273). It might further be mentioned that a small specimen with unripe round, not lobed gonimoblasts but otherwise agreeing with *C. Furcellariæ* was found on Herthas Flak in the Northern Kattegat. Typical specimens of the same species have repeatedly been found in the same place.

Localities. **Sk:** SY, north of Løkken, 1 mile (+ ◯ 8)[1] (aberrant); ZK^{12} off Lønstrup, 8,5 m (+ 8); Hirshals light-house in S.E. 2½ miles 13 m (+ ♀ 8), aberrant); XO, Møllegrund off Hirshals 11—15 m (+ 8). — **Lf:** Oddesund, 6,5 m. — **Kn:** FG and XJ, Herthas Flak, 19—22,5 m (♂ ◯ + 7); ibid. F. Børgesen (+ 9); fE, Krageskovs Rev; Nordostrev at Hirsholm, 7,5—9,5 m (♂ ◯ + 7); harbour of Frederikshavn (+ ◯ 7); TP and TO, Tønneberg Banke, 16—18 m (♂ ◯ + 9); fG, 3 miles W. of Læsø Trindel light-ship, 15 m (◯ + 10); TR, near Trindelen, 23,5 m (+ 9). — **Ke:** VZ, Groves Flak, 24,5 m; Groves Flak, F. Børgs. (◯ + 9); ZF, near Fladens light-ship, 22,5 m (+ 7); 1 mile W. by N. of Fladens light-ship, 17 m (+ ◯ 10). — **Km:** VN, near the entrance to Randers Fjord. — **Ks:** RL, near Ostindiefarer Grund, 15 m (♂ ◯ + 7); D, near Grønne Revle, 11,3 m (◯ 7); aU, Lumbsaas church in S. 32° W., 2 miles (◯, sporg. 8). — **Sa:** YV, near Hatterbarn, 15 m (♀ 2s 6); AO, Endelaves Sydostflak; GC, north of Fyn, 13 m. — **Lb:** Fænø Sund (2s + 6); CF, west of Lyø, 15 m; DX, Vodrups Flak, 13 m (sporg. 5). — **Sf:** CZ, south side of Hornenæs, 9,5—15 m (+ 5); UX, at the North end of Ærø, 9,5 m; UV north of Ærø, 13 m (2s 5). — **Sb:** cN, S.W. of Musholm, 18 m (2s 6); AF, Møllegrund, 7,5 m; DN, Vengeance Grund, 12 m (sporg. 5); LH, off Bøstrup, Langeland. — **Su:** HK off the N.W. end of Hveen, 9,5—21 m; QC, east side of Saltholms Flak. — **Bw:** bV, N.E. of Kobbel Skov (sp. 6); Middelgrund south of Als, 13 m (2s 6); bY, off Sønderskov, Als; cG, Trindelen, West side of Kegnæs; cF, south of Kegnæs light-house; LE, North Side of Vejsnæs Flak, 9,5 m. — **Bm:** QN, off Køge Søhuse, 6,5 m; QS, north of Møens Klint, 20,7 m (+ 7); VG, north of Møens Klint, 17 m; 7 miles N.E. ½ W. of Hestehoved light-house, south of Møen, 11—13 m (st. 6) (C. A. J.). — **Bb:** 8 miles S. ½ E. of Rønne, 11—19 m, (st. 6) (C. A. J.); SL, off Allinge, 5,5—11,3 m (+ 8); 3 miles S.S.E. of Nexø, 21 m (st. 6) (C. A. J.); YD, near Salthammer Rev 19 m; YC near Salthammer Rev 24,5 m (+ 7); 7 miles S.E. ¾ S. of Adler Grund light-ship, 20 m (st. 6) (C. A. J.).

7. Callithamnion sp.

In October 1922 I found a small specimen of a *Callithamnion* growing on *Desmarestia aculeata* dredged in a depth of 30 meters at Fladen in the eastern Kattegat. As this specimen, which is only 3 mm high, cannot be referred with certainty to any known species, it is described here in the hope that it may later be identified. The branching is strictly alternate, biseriate or pectinate, all the branches falling in the same plane. The branches of the main axis (stem) are regularly distichous from the base, and the ramification of the main branches is the same, with the exception that the two or three first branches of the second order are seriate on the upper side of the branch, and in the lowermost main branches the first 1 to 4 joints bear no branches at all. In the branches on the upper part of the plant the secund branching of the branches is very manifest, in particular in the branches with limited growth in which the number of pinnulæ arranged in a row on the upper side of the pinna may be greater, up to 9. This secund branching of the pinnulæ gives the

[1] + designates tetrasporangia, 2s disporangia, sp young sporangia, ♀ procarps, ◯ cystocarps, the number at last the number of the month.

plant a peculiar appearance reminding one of the *Antithamnia*. The main axis is distinct, increasing gradually in thickness downwards. A little above the base it is over 100 μ thick and consists there of cells about twice as long as broad, while the cells in the upper part of the plant are 3—4 times as long as broad. The lowermost two or three joints of the stem are provided with cortical filaments which

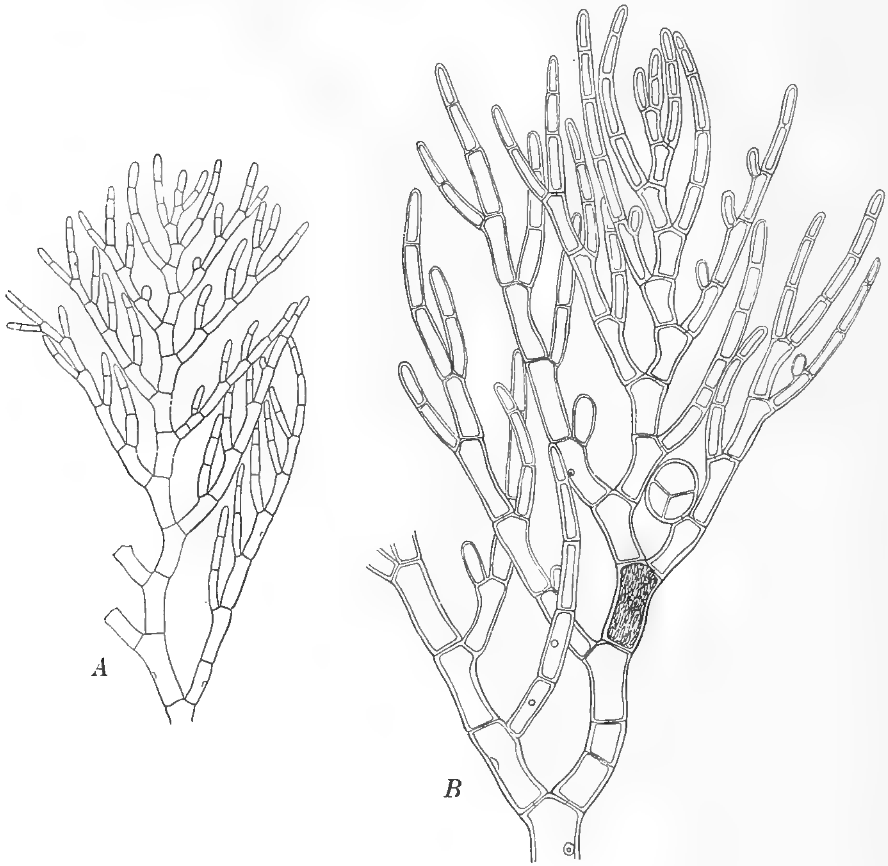


Fig. 274.
Callithamnion sp. *A* 80 : 1. *B* 150 : 1.

continue their way into the basal disc. All the cells contain one nucleus and numerous elongated chromatophores. The upper end of the branches are 12 μ thick; they are rounded, never terminating in a hair or in a point. The plant bears a few sporangia situated in the place of a pinnula. They are tetrahedrically divided, 60 μ long, 46 μ broad.

A pectinate ramification like that described above seems to be rare within the genus *Callithamnion*. According to J. Agardh it occurs in *C. scopulorum* Ag. the pinnæ of which are "rarius interiore latere pinellis brevissimis secundis quarum inferiores longiores instructæ« (Sp. g. o. II p. 47). In the existing figures of this species, however, the pectinate branching is only shown in one pinna in Børgesen's fig. 56 b (Mar. Alg. Fær.), and it is evidently a rare occurrence, as also stated by J. Agardh, while in our specimen it is to be found on all the branches. This may possibly be due to the young age of the plant.

A similar seriate branching occurs in *Phlebothamnion spinosum* Kütz. (Tab. phyc. 11 tab. 98), but only dispores are shown in Kützing's figure, there is not so great a number of seriate pinnulæ, and the primary axis is corticated (comp. Sp. Alg. p. 653). *Call. spinosum* is, by the way, recorded by J. Agardh under *species inquirendæ*. In *Phlebothamnion Gailloni* Kütz. (Tab. phyc. 11 tab. 98 II) two seriate pinnulæ on the upper side of the pinnæ are shown in two pinnæ in the quoted figure, but this species seems to differ more by its fasciculate-corymbose branching.

As only a very small specimen is present it remains undecided, whether the main axis is corticated and whether the described branching is characteristic also of the adult plants.

Locality. **Ke:** fJ $3^1/_2$ miles W. by N. of Fladens light-ship. 30 meters, Oct.

Seirospora Harvey.

1. **Seirospora Griffithsiana** Harv.

Harvey, Phyc. Brit. Vol. I plate 21, 1846; Kützing, Tab. phyc. Bd. 12, Taf. 17, 1862; Schmitz, Die Gattung Microthamnion J. Ag. (= Seirospora Harv.), Ber. deut. bot. Ges. Bd. 11, 1893, p. 277; Jos. Schiller, 1913, p. 207; Oltmanns, Morph. I, 1904, p. 667; L. Kolderup Rosenvinge, 1920, p. 32.
Callithamnion versicolor β, seirospermum Harv. in Hooker's Journ. of Botany Vol. I, 1834, p. 302.
Callithamnion seirospermum Griffiths, Harvey Manual 1841, p. 113; Areschoug, 1850, p. 108, Tab. IV G; J. Agardh, 1851, p. 42; Bornet et Thuret, Notes algol. fasc. I, 1876, p. XIV; Thuret et Bornet, Etudes phyc., 1878, p. 70.
Pœcilothamnion seirospermum Nägeli, 1861, p. 364, Fig. 13.

The ramification of this species which somewhat reminds one of *Callithamnion corymbosum* to which it has also been referred, has been described by Nägeli in 1861 and recently treated at large in my paper (1920) to which the reader may here be referred for more details. The main axes are vigorous, in their lower part covered by a well developed cortex composed of downward growing filaments produced in a number of three from the basal cell of each branch. The branches are almost always arranged in a spiral with a divergence varying between $^1/_5$ and $^1/_3$, most frequently between $^1/_4$ and $^1/_3$. The spiral arrangement, however, does not begin at the very base of the branches, but the first branches are usually biseriate and arranged in a transversal plane, and the first joint (or 1 to 3 joints) is as a rule branchless. In all the specimens examined from Frederikshavn and Tonneberg Banke the spiral turned to the left. On the other hand, in a specimen from Herthas Flak only 4 of 16 examined shoots had a spiral turning to the left; in 9 it turned to the right, one

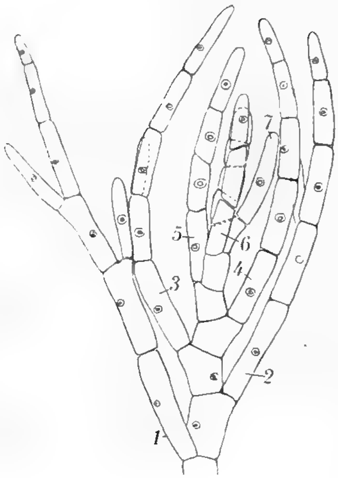


Fig. 275.
Seirospora Griffithsiana. Upper end of shoot, from Frederikshavn (6361). 300 : 1.

had a spiral with changing direction and 2 had irregularly arranged branches. The ramification is often pseudodichotomous in the upper parts of the shoots, the branches being of the same dimensions as the mother shoot and the latter changing direction by each branch (fig. 276 *A*). In a specimen from Tønneberg Banke I once found two vegetative branches of equal size on the same joint, diverging from each other at a right angle (fig. 276 *B*), and in the disporangia-bearing region of a specimen from the same locality I repeatedly found two branches on the same joint arranged now side by side, now one under the other or obliquely under the other (fig. 279). Even three branches were found on the same joint, one of which, however, was probably a young sporangium. The two branches were never opposite.

Hyaline hairs do not usually occur. Only in specimens from the harbour of Frederikshavn thin hyaline hairs were not rarely met with at the end of the branches (fig. 276 *D*).

As shown by SCHMITZ (1893, p. 277), all the cells contain a single nucleus. The usual thallus cells contain numerous chromatophores which may be rather long (fig. 279 *B*).

Plants with sexual organs have not been met with in the Danish waters. For these organs see the quoted papers by BORNET et THURET and SCHMITZ. On the other hand, disporangia, tetrasporangia and paraspores were found. The specimens from Herthas Flak were sterile, those from the Samsø area bore only paraspores. The specimens from Frederikshavn, which were fairly numerous, bore

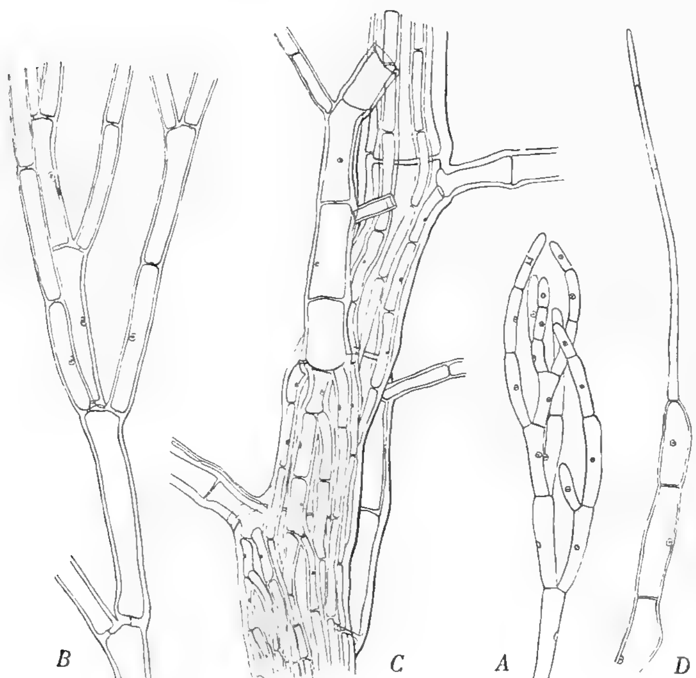


Fig. 276.
Seirospora Griffithsiana. *A*—*C* from Tønneberg Banke; *A*, upper end of shoot with spirally arranged branches. *B*, two branches are borne on the same joint. *C*, lower part of stem with cortication. *D*, hyaline hair. *A*, *B* 200 : 1. *C* 70 : 1. *D* 350 : 1.

many paraspores, but some of them at the same time disporangia and tetrasporangia, though in rather small quantity and partly anomalous. Two specimens were found at Trindelen one of which bore only paraspores, the other only disporangia, and specimens recently collected at Trindelen in October bore only tetrasporangia.

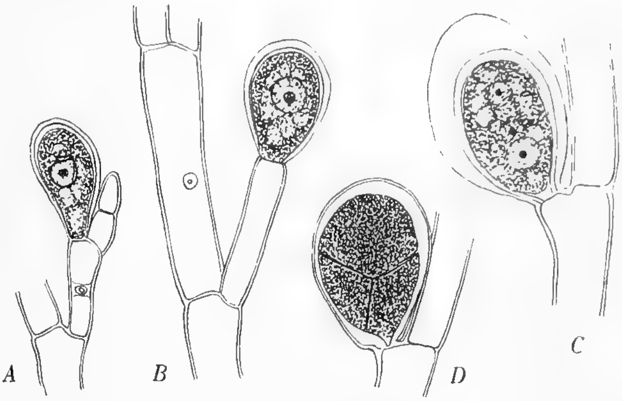


Fig. 277.
Seirospora Griffithsiana. Tetrasporangia. *A*, *B* young, still uninucleated. *C*, with four nuclei. *D* division accomplished. 350 : 1.

The tetrasporangia are borne on the inner side, more rarely on the flanks of the upper branches; they are sessile or are sometimes borne on a unicellular stalk, very rarely on a twocelled one (fig. 278 *A*). The sporangium-bearing joints often bear two or even three sporangia in a longitudinal row, the youngest lowermost, sometimes a sterile branch too. The tetrasporangia are 60—77 μ long, 42—53 μ broad. The outer wall has two layers, each consisting of a firmer outer layer and a soft, gelatinous inner layer. These two layers are not present from the first; the inner one appears only shortly before the division of the sporangium. The division was in some cases regular, tetrahedrical (fig. 277 *D*), in others it was irregular, and sometimes more than 4 spores were present (fig. 278). According to SCHMITZ (1893, p. 277) the sporangia in *Seirospora* are "paarig getheilt (mit zwei gekreuzten Paaren von Sporen) oder zweitheilig (mit gerader oder sattelförmig verbogener Theilungsfläche) oder tetraëdrisch getheilt". The most regularly divided tetrasporangium observed by me was evidently tetrahedrically divided (fig. 277 *B*). Regularly cruciately divided tetrasporangia were not met with.

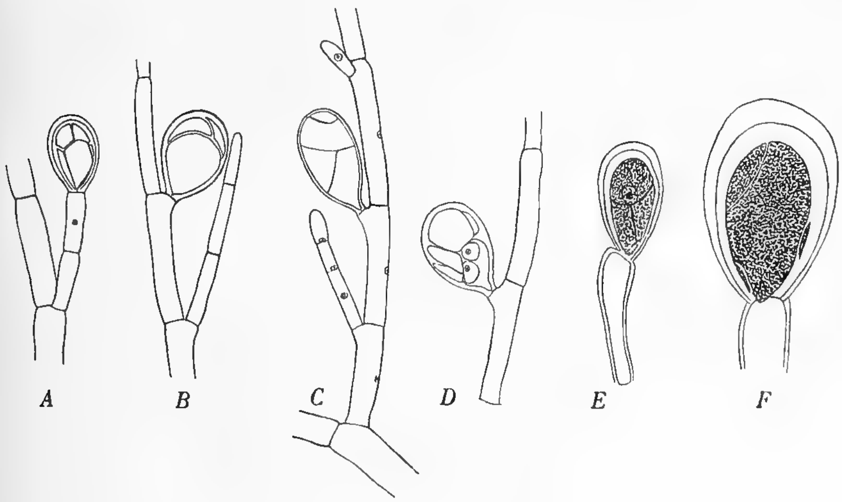


Fig. 278.
Seirospora Griffithsiana. Irregularly divided tetrasporangia. *A*—*D* 190 : 1. *E* 200 : 1. *F* 350 : 1.

The disporangia have the same position as the tetrasporangia, but in the specimen in question, two or even three lateral organs were often borne on the same joint. As a rule one of the lateral organs was a sterile branch, the other a sporangium, but two sporangia might also occur on the same joint, the youngest under the eldest. A sporangium may be placed under the branch, but more frequently beside it (fig. 279 *B*). The disporangia which are usually sessile, but sometimes borne on a one-celled stalk are 56—70 μ long, 35—40 μ broad. They have always a double outer wall, just like the tetrasporangia.

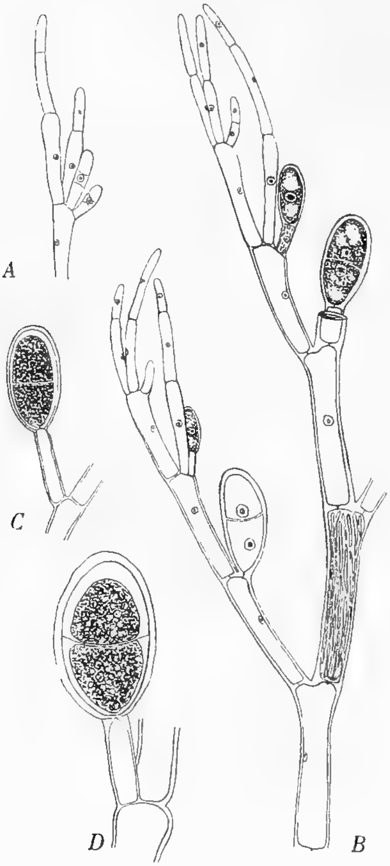


Fig. 279.
Seirospora Griffithsiana. Disporangia. *A*, two very young sporangia on the same joint. *B*, sporangia besides or under a branch. *A*, *B* 190 : 1. *C* 200 : 1. *D* 350 : 1.

The tufts of paraspores are, as well known, terminal on the long shoots, and I usually found them so, but lateral tufts, sessile or borne on a unicellular or bicellular stalk are sometimes met with on the upper branches, thus with a similar position to that of the sporangia. The usual terminal tufts of paraspores are sharply delimited downwards, all the cells of the axis above a certain level and its branches being transformed into paraspores, their form becoming rounded, their contents much condensed and the wall thicker. The branches of the tufts are crowded, and frequently two branches are borne on the same joint. The outer wall of the cells in the tufts is thick and at first homogeneous, but later on it is often composed of two or three layers each of which has a firmer outer membrane. In the middle of the dense dark-red contents a large nucleus is visible after staining. A transitional stage between the terminal and the lateral paraspore-tufts is shown in fig. 281, the lowermost one or two cells in the upper branches being sterile. In other cases similar lateral tufts of paraspores are found at a greater distance from the apex, borne on a two-celled or one-celled stalk or even

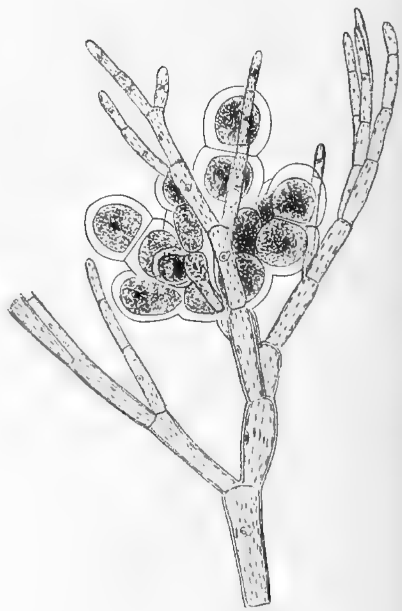


Fig. 280.
Seirospora Griffithsiana. Typical tuft of paraspores. 215 : 1.

sessile (figs. 281, 282). They may then have a similar position to that of the sporangia. There is, however, no reason to consider them as transformed sporangia, (comp. SCHILLER 1913, p. 12), as it is only exceptionally that they have the same place as the sporangia.

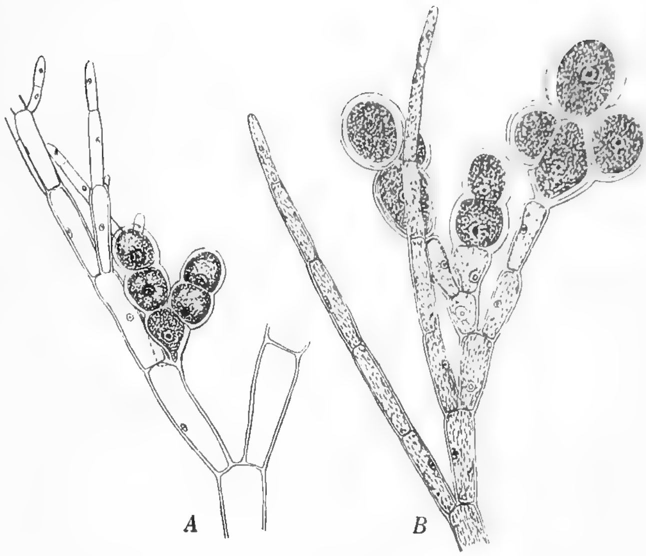


Fig. 281.
Seirospora Griffithsiana. *A*, lateral tuft of paraspores. *B*, the lowermost cells in the lateral branches of the tuft are sterile. 200 : 1.

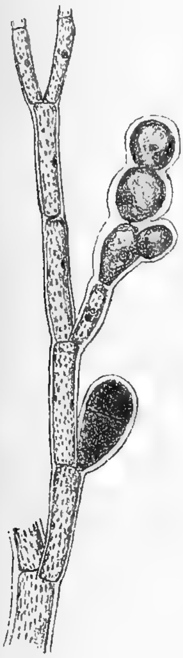


Fig. 282.
Seirospora Griffithsiana. Branch with tuft of paraspores and disporangium. 200 : 1.

At maturity the paraspore escapes from the thick envelope and takes a spherical shape. I have not ascertained whether the paraspore is naked or provided with a thin membrane as asserted by SCHILLER (1913 p. 2[1]). According to this author the germination takes place without formation of a rhizoid; but that is not in accordance with my observations. In my cultures the spherical paraspores had after two days given rise to a rhizoid, and some of these were divided by a transversal wall perpendicular to the rhizoid. At the opposite pole a shoot arose during the following days which soon began to branch in the usual way (fig. 283). In the same culture were found short shoots detached from the plant from which the paraspores were given off; these shoots had also germinated, long rhizoids having arisen from their basal end.

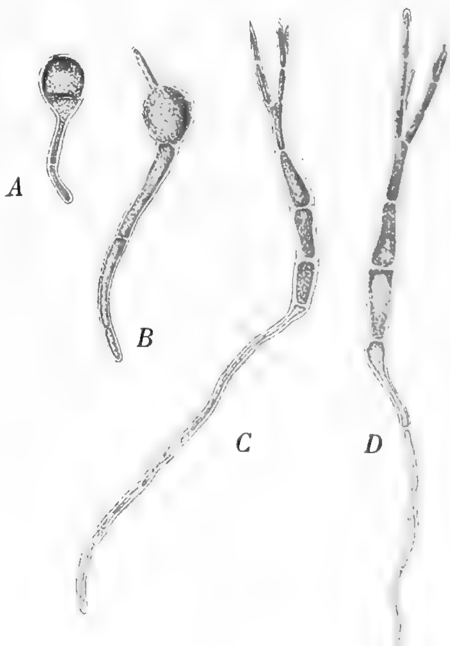


Fig. 283.
Seirospora Griffithsiana. Sporelings arising from paraspores. *A*, two days old, the others some days older. 120 : 1.

[1] "Doch wird der natürlich schon mit einem zarten Häutchen umgebene Inhalt nicht von der Hülle zur Gänze frei".

The species has been found growing on stony bottom in 15—22 meters depth in the northern Kattegat and in the Samsø Water and further in the little boat harbour at the end of the northern mole in the harbour of Frederikshavn near low-water mark. In Herthas Flak it reached a length of 17 cm but was sterile. In the harbour of Frederikshavn it attained a length of 10 cm and bore abundant paraspores, more sparingly tetraspores and dispores. In the other localities the specimens were only 1 cm high but fructiferous. The species has only been met with in July, September and October.

Localities. **Kn:** Herthas Flak[1] (FG, XJ) 20 to 22 m; Frederikshavn (only found in 1896 and 1919); TO, Tønneberg Banke 18 m; fG, 3 miles W. of Læsø Trindel light-ship, 15 m (+ 10). — **Sa:** MS, near Endelave, 15 m, with paraspores.

Plumaria Stackhouse, emend. Schmitz.

Euptilota Cramer.

1. Plumaria elegans (Bonnem.) Schmitz.

Fr. Schmitz, Systemat. Uebersicht, Flora 1889, reprint p. 16; Phillips 1897, p. 361, pl. 18 fig. 17; Kolderup Rosenvinge 1911 p. 210; Kylin 1923, p. 57.

Ptilota elegans Bonnemaison, Hydrophytes loculées ou articulées. Paris 1828. (Not seen). J. Agardh 1851, p. 94; Kützing, Tab. phyc. 12. Bd. 1862, Taf. 56; Pringsheim 1862, p. 32, Taf. 8 Figs. 2—7; Bornet et Thuret, Notes algol. Fasc. I 1876 p. XV; Farlow, Mar. Alg. New Engl. 1881 p. 133; Buffham 1884 p. 342, 1891 p. 247, 1893 p. 303; Wille, Physiol. Gewebesyst. 1887 p. 72 Tab. IV Figs. 42, 43, Tab. VII Figs. 40, 41.

Ptilota plumosa γ tenuissima C. Agardh 1822 p. 386; Nägeli 1847 p. 206, Tab. VI figs. 38—42; Areschoug 1850 p. 97.

Ptilota sericea (Gmel.) Harvey Phyc. Brit. Vol. II 1849 Plate 191.

Ptilota plumosa Cramer 1864 p. 6, 108, Taf. I Figs. 4—5 Tab. II Figs. 1—5, Tab. III Figs. 1—3.

The structure and development of the frond has been carefully described by Nägeli (1847) and Cramer (1864) whose papers may here be referred to.[2] The longer primary shoots are alternating, being usually separated by two joints. There is no distinct limit between the pinnæ with persisting growth and the pinnulæ with limited growth. The ramification of the feebler pinnæ is less regular than that of the vigorous ones. The young branches are more or less curved inwards, in particular in the most vigorous shoots. Most of the branches become short plumose pinnulæ persisting in the older parts of the frond. The frond is sometimes not plane but vaulted, all the tips of the frond being directed to the same side. The convex side seems then to be directed towards the incident light.

[1] In my paper 1911, p. 205, a sterile specimen of *Seirospora Griffithsiana* has erroneously been recorded as *Griffithsia setacea*.

[2] Oltmanns has not noticed the puzzling synonymy of this species caused by Cramer's unlucky denomination; he has therefore been misled into confounding the genera *Ptilota* and *Plumaria* and has in Morph. u. Biol. d. Algen I Fig. 364 under the name of *Ptilota plumosa* reproduced figures both of this species (figs. 1, 4) and of *Plumaria elegans* (figs. 2—3). Comp. Kylin 1923, p. 57.

All the cells contain one nucleus and numerous small disc-shaped chromatophores. The colour is brownish-red. By treating old parts of the plant with concentrated sulphuric acid the cell-walls were stained blue, which must be due to the presence of iodine in the plant.

The upper pinnulæ not rarely end in a hyaline hair, as first mentioned by Pringsheim (1861 Pl. VIII fig. 2) and later by myself (1911 p. 210). As shown by me, the young hairs contain a number of feebly coloured chromatophores, but these are later reduced, and in the full-grown hairs they are only visible as very small colourless grains (fig. 284). These hairs often cause sympodial ramification, the cell on which the hair is borne growing out about in the direction of the branch and pushing aside the hair. Such hairs were found frequently but not always in the specimens collected in April to September; in April and partly in May the hairs were short, but in autumn and winter (October, November, January) no hairs were met with.

Fig. 284.
Plumaria elegans. Hairs with numerous small reduced chromatophores and deformed nuclei. 240 : 1.

The pinnulæ were sometimes found growing out into articulated, long-celled filaments the cells of which when lengthening take a feebler colour. They might perhaps be considered as abnormally developed rhizoids. As they are hair-like but different from the normal unicellular hairs they might be named *trichoids*. They were most strongly developed in a loose specimen found in the Baltic where it must have been introduced by the currents. The same specimen was remarkable by its divaricate, acuminate pinnules (Fig. 285).

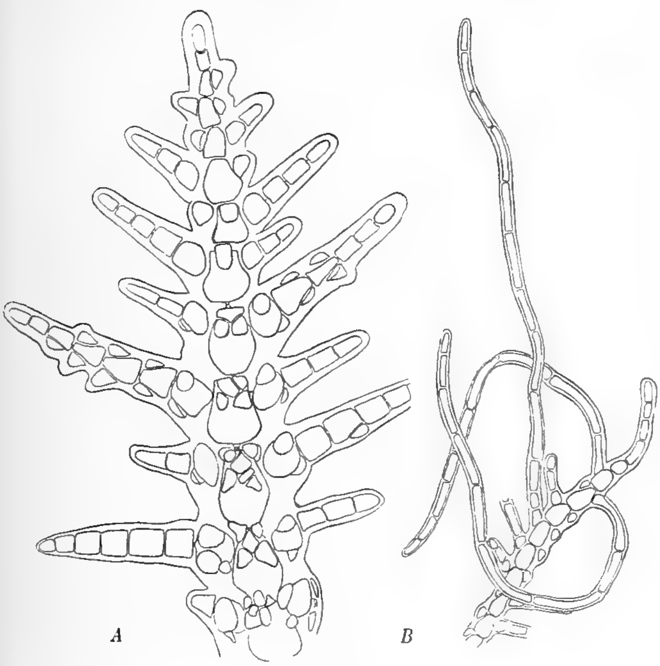


Fig. 285.
Plumaria elegans. A, form with divaricate pinnulæ. *B*, pinnulæ transformed into rhizoid-like filaments. *A* 150 : 1. *B* 80 : 1.

As shown by Nägeli (1847, p. 207, see also Cramer 1864), the cortex early covering the primary filaments is built up of hypha-like filaments fusing together into a dense tissue. In a later stage the cortex shows a pronounced differentiation, as shown by Wille (1887, p. 72), the innermost layer surrounding the axial cell-row becoming a conducting tissue, the intermediate layer a tissue serving for storage, and the outermost, small-celled layer having an assimilatory function. The cells of the central axis gradually increase considerably in size and the pits connecting them increase too. The border of the two callus plates which cover the thin pit-membrane is sometimes bent back and continues their way on the surface of the thick transverse membrane, a phenomenon which is perhaps connected with the peripheral growth of the pit (Fig. 286, above). In older shoots the surface of the cortex is often covered by a felt of adventitious shoots of unbranched cell-rows issuing from the superficial cells (Fig. 286). Cramer (1864 p. 10 and pp. 109—110) has mentioned them and even established three forms of the species according to their frequency: *α, subglabra*; *β, pilosa* and *γ, tomentosa*.

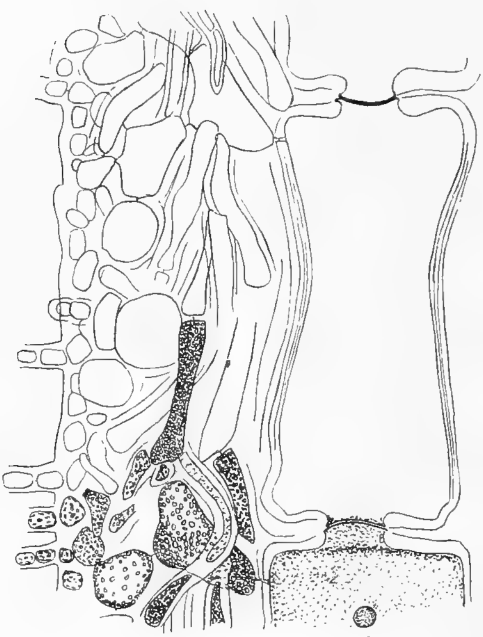


Fig. 286.
Plumaria elegans. Longitudinal section of older stem, perpendicular to the plane of ramification. *p*, pit seen from the face. 200 : 1.

The sexual organs have never been met with at the Danish coasts. The antheridia according to Buffham form "yellowish bunches near the extremities of the pinnules"[1] (1891, p. 247 Pl. XVI figs. 6—7). The structure of the procarps has been described by Phillips (1897 p. 362). The ripe cystocarps are usually said to be naked or provided with involucral branches. But as the sori of paraspores have really often been confounded with cystocarps it may be supposed that the latter are always provided with involucral branches. Buffham asserts, too, that he has never seen the true cystocarps naked (1893 p. 303).

Tetrasporangia have only been met with once and extremely sparsely. In a paraspore-bearing specimen from Busserev gathered in July 1918 I found a ripe and an unripe tetrasporangium (Fig. 287). They had a dense, dark-red content and a thick, two-layered membrane. Within the thin firm cuticle two

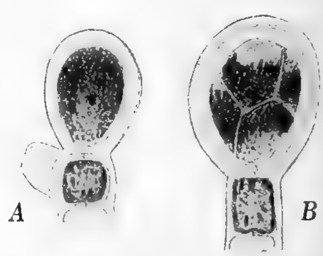


Fig. 287.
Plumaria elegans. Tetrasporangia before and after division. 390 : 1.

[1] The organs which Buffham in a foregoing paper (1884, p. 342, Plate XII Fig. 1) took for antheridia are of dubious nature, possibly foreign sporelings.

distinct layers were present, separated in the young sporangium by a boundary line, in ripe ones by a less refringent intermediary layer. The walls separating the spores were in continuity with the innermost layer of the sporangium. The division was tetrahedrical. The ripe sporangium was 53 μ long, 44 μ broad.

The heaps of paraspores have, as mentioned above, often been confounded with the cystocarps and described as naked favellæ, but they have nothing to do with the female sexual organs. According to SCHMITZ and HAUPTFLEISCH (ENGL. u. PRANTL p. 493) they occur only in the tetraspore-bearing specimens; the only tetrasporiferous specimen I have found bore paraspores at the same time. The heaps of paraspores have further a similar position to that of the tetraspores, namely on the end of the pinnulæ, and it has therefore been supposed that they were modified tetrasporangia (comp. OLTMANNS Morph. p. 667). This interpretation is, however, in my opinion unjustified. While the tetrasporangia are from the first dark-red, darker than the vegetative cells, the young heaps of paraspores are lighter, as emphasized by BUFFHAM (1893 p. 303) and as it is visible in PRINGSHEIM's figures (1862, figs. 3—5), and as shown in my fig. 288. Further, the outer wall has another constitution. It is to begin with similar to that of the vegetative cells, grows gradually thicker and may sometimes be indistinctly lamellate, but it is often homogeneous and is in continuity with the separating walls between the cells of the heap. An end-cell that will develop into a heap of paraspores is distinguishable by its feebler colour and by indistinct chromatophores, while the nucleus appears very distinct. The cell is usually divided by an oblique wall and the daughter-cells are further divided. In the four-celled stage the cells are still rather feebly coloured. During the further divisions the paraspore-heap grows out to a roundish, more or less irregular ovate or obovate or obcordate body and the chromatophores become gradually more distinct and take a deeper red colour. 8-celled and 16-celled heaps are comparatively often met with, but other numbers too occur, f. inst. 5, 6, 12. According to BUFFHAM the number of spores at maturity is 16, and it is certainly frequently so, but I have found at least 18 spores, and in other cases maturity seems to arrive when the number of cells is much lower, as in the four-celled heap represented in fig. 288 *F*.

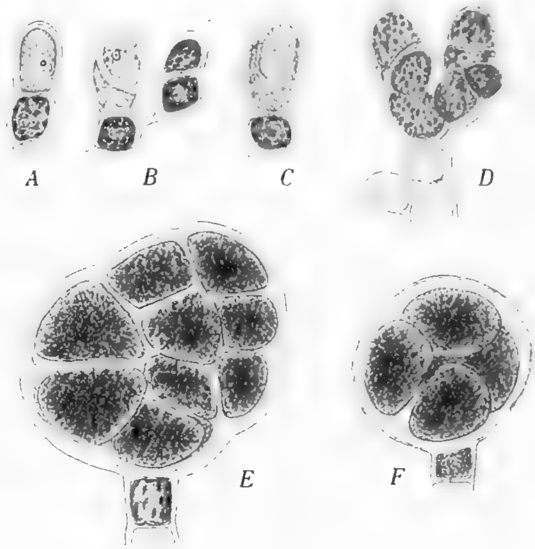


Fig. 288.
Plumaria elegans. Heaps of paraspores. *A—C*, young stages, feebly coloured. *D*, eight-celled stage, the chromatophores more coloured. *E* and *F*, stage of maturation, in *E* about 16 spores. 390 : 1.

The spores when discharged are globular and naked[1], but are soon surrounded with a thin membrane. The cell-wall was sometimes found thickened on one side, undoubtedly where the first rhizoid would later appear. The cell is then divided by an eccentric wall in a smaller cell which gives rise to the rhizoid, and a larger cell which divides by walls parallel to the first and gives rise to the primary axis. The rhizoid is separated from the small cell by a transversal wall. My pictures (fig. 289) agree with PRINGSHEIM's figs. 7 b, d which represent spores germinating within the membrane of the heap.

Fig. 289.
Plumaria elegans. Sporelings from germinated paraspores. 230 : 1.

The species is perennial and has been met with in all seasons. It attains a length of up to 8 cm. In winter it is generally smaller, some of the shoots being shed, but new shoots are produced from the remaining parts. The older shoots are often overgrown with *Membranipora.* It grows partly on stones, partly on various Algæ, as f. inst. *Furcellaria, Chondrus, Ahnfeltia, Fucus serratus,* from low-water mark to 9 meters depth. When occurring near low-water mark it always grows in shadow f. inst. under *Ascophyllum nodosum.* The paraspores have been met with at all seasons except in spring, in the greatest quantity in summer.

Localities. **Kn:** TV, Krageskovs Rev; Hirsholm, at various places (Hornemann 1815, !); Busserev, Brune Rev, Laurs Rev and Marens Rev by Frederikshavn; harbour of Frederikshavn; TL, west of Nordre Rønners light-house, 9—14 m. — **Su:** Gnetare Grund (Swedish coast, Boye Petersen). — **Bm:** SD, N.E. of Møen, 23,5 m, loose, with other loose Algæ, a small specimen with divaricate acuminate pinnules, sterile (see above).

Ptilota C. Agardh.

1. **Ptilota plumosa** (L.) Ag.

C. Agardh, Synops. Alg. Scand. 1817, p. 39; Lyngbye 1819, p. 38 Tab. 9 A; Kützing, Phyc. gen. 1843, p. 378, Taf. 46; Harvey, Phyc. Brit. I, 1846, Pl. 80; Kützing, Tab. phyc. Vol. 12, 1862, Taf. 54; B. M. Davis, Developm. of the procarp and cystocarp in the genus Ptilota, Botan. Gazette Vol. 22, 1896; Buffham 1896 p. 189; R. W. Phillips 1897, p. 362 Pl. 18 Figs. 16, 18; Kylin 1913, p. 58.
Fucus plumosus Linné, Mantissa pl. alt. 1767, p. 134; Fl. Dan. Tab. 350, 1767.
Pterota plumosa Cramer 1863 p. 25 Taf. III Figs. 4, 5, IV Figs. 1—7, V Figs. 1—5, VI Figs. 1—5.

The development of the frond has been carefully described by CRAMER whose paper (1863) may here be referred to. Transversal and longitudinal sections of a younger frond have been figured by KÜTZING (1843, Plate 46). In both is shown a small-celled outer cortex and an inner layer composed of larger cells and surrounding the axile cell-row. In the longitudinal section it is rightly shown that the opposite pinnulæ only issue from every other joint, but the connection between the pinnulæ and the axial cells of the long shoots is not represented. As shown in my

[1] According to BUFFHAM (1893, p. 303) the paraspores are "possessing a cell wall even before discharge". If this must be understood to mean that the spores are also provided with a cell wall when discharged, it is not in accordance with my observations.

fig. 290 the central axes of the pinnulæ traverse the cortex of the stem and are connected with the central axis of the latter through large pits. The greater part of the cortex consists of large rounded cells which have principally the character of storage cells; they contain numerous starch grains and narrow, branched chromatophores. The outermost cells are small and constitute a one- or two-layered assimilatory tissue. The cells of the central axes going out to the pinnulæ are also rich in starch, but the central axes of the stems do not contain starch; the granular plasma of their cells is concentrated in the upper half of the cell while the lower half has only a thin layer surrounding the vacuole. In the somewhat older stems a number of thin rhizines arise from the inner cortical cells, forming a layer surrounding the central axis and increasing in thickness. This production of rhizines later advances outwards, so that the cortical cells in older shoots are partly separated by thick bundles of rhizines, and transverse sections of old stems may in great part be composed of rhizines. All the cells contain one nucleus.

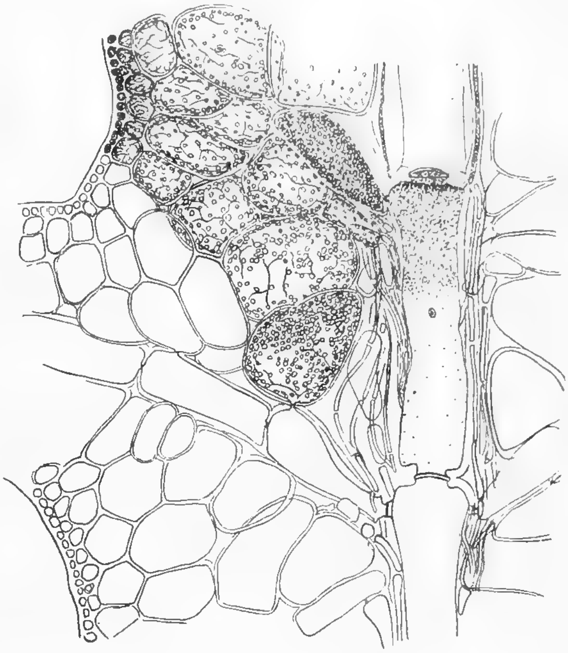


Fig. 290.
Ptilota plumosa. Longitudinal section of frond in the plane of ramification. 110 : 1.

Fig. 291.
Ptilota plumosa. Pinna with tetrasporangia. 230 : 1.

Hyaline hairs have not been met with except those which occur near the procarps and which will be mentioned below.

The tetrasporangia are terminal on short monosiphonous filaments borne on the margins of the pinnulæ and terminal on the pinnæ; they are tetrahedrically divided (fig. 291, comp. Kylin 1923 p. 59, fig. 39).

The antheridia have been shortly mentioned by Phillips (1897, p. 365) who says that they "cover the tips of the branches, and correspond closely in appearance to the similar structures in *Plumaria*, which have been figured by Buffham ('90)". I have found antheridia in a dried specimen dredged in the Kattegat in May. They were borne principally on the edge but also on the flat side of the pinnulæ. They were cut off in a number of 2 or 3 by inclined walls from the low stalk cells (Spermatangien-mutterzellen SVEDELIUS) which seem to contain chromatophores (Fig. 292).

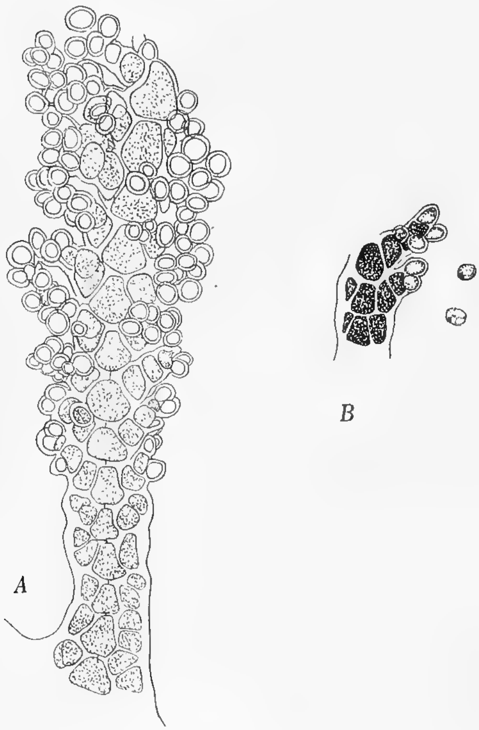


Fig. 292.
Ptilota plumosa. *A*, pinna with antheridia. *B*, pinnula with antheridta and two spermatia. 350 : 1.

The cystocarps develop terminally on short pinnulæ and are surrounded by a whorl of sterile branches. The procarps have been described by DAVIS and PHILLIPS, but the interpretations of these authors are diverging. Upon the end of the fertile pinnæ arises a group of short cell-filaments each ending in a hyaline hair. According to DAVIS (1896) these are groups of procarps the number of which is variable, though typically 5. DAVIS interpreted all the hyaline hairs as trichogynes, but as he has never found spermatia adhering to them and as he has not observed antheridia he supposed that the cystocarp develops apogamously. PHILLIPS (1897) arrived at another interpretation, the 4-celled external short-celled branch being the only true carpogonial branch while the others are only vegetative structures. KYLIN who has recently (1923) carefully studied the development of the procarps arrived at the same conclusion. He observed the fertilisation and the transmission of a small sporogenous cell to the auxiliary cell which is cut off from the basal cell immediately after fertilisation. In one specimen dredged in the Sound north of Helsingør in June I found procarps before fertilisation. The trichogyne was usually thicker than the sterile hairs and frequently swollen at the top. It is strange that these vegetative hairs are normally present while vegetative hairs are otherwise wanting in this species.

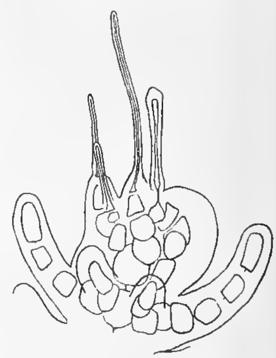


Fig. 293.
Ptilota plumosa. Carpogonial branch (to the right) and surrounding sterile filaments ending in hyaline hairs. 390 : 1.

The gonimoblast according to DAVIS consists of 2—5 nearly globular lobi which are quite separated from one another but are all attached to the central cell. The lobes are as a rule in widely different stages of maturity. According to KYLIN (p. 61) the basal cell ("Tragzelle") fuses more or less with the auxiliary cell and the first cell of the gonimoblast. The number of the involucral branches varies up to at least 8.

The three kinds of organs of reproduction (antheridia, procarps and tetrasporangia) normally occur on distinct individuals. BUFFHAM, however, (1896, p. 189) found tetrasporangia on female plants. In one case "the involucre of an old cystocarp (or possibly of an unfecundated procarp) became branched near the tips and developed tetrasporangia".

The species occurs in the Skagerak, where it has been collected at 11—15 meters depth, in the eastern and southern Kattegat in the under-current with high salinity, in about 20—30 meters depth and in the northern part of the Sound in the same current. It most frequently grows on the stipes of Laminaria hyperborea and L. digitata. It is perennial but has only been collected in the months May to October. It reaches a size of 15 cm. In specimens gathered in June the new shoots had a more clear red colour than the older parts of the frond which were more brown-red. The new shoots in great part formed a continuation of the old ones, but adventitious shoots also occurred, arising from the base of the pinnulæ, as described and figured by CRAMER (l. c.). In August the vegetative growth has ceased. Antheridia were met with in May, unfertilized carpogonia in June, and ripe cystocarps and tetrasporangia in June to September.

Localities. **Sk:** Off Hirshals, 12 m (Børgesen); XO, Møllegrund off Hirshals, 11—15 m. — **Ke:** IQ, ZF and fH, Fladen, 17—30 m; $4^1/_2$ miles S.W. $^3/_4$ W. of Fladens light-ship, 30 m (C. A. J.). — **Ks:** Lysegrund, June 1832 (Lyngbye); Nordvestrev by Hesselø, July 1832 (Lyngbye). — **Su:** Gnetare Grund and Grolle Grund at the shore of Sweden (Boye Petersen); off Hellebæk, soft bottom with shells (id.); north of Helsingør (Liebman, Ørsted).

Antithamnion Nägeli.

1. **Antithamnion cruciatum** (Agardh) Nägeli.

C. Nägeli, 1847, p. 200, id., 1861, p. 378; J. Reinke, Lehrbuch d. allgem. Botanik, 1880, p. 171 Fig. 121; G. Berthold, 1882, pp. 573, 605, Pl. 19 Figs. 1—10, Pl. 20 Figs. 3—4; P. Kuckuck, Bemerk. z. mar. Algveg. Helgoland, Wiss. Meeresunt. Abt. Helgoland N. F. Bd. 1, 1894, p. 254 Fig. 22; Nestler 1899, p. 5, Taf. I Figs. 11—19; B. Schussnig, 1914 p. 2.

Callithamnion cruciatum C. Agardh, Flora 1827 II, p. 637; Harvey, Phyc. Brit. II 1849, p. 164; J. Agardh, 1851, p. 27; Kützing, Tab. phyc. Vol. 11, 1861 Taf, 87 I; J. Agardh, Florideernes Morfologi, 1879 (K. Sv. Vet. Akad. Handl. Bd. 15 No. 6), p. 103 Pl. I Fig. 20 (Cystocarp).

α, genuina.

β, radicans J. Agardh, Symbolae, Linnaea, 1841, p. 44.

This species is easily distinguishable from the two following species. Each joint in the long shoots bears two opposite or four verticillate pinnæ. In the Danish specimens I found them only opposite; they were decussate, and thus arranged in four rows. The angle of divergence often diverged from 90° and was variable, and the arrangement in longitudinal rows therefore not distinct. As shown by BERTHOLD (1882, p. 605), the position of the pinnæ is dependent on the light, the pinnæ being inclined to place themselves in a plane perpendicular to the incident light. According to NÄGELI (1861, p. 379) the pinnæ in the whorls do not arise simultaneously and the first pinnæ of the successive whorls are arranged in a spiral with the divergence

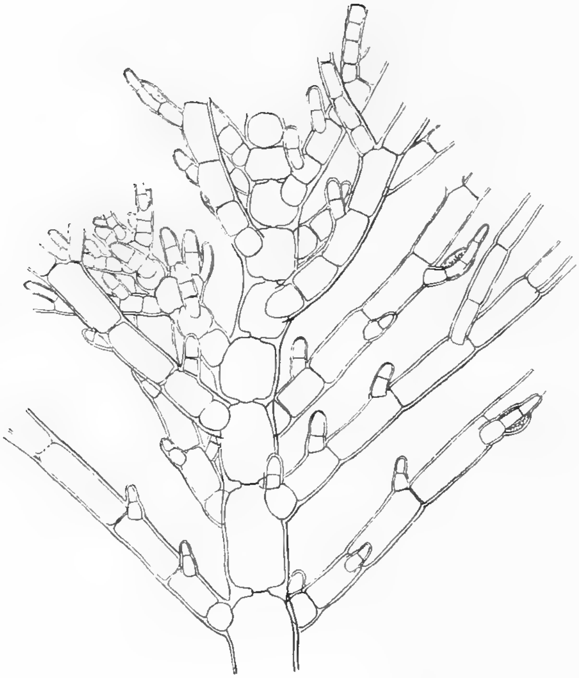


Fig. 294.
Antithamnion cruciatum. Part of erect shoot, gland cells dotted. 270 : 1.

of $^1/_4$. The primary long shoots arise in the place of a pinna; the joint on which it is borne usually bears no other branch (fig. 294, 4th joint). The primary long shoots have no or only a slight influence on the direction of the mother axis. Besides the primary long shoots, adventitious shoots frequently arise from the basal cell of the pinnæ (Nägeli l. c.). They may be given off from the upper side (Reinke l. c.), from the under side (fig. 297) or from the flanks of this joint which remains short and usually produces no pinnulæ.

The pinnæ are variously branched. The lower ones, in particular on the creeping parts of the long shoots, are often entirely unbranched (fig. 295) while those on the upper part of the plant bear alternate, secund or opposite pinnulæ. As shown by Nägeli in 1847, the pinnæ are usually branched in a transversal plane. The plane of ramification is, however, also dependent on the light (Berthold 1882, p. 605). With regard to the gland cells occurring on the pinnulæ reference may be made to Nestler's and Schussnig's papers quoted above; they rest on three cells of the pinnula in contradistinction to those of *A. Plumula.*

Pluricellular rhizoids arise from the basal cell of the pinnæ in the lower part of the plant; they are particularly well developed in the specimens found in the harbour of Frederikshavn and referred to f. *radicans.* The long shoots were here creeping in their whole length or almost so, and bore rhizoids issuing from all the basal cells facing the substratum. These rhizoidal

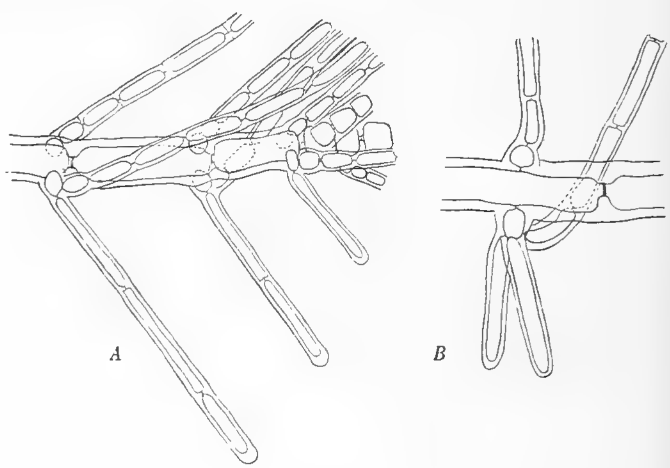


Fig. 295.
Antithamnion cruciatum f. *radicans. A,* the pinnæ unbranched, the rhizoids with free ends. *B,* the outer cells of the rhizoids thrown off. 150 : 1.

filaments had usually free ends; they penetrated a layer of detritus bound together by animal secretion, in which the plants grew without fixing themselves on the algæ covered by the layer of detritus (fig. 295 *A*, comp. KUCKUCK 1894 fig. 22). The outer cells in these filaments lengthen, become gradually poor in contents and are finally thrown off, but the innermost cell often remains for a long time and every trace of the decaying of the outermost cells is then effaced, the wall of the upper end of the cell being rounded (fig. 295 *B*). In Fig. 296 the scar is still visible (×). In other cases, the rhizoids fix themselves on the substratum forming an adhesion disc composed of a number of radiating cell-filaments. According to BERTHOLD (1882, p. 607) the cells of the rhizoids afterwards shorten, the cells becoming barrel-shaped and the cell-wall incrassated. Such rhizoids sometimes arise at a certain distance from the substratum, as shown in fig. 296, where the rhizoid has fixed itself to the mother axis of the pinna and formed an adhesion disc embracing it.

Fig. 296.
Antithamnion cruciatum. Lower part of plant; a rhizoid has fixed itself to the stem. 110 : 1.

The tetrasporangia are placed laterally on the pinnæ, borne on a one- or two-celled stalk. They are larger than those of *A. Plumula*, 73—102 μ long, 51—68 μ broad. They were met with in July. Sexual organs were not observed. They generally seem to be rather rare; HARVEY (Phyc. Brit.) did not know them and HAUCK too did not mention them (Meeresalgen, p. 71). On the other hand, the cystocarps are mentioned and figured by J. AGARDH (1879) as consisting of several lobes.

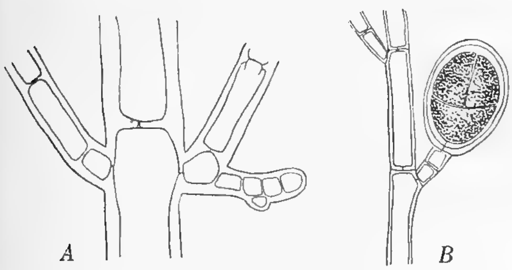


Fig. 297.
Antithamnion cruciatum. *A*, a shoot is produced from the basal joint of a pinna. *B*, tetrasporangium. 200 : 1.

The species has been found only in a few places in the Limfjord and in Kattegat. It has been gathered in June to November, growing on stones and wood (piers) and on other Algæ. In the harbour of Frederikshavn it usually occurs in the creeping form *radicans* which may probably under favourable conditions grow out as the typical erect form.

Localities. **Ns:** $13^1/_2$ miles N.E. $^1/_2$ E. of Hanstholm light-house, 23 m, C. A. J., very small specimen Oct. 1922. — **Lf:** Off Hanklit, Thisted Bredning, on Fucus; MK, Holmtunge Hage, c. 2 meters' depth. — **Kn:** Harbour of Skagen (November 1911, Kramp); harbour of Frederikshavn, berths on the end of the moles and in other places on piers. — **Ks:** aU off Lumbsaas, 13 met.

2. Antithamnion Plumula (Ellis) Thuret.

Thuret in Le Jolis, Algues mar. de Cherbourg, 1864 p. 112; R. W. Phillips 1897 p. 356, Pl. 18 Figs. 11—12; A. Nestler 1899, p. 1, Taf. I Figs. 1—10; Killian, Über die Entwickl. einiger Florideen. Zeitschr. f. Bot. 6. 1914, p. 215; B. Schussnig 1914 p. 1; Kylin, 1915 p. 11; id., Über die Keimung der Florideensporen. Arkiv f. Botanik Bd. 14, No. 22, 1915, p. 15; id. 1923 p. 61.

Conferva Plumula Ellis, Philos. Transact. Vol. 57 I, 1768 p. 424 Tab. 18.

Callithamnion Plumula Lyngbye, 1819, p. 127; J. Agardh, 1851 p. 29; Harvey, Phyc. Brit. III 1851, Pl. 242; Kützing, Tab. phyc. Bd. 11, 1861, Taf. 83 I.

Pterothamnion Plumula Nägeli in Nägeli u. Cramer, Pflanzenphys. Unters. 1. Heft 1855 p. 54, Taf. VI, Figs. 11—13, Taf. VII; Berthold 1882, p. 614, Taf. XX Figs. 1—2, Taf. XIX Fig. 11—17; id., Vertheil. d. Alg. im Golf von Neapel; Mittheil. a. d. zool. Stat. zu Neapel 1882, Heft. III; Schmitz, Unters. üb. die Befrucht. d. Florid., Sitzber. d. k. Akad. d. Wiss. zu Berlin, 1883, p. 236, Fig. 35.

In the Danish waters this species reaches a height of 9 cm, but usually it does not exceed 5 cm. The fixation of the primary shoot is strengthened by free

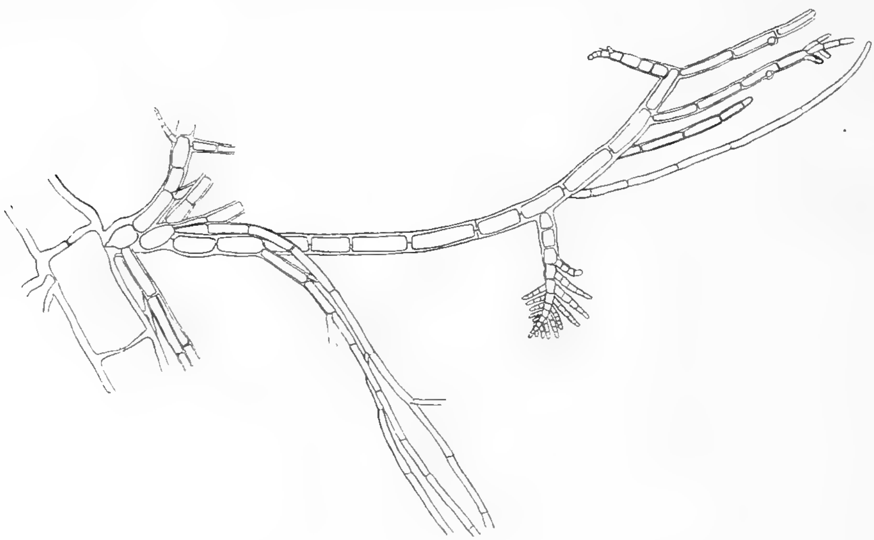


Fig. 298.
Antithamnion Plumula. See text. 70 : 1.

rhizoids springing from the lower end of the cells of the main axes and the lower part of the lateral axes, while intramatrical rhizoids do not occur. It happens, however, that several of the downward growing filaments do not reach the substratum. Some of them may take the character of runners which give rise to upright shoots; they then consist of shorter, thicker cells. Intermediate stages between assimilative shoots and root-like filaments, showing unstable polarity, may occur too. The long shoot to the right in the fig. 298, for instance, is essentially an assimilatory shoot; the filament issuing from its second joint is, however, a branched rhizine though it has been produced at the upper (distal) end of the cell. The 8th cell of the same shoot has also produced at its upper end a filament having if anything the character of a rhizine though it is directed upwards, but from the lower part of the same cell a typical assimilative shoot is given off.

The ramification has been carefully described by Nägeli and Berthold. The frond is usually flat, the long shoots being contained in one plane, issuing alternately to the right and to the left, and the two ranks of opposed pinnæ are given

Fig. 299.
Antithamnion Plumula. Shoots with tetrasporangia, from Herthas Flak. *A*, a normal pinna. *B*, pinnæ mostly unbranched. 95 : 1.

off in the same plane. Each joint usually bears a pair of pinnæ, but the long shoots take the place of a pinna, and the joint which bears a long shoot usually bears no pinna on the opposite side, and in the following joint (or joints) the pinnæ are often wanting over the long shoot (Fig. 299 *B*). On the other hand, the joint which bears a long shoot often produces two unbranched pinnulæ issuing in a plane perpendicular to the plane of the frond (Fig. 299 *B*). Similar pinnulæ sometimes occur on other joints than those situated immediately under the branchings, thus in several specimens from the Kattegat. Such specimens form a transition to others which have normally 3 or 4 ranks of pinnæ, as most of the specimens found in the Skagerak. 3 ranks were most frequently met with. When the number of pinnæ in the whorls is constant, they are usually superposed, though not regularly. In these specimens the long shoots are not contained in one plane but issue in different directions. According to BERTHOLD (1882 p. 614), the ramification is dependent on the light, so that plants growing in unilateral light branch in one plane, while plants illuminated equally from all sides bear branches on all sides. This, however, cannot be the sole determining factor, for in all the specimens examined by me from eight localities in the North Sea and the Skagerak the pinnæ were arranged in 3 or 4 rows, while the specimens from all the localities within Skagen were branched in one plane and at most bore unbranched pinnulæ on the face of the frond at the angle of the branches, or rarely on a few adjacent joints too. Only in specimens from the south side of Skagens Gren and in one specimen from Groves Flak (**Ke**, 26 m) the pinnæ were arranged in 3 or 4 rows. These specimens were all growing in water of comparatively high salinity. In the latter specimen the pinnæ were arranged in 4 rows, those on the flat side were, however, feebler than the others, and in many cases no pinnæ occurred on the flat side.

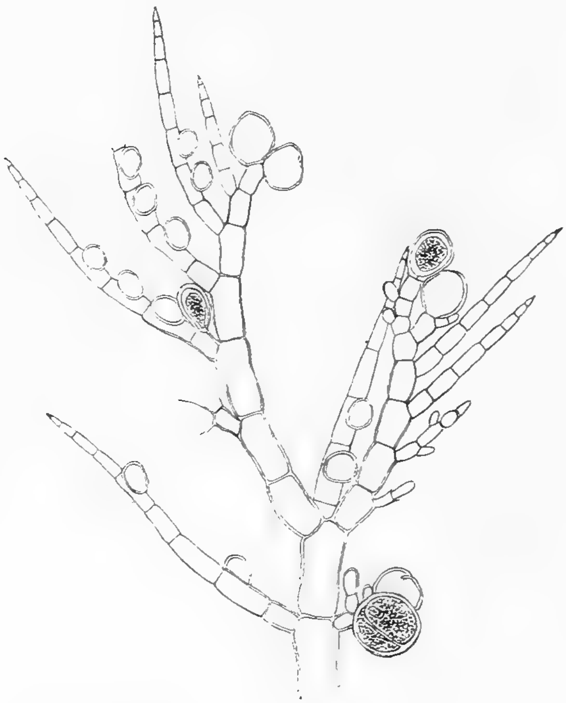


Fig. 300.
Antithamnion Plumula. Tetraspore-bearing shoot with unusually numerous gland cells, from Lille Belt. August. Reduced pinnæ. 380 : 1.

The pinnæ only bear pinnulæ on the upper side, and these may be unbranched or they bear pinnulæ of the second order on their upper side. More rarely the pinnæ are unbranched or very little branched, as in some specimens from Herthas Flak in more than 20 meters depth (fig. 299 *B*), which, however, bore typical branched pinnæ in the lower part of the plants. The pinnæ are at first directed upwards, later usually divaricate, or some of them may even be recurved. Only in specimens from Skagerak off Lønstrup (8 m) a great number of the pinnæ were recurved. The pinnæ and pinnulæ are finally pointed, the ultimate cell ending in a thin point consisting only of the cell-wall. This pointing takes place at the end of the period of growth; in the later part of July and in August acuminate pinnæ may occur, even near the growing point, while in the first part of July specimens without acuminate pinnæ may be met with.

The cells contain one nucleus and numerous ribbon-shaped or irregular chromatophores (Fig. 301 *B*, comp. NESTLER fig. 1). For the nuclei see SCHILLER (1911). The gland cells are borne on the inner (upper) side of the pinnæ, resting on a single cell. Their number is rather variable, owing to unknown causes. They are normally present; in single cases, however, I have sought them in vain. In the Skagerak they were never missing, and they were met with, partly even abundantly, in specimens growing near the southern limit of the species (fig. 300); they further occurred in numbers in slight and in great depths (e. g. Groves Flak, 32 m). The function of the gland cells is unknown. NESTLER is inclined to suppose them to be absorbing organs; SCHUSSNIG supposes that they function in the same manner as air-bladders.

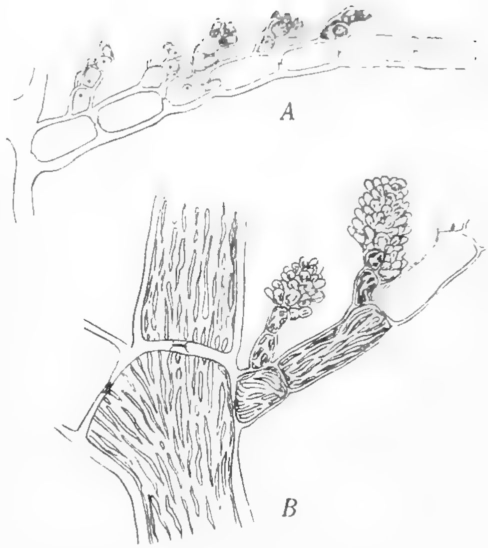


Fig. 301.
Antithamnion Plumula. Antheridial bushes. 390 : 1.

The tetrasporangia are borne on the upper side of the pinnæ usually in small clusters. Often a single sporangium is found terminal on a short stalk-cell, but this cell usually bears further one or two or three younger sporangia or rudiments of sporangia, and the stalk may sometimes consist of two or three cells (figs. 299, 300). Besides the sporangia borne in clusters sessile sporangia may occur too, principally on the outer part of the pinnulæ. Sporangial clusters opposed to a pinna may sometimes be met with; they represent a pinna reduced to a cluster of sporangia (figs. 299, 300). At the end of the period of growth the sporangia may even become terminal on the long shoots, when their growth is ceasing (fig. 300). The ripe sporangia were 42—45,5 μ long, 29—40 μ broad in specimens from the Skagerak; in a specimen from the Little Belt they were only 35—38 μ long, 27—30 μ broad. They open by a slit.

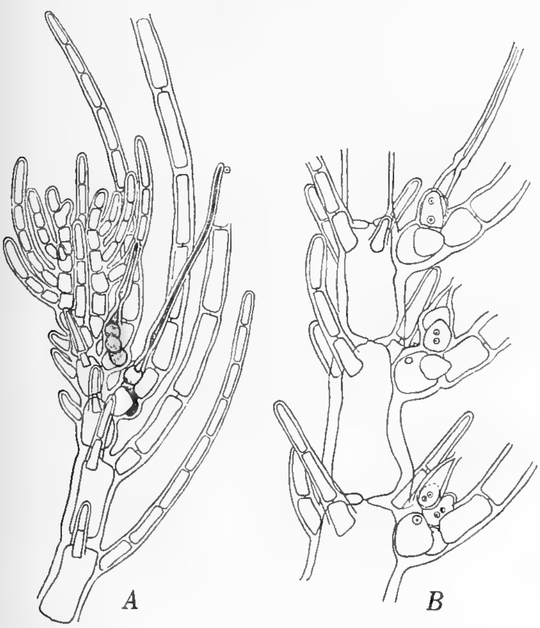


Fig. 302.
Antithamnion Plumula. Procarps. In *A* the carpogonial branches are shaded. *A* 300 : 1. *B* 390 : 1.

The antheridia (fig. 301) have a similar position to the tetrasporangia. They are borne on small bushes, seriate on the upper side of the pinnæ, reminding one of those in *Callithamnion Furcellariæ*, but often a little bigger. These bushes may also occur on the long shoots, taking the place of a pinna. The antheridial clusters may be sessile but are usually provided with a one- or two-celled stalk, their shape is irregularly roundish or more or less lobed, ovate, or more or less elongated with a distinct 4- or 5-celled main axis, and the antheridia may then be most numerous on the acroscopic side.

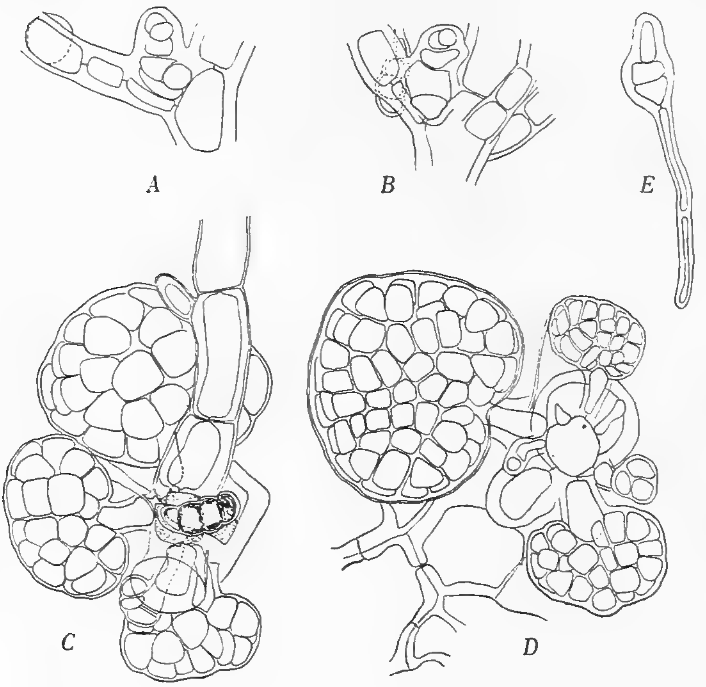


Fig. 303.
Antithamnion Plumula. *A* and *B* young cystocarps showing the first gonimolobe on the upper face of the auxiliary cell; in *B* the carpogonial branch is shown behind the filament. *C*, nearly ripe cystocarp seen from below; the carpogonial branch is still visible. *D*, cystocarp seen from above. *E*, sporeling found on a cystocarp-bearing plant. 350 : 1.

The carpogonial branches are, as described by SCHMITZ and PHILLIPS, and recently by KYLIN, 4-celled and borne laterally on the undermost cell of the pinnulæ and connected with it. The content of the basal cell and of the next cell of the pinnula is different from that of the vegetative cells and resembles that of the cells of the carpogonial filament. The nucleus of the three undermost cells of the carpogonial branch often divide in two before the fertilisation. After fertilisation an auxiliary cell is cut off upwards from the basal cell, and it fuses shortly afterwards with a little sporogenous cell from the fertilised carpogonium (comp. PHILLIPS 1897 fig. 12; KYLIN 1923 fig. 40 h); it then divides, according to KYLIN in a smaller lower and a greater upper cell, the first gonimoblast cell which successively produces the gonimolobes. There are at least four gonimolobes. During this development, according to PHILLIPS (l. c. p. 357), the cells immediately above and below the auxiliary cell become fused with it. The first gonimolobe is given off from the upper side, others downwards in an oblique direction (fig. 303). The particular gonimolobes are borne on an unicellular stalk and are globular or reniform. Their size is very different, the first formed being fully developed while the youngest one only consists of a small number of cells and perhaps never reaches full development. Stalk-cells without fertile cells may occur too. The trichogyne decays quickly while the rest of the carpogonium may be kept for a longer time (fig. 303).

Antheridia, carpogonia and tetrasporangia as a rule occur on distinct individuals; in two cases, however, tetrasporangia were found on cystocarp-bearing plants.

Paraspores in *Anthithamnion Plumula* have been found in the Mediterranean by SCHMITZ and SCHILLER (1913 p. 3, Plate V). Such organs have never been met with in the Danish specimens.

The germination begins, as in *Callithamnion*, by the division of the spore-cell by a transversal wall into two cells, one of which gives rise to the first rhizoid, the other to the primary axis (comp. KILLIAN and KYLIN 1915). Young seedlings were met with on the surface of and in the neighbourhood of the cystocarps (fig. 303).

The species has been met with in several localities in the Danish waters with salinity of 2 p. c. or higher, but it does not occur in the Limfjord or in other fjords. The best developed specimens were found at Skagen, south of Grenen, where it reached a length of over 8 cm, and where it was found as the predominating species in 13 to 15 meters depth in a locality with clayey sand with molluscs. In the Kattegat it otherwise reaches a length of 6 cm, and at Hellebæk in the northern part of the Sound 3 cm; but in the Samsø water and the Little Belt it was only 1,5 cm high at most.

The relation of this species to *A. boreale* will be dealt with under the last named species. Only specimens from one locality in the Little Belt (EE) could be said to approach *A. boreale* by having longer cells in the lower part of the main axis and by the pinnæ bearing, though rarely, pinnulæ on the under side.

The species has been met with in depths of 9 to 32 meters, and furthermore slightly below the surface on vertical granitic walls in the harbour of Frederikshavn. It grows principally on mollusc shells and therefore often occurs on soft bottom, further on the tubes of *Tubularia* and on various Algæ, e. g. *Rhodomela*, *Furcellaria*, *Phyllophora*. It has only been gathered in the months April to October. The tetrasporangia have been met with in July to October, the sexual organs in July and August and ripe cystocarps in July to October; the latter, however, more rarely than the sporangia.

Localities. **Ns:** aF, off Thyborøn, 31 m. — **Sk:** eX, north of Bragerne, 16 m; SY, north of Løkken, 13 m; ZK, off Lønstrup, c. 8 m; YL, XO and other localities off Hirshals, 11—15 m (Børgesen, !). — **Kn:** Skagen, south side of Grenen, c. 5—15 m; FG and XJ, Herthas Flak, c. 20 m; YS², north of Hirsholmene, 15 m; YX, east of Nordostrev, Hirsholm, 23—28 m; on shells of Ostrea, Frederikshavn (Ørsted 1840); off Frederikshavn, east of Marens Rev, c. 20 m (!, Ostenfeld), 11 m (Kramp); harbour of Frederikshavn; TP, Tønneberg Banke, 16 m; near Læsø Trindel, 11—26 m; 3 miles W. of Læsø Trindel light-ship 15 m. — **Ke:** FC, east of Læsø, 17 m; fH and fI, 1 and 3 miles W. by N. of Fladen light-ship, 17 and 30 m; ZH, ZI, Groves Flak, 32 and 26 m, soft bottom; EQ, east of Anholt; 14½ miles S.S.E. of Anholt Knob light-ship, 10 m (C. A. J.). — **Sa:** MS, west of Endelave, 15 m. — **Lb:** North side of Fænø; EE, west of Fænø, 15 m; Fænø Sund, 10—15 m. — **Su:** Hellebæk (Schmidt 1873).

3. **Antithamnion boreale** (Gobi) Kjellman.

Kjellman, Norra Ish. algfl. 1883 p. 226, Pl. 16 figs. 2—3 (Alg. Artc. Sea p. 180); Reinke, Algenfl. westl. Ostsee 1889, p. 23 (f. baltica), Atlas deutsch. Meeresalg. I 1889 Taf. 22; Kylin 1907, p. 173.
Antithamnion Plumula var. *boreale* Gobi, Algenfl. des weissen Meeres. St. Pétersbourg 1878, p. 47.

While in a former paper (Grønlands Havalger, 1893, p. 787; Ann. sc. nat. 7^{e} sér. t. 19, 1894, p. 64) I have regarded this species as a variety of *A. Plumula*, in accordance with Gobi, my later investigations of the Danish specimens have led me to agree with Kjellman's view that it must be considered as a distinct species. According to Kjellman and other authors it differs from *A. Plumula* by being more slender, by longer cells in the long shoots, by the pinnæ in great part bearing pinnulæ on two sides and then opposed or alternate, while the pinnæ of *A. Plumula* bear only pinnulæ on the upper side, and by the sporangia being always sessile. Kylin adds the character that *A. boreale* is sporangia-bearing early in June while in *A. Plumula* the sporangia appear only in July. I can confirm these statements and add a little more.

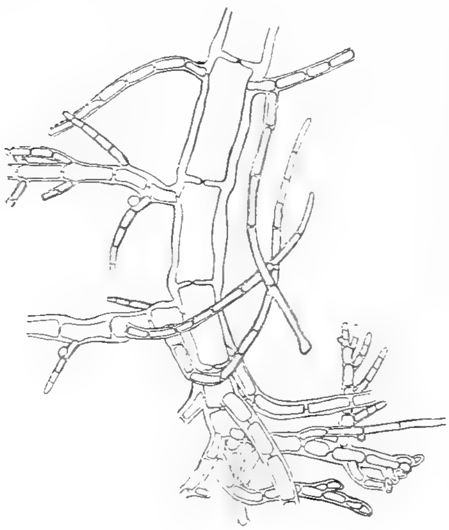


Fig. 304.
Antithamnion boreale. Lower part of plant. 100 : 1.

The base of the plant resembles that of *A. Plumula*, as shown in fig. 304 where free descending filaments are given off from the cells of the main axis and the proximal part of the pinnæ. Fig. 305 shows the lower part of a plant gathered in April. The lowermost part which is short-celled and had a darker colour had undoubtedly been formed in the foregoing year while the upper, brighter and more long-celled part of the shoot had grown out in spring. The first pinnæ are unbranched and the next following ones bear only one or two pinnulæ on the upper side.

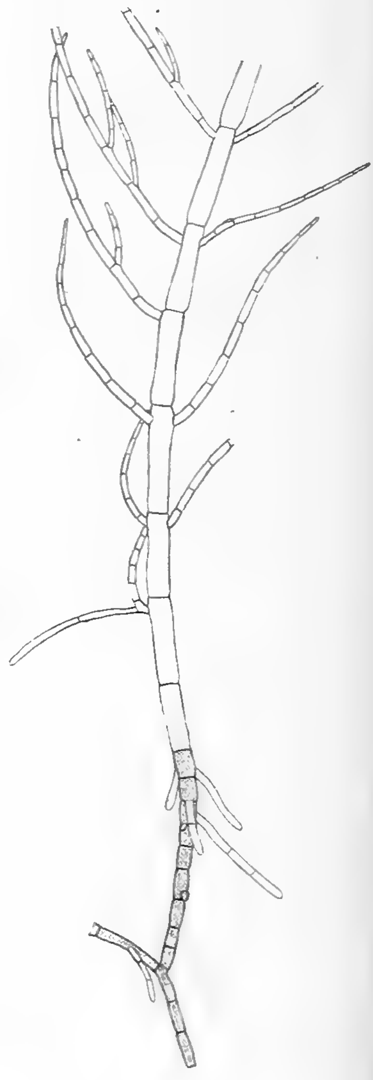


Fig. 305.
Antithamnion boreale. Specimens gathered in April. The lowermost part (shaded) is a survival from the foregoing year. 95 : 1.

The shoots usually bear two rows of pinnæ; however, a certain number of joints occur which bear only one pinna. On the other hand, joints which bear three pinnæ may also occur, though rarely. The pinnæ

Fig. 306.
Antithamnion boreale. Tetraspore- and antheridia-bearing specimen from the Baltic Sea (UL), May. 70 : 1.

bear not only pinnulæ along their upper face but also on the under face or on the flanks; in the first case the pinnulæ are very often opposite. The pinnæ are more slender and often longer than in *A. Plumula*. Gland-cells (fig. 307) similar to those of *A. Plumula* may be present or wanting. They were present in all the examined specimens from the eastern Kattegat and further in some of the specimens from the Samsø waters, though in some cases only in small number, while they were wanting in other specimens, and they were also wanting in all the examined specimens from the Øresund and from the Baltic Sea. The latter specimens can be referred to f. *baltica* Reinke (l. c.) which is chiefly distinct by this character. The specimen represented by Kuckuck in Atlas deutsch. Meeresalg. Taf. 22 has in great part unbranched pinnulæ, which occurs more rarely in the specimens from the Danish waters.

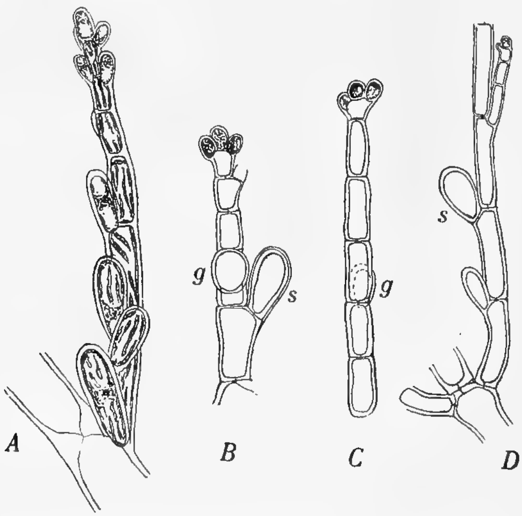


Fig. 307.
Antithamnion boreale. Pinnulæ bearing antheridia at the top, and sporangia, *s*. *g* gland cells. In *A* the chromatophores are shown. *A—C* 390 : 1. *D* 230 : 1.

The tetrasporangia are sessile on the upper face of the pinnulæ or on their flanks, usually singly on the joints but sometimes in pairs and the second being inserted at a lower level but at the same time beside the first. The sporangia are bigger than in *A. Plumula*, usually 60—85 μ long, 35—50 μ broad. In the specimens from Fænø Sund, however, I found them a little smaller, only 46—49 μ long, 35 μ broad, thus almost of the same size as those in *A. Plumula*.

In some specimens from the Little Belt and the Baltic Sea antheridia were met with. They were borne on the upper end of short pinnulæ which in several cases bore sporangia too (figs. 306, 307). These pinnulæ usually consist of 3—6 cells the uppermost one or two of which bear a small number of closely placed nearly globular antheridia. The pinnula may sometimes bear a small branch which likewise bears antheridia at its top (fig. 306 above), but antheridial clusters like those in *A. Plumula* never occur.

Female sexual organs and cystocarps have never been observed in this species.

The presence of antheridia-bearing pinnulæ in tetraspore-bearing specimens and the different shape of these branchlets corroborate the view that *A. boreale* is specifically distinct from *A. Plumula*. As stated by previous authors, *A. boreale* is nearly related to *A. americanum* (*Callithamnion americanum* Harvey, Nereis bor. amer. II, 1853 p. 238 pl. 36 A). In a specimen of this communicated in Phykotheka univers. No. 501 I found gland-cells and sporangia 56—60 μ long, 35—37 μ broad.

A. boreale occurs in the Danish waters almost exclusively south of Anholt, in 7 to 40 meters depths, most frequently in 13 to 30 meters depths. The innermost localities known are Davids Banke north of Bornholm and a place east of Bornholm where only very small specimens were met with which were much reduced, many of the joints bearing only one branchlet. The specimens from the Kattegat were up to 5 cm high while those from the southern waters reached only a length of 2,5 cm. It usually grows on other Algæ e. g. *Delesseria sinuosa*, *Furcellaria fastigiata* and *Corallina offinalis* and on Hydroids. It has been met with in the months April to August and bore sporangia in the same months. Antheridia were met with in May and June. — In the western part of the Baltic Sea it has been found by REINKE in four localities, at the west coast of Sweden it has not been found north of Laholms Bugt (KYLIN).

Localities. **Kn:** Harbour of Frederikshavn. — **Ke:** ER, Fyrbanken, east of Anholt, 28 meters. — **Ks:** EO, north of Lysegrund, 26 m. — **Sa:** PJ, Ebeltoft Vig, 13 m; PL, Wulffs Flak; DK, Bolsaxen, 14 m. — **Lb:** Fænø Sund, 15 m; dQ, bank south of Lyø, 22 m; dH^1, east of Hesteskoen, 18—19 m. — **Sb:** DL, south of Refsnæs, 7 m; cN, south-west of Musholm, 18 m; cL, north-east of Sprogø, 25—27 m; Z, off Skagbo Huse, 19 m; UH and UT, Langelandsbelt, 19—22 m; US, Langelandsbelt, c. 40 m; US^1, near the former, 20 m. — **Su:** Off Aalsgaarde, shelly bottom (Boye Petersen); north of Lappegrund, 19—26 m (Henn. Petersen); bM, south of Hveen, 23 m. — **Bw:** Trindelen, west side of Kegnæs, Als; UL, Øjet, 20 m. — **Bb:** SN, Davids Banke, 15—17 m; 3 miles S.S.E. of Nexø, 21 m (C. A. J.).

MAGNUS (Bot. Erg. Nordseefahrt p. 67) has reported *Callithamnion Plumula* Lyngb. from "N.W. von Roesnäs 28 Faden" and "N.W. von Fænö 16—10 Faden". Without examining the specimens in question it is impossible to decide whether they must be referred to *A. Plumula* or *A. boreale*.

Ceramium (Roth) Lyngbye.

In 1908 Dr. HENNING PETERSEN published a monograph on the Danish species of the genus *Ceramium*, based principally on the material contained in my collections, and in a later paper (1911) he has again mentioned some of the species. Since the publication of these papers I have made further collections of *Ceramia* in the Danish waters, and Dr. PETERSEN has then readily complied with my request to examine these new collections together with his own later gatherings, and he has at the same time made a revision of his earlier determinations. These investigations have in several cases led Dr. PETERSEN to another limitation of the species, and as the new collections have brought species to light which were formerly not known from the Danish coasts, the number of Danish species has been increased from 10 to 18. Dr. PETERSEN has communicated to me descriptions and remarks on several of the species, which are given below, partly with Dr. PETERSEN's own words. further some drawings and a new key to the species, while I contribute the account of the occurrence and fructification of the species and give some drawings and a few general remarks on the morphology.

The vegetative morphology and development has been treated by CRAMER (1863).

The germination has been repeatedly studied by various authors, (comp. KYLIN 1917, where further literature is quoted). I have examined the germination of the tetraspores of *C. rubrum* and of the paraspores of *C. strictum* which take place in essentially the same manner, but I have nothing to add to the earlier descriptions.

In more developed plantlets several multicellular rhizoids are developed from the corticating bands near the base of the plant, giving rise to adhesive discs (holdfasts) at their tip. In fig, 308 is represented a long rhizoid showing narrow cortical bands at the nodes like the upright fronds.

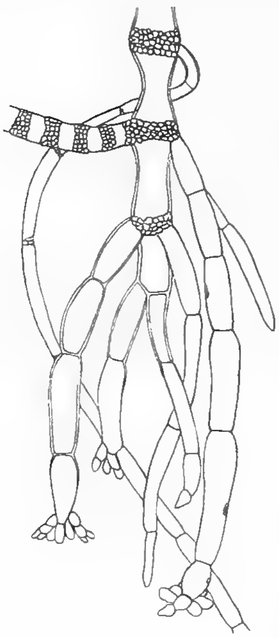


Fig. 308.
Ceramium diaphanum. Base of plant with downward growing branches producing finally terminal hapters. 48 : 1.

The hyaline hairs have been mentioned by HENN. PETERSEN (1908) and by me (1911). They have been met with in almost all the species and may perhaps occur in all of them. However, in one species they have not been observed, namely in *C. cimbricum*, which has only been found in the Limfjord in rather deep water of slight transparency. These hairs may be very numerous and vigorous (K. R. 1911, fig. 3) and remain alive long; in other cases they reach only an inconsiderable size and decay early (fig. 314). They appear early in the plantlets a few days after the beginning of the germination. According to PETERSEN the hairs are wanting in winter.

Gland cells occur in *C. tenuissimum* and *C. Areschougii*, as shown by PETERSEN (1908 and 1911).

The antheridia were briefly described and pictured by BUFFHAM (1884 p. 342 pl. XII figs. 2—5, 1888 p. 260, pl. XX fig. 4), and HENN. PETERSEN described their development (1908 p. 50); they were recorded in several Danish species, as a rule in particular male plants, in *C. fruticulosum* in the same plants as the carpogonia.

The development of the cystocarps was described by JANCZEWSKI (1876), PHILLIPS (1897) and KYLIN (1923). In the species examined by the two first-named authors two carpogonial branches were found, one on each side of the auxiliary mother-cell, while KYLIN found only one in *C. rubrum*. In *C. fruticulosum* I found two (fig. 309). In the same species I found numerous spermatia loosely adhering to sterile hairs in the neighbourhood of the procarps (fig. 309 *B*).

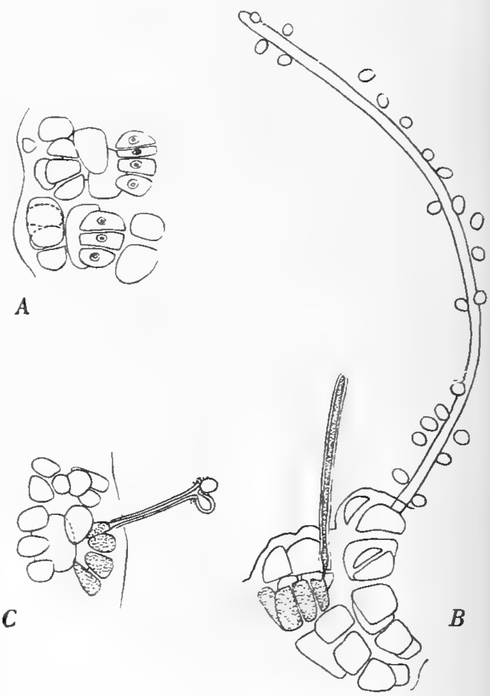


Fig. 309.
Ceramium fruticulosum. *A*, young carpogonial branches, partly still tricellular. *B*, carpogonial branch with still infertilised trichogyne; numerous spermatia adhere loosely by a sterile hair. *C*, fertilised carpogonium. *A*, *B* 625 : 1. *C* 390 : 1.

The division of the tetrasporangia in the genus *Ceramium* is said in the systematical works (Kützing, J. Agardh, Hauck) to be tetrahedral (triangular) and most of the pictures of Kützing and Harvey are in accordance with this statement. In Kützing's figure of *C. rubrum* (Tab. phyc. XIII pl. 4), however, the oblong sporangia are shown divided by a transversal and a vertical wall. Henn. Petersen does not mention the mode of division, but his picture of *C. strictum* (1908 fig. IV, 1) shows very clearly a similar rectangular division, while the mode of division is not quite clear in his fig. III, 2 of *C. tenuissimum*. Collins and Hervey[1] describe a new species *C. cruciatum* in 1917, the sporangia of which are "cruciate, sometimes regularly, sometimes decussately". And recently Mrs. Weber-van Bosse[2] describes another new species *C. cingulatum* with a similar division of the sporangia. As I have myself found sporangia with rectangular division in *C. vertebrale* (figs. 310, 322), *C. septentrionale* a. o. species but on the other hand have also ascertained the occurrence of tetrahedral division in Danish species (e. gr. *C. tenuissi-*

Fig. 310.
Ceramium vertebrale. An isolated tetrasporangium seen from three sides. 230 : 1.

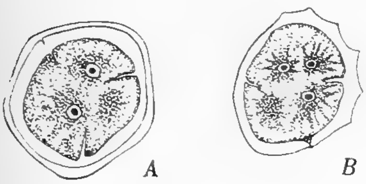


Fig. 311.
Ceramium diaphanum. Tetraspore mother-cells, dividing. Only two, resp. three nuclei were present in the sections. In *A* tetrahedrical division. 390 : 1.

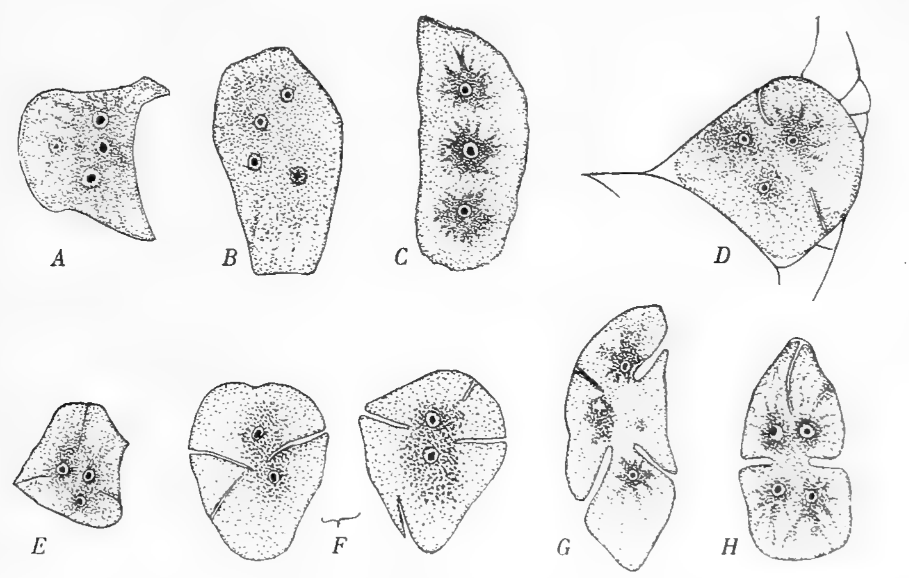


Fig. 312.
Ceramium rubrum. Tetrasporangia in division. *A—C* after the division of the nuclei but before the division of the cell. *F* two sections of the same sporangium. 340 : 1.

[1] The Algae of Bermuda. Proceed. Amer. Acad. Vol. LIII No. 1. Cambridge 1917, p. 144.
[2] Liste des Algues du Siboga. III Rhodophyceae. 2e partie. Leiden 1923, p. 332.

mum, fig. 314) I judged it convenient to examine the division process itself in imbedded proofs of *C. diaphanum* and *C. rubrum*, and in both species tetrahedral and rectangular division was ascertained in different sporangia of the same plant. In every case the division of the nuclei was accomplished before the division began (fig. 312 *A*—*C*). The division of the cell takes place by walls growing gradually from the periphery towards the centre of the cell, but the orientation of the walls is variable. In figs. 311 *A* and 312 *E* are represented typical tetrahedral divisions. In other cases a transversal wall is first formed as an annular list while two other walls, perpendicular to the first are formed a little later but before the first wall is finished (figs. 311 *B*, 312 *D*, *F*, *H*). The division seems thus in all cases to be a division in four of one cell and not a bipartition of the spore-mothercell into two cells which afterwards divide into two.

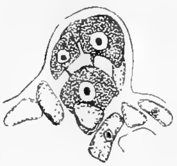


Fig. 313. *Ceramium diaphanum.* Young heap of paraspores. 390 : 1.

Paraspores occur in *C. diaphanum*, *C. strictum* (comp. Henn. Petersen 1908 pp. 51, 85) and *C. Deslongchampsii*, and I have found a couple of sori of paraspores in a specimen of *C. vertebrale* which bore at the same time tetrasporangia (fig. 323). These paraspores were remarkable by peculiar pseudopodia from the protoplast to the membrane. The paraspores, as shown by Henn. Petersen, develop from a superficial cortical cell (fig. 313), often from a marginal cell of a cortical band. They never occur in the sexual plants but often in tetrasporiferous plants.

Henn. Petersen states briefly that he has met with a sort of monospores in *C. diaphanum* (1908 p. 14).[1]

Key to the Danish species of Ceramium.

(By Henning E. Petersen).

1. Cortication only at the nodes; distinct cortical bands.
   2. Gland cells present, outer edge of apex dentate .... 1. *C. tenuissimum.*
   2*. Gland cells wanting, outer edge of apex usually even.
      3. Cortical bands usually over 100 μ high, lower border-cells irregularly shaped; frond not creeping.
         4. Apices always curved inward.
            5. Cells in the lower edge of the lower bands usually not over 13 μ in transversal diameter; cortication often much developed, bands sometimes upward growing............. 2. *C. diaphanum.*
            5*. The named cells usually 17—20 μ in transversal diameter .... 3. *C. strictum.*
         4*. Apices always straight.
            5. Bands of about equal height and breadth .... 5. *C. Deslongchampsii.*
            5*. Bands usually broader than high; often up to 30—40 axial cells between the bifurcations; only in the inner waters ... 6. *C. vertebrale.*

[1] Dr. Petersen refers to Gobi's fig. 8 in Die Rothtange des Finn. Meerbusens. Mém. Acad. St. Pétersb. XXV No. 7, 1877; but the bodies alluded to in this figure according to the author represent tetrasporangia ("Tetrasporen") the division of which is not shown.

3*. Bands very narrow, usually c. 50 μ, rarely over 100 μ high, consisting of 1—3 (usually 2) transversal rows of cells; cells in the lower edge of the bands often with parallel upper and lower sides; frond sometimes creeping .... 4. *C. cimbricum.*

1*. Cortication partly or entirely continuous.
2. Cortication with distinct bands in the upper part or in a greater part of the frond.
3. The outer cortical cells very small, 7—10 μ in diameter, usually longitudinally elongated .... 12. *C. Boergesenii.*
3*. Not so.
4. Bands with sharply limited lower border occur; bands at least thrice higher than the diameter.
5. Ramification biseriate alternate or dichotomous; in the latter case the apices are incurved .... 16. *C. fruticulosum.*
5*. Branches not biseriate, apices straight, at least in older specimens.
6. Bands often over 2 mm high, usually distinct below, though often approaching each other .... 17. *C. septentrionale.*
6*. Bands not 10 high. Cortication usually continuous below; apices thin .... 15. *C. Areschougii.*
4*. Bands with sharply limited lower border do not occur; bands not so high, increasing downwards in various degree.
5. Cells of the bands, in particular of the upper ones, are arranged in distinct longitudinal rows; distinct bands only in the upper parts of the frond .... 13. *C. scandinavicum.*
5*. Cells not in distinct longitudinal rows; distinct bands in the upper parts or in greater parts of the frond.
6. Bands slightly increasing downwards, cells in the lower border often broad .... 14. *C. abyssale.*
6*. Bands much increasing downwards; altogether slight difference between upper and lower border of the band.
7. Cortication usually continuous over more than two thirds of the length.
8. Apices very thin, often capillary, much branched.
9. Main axes much developed, with secondary branches .... 9. *C. arborescens.*
9*. Ramification usually pronouncedly dichotomous, secondary branches not much developed. 8. *C. rubriforme.*
8*. Apices vigorous, slightly branched near the top.
9. Colour dark, often much developed main stems and secondary branches; cortication continuous over the greater part of the frond 11. *C. atlanticum.*
9*. Colour light; vigorous main stems without secondary branches .... 10. *C. Rosenvingii.*
7*. Bands distinct in the upper third of the frond; light colour .... 7. *C. danicum.*

2*. Cortication continuous over the whole frond .... 18. *C. rubrum.*

1. **Ceramium tenuissimum** (Lyngb.) J. Agardh.

J. Agardh, 1851, p. 120; Henn. Petersen 1908, pp. 54, 49 pl. I Fig. 1, 190, p. 97; idem 1911, p. 97.
C. diaphanum var. *tenuissima* Lyngbye Tent. p. 120.

As shown by Henn. Petersen, the species is easily distinguished by the denticulate outline of the young incurved branches, by the presence of gland cells and by the extruding tetrasporangia usually single in the cortical zones. It reaches a length of 8—10 cm; in the Little Belt and the South Fyn Waters, however, specimens higher than 3 cm were not met with. It occurs in all seasons; in winter, however, it is only 1—2 cm high. It is spread in all the Danish waters from the Skagerak to the south Fyn waters, but has not been met with in the Great Belt, the Sound and the Baltic Sea; it thrives well in the fjords (Limfjord, Isefjord, Odensefjord). It occurs from a little under low-water mark downwards; in the eastern Kattegat it has been met with in 22,5 m depth. It has been found with tetrasporangia in July and August, with cystocarps in July and September. Antheridia were met with in July 1923; they covered the surfaces of the joints in longer stretches of the frond. Epiphytic on various Algæ and on Zostera.

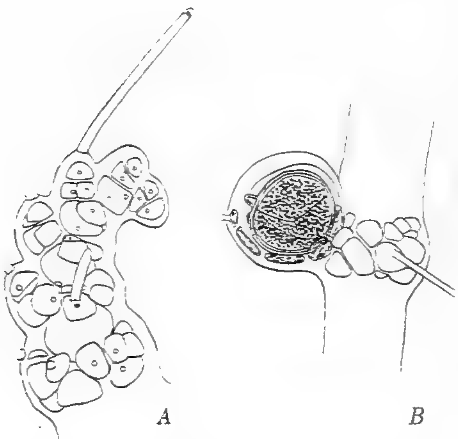


Fig. 314.
Ceramium tenuissimum. A, upper end of filament with hairs, partly decayed. *B*, band with tetrasporangium. *A* 390 : 1. *B* 230 : 1.

Localities. **Sk:** YN², E. of Bragerne; SY, N. of Løkken, 13 m; XO off Hirshals; Hirshals mole (Børgesen) and near land. — **Lf:** Nissum Bredning; ZS, ZY; Thisted Bredning: MH; Sallingsund: Nykøbing; Løgstør Bredning: LS, 7 m, bT; off Feggeklit, 4 m. — **Kn:** Off Hulsig, 8 m (B. Petersen); N.E. of Hirsholm (Ostenfeld); TP, Tønneberg Banke, 16 m; Brune Rev by Frederikshavn (H. E. P.); ZP, UC, N. of Nordre Rønner. — **Ke:** Fladen: ZG, ZF, VY, 18—22,5 m; Gilleleje (Lyngbye). — **Km:** Læsø Rende: Dana St. 2919 (C. A. J.); BO off Stensnæs; ZC¹ within Kobbergrund; VL south of Tangen; BH off Gjerrild Klint. — **Ks:** Isefjord: EH off Lynæs, near Rørvig (Joh. Lange), Lammefjord. — **Sa:** Reef by Kalø; BB, Søby Rev; Korshavn, reef; Odensefjord, Hofmansgave (Lyngbye, C. Rosenberg). — **Lb:** Helnæs Hoved Flak; CC, Hornenæs. — **Sf:** Shoals off Nakkebølle Fjord.

2. **Ceramium diaphanum** Harv. et J. Agardh.

Henn. Petersen 1908 pp. 56, 87 figs. I,1, II and IV,1, 4, pl. I figs. 2—5, pl. II figs. 3—4, 1911 p. 98, fig. I,1, 4, pl. I fig. 2.

This species is common in the inner Danish waters where it usually grows near the low-water mark on piers in harbours and in stony reefs in about one meter's depth, more rarely descending to 4—5 meters depth or even to 13 m. It grows on stones and wood, *Chorda Filum*, *Zostera*, *Fucus vesiculosus* a. o. Algæ. It reaches a length of 8 cm. It has been met with from April to November but is most developed in the summer months. The most frequent fructifications are tetraspores and paraspores, often occurring in one individual. Tetraspores have been met with in May to Sept., paraspores in July to Sept., antheridia and cystocarps each once in September.

Dr. PETERSEN has in 1908 distinguished 5 forms to which he has now added the f. *umbellifera* here described.

1. F. *typica.*
2. F. *strictoides,*
   subf. *α,*
   subf. *β, corticatula* Kylin (Cer. corticatum Kylin 1907 p. 176).
3. F. *modificata.*
4. F. *radiculosa.*
5. F. *zostericola.*

6. F. *umbellifera* H. Prtsn. n. f. — Much branched towards the apex, with short internodes and somewhat divaricate branches. Form from protected water, analogous to *C. rubrum* f. *radians* and *C. strictum* f. *stricto-tenuissima*. Related to f. *strictoides*. (Henn. Petersen).

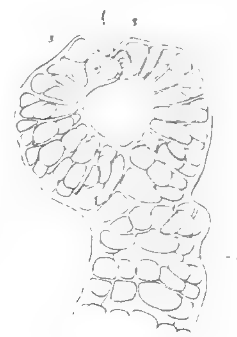


Fig. 315.
Ceramium diaphanum. Young pseudodichotomy. In both branches the last segment is on the point of branching. *t*, apical cell; *s*, new branches, *c*, central cell. 390 : 1.

Localities. *F. typica.* **Ks:** Harbours of Anholt and Lynæs. — **Sa:** Harbours of Koldby Kaas and Horsens. — **Lb:** Harbour of Rosenvold. — **Sf:** Svendborg. — **Sa:** Hofmansgave (Hofm. Bg.). — **Sf:** Svendborg. — **Su:** Harbour of Sletten. — **Bw:** Harbour of Gedser. — **Bm:** Rødvig; Faxe Ladeplads.

F. *strictoides.* **Ks:** 3 localities in Isefjord. — **Sa:** Hofmansgave (Hofm. Bg.). — **Sf:** UV, 13 m. — **Sb:** 3 loc.; Nakskov Fjord (Th. Mortensen). — **Sm:** Venegrund. — **Su:** 5 loc.; harb. of Helsingør; Kalvebod Strand (M. L. Mortensen). — **Bm:** 1 loc.

F. *modificata.* **Ke:** Gilleleje (Lyngbye). — **Ks:** Harbour of Grenaa; near Rørvig. — **Sa:** 4 local. — **Lb:** 3 loc. — **Sf:** Svendborg Sund (E. Rostrup). — **Sb:** 4 loc. — **Sm:** 6 loc. — **Su:** 6 loc. — **Bw:** Near Sønderborg. — **Bm:** Stevns, Rødvig, harbour of Hesnæs. — **Bb:** 6 loc. around Bornholm, Christiansø, That.

F. *radiculosa.* **Bb:** Allinge, Gudhjem, Christiansø.

F. *zostericola.* **Lf:** LR, E. of Livø. — **Sb:** GY, 5,5 m. — **Sm:** HI; Stubbekøbing; Guldborgsund. — **Su:** Knollen.

F. *umbellifera.* **Ke:** Gilleleje, E. of the harbour. — **Su**; Bay of Hornbæk.

3. **Ceramium strictum** Greville et Harvey.

Harvey, Phyc. Brit. III Plate 334. Henn. Petersen 1908 pp. 61, 89, Figs. IV,2, 3. Tab. I Figs. 6, 7, Tab. II Fig. 1; idem 1911, p. 98, Fig. I,2, 3.

With regard to the relation of *Ceramium strictum* to *C. diaphanum* reference may be made to the quoted papers by Dr. PETERSEN. *C. strictum* in the Danish waters reaches a length of 10 cm. Paraspores are the most frequent organs of reproduction; they were met with in almost all the waters where the species occurs, in May to September. The tetrasporangia are much less common (once in **Sm** and some places in **Bb**, July and September); they occur partly in paraspore-bearing specimens, Sexual reproduction seems to take place much more rarely than the asexual. Antheridia have been met with only in a few places (**Su**, **Bw** and **Bb**, July, August); they covered completely globular joints. Cystocarps have only been observed in one place (**Bb**, August); they were subtended by up to six involucral ramuli. A specimen collected by dr. O. Paulsen in Kriegers Flak (**Bm**) in 15 meters depth, showed witches' broom-like bushes of dark-red, much branched, short straight branches with short articles and with monopodial, lateral branching. The species has only been met with in April to October.

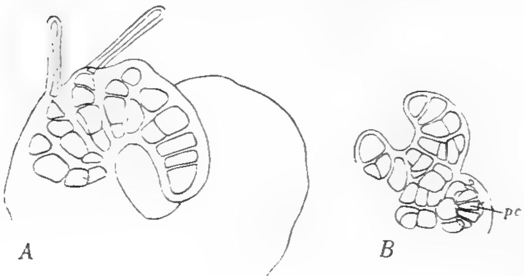


Fig. 316.
Ceramium strictum, from Bornholm. *A*, upper end of shoot with hairs. *B*, upper end of shoot of female plant. *pc* procarpial branch. 390 : 1.

Ceramium strictum occurs in all the Danish waters within Skagen, most frequently in the inner waters, from low-water mark to c. 10 meters depth, more rarely deeper; it has been met with in the greatest depth at Bornholm (29 m).

Dr. Petersen distinguishes forma *vera* and f. *stricto-tenuissima*, characterised by more divaricate branches and more elegant habit.

F. *vera* H. Ptrsn.

Localities. **Lf:** 5 localities. Oddesund, S. side of Jegindø Tap. — **Kn:** FF, Læsø Trindel, 15 m (?). — **Ke:** East end of Anholt; IC, Store Middelgrund, 10,5 m; about same place (Dana St. 2925 C. A. J.); Gilleleje, 1—5 m. — **Ks:** EH, West of Lynæs; GG, Sjællands Rev. — **Sa:** GE near Sejerø; PG, west of Hatter Rev; Begtrup Vig, stony reef. — **Lb:** Off Ivernæs; Aarøsund; DB, Lillegrund. — **Sf:** CU; CV. — **Sb:** LK, Elefantgrund; Kerteminde; Nyborg; UF, N. of Langeland; Snøde Rev; Smørstakken; Nakskov Fjord (Th. Mortensen). — **Sm:** CL, Raagø Sund (+); CO; Holsteinborg Nor; Karebæk Fjord (Warming); Petersværft; Grønsund, 4 m. — **Su:** Off Aalsgaarde (♂, Aug.) (H. E. P.); N. of Julebækshusene; the point at Hvidøre; Copenhagen; SA, SB, Flinterenden. — **Bw:** bV, N.E. of Kobbel Skov; bZ and dO, S. of Als; DU, off Dimes Odde; KY, Femerbelt, 12,5 m; KZ, off Kramnisse; Gedser Rev, 8,5 m, (♂, July). — **Bm:** KS, E. of Falster; VH, S. of Møen; Præstø Fjord; Faxe Ladeplads; off Mandehoved, Stevns; QF, S. of Saltholm; QH, Falsterbo Rev; bP, Kriegers Flak (O. Paulsen). — **Bb:** N.W. of Sandvig on rock; Allinge (♂ ◯); Davids Banke, 15—29 m; YF, within Arnager Rev; YE, off Øleaa; near Salthammer Rev (+, p).

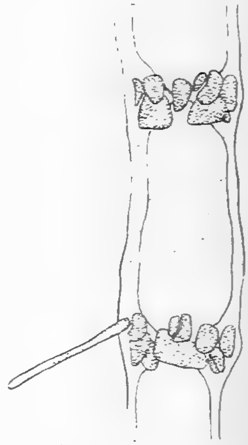


Fig. 317.
Ceramium strictum, from Bornholm. The dotted part of the wall of the internodial cell was more deeply stained by hæmatoxylin than the lowermost part; the latter was probably younger. 230 : 1.

F. *stricto-tenuissima* H. Ptrsn.

New localities. **Sa:** Hofmansgave (Hofm. Bang). — **Sb:** DN, Vengeance Grund, 12 m.

4. **Ceramium cimbricum** Henn. Petersen n. sp.

C. interdum repens, subdichotome ramosum, apicibus rectis, longis, sæpe inæqualibus; zonis semper distantibus, marginibus non crescentibus, e cellulis paucis

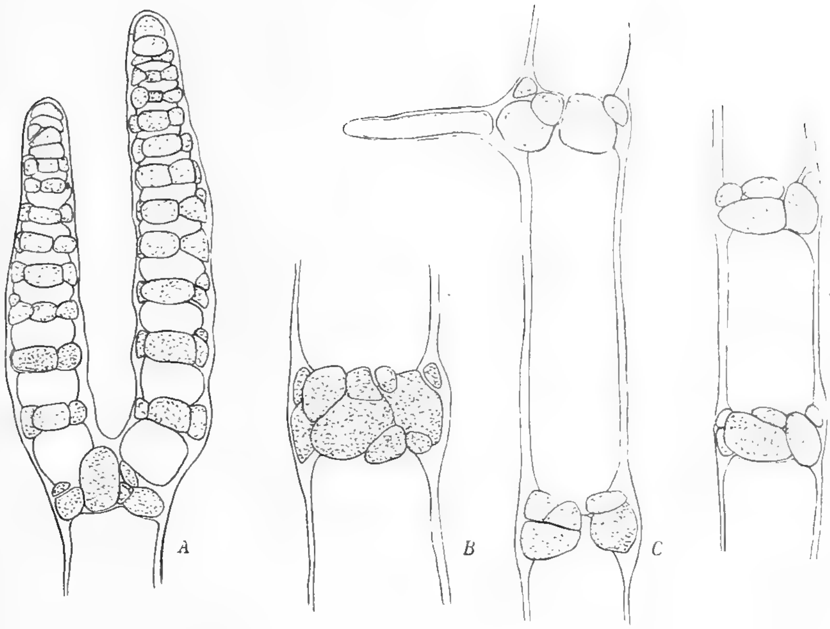


Fig. 318.
Ceramium cimbricum. *A*, young pseudodichotomy. *B—D*, adult cortical bands. Henn. E. Petersen del. 330 : 1.

compositis, plerumque 2—3 cellulis altis, maximis 60 μ altis, 100 μ latis, aliis 1—2 cellulis altis, c. 25 μ altis, 50 μ latis, cellulis inferioribus sæpe usque ad 32 μ latis; internodiis maximis zonis 5—7-plo longioribus. — Color rubro-violaceus. — Pili, tetrasporangia et organa sexualia non observata (figs. 318, 319).

Habitat in Limfjorden.

Affine *C. stricto* sed differt zonis angustissimis et ramificatione. Apices juveniles sæpe curvatura characteristica supra nodos instructi sunt (fig. 318 *A*). (Henn. Petersen).

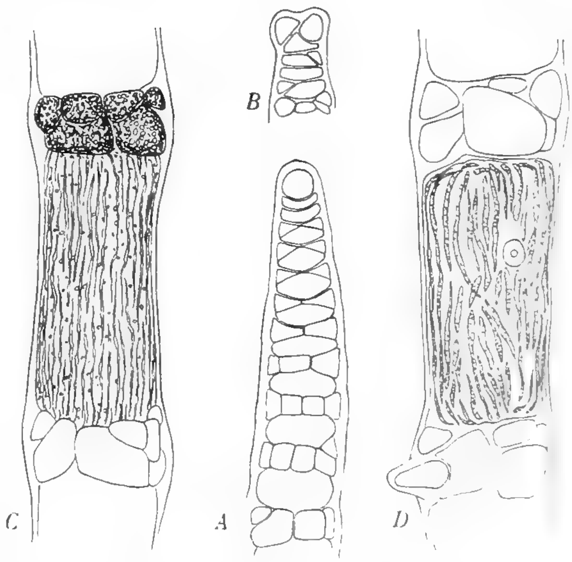


Fig. 319.
Ceramium cimbricum. *A*, end of shoot. *B*, branching. *C*, *D*, bands and internodial cells. 345 : 1.

This small *Ceramium*, which has only been met with in two localities in the Limfjord, was first referred to *C. strictum*. However, as it differs by the habit, the branches of the pseudodichotomies being often of unequal size, and by the very narrow cortical bands, Dr. Petersen has distinguished it later as a distinct species and given me the diagnosis above. *C. cimbricum* is found growing on *Laomedea* and on various algæ, partly creeping with rhizoids, reaching a length of 1—3 cm. It has only been found sterile.

Localities. **Lf:** near Jegindø Tap, 5,5 m; IT, West of Ejerslev Røn, 7 m.

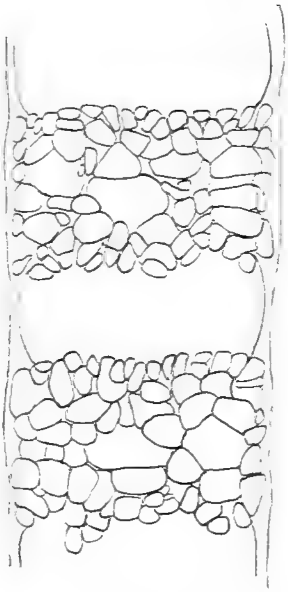


Fig. 320.
Ceramium Deslongchampsii. Part of frond with two bands. Henn. Petersen det. 270 : 1.

5. **Ceramium Deslongchampsii** Chauvin.

J. Agardh, 1851 p. 122; Henn. Petersen 1908 p. 83 (89).

This species which is principally characterized by the cortical bands being of almost equal height and breadth, and by the straight ends of the branches, has only been recorded with certainty from one locality, viz. the harbour of Frederikshavn, where it occurs constantly at the ends of the northern outer mole and of the northern transverse mole. It grows at low-water mark and reaches a length of 4 cm. All the specimens collected were sterile till July 1923 when specimens up to 6 cm high were met with, partly with tetrasporangia or paraspores. The sporangia were verticillate, the fertile joints much swollen. The heaps of paraspores are solitary or several on the same joint (fig. 321, comp. Harvey Phyc. Brit. pl. 219).

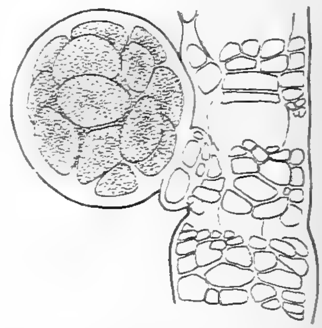


Fig. 321.
Ceramium Deslongchampsii. Heap of paraspores. 200 : 1.

Localities. **Lf:** Nykøbing Mors (Børgesen), referred with doubt to this species. — **Kn:** Harbour of Frederikshavn (April—August).

Fig. 322.
Ceramium vertebrale. Part of frond with tetrasporangia. 230 : 1.

6. **Ceramium vertebrale** Henn. Petersen.

Henning Petersen, 1908 p. 63, 90 Fig. V, Tab. II Fig. 2.

As shown by Dr. Petersen, this species is on the one hand related to *C. diaphanum* and *C. strictum*, on the other hand to *C. Deslongchampsii*. It is distinguished in particular by the last branches becoming straight, by the great number of articles in the internodes and by the thick cell-membranes. It reaches a length of 4 to 6 cm.

Dr. Petersen did not find hairs in this species. I observed these organs in specimens gathered in August; the rare occurrence of hairs probably depends on the fact that the species has only been recorded in July and August. Tetrasporangia were observed in specimens collected in August at Bornholm;

I found them cruciately divided (or better perpendicularly divided). The tetrasporangiferous bands which contain one or a small number of sporangia are considerably swollen (figs. 322). In a tetrasporangiferous specimen a few sori of paraspores were observed, developed from superficial cortical cells (fig. 323). *C. vertebrale* occurs in 5,5 to 15 meters' depth. It has only been recorded from localities around Bornholm and from one locality at the boundary between the Sound and the Baltic Sea.

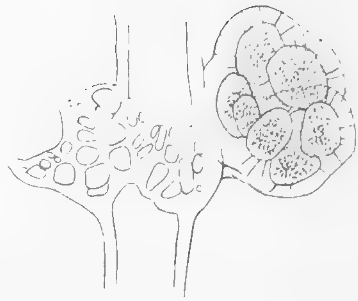


Fig. 323.
Ceramium vertebrale. Zone with a heap of paraspores. From a dried specimen. Delicate pseudopodia radiate from the protoplasts towards the outer wall.

Localities. **Bm:** RH, at Knollen west of Saltholm. — **Bb:** SN, Davids Grund, 15—17 m; SL, off Allinge; SO, off Gudhjem; SK, Højbratterne; SH, South of Broens Rev; YF, within Arnager Rev; SF, Adler Grund. — (The locality Nyborg Havn recorded by Dr. Petersen (1908 p. 64) must be omitted, the specimens being now referred by Dr. Petersen to *C. strictum* f. *radiculosa*).

7. **Ceramium danicum** Henn. Petersen n. sp.

C. Rosenvingii H. Petersen f. *tenuis* et f. *intermedia* H. Petersen 1908, pp. 66, 90, pl. II figs. 5, 6.

Frons dichotoma, apicibus incurvatis teretibus, in partibus superioribus et intermediis zonis discretis, in partibus inferioribus cortice continuo instructa. Zonæ juveniles marginibus non crescentibus, adultiores ab utroque margine crescunt ut in *C. Rosenvingii.* Interstitia pellucida interdum zonis 5—7-plo longiora. — Cystocarpia in ramis primariis. — Color subruber. — Individua minus corticata habitum *Cer. stricti* offerunt.

Ceramium Rosenvingii as described by me in 1908, comprises partly forms with feebly developed cortex, with the habit of *C. diaphanum* and *C. strictum,* partly forms with somewhat more developed cortex and finally forms approaching to *C. rubrum.* As such a variation must be considered too great, even when taking the species in a wide sense, I have found it correct to divide the species into two. It would perhaps be most correct to distinguish three species corresponding to the three forms which were described in 1908; however, I am not satisfied whether there is so distinct a limit between f. *tenuis* and f. *intermedia* that they ought to be regarded as distinct species. On the other hand f. *transgrediens* is so distinct from the two just named forms that it seems warranted to draw a specific limit between them. I describe therefore a new species comprising the forms *tenuis* and *intermedia,* while the name *C. Rosenvingii* is retained for the f. *transgrediens.*

C. danicum comprises forms with continuous cortex at the base or reaching a little over the middle of the frond and with the habit of *C. diaphanum* or *C. strictum* in the upper parts of the frond, while *C. Rosenvingii* comprises more robust forms with continuous cortex reaching to the apex or near the apex, with rubroid branches and without any habit of *C. strictum.* HENN. PETERSEN.

C. danicum has been met with in May to July, in 4—13 meters' depth. It reaches a length of 15 cm and has been found with antheridia in May, with cystocarps and tetraspores in July.

Localities. **Sa:** GC, north of Fyn. — **Lb:** DF, E. of Bogø; DC, Aakrog Bugt; DB, Lillegrund; DX, Vodrups Flak. — **Sf:** UX, Skjoldnæs; CV, Billes Grunde. — **Sb:** UE, Vresens Puller; UU, Snøde Rev. — **Bw:** DU, off Dimes Odde. — **Bm:** KT, Gedser Rev; at Stevns Klint (Joh. Lange).

8. **Ceramium rubriforme** Kylin.

Kylin 1907 p. 183, pl. 7 fig. 7.

After having examined recently original speeimens of *C. rubriforme* Kylin Dr. Petersen refers to this species two specimens from one locality in the northern Kattegat and with doubt one from the South Fyn Waters, formerly referred to *C. Rosenvingii* f. *intermedia*. The former are 15 cm long and bear ripe tetrasporangia (May).

Localities. **Kn:** Krageskovs Rev, 4—5 m. — **Sf:** (?) CU, at the N. end of Flæskholms Flak, 5,5 m.

9. **Ceramium arborescens** J. Agardh.

J. Agardh 1894 p. 33; Henn. Petersen 1908 p. 67 and 91, pl. III figs. 1—2; 1911 pl. II fig. 6.

The species is rather extensively spread in the Danish waters from the North Sea to the Baltic Sea around Møen. It seems to be only little influenced by the salinity of the water, for the maximal length, 17—18 cm, is reached in the North Sea and the Baltic Sea as well. It occurs mostly near low-water mark, but has been met with in depths down to 12 meters. It is most frequent in spring (May) but has been observed in the months of April to September, with cystocarps and tetrasporangia in May to July.

Localities **Ns:** Thyborøn, pier. — **Sk:** Hirshals, E. side of mole and stony reef near land. — **Lf:** Glyngøre. — **Kn:** Frederikshavn, harbour; boulder at Jegens Odde. — **Ke:** GI, Ostindiefarer Grund. — **Ks:** OP, Lysegrund. — **Sa:** KL, Bjarkes Grund; Kalø reef; Korshavn, reef; Hofmansgave (Hofm. Bang); Odense Fjord (C. Rosenberg). — **Lb:** Knudshoved, S. of Anslet Hage. — **Sf:** Svendborg. — **Sb:** Korsør (Hornemann); DN, Vengeance Grund, 12 m; UF, near Hov Sand; DQ, off Nakskov Fjord; UR, S. of Albuen. — **Su:** Dragør. — **Bw:** UQ, off Tillitse; UP, off Kramnisse Gab. — **Bm:** Stevns Klint, washed ashore (Joh. Lange); Rødvig, reef E. of the harbour; Klintholm harbour.

10. **Ceramium Rosenvingii** Henn. Petersen emend. auct.

C. Rosenvingii Henn. Petersen f. *transgrediens* Henn. Petersen 1908, pp. 66, 91, figs. VI,2, VII,1, pl. II fig. 7.

Frons dichotoma, apicibus rectis vel curvatis. Corticatio confluens, exceptis apicibus ramisque superioribus. Zonæ corticales discretæ ab utroque margine crescentes. Tetrasporangia verticillata non erumpentia. Color subruber. Henn. Petersen.

With regard to the present circumscription of the species comp. above p. 381. It has been collected in April to July, most frequently in May, in 1 to 9,5 meters' depth.

The frond reaches a length of up to 14 cm. Tetrasporangia have been met with repeatedly in May to July, antheridia once in May, cystocarps only once in a dubious specimen from the southern Kattegat, gathered in July. The tetrasporangia were at any rate often cruciately divided.

Localities. **Kn:** Skagen, south side of Grenen. — **Ks:** (?) EJ, Lysegrund; OT, Hastens Grund. — **Sa:** PG, W. of Hatterrev; Hofmansgave (Lyngbye). — **Lb:** FZ, Kasserodde; Baaring, harbour; Dyreborg. — **Sf:** CV, Billes Grunde; DZ, Egholms Flak. — **Sb:** UU, Snøde Rev.

11. **Ceramium atlanticum** Henn. Petersen.

Henning Petersen 1911 p. 112.

Dr. Petersen refers to this species a specimen collected in April 1906 in the harbour of Skagen then unfinished. It has formerly (1908) been referred to *C. fruticulosum* f. *rubroides*. It was 13 cm high, but still sterile. *C. atlanticum* has till now been recorded from Iceland and the Færöes.

Locality: **Kn:** Harbour of Skagen.

12. **Ceramium Boergesenii** Henn. Petersen.

Henning Petersen 1911, p. 108, fig. I, pl. II fig. 8.
C. fruticulosum f. *rubroides* Henn. Petersen 1908 pp. 73, 93 ex parte, pl. IV fig. 1.

Dr. Petersen has found that some specimens from the Limfjord, formerly referred to *C. fruticulosum* f. *rubroides*, must be referred to *C. Boergesenii* which was described on the basis of specimens from the Færöes, and which is easily recognisable by the characteristic small-celled cortication. The species was met with near low-water mark in July and September, in all the places with tetrasporangia, in one place with cystocarps in July. The collected specimens are 7—9 cm long.

Localities. **Lf:** Thisted; Nykøbing; Hals. — **Kn:** Two specimens from Nordre Rønner must probably, according to Dr. Petersen, be referred to this species though the cortication is not quite typical.

13. **Ceramium scandinavicum** Henn. Petersen. n. sp.

C. fronde regulariter dichotoma ± corymbosa fastigiata apicibus incurvatis, in partibus basalibus et intermediis cortice continuo, in partibus superioribus interstitiis pellucidis semper brevibus instructa. Zonæ superiores ab initio adproximatæ, marginibus vix crescentibus, deinde ab utroque margine inprimis a superiori crescentes. Cellulæ marginis inferioris semper latæ in seriebus longitudinalibus ordinatæ. Cystocarpia in ramis principalibus; antheridia in soris; tetrasporangia verticillata in partibus nodalibus parum erumpentia. — Color in individuis danicis subruber, in individuis ex regionibus borealibus fusco-rubiginosus. (Fig. 324).

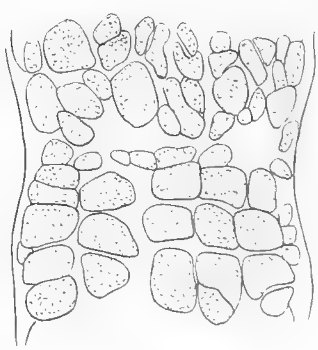


Fig. 324.
Ceramium scandinavicum. Cortical band. H. Ptrsn. del. 330 : 1.

This species comes near to *C. atlanticum*, *C. Rosenvingii* and *C. rubriforme*, from which it differs by cortical bands more resembling those in *C. Areschougii*, with cells arranged in characteristic rows in the lower part of the zones. In contradistinction to *C. atlanticum* the ramification is distinctly dichotomo-corymbose with slight formation of secondary shoots. The specimens from the Baltic Sea have formerly been referred to *C. Rosenvingii* f. *transgrediens*. (Henning Petersen).

In the Northern Kattegat it has been found with antheridia, cystocarps and tetrasporangia in June. The Danish specimens reach a length of 8,5 cm.

Localities. **Kn:** Several places in the neighbourhood of Frederikshavn, e. g. Degets Nordøstrev. — **Bw:** KU, Schönheyders Pulle. 11 m. — **Bm:** VH, Böchers Banke.

14. **Ceramium abyssale** Henn. Petersen n. sp.

C. rubrum f. *decurrentoides* Henn. Petersen 1908, pp. 82, 96.

C. fronde dichotoma vel subdichotoma, apicibus excl. juvenilibus ± rectis, cortice continuo vel zonis juxappositis difficile distinguendis instructa. Zonæ discretæ solomodo in basibus ramorum occurrunt, typo C. fruticulosi vel C. Areschougii, in marginibus superioribus magis quam in inferioribus crescentes. Cystocarpia in ramis principalibus vel secundariis. Tetrasporangia verticillata vel sparsa parum erumpentia. Color subruber. Hab. in regione abyssale.

On closer examination of the specimens which in 1908 were referred to *C. rubrum* f. *decurrentoides* I have found that these specimens, owing to the structure of the cortication, must rather be considered as related to *C. fruticulosum* than as a form of *C. rubrum*. It differs from *C. fruticulosum* in particular by the presence of distinct bands at the base of the branches. Henning Petersen.

C. abyssale has only been met with in considerable depths, (8,5—31 m) in water of high salinity. It has been collected only in summer (July, August), with cystocarps and tetraspores; it reaches a length of 11,5 cm.

Localities. **Ns:** aF, Jydske Rev, 31 m. — **Sk:** ZK^{12}, off Lønstrup, 8,5 m; off Hirshals, 15 m. — **Kn:** FG, Herthas Flak, 21 m. — **Ke:** VY, Fladen, 18 m.

15. **Ceramium Areschougii** Kylin.

Kylin 1907, p. 179, Taf. 7 Fig. 6; Henn. Petersen 1908 p. 69, Figs. VI, 1 and VII, 2, 1911 p. 100 Fig. II.

The species has only been met with in summer, May to August, most frequently in June and July. It seems to thrive best in the inner western waters where it reaches a length of 15—16 cm. It has been found with tetraspores in May to August, with cystocarps in June and July, and both modes of fructification occur in all the waters where the species has been met with. It grows in all the waters in various depths from $^{1}/_{2}$ m to 15 m; in the Little Belt it has once been found in a depth of 19 m or deeper.

Localities. **Kn:** Various localities at Frederikshavn and Hirsholmene (C. M. Poulsen, H. E. P., K. R.); VT, VU, ZL, North of Læsø; FE, FF, Læsø Trindel, 10—15 m. — **Ke:** EU, Lille Middelgrund. — **Km:** FA and XC south of Læsø. — **Ks:** D, off the entrance to Isefjord. — **Sa:** FT, north of Samsø; bay of Nexelø (Th. Mortensen); BD, north of Tunø; AH[1], Lillegrund at Fyns Hoved. — **Lb:** W. side of Æbelø; cV, off Røgle church; Snoghøj; Fænø Sund; Linderum; Aarøsund; Augustenborg Fjord. — **Sf:** UV, north of Ærø, 13 m; Nakke Odde, Avernak Ø. — **Bw:** Several places south of Als (bV, bY, bZ, cE, cG, near land at Kegnæs light-house, dK, Pøls Rev); LE, Vejsnæs Flak; LC, south of Gulstav.

16. **Ceramium fruticulosum** (Kützing) J. Agardh.

J. Agardh 1894 p. 31; Henning Petersen 1908 p. 70, 1911 p. 101.
Hormoceras fruticulosum Kützing, Linnæa 1841 p. 734, Spec. Algar. 1849, p. 676, Tab. phyc. 12 1862, pl. 73.

Dr. Petersen distinguishes the following forms:

α, dichotoma H. Ptrsn. 1911 p. 71, H. Ptrsn. 1908, Tab. IV Fig. 2).
Branches dichotomous or main stems may be developed.

β, penicillata (Aresch.) H. Ptrsn. 1908 Tab. IV Fig. 3; 1911 Plate I Fig. 4. (*Hormoceras fruticulosum* Kütz. sensu stricto et *Ceramium penicillatum* Aresch.; *C. penicillatum* f. *fasciculata* Kylin 1907 p. 177).
Very distinct main axes with lateral distichous shorter bushels.

The third form described in 1908, f. *rubroides* H. Ptrsn., has been withdrawn by Dr. Petersen as, on closer examination, it turned out to comprise two distinct species, most of the specimens belonging to *C. Boergesenii*, one to *C. atlanticum*.

C. fruticulosum occurs in the Northern Danish waters with comparatively high salinity. It has been met with in all seasons but most frequently in summer. It reaches a length of 9 to 13 cm. It was found sterile in winter (December), and spring (April), with tetrasporangia in May to October, with cystocarps in June to August; antheridia were met with in July. Antheridia may occur in the same individuals as the cystocarps; they cover completely the joints of the upper part of the branches. In female plants spermatia may be found adhering in great number to sterile hairs in their whole extent (fig. 309). Sexual specimens are at least just as common as tetrasporiferous ones. The species occurs always near the low-water mark where it may be rather abundant, in particular in exposed localities, in the Skagerak often in company with *Polysiphonia Brodiæi*.

The two varieties have much the same distribution (Skagerak, northern Kattegat) and occur often in the same locality connected with intermediate forms.

Localities. **Ns:** Thyborøn harbour, outside of W. mole (β). — **Sk:** Hanstholm, 2 m (β); Bragerne, 2 m (β); Lønstrup (β); Hirshals, mole and stones (α, β); Højen (α). — **Kn:** Harbour of Skagen (α, β); harbour of Hirsholm (α); Deget (α) (Boye Petersen); Rønnerne N. of Frederikshavn; Busserev, in Ascophyllum nodosum (β); harbour of Frederikshavn (α, β, outside of S. mole); off Frederikshavn (α) (A. Otterstrøm); Østerby harbour, Læsø (α); harbour of Sæby (α).

17. **Ceramium septentrionale** Henn. Petersen.

Henn. Petersen 1911 p. 110, figs. II—IV.[1]

C. circinnatum Kützing f. *borealis* Foslie, The norweg. forms of Ceramium. D. kgl. norske Vidensk. Selsk. Skrifter 1893, Trondhjem 1894 p. 9.

Having examined FOSLIE's original specimens of the above named form I must consider this form as belonging to *C. septentrionale* described by me in 1911. It differs much from *C. circinnatum* which is characterised by downward growing zones. *C. septentrionale* is characterised by very high cortical bands, often reaching a height of 1—2 mm. (HENN. PETERSEN).

The Danish specimens referred to this species are all older specimens reaching a length of 13 cm, collected in July and August, with tetrasporangia and cystocarps. The tetrasporangia are cruciately divided. A specimen still in growth, with cystocarps, collected by A. OTTERSTRØM off Frederikshavn in Aug. 1902, formerly referred to *C. fruticulosum* f. *dichotoma* and represented under this name in Ceram. Stud. 1911 pl. I fig. 1 is now referred with some doubt by Dr. PETERSEN to *C. rescissum* Kylin.

Localities. **Kn:** Near Hjellen 6—7 m (H. E. P.), Københavner Rev (Boye Petersen) and Borrebjergs Rev (H. E. P.) near Frederikshavn.

18. **Ceramium rubrum** (Huds.) Agardh.

Henning Petersen 1908 pp. 73 and 93, Plate IV Figs. 5, 6, Plates V—VII; id. 1911 p. 113, Plates III, IV, V Figs. 25, 27—30.

Whereas in 1908 I referred certain forms with partly separate cortical bands to this species, I now judge it better to exclude such forms. Distinct bands have been met with in certain forms from deeper water, which in 1908 were named f. *decurrentoides*, and further in f. *irregularis* subf. *subcorticata*. As to the latter I am at present in doubt but I hope to contribute later to the question of its systematical position. On the other hand I do not doubt that f. *decurrentoides* cannot be referred to *C. rubrum*, and I have therefore described it as a new species, *C. abyssale* (p. 384).

As a new form is distinguished f. *furcata* which seems to be a f. *irregularis* developed from f. *prolifera*; it has a similar occurrence to this. It is characterised by robust branches and often straight apices with long forcipes. In certain cases it resembles *C. rubrum* f. *linearis* H. Ptrsn. 1911, p. 116 fig. VI, pl. IV fig. 21.

Another form new in the Danish flora is f. *fasciculata*. HENN. PETERSEN.

The numerous forms occurring in the Danish waters of this widely spread species have been treated at length by Dr. PETERSEN (1908 pp. 73 et seq.). All the forms now distinguished by this author are named below.

The forms *prolifera*, *secundata* and *pedicellata* (*virgata*) have only been met with from Ns and Sk except f. *prolifera*, which has also been found in the Limfjord (N. side of Fur).

[1] In Cer. Stud. 1911, the pl. V fig. 26 is given as representing *C. septentrionale*, but this is erroneous; the figure in question represents either a new species or a particular form of *C. rubrum* (H. Ptrsn.)

Forma *fasciculata* H. Ptrsn. 1911 pp. 114, 116, pl. IV fig. 23. Habit of *C. fruticulosum* f. *penicillata*.

Localities. **Ns:** Thyborøn, groin. — **Kn:** Østerby harbour, Læsø.

Forma *modificata* H. Ptrsn.

Localities. **Sk:** Hirshals. — **Lf:** Common. — **Kn:** Common along the east coast of Jutland from Skagen to Sæby; Læsø Trindel. — **Km:** Asaa.

Forma *subtypica* H. Ptrsn.

New localities. **Sk:** Off Højen. — **Ke:** Gilleleje. — **Km.** — **Ks.** — **Sa.** — **Lb:** Bogense, harbour. — **Sf.** — **Sb:** Lundeborg, harbour. — **Sm:** Nykøbing F. — **Su:** SB, Flinterenden, 8,5 m.

Forma *furcata* H. Ptrsn. n. f., a vigorous f. *irregularis* with long straight ends of branches. The plant represented 1908 pl. 7 fig. 3 approaches to this form. (Henn. Petersen).

Localities. **Sk:** Off Hirshals, 14 m. — **Lf:** Nykøbing Mors. — **Kn:** Hirsholm, E. side of Tyskerens Rev (18 cm long).

Forma *irregularis* H. Ptrsn.

Localities. **Lf:** MD, off Doverodde. — **Kn** S. of Hirsholm. — **Ke:** Off Gilleleje. — **Ks:** RL, Isefjord. — **Sa:** Kyholm, Korshavn, Hofmansgave. — **Lb:** Off Stenderup; CC, Hornenæs. — **Sf:** Birkholm. — **Sb:** MN, N. of Asnæs; Lerchenborg (O. Smith), Kerteminde. — **Sm:** Guldborgsund; Petersværft. — **Su:** Hellebæk (Joh. Lange); RH, Knollen; SB, Flinterenden. — **Bw:** S. side of Als; cE, S. of Als, 13 m; UP, off Kramnisse Gab; Gedser. — **Bm:** Hesnæs; QZ, off Møens light-house; Stevns; QF, S. of Saltholm; RG.

Forma *irregularis subcorticata* H. Ptrsn.

Localities. **Km:** Boels Rev off Randers Fjord. — **Su:** BQ, off Ellekilde; PS, off Charlottenlund. — **Bm:** QG, off Bredegrund; QP, Kalkgrund; QR, Gyldenløves Flak; RB, within Hollænder Grund. — **Bb:** SQ, S. of Broens Rev, 9 m.

Forma *baltica* H. Ptrsn.

Localities. **Bw:** UL, Øjet, 20 m. — **Bm:** QY, Bjelkes Flak; RC, within Danneskiold; QG, off Bredgrund. — **Bb:** Rønne; SH, Rønne Banke; SK, Højbratterne, 11 m; YG, Arnager Rev; SQ, S. of Broens Rev, 9 m; off Allinge, off Gudhjem; Christiansø; That.

Forma *radians* H. Ptrsn.

New localities. **Lf.** — **Sa:** Hofmansgave. — **Lb:** E. side of Aarøsund. — **Sf.** — **Bw:** bV, N.E. of Kobbel Skov.

Forma *divaricata* H. Ptrsn.

New localities. **Lb:** Near Fænø Kalv; Augustenborg Fjord.[1]

[1] 19. *C. rescissum* Kylin. The above (p. 386) named specimen collected by Mr. A. Otterstrøm at Frederikshavn, earlier referred by me to *C. fruticulosum* f. *dichotoma* (1911 Tab. I fig. 1) must probably be referred to *C. rescissum* Kylin (1907, p. 182). This species is in my opinion nearly allied to *C. septentrionale* H. Ptrsn., but the latter differs from it by another habit, caused in particular by the straight or little branched apices. Henning Petersen

(Note added during printing).

Rhodochorton Nägeli.

The systematical position of the genus *Rhodochorton* is undecided owing to the fact that cystocarps are unknown, and it is even uncertain whether its place is rightly within the *Ceramiaceæ*. There is much resemblance to certain species of *Acrochætium* (*Chantransia*[1]) of the family *Helminthocladiaceæ*, and transfers have in reality taken place between the two genera. Thus, *Rhodochorton chantransioides* has been transferred to the genus *Chantransia* by Kylin in 1906, I have judged it necessary to transfer *Rh. seiriolanum* Gibs. to the same genus (see below, p. 390), and I think that it may be necessary also with *Rh. endophyticum* Kylin (1907, p. 188) which has only monosporangia, no tetrasporangia.

The cell structure usually gives good distinctive characters between the two genera, most of the species of *Acrochætium* having one chromatophore with a pyrenoid, while *Rhodochorton* has several band-like chromatophores. However, as shown by Kuckuck (1897, p. 21), *Rh. floridulum* has several stellate chromatophores containing a central pyrenoid, which organ is otherwise only known within the *Helminthocladiaceæ*. On the other hand, the species of *Acrochætium* subg. *Grania* have several ribbon-shaped, more or less spiral-shaped chromatophores without pyrenoids in each cell.

Antheridia have hitherto not been observed in the genus *Rhodochorton*. As mentioned below, they have now been detected in *Rh. penicilliforme*; these organs give no indication of the systematic position of the genus as they are in accordance with the antheridia of other *Ceramiaceæ* and of *Acrochætium* as well. The discovery of the antheridia raises the hope that cystocarps may also be found.

The sporangia are always first divided by a transversal wall and afterwards by two vertical ones. The same mode of division occurs in *Acrochætium* and in *Antithamnion* as well.

1. **Rhodochorton penicilliforme** (Kjellm.) K. Rosenv.

L. Kolderup Rosenvinge, Les Algues marines du Groenland. Ann. d. sc. nat. Bot. 7^{e} série tome 19, 1894, p. 66; id., Deuxième Mém. Alg. mar. Groenl. 1898, p. 23; F. Børgesen, Mar. Alg. Fær. 1902, p. 389.

Thamnidium mesocarpum f. *penicilliformis* Kjellman, Spetsb. Thallof. I, Bih. K. Sv. Vet. Akad. Handl. Bd. 3 No. 7, 1875, p. 30.

Rhodochorton mesocarpum f. *penicilliformis* Kjellman, N. Isl. Algfl., 1883, p. 235 (Alg. Arct. Sea p. 187), tab. 16 figs. 6—7; Kolderup Rosenvinge, Grønlands Havalger, 1893, p. 792.

The species is easily recognisable by its basal system composed of regularly radiating connate filaments; it has been figured by myself (1893, fig. 9 A) and Børgesen (l. c.). Transverse fusions between cells belonging to different rows were repeatedly observed (fig. 325). The free filaments project in dense tufts or more scattered. In several cases they were unbranched and sterile; they are 9—12 (—14) μ

[1] Though I do not see the necessity of exchanging the old name *Chantransia*, which has been autorized by long spending, with the later *Acrochætium*, I here follow the modern authors in using the latter name.

thick. The cells are usually $1^1/_2$—3 times as long as broad; they contain one nucleus and several more or less elongated disc-shaped or ribbon-shaped chromatophores (fig. 326).

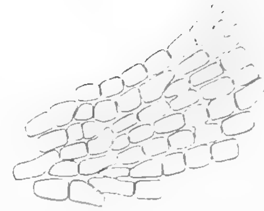


Fig. 325.
Rhodochorton penicilliforme. Basal layer showing cell-fusions. 300 : 1.

The sporangia are usually, as figured by Kjellman (N. I. Algfl. 1883, fig. 6—7), terminal on short lateral branches mostly given off from the upper part of the otherwise unbranched erect filaments. But they may also be terminal on these filaments or, more rarely, terminal on longer lateral branches. The sporangiferous branchlets may be branched; Kjellman has figured such a case (l. c. fig. 7). In specimens from the Little Belt near Fænø Kalv (no. 1365) I found several cases of branched branchlets, the branchlets of the second order terminating also with a sporangium (fig. 327). The sporangia are first divided by a transversal wall and afterwards by two vertical ones which are never in the same plain. The sporangia are (25—) 29—32 (—35) μ long, (21—) 23—25 (—27) μ broad. After evacuation of the spores a new sporangium may arise within the empty sporangial wall by budding from the next cell (fig. 326).

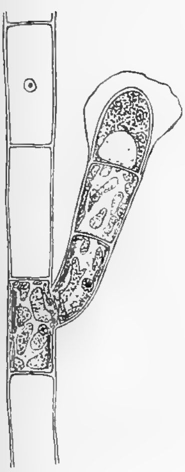


Fig. 326.
Rhodochorton penicilliforme. Young sporangium growing out within the wall of an emptied sporangium. 625 : 1.

In the named specimens from the Little Belt (no. 1365), growing on *Phyllophora membranifolia* gathered in 13 meters' depth in June 1891, antheridia were found besides tetrasporangia. They occurred in small clusters in the same specimens which bore tetrasporangia and in the neighbourhood of these, sometimes even on the same lateral branch. The antheridial clusters are usually lateral, more rarely terminal on the

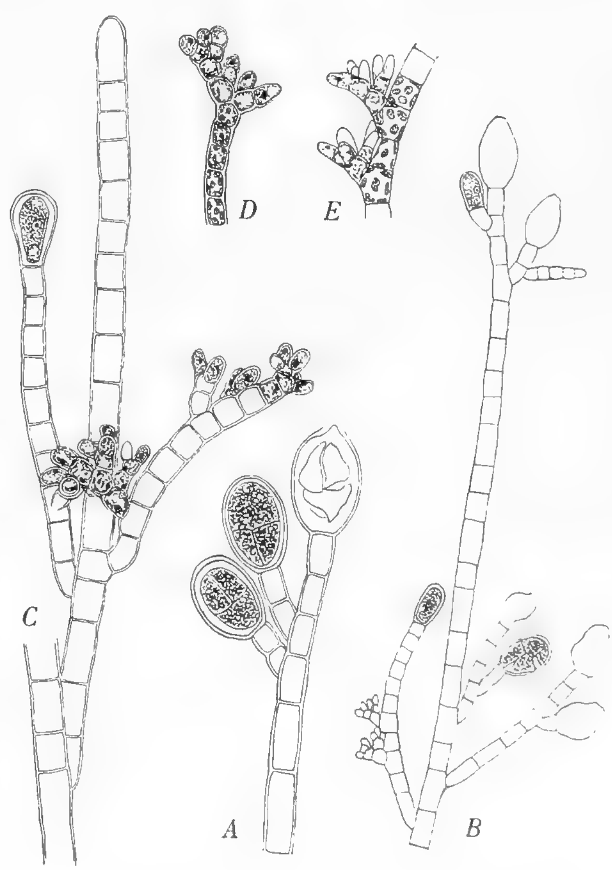


Fig. 327.
Rhodochorton penicilliforme. Upper ends of upright filaments with tetrasporangia and antheridia. *B* 230 : 1, the others 390 : 1.

erect filaments (fig. 327) or on lateral branches. The lateral branches bearing antheridial clusters are short-celled. The antheridial clusters consist of short, recurved filaments composed of short, rounded cells and bearing on their convex side a small number of one- or two-celled short branches bearing together with the main axis of the cluster a number of antheridia on the upper side and giving to the cluster a corymbose appearance. The antheridia are ovate, 6—7 μ long, 4—5,5 μ broad; they contain a rather large nucleus. As these organs have only been observed in specimens conserved in alcohol, their colour could not be ascertained, but they seem to contain no chromatophores.

Female sex organs have not been observed.

The species has been found growing on *Phyllophora membranifolia, Ph. Brodiæi* and *Ph. rubens,* further on the chitinous membranes of *Tubularia* sp. and *Abietaria abietina,* in 5 to 25 meters' depth.

A membrane agreeing exactly with the basal layer of this species, but without erect filaments, was found growing on a specimen of *Cladophora rupestris* gathered near Kerteminde. — The species was found with sporangia in May, June, September (unripe) and November.

Localities. **Kn:** Near Hirsholm, 11 met.; Nordøstrev by Hirsholm. — **Ke:** IT and EV, Groves Flak, 23—25 met.; IQ, Fladen. — **Ks:** Nakkehoved, 22. Nov. 1827, (Lyngbye). — **Sa:** MS, south of Klophagen, 15 m. — **Lb:** North of Fænø Kalv, 13 m; off Stenderup; dQ, bank south of Lyø, 22 m. — **Sb:** LL, off Brolykke by Kerteminde, on Cladophora rupestris, without free filaments; determination uncertain; UH, east of Langeland. — **Bw:** cE, Middelgrund south of Als, 13—15 m.

Rhodochorton seiriolanum Gibs., described in 1890 by HARVEY GIBSON (Journ. Linn. Soc. Bot. Vol. 28, p. 204) has a monostromatical layer resembling that of *Rh. penicilliforme.* In a specimen of the same species from the Færöes kindly communicated to me by Dr. F. BØRGESEN I found that the cells contain one single chromatophore with a thick central portion including a pyrenoid. The species must certainly be referred to the genus *Chantransia* (*Acrochætium*).

2. **Rhodochorton Rothii** (Turton) Nägeli.

Nägeli, 1861, p. 356, Taf. I Figs. 1, 3; Reinke, Algenfl. westl. Ostsee, 1889, p. 22; H. Gibson, Developm. of the sporang. in Rhodochorton Rothii. Journ. Linn. Soc. Bot. Vol. 28, 1891, p. 201; Kuckuck, 1897, p. 20, fig. 5 (cell contents); Børgesen, Mar. Alg. Færöes, 1902, p. 390.

Conferva Rothii Turton, System of Nature VI, p. 1806 (teste Dillwyn); Dillwyn, Brit. Conf., 1809, plate 73.

Callithamnion Rothii Lyngbye, Tent., p. 129, Tab. 41 A; Hornemann, Flor. Dan. tab. 2261, 2—3; Harvey, Phyc. Brit. Vol. I, 1846, Plate 120 B; J. Agardh, 1851, p. 17; Kützing, Tab. phyc. Vol. XI, 1861, pl. 62 I.

Thamnidium Rothii Thuret, in Le Jolis, Alg. mar. de Cherbourg, 1861, p. 111, Pl. V.

This species occurs frequently in the littoral zone where it forms purple velvety patches e. g. under the *Fucus* bushes. These patches consist of creeping filaments from which arise erect filaments which are usually without branches below. The creeping filaments may be composed of short inflated cells (fig. 328) or they may be thinner, composed of rather long cells (fig. 330). The erect filaments are usually given off from the middlemost part of the cells of the creeping filaments. Descending filaments are sometimes given off from the lower part of the erect filaments; they have the same appearance as the creeping ones and usually issue from the lower end of the cells while the erect branches are produced at their upper end. Exceptions from this rule and transitional forms between the erect and the descending or creeping filaments may sometimes occur. Thus, creeping filaments may arise from the upper end of a cell, and erect filaments may change into a creeping one (fig. 330 *A*).

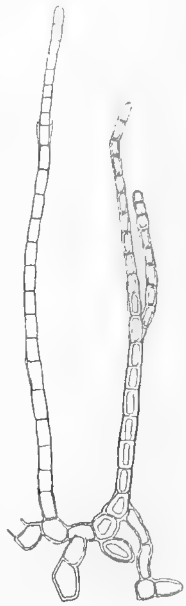


Fig. 328.
Rhodochorton Rothii, from Bornholm. Creeping filament giving off two erect filaments. The latter have been regenerated after the apical part has died. 270 : 1.

The erect filaments are usually 10—15 μ thick (6—17 μ), and the thickness is essentially the same in all the Danish waters; at Bornholm, however, the thickness is on an average a little smaller, 6—12 μ. The cells contain a single nucleus and a number of small parietal chromatophores without pyrenoid (Kuckuck, l. c.). In the older transversal walls a refringent ring like that described by me in *Rhodochorton islandicum* K. Rosenv.[1] may sometimes appear.

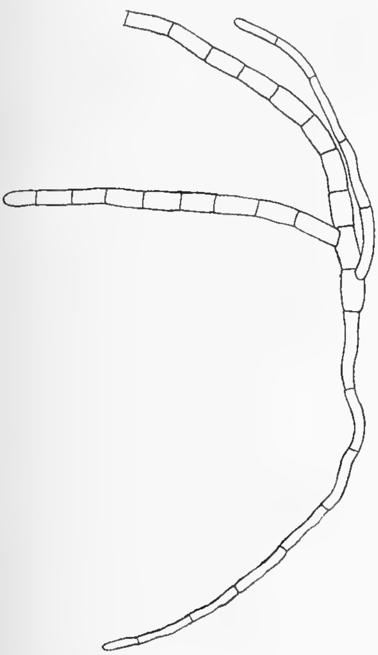


Fig. 329.
Rhodochorton Rothii. Plant probably arisen by regeneration of an isolated part of the frond. 200 : 1.

A vegetative propagation is sometimes realised by fragments of the thallus consisting of a branched filament loosening from the mother plant and producing at the surface of fracture a downward growing filament (figs. 329, 330 *E*), becoming thus "cuttings" such as those described by me in *Rhodochorton islandicum*, l. c. p. 67. The middlemost cell in fig. 330 *D* is perhaps preparing the formation of such a cutting, giving rise to a small rhizoid penetrating into the subjacent cell. These cuttings were principally found in specimens collected at Copenhagen (Frederiksholms Kanal) in September.[2]

The sporangia are usually clustered at the ends of the erect filaments, as admirably represented in Le Jolis Liste, pl. V, but they may also be more scattered in the upper end of these filaments. They

[1] Note sur une Floridée aérienne. Bot. Tidsskr. Vol. 23, 1900, p. 67.

[2] Svedelius (Östersj. Algflora, 1901, p. 129) mentions the "cuttings" described by me in *Rh. islandicum* as stolons; they are, however, no stolons, but fragments of ordinary filaments loosening by splitting of a transversal wall, and germinating by giving rise to creeping filaments.

are usually 25—28 μ long, 14—19 μ broad. The longest sporangium which was met with (Middelfart, April) measured 36 μ in length. The sporangium is first divided by a transversal wall, afterwards by two longitudinal ones. The sporangia are probably produced in autumn; they were found ripe in the months January to May, empty in June. In specimens collected at Bornholm as late as August a few sporangia were still present, while the greater part had emptied and were fallen off. And specimens found by LYNGBYE near Hesselø in the southern Kattegat in July 1832, growing on *Phyllophora Brodiæi*, still bore ripe sporangia. During and after the fructification new long erect branches may be produced from the sporangial cluster, between and under the sporangia, growing out to a bundle of long filaments.

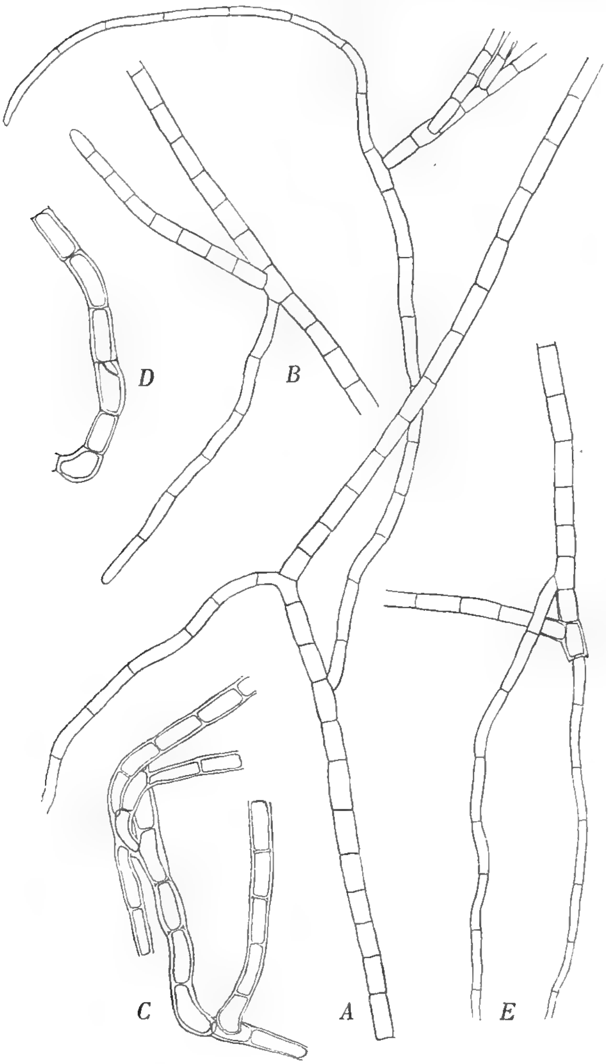


Fig. 330.
Rhodochorton Rothii. Parts of upright filaments with upright and descending or creeping branches. In *E* regeneration of loosened filament by formation of descending filaments. 270 : 1.

The erect filaments attain only a length of 6 mm. Mr. BOYE PETERSEN has, however, given me a specimen gathered at Middelfart in the beginning of July, measuring 17 mm. It reminds one very much of *Rh. intermedium* KJELLMAN (Spetsb. mar. klorof. Thallof. I, 1875, p. 28, Nor. Ish. Algfl. 1883, p. 231 pl. 15 fig. 8), which possibly is not specifically distinct from *Rh. Rothii.* As the specimen in question is sterile, a closer comparison with KJELLMAN's plant cannot be made.

R. Rothii is perennial. It occurs principally in the littoral zone between middle and low-water mark, but it has also been found in the sublittoral zone to a depth of 36 m; in this zone, however, it does not occur so abundantly as in the littoral zone. In exposed places on the rocky coast of Bornholm and the neighbouring Christiansø it may ascend 2 or 3 meters above the sea level, usually associated with *Verrucaria maura* and

Hildenbrandia prototypus. Here it forms velvety patches of the usual aspect, but the erect filaments are short, about 1 mm, simple or little branched, thin, usually 7—10 μ broad, the cells being about twice as long as broad (fig. 328). The lower part of the filaments are sometimes moniliform, consisting of short inflated cells scarcely longer than broad. These supralittoral specimens thus show no resemblance to *Rhodochorton islandicum.* — The species is usually found growing on rocks and stones, further on wood (in harbours), more rarely on *Mytilus* and the hapters and stipe of *Laminaria hyperborea* and *L. digitata,* further on *Phyllophora Brodiæi,* partly on a Bryozoan on this. — In three localities in the North Sea, W. of the Limfjord, very small specimens of a *Rhodochorton* were found growing on Flustra foliacea, forming small tufts reaching only a height of 180 μ. They were supposed to be much reduced specimens of *Rh. Rothii.* The creeping filaments were often more or less densely united into a pseudoparenchymatic layer reminding one somewhat of that in *Rh. membranaceum,* but they were creeping on the surface of the skeleton of the Bryozoan, not penetrating it as in the last-named species, and the free, erect filaments were thicker (6—9 μ, most frequently 7—8 μ). Sporangia were not present, only stipes of shed scattered sporangia (Sept.—Oct.). — The species has been met with in almost all the Danish waters and is probably widely spread except in the Limfjord (and other fjords).

Localities. **Ns:** eE, 12 miles N.W. by N. of Bovbjerg light-house, 16 m; dZ, 17 miles W. 3/4 N. of Lodbjerg light-house, 36 m; eQ, 8 miles NW. by W. 1/2 W. of Lodbjerg light-house, 27 m, in all localities on Flustra foliacea. — **Sk:** Hirshals, reef, under Fucus. — **Kn:** Tyskerens reef and N.E. reef by Hirsholm, Frederikshavn, moles; Busserev; off Laurs Rev, c. 10 m, on Laminaria digitata; Østerby harbour, Læsø; fG, Tønneberg Banke, 15 m. — **Ks:** Grenaa, harbour; Nordvest-Renden by Hesselø, on Phylloph. Brodiæi (Lyngbye). — **Sa:** PG, west of Hatterrev, c. 8 m; north side of Refsnæs, 19 m, on Mytilus (C. H. Ostenfeld). — **Lb:** Baaring, harbour; Bogense, harbour; Fredericia (Hofm. Bang); Middelfart, harbour; Kongebro; Snoghøj, harbour; dH[1], east of Hesteskoen, 18—19 m, on Phyllophora. — **Sb:** Kjerteminde, harbour; near Sprogø, 10—28 m (C. H. Ostenfeld); near Vresen, on Mytilus, 8—9 m (C. H. Ostenfeld); US[1], Langelandsbelt, 20 m. — **Su:** København, Frederiksholms Kanal. — **Bm:** Køge, harbour. — **Bb:** Davids Banke, 29 m; near Hammershus, up to 2 m above the sea level; Rø, "den vaade Ovn", at the entrance to "den sorte Gryde" up to 3 m, Helligdomsklipperne (Liebman, J. Hartz, !); Græsholm at Christiansø, up to 2 m above sea level.

3. **Rhodochorton membranaceum** Magnus.

Callithamnion (Rhodochorton) membranaceum Magnus, Die botan. Ergebnisse der Nordseefahrt 1872. II. Jahresber. d. Komm. z. Unters. d. deutsch. Meere in Kiel. Berlin 1874, p. 67, Taf. II figs. 7—15; Collins, Notes on New England Marine Algæ II, 1883, p. 56 (Bull. Torr. Bot. Club, Vol. X); Strömfelt, Botaniska Notiser 1887, p. 109; Kolderup Rosenvinge, Grønlands Havalger 1893. Meddel. om Grønland III. 3, p. 794; Kuckuck, Beitr. 1897, p. 13.

As shown by Collins, Strömfelt and Kuckuck (ll. cc.), the vegetative filaments live in the chitinous walls of various Hydroids. In the Danish waters the species is most frequently found in *Sertularia pumila,* further in *Abietaria abietina* (North Sea, Skagerak and Kattegat), *Tubularia, Hydrallmania falcata* (North Sea), *Laomedea, Thujaria Thuja.* When growing in *Sertularia*, the filaments to a great extent fuse together into the membranes first described by MAGNUS. In the tubes of *Tubularia* they may for long stretches remain separate, consisting of long cylindrical cells and giving rise to numerous, often opposite, divaricate branches (fig. 331). Specimens growing in the test of *Laomedea* never fused into membranes; the filaments growing in the soft substance between the outer and the inner membrane of the wall were curled and consisting of long narrow cells, while the filaments situated near the surface were usually composed of broader and shorter cells (fig. 332). In these specimens foldings of the membrane were not observed probably owing to the soft consistence of the medium, while they are frequently met with in the filaments growing in the firmer tubes of *Sertularia* and *Tubularia*. MAGNUS (l. c. p. 67) explains these foldings as caused by the surrounding cells of the same species hindering the extension of the membranes in the places where the filaments are densely crowded. The foldings are, however, also produced when the filaments are growing separately, as f. inst. in the tubes of *Tubularia* (fig. 331), in which case the foldings must be caused by the resistance of the chitinous membrane in which they grow. As emphasised by KUCKUCK (l. c. p. 23), the penetration of the filaments into the membrane of the Hydroid must take place by means of an enzyme dissolving the chitine, but this enzyme is probably only secreted by the young cells, and the older cells are therefore only able to realise their growth by folding their walls when imbedded in chitine on all sides. As shown by KUCKUCK (1897) the cells contain several ribbon-shaped chromatophores (comp. fig. 333).

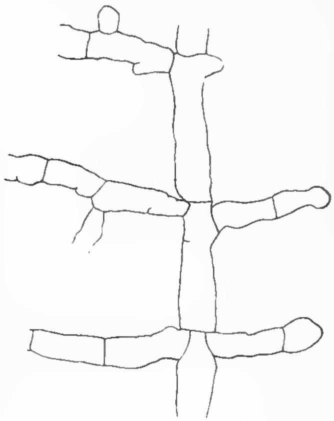


Fig. 331.
Rhodochorton membranaceum. Growing in the tube-wall of Tubularia. 310 : 1.

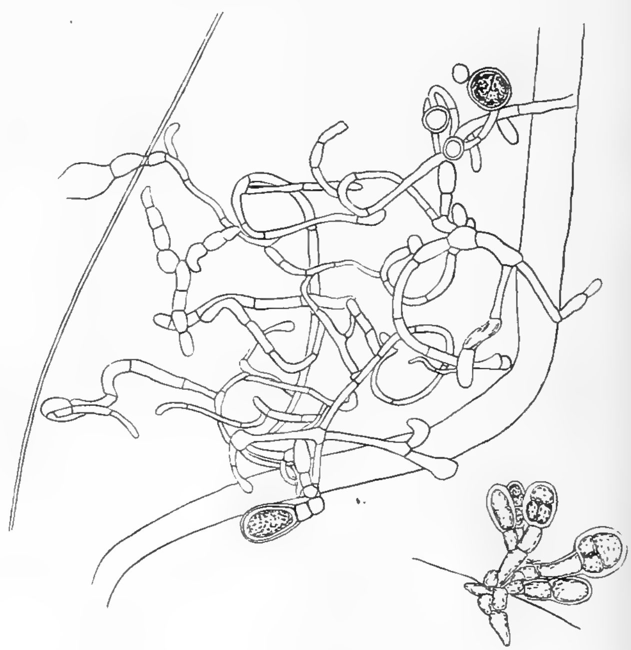


Fig. 332.
Rhodochorton membranaceum, growing in the test of Laomedea at Hirsholm. On the right a tuft of sporangiferous filaments. 310 : 1.

The free fertile filaments are always short in the specimens growing in *Sertularia pumila*, 7—8 μ

Fig. 333.
Rhodochorton membranaceum. Living cell showing chromatophores and nucleus (*n*). 675 : 1.

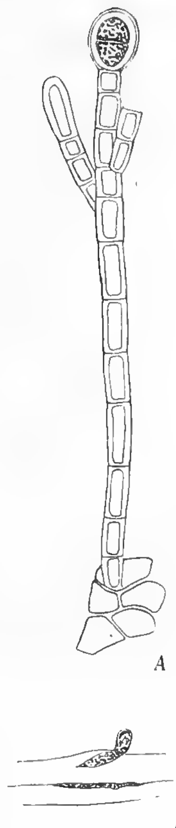


Fig. 334.
Rhodochorton membranaceum. From the North Sea, aF, growing in Abietaria abietina. *A*, portion of basal layer with a fertile branch. *B*, section of the wall of Abietaria showing the intramatrical growth of the Rhodochorton. 390 : 1.

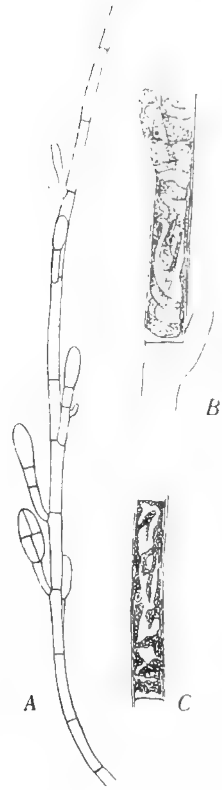


Fig. 335.
Rhodochorton membranaceum, growing in Abietaria abietina off Refsnæs. *A*, free filament with sporangia. *B* and *C*, cells showing chromatophores. *A* 230 : 1. *B*, *C* 625 : 1.

thick, frequently extremely short and unbranched, consisting of one or a small number of short cells and terminating with a sporangium. Or they may be branched, but the primary filament then always bears a terminal sporangium, and the branches also end with a sporangium (fig. 334, comp. Kuckuck, l. c. p. 16—17, fig. 2). The free filaments may behave in the same manner when the species is growing in other Hydroids; but in the plants infesting *Abietaria abietina*, the free filaments are sometimes much longer, ending in a long sterile apical cell, while the sporangia are terminal on short lateral branches or sometimes also on branches of the second order. Kuckuck has described such specimens found growing in the same Hydroid (l. c. p. 17—19, fig. 3); he concludes, in accordance with me, that they must be referred to *Rhodochorton membranaceum*, not to a special form of it. Having found similar specimens in an *Abietaria abietina* dredged at PF off Refsnæs (Sa)[1] (fig. 335), I have recently been in doubt. The sum of characters found in

[1] Similar specimens have been recently found in cL, N.E. of Sprogø.

these specimens, the free filaments emerging singly, not in bunches, the cells of these filaments being longer, the chromatophores of the long cells being sometimes partly spiral, the sporangia never being terminal on the principal filaments, give these specimens an appearance so different from those growing in *Sertularia pumila* that one is tempted to regard them as a distinct form. On the other hand, it must be admitted that the said *Abietaria abietina* covered with numerous free filaments of the described appearance bore also shorter and very short filaments with terminal sporangia, agreeing perfectly with those typical of the species. It must therefore be assumed that the species under particularly favourable conditions, which are sometimes realised when it is growing in *Abietaria abietina*, produces longer fertile filaments with longer cells and without terminal sporangia. These filaments remind one rather of *Rhodochorton chantransioides* Rke. which, as shown by Kylin (Z. Kenntnis ein. schwed. Chantransia-Arten, Botan. Stud. tilägn. Kjellman, Upsala 1906, p. 118) must be regarded as the asexual form of *Chantransia efflorescens*, an opinion which I have supported in 1909 (Mar. Alg. D. I, p. 137). Monosporangia were, however, not found in the form growing in *Abietaria abietina*, and the free filaments of this plant differed otherwise by greater thickness (6,5—8 μ), by the shape of the chromatophores being only exceptionally and partly spiral and by the tetrasporangia being larger, 25—30 μ long, 12—17 μ broad.

The sporangia in the specimens growing in *Sertularia pumila* were 17—21 (25) μ long, (11) 13—15,5 μ broad; in those growing in *Sertularia pumila* and *Tubularia* they were 17—30 (31) μ long, 12—19 (20) μ broad. The fact that the size of the sporangia is rather variable in the same specimen suggests that the sporangia increase in size after division.

Kuckuck found as a rare case a hyaline hair, like those common in *Acrochætium* (l. c. p. 17, fig. 2E). I never observed these organs.

The great resemblance with *Acrochætium efflorescens* suggests that the species might perhaps be referred to the genus *Acrochætium*.

A sponge dredged in Skagerak off Hirshals (possibly *Chalina oculata*) showed some purple spots, the largest abt. $1^1/_2$ cm long. These spots are due to an alga growing in the chitinous skeleton in a similar manner to *Rhodochorton* in the hydroids, and probably identical with this species. They consist of branched filaments, mostly running immediately under the surface, but also deeper, partly distinct, partly fusing together in parenchymatous plates. Some cells showed foldings of the walls. Free filaments were not found, only numerous short round protuberances, probably checked rudiments of free filaments. For want of fructification a conclusive determination is not possible.

The species has been found in all the Danish waters with the exception of the inner parts of the Baltic, from low-water mark to 38 meters' depth. It has been found with sporangia in all depths and in all seasons: in the specimens growing in *Abietaria* collected in September and October in the North Sea and Skagerak, the sporangia were, however, thrown off. In small depth it occurs only in shaded places, particularly in *Sertularia* growing on the older parts of *Fucus* (*serratus*).

Localities. **Ns:** aF, off Thyborøn 14½ miles, 31 met. in Abietaria abietina[1]; aG, off Thyborøn 19½ miles, 38 met., in Hydrallmania falcata; dZ, 17 miles W. ¾ N. of Lodbjerg light-house, 36 m; eQ, 27 m; eO, 23 m, in Abietaria abiet. and Hydrallmania falc.; aD, off Lodbjerg, 23,5 m; XR, off Ørhage. — **Sk:** eV, 6 miles N. by E. of Hanstholm light-house, 22 m, in Thujaria Thuja; off Hirshals in Abiet. ab. (Børgesen, !). — **Lf:** ZS, off Kobberød; XU, W. of Oddesund. — **Kn:** Various places near Hirsholm, partly in Laomedea; KC, Krageskovs Rev; Frederikshavn; Marens Rev. — **Ke:** IQ, Fladen, in Abiet. ab.; EV, Groves Flak; ER, Fyrbanken, east of Anholt, 28 m; HY, store Middelgrund. — **Km:** XF, Læsø Rende; bK, N.W. of Anholt, 15 m, in Tubularia; BK, Tangen; BH, off Gjerrild Klint, in Tubularia. **Ks:** OU, Schultz's Grund; GF, Sjællands Rev; D, grønne Revle; EI, entrance to Isefjord: Lammefjord. — **Sa:** Bjarkes Grund; PC, between Sejerø and Ordrups Næs; PF, off Refsnæs, 18—21 m, on Abiet. abiet. (long free filaments); MP, Falske Bolsax. — **Lb:** Bjørnsknude by Vejlefjord; near Damgaard, 13 m, in Tubularia; Linderum, dG, Hesteskoen, N.E. of Als. — **Sb:** GS, Lysegrundene; LK, Elefantgrund; Kjerteminde; between Korsør and Sprogø, "22—32 fathoms" (Magnus 1872); cL, N.E, of Sprogø, 25—27 m, in Abietaria abietina; DN, Vengeance Grund; UF, Hov Sand; Lohals; Spodsbjerg. — **Su:** BQ, off Ellekilde; SB, Flinterenden. — **Bw:** LE and UY, Vejsnæs Flak.

General remarks on the Ceramiaceæ.

Referring the reader to the quoted works of Schmitz and Hauptfleisch and Oltmanns for the general morphology and biology of the Ceramiaceæ, I shall here only advance some remarks on some special subjects, based upon observations of the Danish species.

1. **Number of nuclei.** The cells in the majority of the species contain a single nucleus. In *Callithamnion corymbosum* the young cells contain a single nucleus, but at a certain distance from the top the nuclei divide without a subsequent cell-division, and by continued divisions of the nuclei the old cells become multinucleate, the nuclei being uniformly distributed over the cell. The same takes place in *Callithamnion tetragonum*, but the said division of the nuclei begins earlier and may occur already in the apical cell, which often contains two nuclei in a resting stage before any sign of cell-division is to be seen. In both species the downward growing cortical filaments consist from the first of multinucleate cells. In *Spermothamnion repens* all the cells contain several nuclei, also the apical cells and the mother-cells of the branches. On the other hand the reproductive cells contain from the first one nucleus only. As far as I have ascertained, this is not realized by degeneration of nuclei in an originally multinucleate cell but so that the divisions of the nuclei do not keep pace with the cell-divisions at the transition from the vegetative to the fertile phase, in consequence of which the number of nuclei in the cells diminishes and is finally one in the young fertile cells.

[1] When no host is indicated the plant was found in *Sertularia pumila*.

2. **Cell-fusions.** Secondary pits in the cell-walls have not been observed in any of the Danish species of Ceramiaceæ. Cell-fusions like those occurring in many Cryptonemiales (comp. part II p. 279) have only been met with in *Rhodochorton penicilliforme*, where they take place between cells belonging to different rows in the basal disc. I have further in a single specimen of *Callithamnion Furcellariæ* met with a few cases of fusion between two contiguous cells of the same filament, consequently between cells which were before connected by a central pit in the transversal wall (fig. 264). As this sort of fusion was only observed in one specimen, it must certainly be regarded as an abnormal process.

3. **Hyaline unicellular hairs** (comp. K. R. 1911) occur normally in almost all the species of *Ceramium*, in *Callithamnion Brodiæi* and *C. corymbosum*; they are only wanting in winter when the growth has ceased. They occur often in *Plumaria elegans*, sometimes in *Spermothamnion repens* and *Callithamnion Furcellariæ*, rarely in *C. roseum* and *Seirospora Griffithsiana*, never in *Trailliella intricata*, *Callithamnion Hookeri* and *C. tetragonum*, further in the species of *Antithamnion* and *Rhodochorton*.[1] In *Ptilota plumosa* they occur only at the ends of the branches which surround the procarps.

4. **The number of the auxiliary cells** is usually constant. In *Callithamnion* there are normally two, one on each side of the carpogonial branch. In *C. Furcellariæ* and *C. roseum*, however, there is often only one auxiliary mother-cell, namely that which gives rise to the carpogonial branch.

5. **The sporangia** are lateral, sessile, or terminal on short branchlets. In *C. Hookeri* only have I as a rare exception found intercalary sporangia. In *Trailliella intricata* the sporangia are cut off by longitudinal division of the ordinary cells, a mode of formation which is not known in any other filamentous Ceramiaceæ; it is, however, doubtful, whether *Trailliella* belongs really to this family. The sporangia are usually 4-parted. 2-parted sporangia occur in *Callithamnion Furcellariæ* and *Seirospora Griffithsiana* besides 4-parted, but in different plants. In the last-named species, however, a small number of tetrasporangia were met with on a plant with disporangia.

The division of the tetrasporangia is either rectangular or tetrahedrical ("triangular"). In *Antithamnion*, *Rhodochorton* and *Trailliella* the sporangium is first divided by a transversal wall in two cells which afterwards are divided by vertical walls, perpendicular to the first wall. In the greater part of the Danish Ceramiaceæ (*Spermothamnion*, *Callithamnion*, *Seirospora*, *Plumaria*, *Ptilota*) the division is tetrahedrical, the sporangium after the quadripartition of the nucleus being divided by six walls meeting in the centre of the sporangium. In *Ceramium* the division is variable, now triangular, now rectangular, and the two modes of division may occur in one and the same species; but, as shown above, the division of the cell begins only after the accomplishment of the nuclear division, and the rectangular division in Ceramium is thus a true quadripartition, while that in the three first-named genera is established by two consecutive bipartitions.

[1] Kuckuck once met with a hyaline hair in *Rhodochorton membranaceum* (1897, p. 17).

Sporangia containing more than four spores were met with as rare exceptions in *Spermothamnion repens* and *Seirospora Griffithsiana*.

6. **Paraspores** have been met with in the following species occurring in the Danish waters: *Callithamnion Hookeri, Plumaria elegans, Seirospora Griffithsiana, Ceramium diaphanum, C. strictum, C. Deslongchampsii, C. vertebrale.* According to SCHMITZ and SCHILLER (1913) they occur in the Mediterranean also in *Antithamnion Plumula*.

Paraspores are never produced in sexual plants. The paraspore-bearing plants often bear only these organs, but in all the species in question tetrasporangia are sometimes produced by the same plants, most frequently in the *Ceramium*-species. In *Antithamnion Plumula* SCHILLER found at Triest paraspores in numerous plants which all bore tetrasporangia too. This author tries to show that the paraspores in the *Ceramiaceæ* must be interpreted as modified tetrasporangia, relying on the fact that they always occur on tetrasporiferous plants and that they often have the same position as the tetrasporangia. This interpretation is certainly warranted for the polysporangia in *Pleonosporium* which wants typical tetrasporangia, but it cannot be accepted for the true paraspores here in question. The paraspores are at their first appearance decidedly different from tetrasporangia. Whereas the latter have an especial form and early show a firm two-layered cell-wall, the shape of the young heap of paraspores is more indefinite, they have a homogeneous more soft wall and the content in an early stage is not more coloured than the vegetative cells, in *Plumaria* even decidedly less coloured, while the young sporangia are deeper coloured than the vegetative cells. Further, the position of the paraspores is not always the same as that of the tetrasporangia, in particular in *Ceramium* which is also admitted by SCHILLER (1913 p. 149). According to this author two sorts of "paraspores" occur in Ceramium 1° polyspores and 2° true paraspores. The first named organs are produced in the cortical bands, e. g. in *C. strictum* and *C. Deslongchampsii* and according to SCHILLER arise from "eine mit einer Tetrasporangienmutterzelle identische Zelle" l. c. p. 11). I have not observed these organs that seem to be similar to the polyspores in *Pleonosporium*. The second sort of paraspores develop in a quite different manner. In *C. strictum*[1] described by SCHILLER they arise at the tips of the branches, all the young cells, even the central cells, being transformed into paraspores. In *C. diaphanum* and *C. strictum* from the Danish waters the paraspores arise, as shown by HENN. PETERSEN, only from the peripheral cells in the cortical bands, most frequently near the upper edge of the bands, often from the marginal cells (HENN. PETERSEN 1908 p. 52, 57, figs. II, IV, comp. my fig. 313). When SCHILLER, in order to show the derivation of the paraspores in *C. strictum* from the tetrasporangia, only adduces the facts that they only occur in the tetraspore-bearing plants, and that the tetraspore-formation decreases in the same degree as the paraspore-formation increases, it must be said that this proof is quite insufficient. The fact that

[1] SCHILLER's *C. strictum* is certainly not the true *C. strictum* Grev. et Harvey. Dr. HENN. PETERSEN thinks that it is rather a form of *C. diaphanum*.

the paraspores only arise in the tetraspore-bearing plants is probably connected with their number of chromosomes. Their nuclei are undoubtedly diploid, and it must be expected that they always give rise to tetraspore-bearing plants. It is in that respect interesting that in all the paraspore-producing species sexual individuals are either entirely wanting or extremely rare (*Ceramium*) in the Danish waters. And the fact that their development is in inverse proportion to that of the tetrasporangia is certainly the expression of a correlation similar to that existing in numerous Hepaticæ, Musci and many other plants between the sexual reproduction and the asexual propagation.

7. **The occurrence of sexual organs and tetrasporangia in the same plant** has been ascertained in several species in the Danish waters. It is a particularly common appearance in *Spermothamnion repens*, where the sexual organs almost always occur together with sporangia. In *Callithamnion tetragonum* too the antheridia and the procarps occur frequently in the tetraspore-bearing plants. In 1864 and 1878 Thuret described a f. *amphicarpa* of *C. corymbosum* presenting the same combination but this form has not been observed in the Danish waters. In *C. Furcellariæ* I have once met with a procarp in a tetraspore-bearing plant, and in *Antithamnion Plumula* tetrasporangia were twice met with in a female plant. In *Antithamnion boreale* and *Rhodochorton penicilliforme* antheridia were detected, occurring in tetraspore-bearing plants, while female sex organs are still unknown.

8. **Occurrence of the various organs of reproduction in the Danish waters.** Sexual organs have not been met with in *Callithamnion Hookeri*, *Seirospora Griffithsiana*, *Plumaria elegans* and *Antithamnion cruciatum*, while sexual plants of these species occur elsewhere. The three first-named species propagate in the Danish waters principally by paraspores, but tetraspores have been met with in all of them. In *Antithamnion cruciatum* sexual organs seem altogether to be a rare occurrence. Sexual plants of *Spermothamnion repens* occur only in the North Sea, the Skagerak, the Kattegat and the northern part of the Sound while the species in the inner waters only bears tetrasporangia or is sterile. In *Ceramium diaphanum*, *C. strictum*, *C. Rosenvingii*, *C. Boergesenii* and *Antithamnion Plumula* the sexual plants are much rarer than the tetraspore-bearing ones. Of *Callithamnion corymbosum* only sterile plants have been met with in the inner parts of the area of the species (**Sm**, **Su** south of Hveen, Baltic).

9. **Vegetative propagation** occurs in *Rhodochorton Rothii*, fragments of the erect shoots loosening and producing from the plane of detachment a downward growing filament which is able to fix the fragment as a cutting to a new substratum. Similar cuttings were observed in a culture of *Seirospora Griffithsiana*.

Fam. 12. Bonnemaisoniaceæ.

Bonnemaisonia C. Agardh.

1. Bonnemaisonia asparagoides (Woodw.) Agardh.

C. Agardh, Spec. Algar. 1821, p. 197; Harvey, Phycol. Brit. I, 1846, pl. 51; J. Agardh, Spec. g. o. Alg. II, pars III, 1863, p. 779; Cramer, Physiol.-system. Unters. üb. die Ceramiaceen. Neue Denkschr. d. allg. schweiz. Ges. f. Naturw. 20. Zürich 1864, p. 52, Taf. VIII, figs. 4—11, X, figs. 1—12; Kützing, Tab. phyc. 15. Band, Taf. 32, 1865; Wille, Beitr. z. Entwick. d. phys. Gew. b. ein. Florideen. Nova Acta Leop.-Carol. Akad. 1887, p. 73, figs. 44—54; Golenkin, Algologische Notizen. Bull. soc. nat. de Moscou, N. S. VIII, 1894, p. 257; Bruns, Ber. deut. bot. Ges. 12, 1894, p. 179; Phillips, Developm. of the cystocarp in Rhodymeniales. Ann. of Botany, Vol. XI, 1897, p. 348, pl. 17 figs. 1—3; Kylin, Blasenzellen einig. Florid., Arkiv för Botanik. Bd. 14 No. 5, 1915; id., Entwicklungsgesch. u. syst. Stell. von Bonnemaisonia asparagoides. Zeitschr. f. Botanik VIII, 1916, p. 545; id., Über die Keimung der Florideensporen. Arkiv för Botanik, Bd. 14, No. 22, 1817, p. 12.

Fucus Asparagoides Woodward, Trans. Linn. Soc. Vol. II p. 29, 1794.

The structure and development of the alternately pinnate frond has been described by Cramer, Wille and Kylin (1916). Golenkin, Bruns and Kylin (1915) have described peculiar gland cells situated among the cortical cells and containing a compound of iodine which is easily decomposed, producing free iodine. I have also observed, many years ago, the power of the species of giving a blue stain to paper. — According to Kylin (1916, p. 549), rather short unicellular hairs may occur sparingly.

Tetrasporangia are wanting; all specimens are monoecious sexual plants. The sexual branchlets are alternate, opposite to the alternate sterile pinnulæ. The antheridia are produced on the surface of the oval male branchlets (Kylin 1916, p. 551). The carpogonial branches develop singly on the female branches. Their development and that of the cystocarps has been followed by Kylin (1916) who has found that it most resembles that of *Wrangelia* and *Naccaria*. Oltmanns and Kylin think that this group of genera makes transition from the *Nemalionales* to the *Cryptonemiales* and the *Gigartinales*. The germination takes place, as shown by Golenkin and Kylin (1917), by the formation of a basal disc, from the margin of which numerous rhizoids are given off. The formation of the erect shoots were not observed. As emphasised by Kylin, this mode of germination is very different from that of the *Rhodomelaceæ* to which the *Bonnemaisoniaceæ* have been considered related.

The species is annual. It has only been found rarely in a few localities in the northern and eastern Kattegat, in 18 to 24,5 meters depth, growing on various Algæ (*Delesseria sanguinea, Polysiphonia elongata, Laminaria saccharina*). The largest specimen observed (from Herthas Flak) was 13 cm long. Collected with ripe cystocarps in July and September.

Localities. **Kn:** Herthas Flak (!, Børgesen). — **Ke:** VZ, Groves Flak, VY, Fladen.

Fam. 13. Rhodomelaceæ.

J. G. AGARDH (1863), Species, genera et ordines Floridearum. Vol. II pars 3.

LILY BATTEN (1923), The Genus Polysiphonia, Grev., a critical revision of the British species based upon anatomy. The Journal of the Linnean Society. Vol. 46 No. 308.

P. FALKENBERG (1901), Die Rhodomelaceen des Golfes von Neapel. Fauna und Flora des Golfes von Neapel. 25. Monographie. Berlin.

L. KNY (1873), Ueber Axillarknospen bei Florideen. Festschr. z. Feier d. hundertj. Best. d. Ges. d. naturf. Freunde zu Berlin.

L. KOLDERUP ROSENVINGE (1884), Bidrag til Polysiphonia's Morfologi. (Résumé français). Botan. Tidsskr. Bind 14.

—, (1902), Ueber die Spiralstellungen der Rhodomelaceen. Jahrb. für wiss. Bot. Bd. 37.

—, (1903), Sur les organes piliformes des Rhodomelacées. Overs. K. Danske Vidensk. Selsk. Forh. København.

C. NÄGELI (1846), Polysiphonia. Zeitschrift für wiss. Botanik von Schleiden und Nägeli. 3. u. 4. Heft. Zürich.

R. W. PHILLIPS (1896), Development of the Cystocarp in the Rhodomelaceae. II. Annals of Botany X.

Fr. SCHMITZ und P. FALKENBERG (1897), Rhodomelaceae. Engler u. Prantl, Die natürl. Pflanzenfam. I, 2.

S. YAMANOUCHI (1906), The life-history of Polysiphonia violacea. Botan. Gazette, Vol. 42 p. 401—449, plates 19—28.

See further p. 297.

Heterosiphonia Mont.

1. **Heterosiphonia plumosa** (Ellis) Batters.

Batters, Catalogue of Brit. Mar. Algæ. 1902, p. 83.

Conferva plumosa Ellis, Philosoph. Transact. Vol. 57, 1768, p. 424, Tab. 18, fig. c, d.

Conferva coccinea Hudson, Fl. angl. Ed. 2, 1878, p. 603.

Callithamnion coccineum Lyngbye, Tent., 1819, p. 144.

Dasay coccinea Agardh, Spec. Alg. II, 1828, p. 119; Flora Danica tab. 2456 (1845) (f. tenuis); Harvey, Phyc. Brit. III, 1851, pl. 253; Areschoug, 1850, p. 42; J. Agardh, 1863, p. 1185; Kny, 1873, p. 108, Taf. II Fig. 7; Janczewski, Dév. du cystoc. d. l. Florid. Mém. Cherbourg, Vol. XX, 1877, p. 129, pl. 4, figs. 19—21, pl. V, figs. 1—8; Buffham, Reprod. Organs, espec. Anther., Journ. Queck. micr. Club, Vol. III Ser. II 1888, p. 263, pl. XXII, figs. 19—20; Phillips, 1896, p. 187, pl. XII figs. 1—7.

Trichothamnion hirsutum Kütz., Tab. phyc. 14, tab. 90.

Heterosiphonia coccinea Falkenberg, 1901, p. 648, Taf. 18 Fig. 21; Kylin, 1907, p. 149.

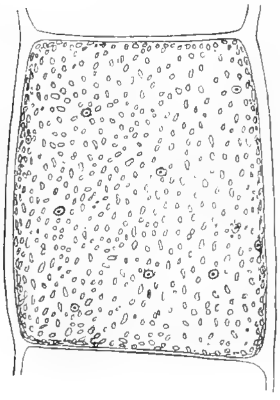


Fig. 336. *Heterosiphonia plumosa.* Cell showing chromatophores and nuclei. 350 : 1.

The structure and development of the frond have been described by KNY (1873) who first recognised the sympodial character of the ramification. The cells of the monosiphonous pinnules contain a number of small nuclei and numerous minute chromatophores (fig. 336).

The Danish specimens generally agree with *β, tenuis* J. Agardh, l. c. The older stems are usually naked, sometimes, however, beset with numerous adventitious branchlets.

As shown by BATTERS, l. c., the antheridia form a covering on the monosiphonous branches with the exception of the two or three basal and the four to six terminal cells which remain undivided. The antheridia (spermatangia) are not produced directly from the central cell, as asserted by BUFFHAM, but from a layer of small cells surrounding the central cell and budding the spermatangia on their outer face (fig. 337 *B*).

As regards the development and structure of the cystocarps, reference may be made to the papers quoted of JANCZEWSKI and PHILLIPS. The procarps are usually borne on the fourth joint from the sympodial axis (PHILLIPS), from the last joint of the pushed aside main axis which in sterile plants becomes polysiphonous (FALKENBERG). The spores of the gonimoblast are seriate.

The tetrasporangia are produced in distinct stichidia arising in the upper part of the sympodia; their structure has been described by FALKENBERG (l. c. p. 649).

The Danish specimens only reach a length of 10 cm. They were found growing on stony bottom in 13 to 31 meters' depth, attached to stones or to *Delesseria sinuosa* or *Furcellaria*. It was dredged in July to September. Antheridia and tetrasporangia were found in August, young cystocarps in July.

Localities. **Ns:** aF, off Thyborøn, 14,5 miles, 31 meters. — **Sk:** ZK[7], off Lønstrup, 4 miles, 17—19 m; YL, N.W. of Hirshals, 2,5 miles, 13 met. and deeper. — **Kn:** TO, Tønneberg Banke, north of Trindelen, 18 m; FF, Trindelen, 15 m. — **Ke:** ZG, Fladen, 18 m. — **Su:** Øresund, "in the deeper region of Algæ" (Lönnberg, Undersökn. rör. Öresunds djurlif, Uppsala 1898).

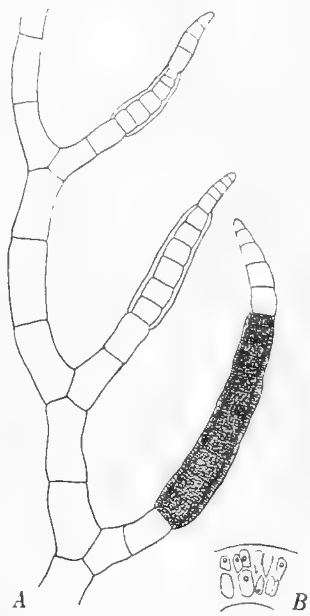


Fig. 337.
Heterosiphonia plumosa. *A*, part of male plant. 63 : 1. *B*, transverse section of antheridial covering. 625 : 1.

Laurencia Lamouroux.

1. Laurencia pinnatifida (Gmel.) Lamouroux.

Lamouroux, Essai des Thalass.. Ann. du Mus. XX, 1813 p. 130; Greville Alg. Brit. 1830 p. 108 tab. 14 figs. 1—5; Harvey Phyc. Brit. pl. 55, 1846; J. Agardh 1863 p. 764; Kützing Tab. phyc. XV, 1865 tab. 66; Kolkwitz, Beitr. Biol. Flor., Wiss. Meersunters. N. F. IV Abt. Helgoland Heft 1, 1900, p. 52; Falkenberg 1901 p. 248, Taf. 23 figs. 20—36; Kylin 1907 p. 138; id. 1917 p. 20; id. 1923 p. 123.
Fucus pinnatifidus Gmelin Historia Fucorum 1768, p. 156 tab. 16 fig. 3; Hornemann, Flora Danica tab. 1478, 1813; Smith, English Botany Vol. VII pl. 1202, 1808.
Fucus ramosissimus etc. Oeder Flor. Dan. tab. 276, 1765.
Gelidium pinnatifidum Lyngbye Tent. 1819 p. 40 tab. 9 C.

As regards the basal part of the frond strange discrepancies exist between the statements of the various authors. SMITH (Engl. Bot. 1808) and J. AGARDH describe it as a branched "root" ("radix fibrosa"). TURNER (1808) describes it thus: Root a flat disk throwing out a few creeping fibres. GREVILLE (1830) and HARVEY describe it in a similar way; the figure of HARVEY shows cylindrical feebly branched creeping organs radiating from the base of the stem while the disc is not distinctly visible. According to LYNGBYE (1819) the basal part is a "callus explanatus, fibris brevibus interdum instructa". KOLKWITZ found at Helgoland an extensive basal disc producing a number of distant erect shoots (1900 p. 52, fig. 6), but he does not mention any creeping shoots. In Danish specimens I found no creeping root-like organs but only a flat basal disc becoming thinner towards the border which has an even outline. This disc may sometimes have a considerable extension and produce numerous erect shoots (fig. 338). It is early formed in the sporeling; in the young plant represented in fig. 338 *A* it has increased considerably in circumference and has produced four new shoots. These arise from superficial cells.

Fig. 338.
Laurencia pinnatifida. *A*, young plant gathered in September (Frederikshavn). 18 : 1. *B*, Basal disc growing on Fucus serratus, with numerous erect shoots (Hirshals June). 3 : 1.

The development of the erect shoots has been thoroughly studied by FALKENBERG and KYLIN. The growing point sunk in the apical groove of the shoot produces spirally arranged trichoblasts while the lateral branches, according to FALKENBERG arise as axillary shoots of the trichoblasts, but only of those which are placed in two longitudinal rows whereby the pinnate ramification and the compressed form of the frond arise. FALKENBERG found the trichoblasts well developed only in cystocarp-bearing specimens having ceased to grow in length and to branch. According to KYLIN they are well developed during the development of the organs of reproduction, while they are very small during the vegetative development of the plant. I found them well developed and visible outside the apical groove in the specimens gathered in July to September; they were not visible externally in the specimens collected in winter and spring, and in the specimens collected in May and June they were in several cases long, in other cases not visible outside. The long trichoblasts were found both in sterile and fertile specimens (fig. 338 *A*).

The antheridia are borne on cylindrical fertile trichoblasts closely placed in cup-shaped bodies near the tips of the shoots. These trichoblasts which cover the whole surface of the cup are much more numerous than the trichoblasts produced by the growing point in the centre of the cup and FALKENBERG therefore suggests "dass hier eine verkümmerte und verkannte oder normale Achselspross-Bildung vorliegt". The development of the antheridia has been recently described by KYLIN.

The procarps arise as in the other *Rhodomelaceæ* from the second segment of the trichoblasts; they are developed in trichoblasts of various position, and the cystocarps are therefore placed on the edges and on the flat sides of the frond as well. The development of the procarps and the cystocarps has been carefully studied by KYLIN (1923, pp. 125—129). In the ripe cystocarp the wall consists only of three or four cell-layers, the innermost ones being disorganised and transformed into a tough mucilage (FALKENBERG p. 246, pl. 23 figs. 20—21, KYLIN p. 128 fig. 80 d).

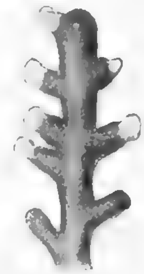


Fig. 339. *Laurencia pinnatifida.* Portion of frond gathered in April; the branches have recommenced growing. 3,5 : 1.

The tetrasporangia are immersed in the cortical layer of the upper ends of the frond; according to KYLIN (1923 p. 130) they arise from young cortical cells by divisions similar to those by which the sporangia arise in the pericentral cells of *Polysiphonia.*

The germination of the tetraspores has been examined by KYLIN (1917) who showed that a pluricellular basal disc is early developed. The young disc is composed of connate radiating filaments, it increases in diameter by marginal growth and early begins to produce new erect shoots by budding from the surface. The new shoots resemble the primary one (fig. 338 *A*).

The species has been met with in all the seasons. It occurs at low-water mark or a little deeper, down to 6,5 meters' depth. It grows most frequently on *Fucus vesiculosus* and *F. serratus,* further on stones and more rarely on *Chorda Filum* a. o. algæ (*Chondrus crispus, Furcellaria, Cystoclonium,* and the blade of *Laminaria digitata*). It usually attains a length of 2 to 5 cm, more rarely up to 7 cm. The fructification takes place in summer. Antheridia have been met with in May and June, cystocarps in May to September, in the last month partly empty, and tetrasporangia in May (unripe) to August.

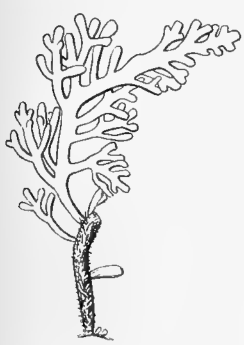


Fig. 340. *Laurencia pinnatifida.* Limfjord July. The largest new frond has reached its full size; the old frond is darker, covered with epiphytes. 1,3 : 1.

According to GREVILLE and HARVEY, the species is annual, and it may certainly frequently be so also at the Danish coasts. Young plants are to be found in summer and autumn, July to September (fig. 338 *A*); they produce a number of erect shoots which remain sterile in autumn and winter and at the end of the winter attain a length of 3—5 cm. In winter the growth ceases but it recommences at the end of the winter. In March and April the new-formed tips of the frond are easily recognised and sharply limited against the old frond, but only about 1 mm long (fig. 339). In summer the new shoots have reached their full size and are distinguished from the old frond by the colour and by the want of epiphytes (fig. 340). The fertile erect fronds probably die in autumn, but the basal disc seems to be able to continue the development, growing at the margin and producing new erect fronds fructifying next year. Thus, the basal disc shown in fig. 338 *B,* collected in June, is probably more than one year old.

The species occurs in the Danish waters with rather high salinity but requires protected localities. It occurs most abundantly and most well developed in the Limfjord, undoubtedly owing to the high salinity and the high summer temperature; in some stony reefs in the Løgstør Bredning it was found to be the characterising species. The specimens growing in very sunny localities are yellow, owing to yellow cell-sap in the outer cortical cells, while the specimens growing in shady places are red-brown.

Localities. — **Sk:** Nørre Lyngby north of Løkken, washed ashore (Ove Paulsen); Hirshals, on stones west of the mole, under Fucus vesic. and serr., and on Fuc. serr. (fig. 338 *B*). — **Lf:** ZS, Nissum Bredning, off Kobberød, Rønnen and Søndre Røn by Lemvig; Malle (J. P. Jacobsen) and MG, off Hanklit in Thisted Bredning; Sallingsund, east side of Ørodde by Nykøbing and further north and south of Nykøbing; off Grønnerup; Knudshoved, Fur; off Lisehøj north coast of Fur; Ejerslev Røn, Amtoft Rev, Holmtunge Hage and Lendrup Røn in Løgstør Bredning. — **Kn:** Hirsholm (Hornemann, !) Kölpen, Deget and Busserev by Frederikshavn; Nordre Rønner; UB and ZL south-east of Nordre Rønner, 6,5 met.; stony reef by Jegens Odde. — **Km:** ZC, Kobbergrund, 4—4,5 m; Boels Rev between Randers Fjord and Mariager Fjord. — **Sa:** Rønnen in Begtrup Vig; Kalø Rev; Hofmansgave (Lyngbye, Hofm. Bang, Car. Rosenberg).

Chondria Agardh (Harvey).

1. Chondria dasyphylla (Woodw.) Agardh.

C. A. Agardh, Spec. Algar. Vol. I pars post. 1822, p. 350; Falkenberg, 1901, p. 197, Taf. 22, figs. 4—18.
Fucus dasyphyllus Woodward, Trans. Linn. Soc. Vol. 2, 1794, p. 239 tab. 23.
Laurencia dasyphylla Greville, Alg. Brit., 1830, p. 112, pl. 14, figs. 13—17; Harvey Manual, 1841, p. 70, Phyc. Brit. II, 1849, pl. 152; Kützing, Phyc. gener. 1843, Taf. 55 II, Tab. phyc. 15. Band, 1861, Tab. 43.
Chondriopsis dasyphylla J. Agardh, 1863, p. 809.

The morphology of the frond and of the reproductive organs have been exhaustively treated by Falkenberg to whose work reference may be made. The plant forms tufts, several erect shoots issuing from the base; these shoots are 10—11 cm high. It was found growing near land in a depth of 1 meter or a little deeper. All the 29 specimens collected by me in August bore ripe tetrasporangia. One specimen only collected by J. P. Jacobsen bore cystocarps.

Localities. **Ns:** "Vesterhavet ved Thy" (J. P. Jacobsen). — **Sk:** Løkken, washed ashore; Hirshals, on stones east of the mole, in company with Gracilaria confervoides, Polysiphonia nigrescens, Ceramium rubrum a. o.; west side of Hirshals, August.

Polysiphonia Greville.

1. Polysiphonia urceolata (Dillw.) Grev.

Greville, Flora Edinensis 1824 p. 309; Harvey Phyc. Brit. II, 1849 pl. 167; J. Agardh 1863 p. 970; Kützing Tab. phyc. Bd. 13 1863 Taf. 92; Kolderup Rosenvinge 1884 p. 24 (rés. p. 4) fig. 32; Buffham 1893 p. 298; Falkenberg 1901 p. 150; Kolderup Rosenvinge 1902 p. 347 pl. VI figs. 3—14; id. 1903 p. 449 figs. 2—3; Kylin 1907 p. 139; F. Tobler, Weitere Beitr. z. K. d. Florideenkeimlinge. Beih. z. Bot. Centralbl. Bd. 21 Abt. 1, 1917 Taf. 7 figs. 15—20.

Conferva urceolata Dillwyn Brit. Conf. p. 82, plate G (The name is originally due to Lightfoot).
Hutchinsia urceolata Lyngbye Hydr. 1819 p. 110 pl. 34.
Hutchinsia stricta Ag., Lyngbye Hydr. p, 115 pl. 36 (e specim.)
Hutchinsia lepadicola Lyngbye Hydr. p. 113 pl. 35, c; Flora Dan. tab. 2313, 1840.
Hutchinsia roseola C. Agardh Sp. Alg. p. 92.
Polysiphonia formosa Suhr, Flora 1831; Harvey Phyc. Brit. II, pl. 168, 1849; Kützing Tab. phyc. Bd. 13 tab. 78, 1.
Polysiphonia pulvinata Flora Dan. tab. 2458. 1845 (?).
Polysiphonia roseola (Ag.) Areschoug Phyc. 1850 p. 59.
Polysiphonia lepadicola (Lyngb.) Kützing Sp. Alg. 1849 p. 807; Liebman, Kröy. Tidsskr. II Hefte 5 1839, p. 478; J. Agardh 1863 p. 945.
Hutchinsia abyssina Lyngbye Rariora Codana (ed. Warming) 1880, Vidsk. Medd. fra Naturh. Foren. 1879—80 p. 227.

The primary shoot of the seedling is erect but a lateral shoot is early produced at its base (fig. 341, comp. Tobler fig. 19) or sometimes two. Creeping branches appear later and form a system of procumbent shoots attached to the substratum by scattered rhizoids and giving rise to a great number of erect shoots forming a dense tuft. The procumbent branches are often very short-celled, the articles being much broader than long (fig. 342) while in other cases the articles are of equal length or a little longer than broad (fig. 343). The growing end of the decumbent branches usually grows upwards at last and becomes an erect shoot, but the procumbent filaments may remain creeping for a long time, in particular in the f. *lepadicola*,

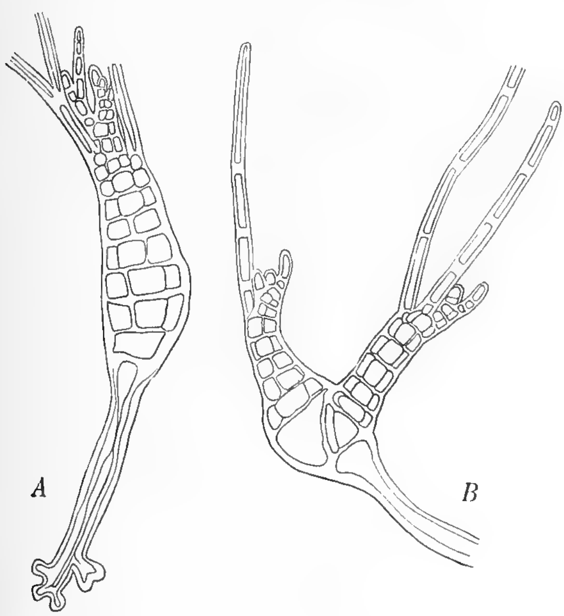


Fig. 341.
Polysiphonia urceolata. Sporelings, 9 days old. In *A* the trichoblasts are arranged in a spiral turning to the right. 227 : 1.

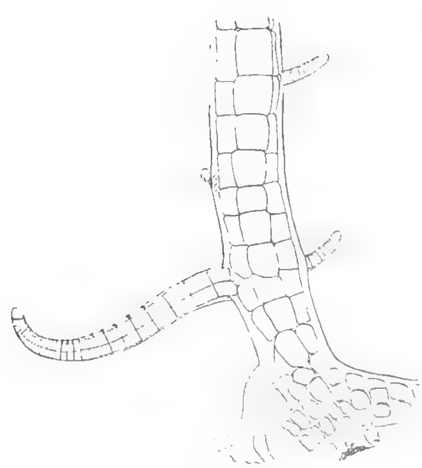


Fig. 342.
Polysiphonia urceolata. Lower part of an erect branch issuing from a procumbent branch. 95 : 1.

where erect shoots may be entirely wanting. The procumbent and erect shoots issuing from a procumbent one are always of endogenous origin, budding from the central cell, usually very near to the rhizoids (fig. 343). Endogenous branches also frequently arise from the lower part of the erect shoots (fig. 342). The rhizoids which always arise from the pericentral cells, except the first rhizoid of the sporeling, sometimes obviously testify to a shortening, the cuticle being transversely wrinkled (fig. 343).

FALKENBERG has maintained that *P. urceolata* lacks trichoblasts (1901 p. 151). As shown by me (1903, p. 450), this may be true but only in autumn and winter, when the development of the plant has ceased, while the specimens collected in the months of March to June are normally provided with trichoblasts, and these organs may still be present in July and August. In the creeping branches, however, they

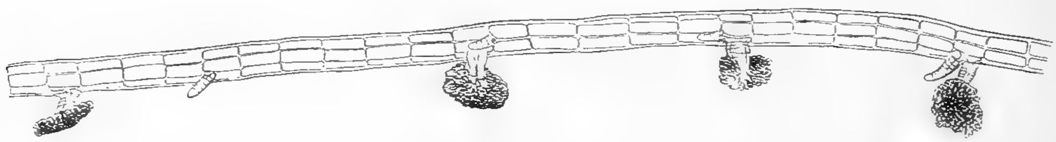


Fig. 343.
Polysiphonia urceolata. Procumbent branch with rhizoids and endogenous branches. 50 : 1.

are always wanting. The trichoblasts show the typical structure, having the first branchlet always on the right side (fig. 346); their cells contain one nucleus and small plastids which are usually colourless but may be feebly rose-coloured in early spring or in shaded localities. They are arranged in a spiral turning to the left[1] but are usually separated from each other by more than one joint. The branches occur in the spirals in the place of the trichoblasts, but the relation of frequency of the two kinds of organs to each other is very variable. The erect shoots often over a long stretch only bear branches arranged in a spiral with a divergence of $^1/_4$ separated from each other by 3 to 5 joints, and the trichoblasts appear only at the upper end of the shoot intermingled with branches; but in other cases the trichoblasts appear already in the lower part of the shoots. At the upper end of the shoots in particular of the fertile male and female plants, the trichoblasts may be more densely placed, each joint bearing one trichoblast. The erect filaments issuing from the creeping ones are often without primary lateral organs over a long stretch from the base, but endogenous adventitious shoots may frequently occur here (fig. 342). Trichoblasts have been met with in specimens collected near land and in specimens from greater depths as well (f. inst. bM, south of Hveen Su 22,5 m). They are shed in summer, when the growth is sisted. This usually takes place in June or July, but specimens in vegetative development may still be met with in August; these specimens seem, however, always to be young plants produced from spores germinated in the same season.

[1] A rare exception is shown in fig. 341 *A*, where the spiral turns to the right.

1) 7 *e* 3 *e* 5 *e* 4 *e* 2 *e* 3 *e* 3 *e** 17 *b* 3 *b* 4 *b* 4 *b* 4 *b* 3 *b* 5 *b* 10 *b* 3 *b*
2) 8 *e* 7 *e* 17 *b* 6 *b* 8 *b* 3 *b* 3 *b* 3 *b* 3 *b* 4 *b* 2 *b* 2 *b* 2 *b*
3) 10 *b* 5 *t* 3 *b* 2 *b* 4 *t* 3 *b* 3 *b* 4 *b* 3 *b*
4) 10 (*t*) 5 (*t*) 3 (*t*) 2 *b* 3 *b* 3 ♂ 3 ♂ 3 ♂ 1 ♂ 2 ♂ 1 ♂ 1 ♂ 1 ♂ 1 ♂ 1 ♂ 1 ♂
5) . . . *b* 5 *b* 5 (*t*) 4 ♂ 3 *b* 3 *b* 3 ♂ 2 ♂ 3 ♂ 2 ♂ 2 ♂ 1 ♂ ? 1 ♂ ? 1 ♂ 2 ♂ 1 (?) 2 ♂ 1 ♂ 1 ♂ 1 ♂
6) . . . (*t*) 1 (*t*) 2 (*t*) 2 *b* 1 (*t*) 2 (*t*) 2 (*t*) 1 (*t*) 1 (*t*) 2 *b* 1 (*t*?) $\underset{+}{1}$ (*t*) 1 (*t*) 1 *b* 1 $\underset{+}{1}$ *t* $\underset{+}{1}$ (*t*) 1 (*t*) 1 *t* 2 (*t*) 2 (*t*) $\underset{+}{1}$ *t* (?) 1 *t* 1 *t* 1 *t* 1 *t* 1 *t*

Schemes of branches of *Polysiphonia urceolata*. The figures signify the numbers of joints between the consecutive lateral organs. *e* endogenous branches; *b* ordinary exogenous branches; *t* trichoblasts; (*t*) basal cells of shed trichoblasts; ♂ male trichoblasts; + tetrasporangia, the sign denotes the joint in which the sporangium is seated. . . . designates that the base of the branch was not observed. 1)—3) branches of male plant from Frederikshavn April. In 1) the basal portion of the branch is procumbent; from * the shoot is erect. The endogenous branches were feebly developed. Always a divergence of $^1/_4$. 4) and 5) from Store Middelgrund (**Ke**) May. 6) from Hirshals July.

The young segments of the shoots are lower than in the other Danish species, but the segments producing branches are higher and cut off by more inclined walls (fig. 344).

Fig. 344. *Polysiphonia urceolata*. Tip of shoot with young trichoblasts. The last segment is higher than the foregoing ones; it will produce a branch. 390 : 1.

The antheridia cover the greater part of unbranched trichoblasts; these organs have a short two-celled stalk and terminate with a sterile filament composed of a small number of cells, most frequently three. A sterile branch does not occur in the antheridia-bearing trichoblasts, but I have once met with a male trichoblast bearing a fertile branch corresponding to the first branch in the sterile trichoblasts (fig. 345). The male trichoblasts are densely crowded in corymbiform clusters at the tip of the shoots, each segment often bearing one trichoblast. The male trichoblasts often appear suddenly without foregoing sterile trichoblasts.

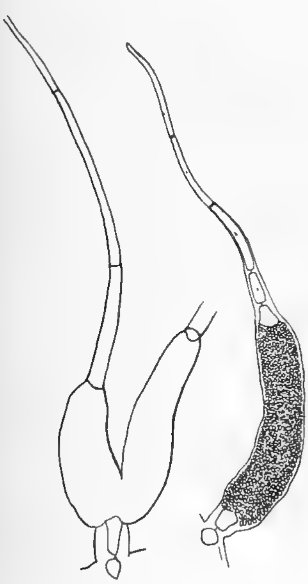


Fig. 345. *Polysiphonia urceolata*. Male trichoblasts, *a* normal, *b* branched. 124 : 1.

The procarps arise as in the other species in the second joint of the female trichoblasts, the upper part of which takes the shape of a sterile trichoblast. The third joint remains short and undivided and the first sterile branch is given off from the 4th joint, usually to the right (fig. 346). Of 33 examined female trichoblasts 26 bore the first sterile branch on the right side, 7 on the left. A cystocarp with its ostiole protracted in a cylindrical neck is shown in fig. 247. A remnant of the sterile part of the trichoblast may sometimes be found on the fully developed cystocarp.

The arrangement of the tetrasporangia differs according to whether the filament bears trichoblasts or not. In the latter case the sporangia are seriate and the filament

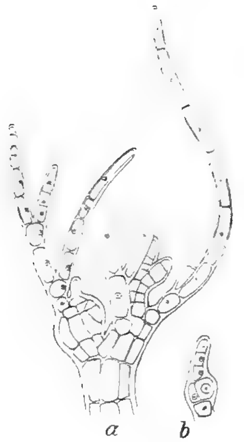


Fig. 346.
Polysiphonia urceolata. a, portion of female plant. *b,* young procarp-bearing trichoblast. 220 : 1.

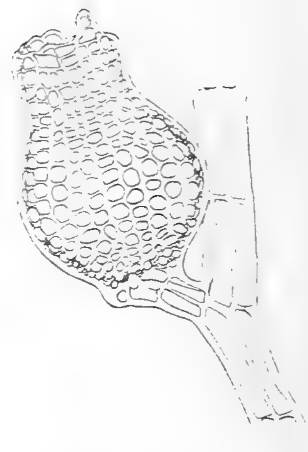


Fig. 347.
Polysiphonia urceolata. Ripe cystocarp. 68 : 1.

is usually curved so that the sporangia are placed in a row at the convex side. When trichoblasts are present, the sporangia are placed to the right of the foregoing trichoblast (fig. 348 *A*). The sporangia-bearing joints have 6 pericentral cells. In the trichoblast-bearing shoots a small peripheric cell is further cut off at the base of the joint; in the joint next to a trichoblast this cell is situated immediately to the right of the trichoblast. In spore-bearing shoots without trichoblasts such a small peripheric cell was not cut off (fig. 348 *B*).

In a female plant with fully developed cystocarps containing apparently normal carpospores, sporangia were here and there met with in the filaments. The sporangia were developed in the usual manner (without formation of a small peripheral cell) but they were small and undivided and obviously abnormal. A very remarkable case is shown in fig. 349. A trichoblast has produced an aborted procarp in its second joint but has then over it been transformed into a sporangia-bearing shoot, with incompletely developed sporangia. The third joint

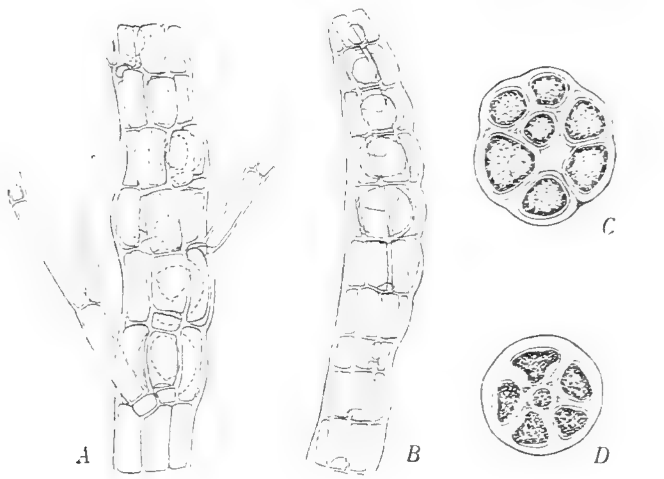


Fig. 348.
Polysiphonia urceolata. A, portion of tetrasporiferous branch with trichoblasts. *B,* portion of tetrasporiferous branch without trichoblasts. *C,* transverse section of tetrasporiferous joint after evacuation of the tetraspores. *D,* transverse section of a sterile joint of the same branch, with five pericentral cells. *B* 95 : 1. *A, C, D* 200 : 1.

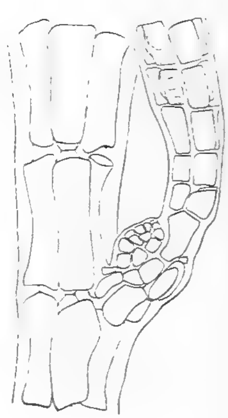


Fig. 349.
Polysiphonia urceolata. A female trichoblast has been transformed from the fourth joint into a tetraspore-bearing branch. 150 : 1.

was undivided as in the normal female trichoblasts, but the following joints had produced 4 pericentral cells, and in the 7th joint the formation of sporangia was beginning. YAMANOUCHI has formerly described abnormal tetrasporangia in female plants of *Polysiphonia violacea* (1906 p. 425, figs. 168—171). BUFFHAM found antheridia in tetrasporic plants of *Pol. urceolata* (1893 p. 298).

Tetraspores sown in July germinated immediately and gave rise to young plants provided with trichoblasts and producing in great part one or two vigorous branches at the base (fig. 341). The sporelings obtained by Tobler (l. c.) from carpospores showed no trichoblasts.

P. urceolata has been met with from low-water mark to deep water. The deepest observed localities are 31 meters in the North Sea, 26,5 m in the Eastern Kattegat and 22,5 m in the Øresund (south of Hveen). It occurs near low-water mark in all the waters except the Sound where it has only been met with in 5,7 to 22,5 meters' depth, without doubt owing to the varying and often very low salinity of the surface water.

The species is perennial through its creeping filaments. The erect, fructiferous filaments are thrown off after the evacuation of the spores, but the sterile ones may persist, and the species may be found in every season with erect filaments. The length of these varies from 1 to 15 cm and may even reach 23 cm; it does not diminish towards the limits of the occurrence of the species. — Antheridia have been met with in January to July, procarps in April to June, fully developed cystocarps in May but in particular in June to August and further in September (Skagerak), and as late as January I have met with cystocarps containing ripe carpospores by Frederikshavn. Tetraspores have been met with in May to August and in September (Hirshals). The germination takes place immediately, but the new plants seem only to fructify in the following year. The species is comparatively often found in a sterile state, but there is no general relation between the sterility and the size of the individuals.

The species grows in particular on stones and is very common on moles in harbours, but it occurs too on several Algæ, in particular on the stipes of *Laminaria hyperborea* in the Skagerak, further on *Phyllophora membranifolia*, *Furcellaria fastigiata*, *Fucus* etc., on *Ascidiae* and shells of molluscs and barnacles.

P. urceolata is not very variable. Several specimens from deep localities in the inner waters may be referred to f. *roseola*, remarkable by slender filaments and long joints. Small, poorly developed specimens consisting principally of creeping filaments have been described by LYNGBYE as a particular species, *Hutchinsia lepadicola* Lyngb. (*Polys. lepadicola* Ag.)

Localities. **Ns:** 6 miles S.E. to E. of Vyl light-ship, 17 m on Lam. hyperb., loose (A. C. Johansen); aF, off Thyborøn, 31 m; Thyborøn, on groins; XR, off Ørhage. — **Sk:** Dana 2904 23 m (C. A. J.); YM[1], Bragerne, 2,5 m; ZK[2] and ZK[13], off Lønstrup, 1 and c. 9 m; XO and other places off Hirshals 11—15 m; mole at Hirshals; Højen, within the shoals. — **Lf:** Krik, pier; Lemvig harbour; XY and LV in Nissum Bredning; Oddesund; Thisted harbour; MH, off Skrandrup on firm clay; Nykøbing and other places in Sallingsund; Agersund harbour; Nibe, pier; Aalborg; Hals harbour. — **Kn:** Skagen harbour; Herthas Flak c. 20 m; Hirsholm; Deget; Frederikshavn harbour; off Laurs Rev; off Marens Rev; north of Læsø, on Hyas (E. Bay); Trindelen (Børgesen); fG, W. of Læsø Trindels light-ship. — **Ke:** Fladen IM, ZF, ZE, VY, 16—26,5 m; EV, south end of Groves Flak; EU, Lille Middelgrund, 14 m; IA, IB, HY, Store Middelgrund; off Gilleleje, Lyngbye (*Hutchinsia lepadicola*: 1. Marts 1833 in tergo Cancri Aran., and 26. Mart. 1833 in Lepad. Balano. *Hutchinsia abyssina*: Juni 1834 in Buccino undato and 31. Marts 1835 in testa Balani e profunditate 16 org. (30 m)); Gilleleje harbour. — **Km:** FL, south of Læsø Rende, 9,5 m. — **Ks:** Grenaa harbour; HS, Briseis Grund, 7,5—13 m; Nordvestrev by Hesselø (Lyngbye); Holbæk Fjord, on Mytilus. — **Sa:** KJ, south of Hjelm, 13 m; PJ, Ebeltoft Vig; PL, Wulffs Flak; Kalø Rev; FS, Vejrø Sund; PA, near Albatros, 7,5 m; PC, between Sejerø and Ordrups Næs; PF, north of Refsnæs; Hov (O. Paulsen); Hofmansgave (Lyngbye, Hofm. Bang, C. Rosenberg); inlet to Odensefjord (Lyngbye, *Hutch. stricta*). — **Lb:** Bogense harbour; Fredericia harbour (Hofm. Bang, !); Strib harbour; Middelfart; Fænø Sund; off Stenderup; Heilsminde; DF, Remmen; Assens harbour; Aarøsund; Aarø; DA, Bøjgden; CZ, Hornenæs; dH[1], E. of Hesteskoen, 18—19 m; dQ, south of Lydø, 22 m; Sønderborg harbour (10 cm long). — **Sf:** Søby harbour; UV, north of Ærø, 13 m; Aasø, Langeland; Marstal harbour; Ærø (Kjærbølling). — **Sb:** Kalundborg harbour; cT, Ryggen; Stavreshoved; Kerteminde harbour; Nyborg, harbour and Avernakhage; DN, Vengeance Grund, 12 m; UK, Langelandsbelt, 12 m; Spodsbjerg harbour. — **Su:** Hellebæk (Ørsted); Blokhus Grund north of Helsingør, 13 cm long (Boye Petersen); Helsingør (Liebman, *P. lepadicola*); bM, south of Hveen, 22,5 m; Taarbæk Rev, 6 m. — **Bw:** Sønderhav and Brunsnæs in Flensborg Fjord, piers; pier at the East end of Sønderkov, Als; dP, Bredegrund south of Als; dK, Pøls Rev; DU, off Dimesodde, 11 m. — **Bm:** 7,5 miles E. of Hellehavns Nakke, 27 m (C.A. J.).

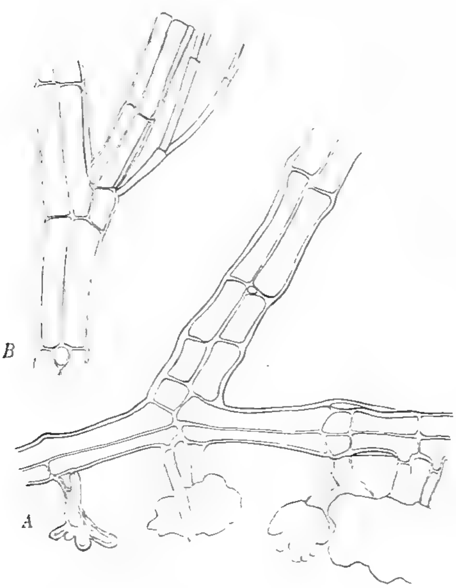


Fig. 350.
Polysiphonia orthocarpa. *A*, portion of decumbent branch and the lowermost part of an erect branch given off from it. 50 : 1. *B*, trichoblast with axillary branch. 150 : 1.

2. Polysiphonia orthocarpa K. Rosenv. n. sp.

Cæspitosa, c. 7 cm alta, filis erectis numerosis, e filis repentibus exeuntibus, inferne rhizoideis numerosis, partim fasciculatis, substrato non adfixis, instructis, sursum paululum attenuatis, articulis tetrasiphoniis non corticatis, in parte inferiori filorum ad geniculas leniter incrassatis. Rami in axillis pilorum (trichoblastorum) oriuntur; rami axillarii secundarii, e cellulis basilaribus pilorum deciduorum orti, desunt. Fila inferne crass. 135—160 μ, articulis diametro 1,5—2,5-plo longioribus, in parte media articulis diametro 4—6-plo longioribus, superne crass. 40—60 μ. Tetrasporangia in ramulis torulosis longe spiraliter seriata. Antheridia ignota. Cystocarpia subglobosa, ostiolo apicali, non protracto. — Color fusco-purpureus. (Plate V fig. 1).

This species which was found in two localities in the Limfjord in some respects resembles *P. violacea* but it differs from it particularly by the much developed creeping filaments and the caespitose growth and further by the want of cortication and of secondary axillary shoots. By these characters it agrees with *P. Rhunensis*

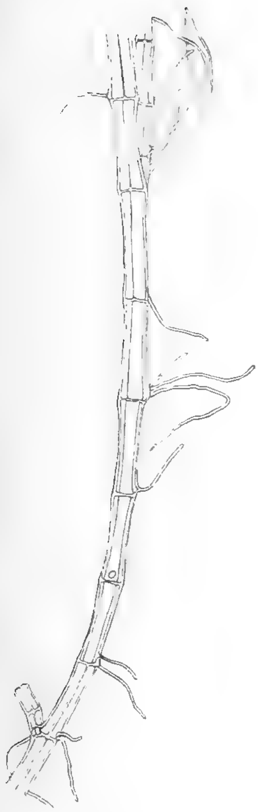


Fig. 351.
Polysiphonia orthocarpa. Lower part of an erect filament with numerous rhizoids. 20 : 1.

Thur., to which it seems to be nearly related; but as it differs from it by other characters, especially the dimensions of the articles, the presence of rhizoids on the erect filaments, and the shape of the cystocarps, it seems legitimate to consider it as a distinct species.

The erect filaments issue in great number from creeping filaments fixed to the substratum by short rhizoids ending in attachment discs. These rhizoids are given off not only from the basal but also from the apical end of the pericentral cells, from which they are separated by a cell-wall. The articles of the creeping filaments are two to four times as long as broad. Rhizoids are also given off from the lower part of the erect filaments, but these rhizoids are not fixed to any substratum; they are of equal diameter in their whole length and form no attachment disc. They are always given off from the undermost end of the articles, often two or three from the same article. In rare cases I have found them fixed by the end to the same filament from which they had issued.

Fig. 352.
Polysiphonia orthocarpa. Portion of branch with tetrasporangia. 200 : 1.

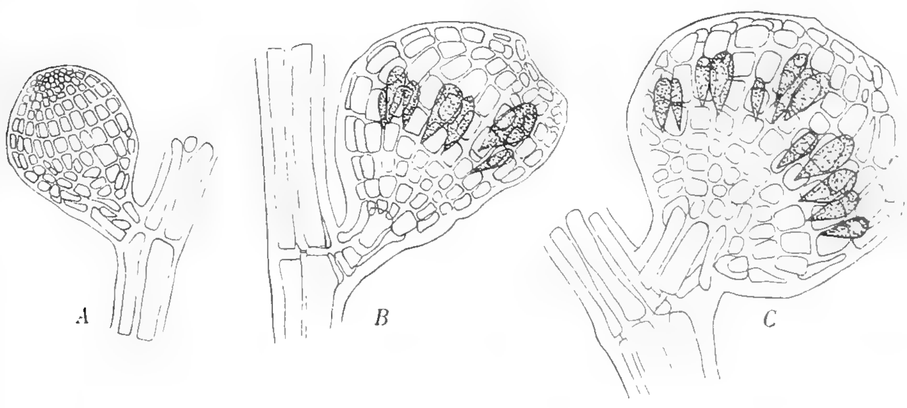


Fig. 353.
Polysiphonia orthocarpa. A young and two ripe cystocarps. 107 : 1.

The erect filaments are very slowly attenuated upwards; at the base they are 135—160 μ thick.

The upper end of the shoots has the same aspect as in *P. violacea.* Each joint bears a trichoblast except the undermost 3 or 4 (or 5) of the branches. The trichoblasts, which remain rather long, have the usual appearance; their cells contain one nucleus only. The branches arise as axillary buds of the trichoblasts; they are separated by 4 or 5 trichoblasts without branches, but two branches frequently follow one another. Secondary axillary shoots do not occur, or only appear exceptionally on the lower rhizoid-bearing joints. The first trichoblast of the branches appears on the 4th, 5th or 6th joint. Endogenous branches may occur in the procumbent filaments and in the lower part of the erect ones.

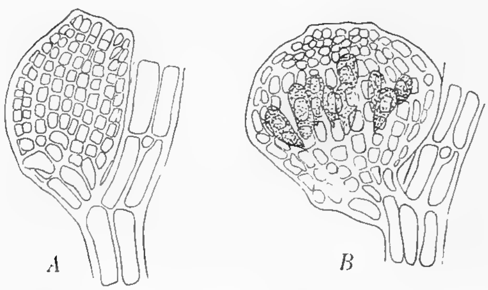


Fig. 354.
Polysiphonia Rhunensis Thuret, from St. Vaast (herb. Thuret), an unripe, and a ripe cystocarp. 107 : 1.

The tetraspore-bearing shoots have the same structure as in *P. violacea.* The joints have 6 pericentral cells and, under one of them, a short peripheral cell situated to the right of the basal cell of the trichoblast of the foregoing joint (fig. 352).

The antheridia are unknown.

The cystocarps are subglobose or slightly depressed (fig. 353). The ostiole is not protracted, it is situated on the apex of the cystocarp opposite to the point of insertion, not on its ventral side as in *P. violacea* and in *P. Rhunensis*, of which I have examined an original specimen from Thuret collected at St. Vaast (fig. 354). The series of cells forming the outer layer of the wall run in the same direction as the stipe, and the placenta is perpendicular on this direction (fig. 353), while in *P. Rhunensis* the cell-rows run towards the ventral side and the placenta has an oblique position to the stipe. In the latter species the ostiole is moreover a little protracted and, according to Thuret (l. c. p. 85), often a little sinuous. The cells surrounding the ostiole in *P. orthocarpa* are low, not prominent.

The specimens from the Limfjord resemble *P. Rhunensis* so much that I have been inclined to consider them as belonging to the same species. They agree with it by the cespitose growth, numerous erect filaments issuing from a system of creeping filaments, by the want of cortication, further, as substantiated by examining original specimens of Thuret's, by the branches arising in the axils of the trichoblasts and by the want of secondary axillary branches. Our species differs, however, from Thuret's species by the erect filaments being thinner at the base ($^1/_4$ mm in *P. rhunensis*) and less tapering upwards, by the presence of rhizoids from the erect filaments and by the apical, not protracted ostiole of the cystocarps. By the shape of the cystocarp it is also distinct from *P. violacea*, in which the ostiole has a more or less ventral position and is surrounded by a prominent border composed of rather large projecting cells.

Localities. Lf: Under Lisehøj, N.W. point of Fur, 1—2 m, apparently growing on diatomite (dan. Molér) with ripe sporangia in July; Amtoft reef, from a slight depth to 4 meters (unknown in which depth t has been growing). Sand and clay is retained between the erect filaments. With cystocarps in August.

3. **Polysiphonia elongata** (Huds.) Harvey.

Harvey in Hooker, Brit. Flora 1833 p. 333; Harvey Phyc. Brit. III 1851 pl. 292, 293; Kützing, Phycol. gen. 1843 Taf. 50 V; Tab. phyc. 14, 1864 Taf. 4; J. Agardh, 1863, p. 1004; Kny 1873, p. 107, Taf. II Fig. 5; Kolderup Rosenvinge 1884, p. 24, 1903, p. 405; Falkenberg, 1901, p. 126, Taf. 21, Fig. 6—9; Kylin, 1907, p. 144; L. Batten 1923 pp. 279, 297.

Conferva elongata Hudson, Fl. angl. II, 1778, p. 599.

Ceramium elongatum Lyngbye, Hydr. 1819, p. 117.

Ceramium brachygonium Lyngbye Hydr. p. 118, Tab. 36 C.

Hutchinsia strictoides Lyngbye Hydr. p. 114, Tab. 35 D.

Hutchinsia elongata Flora Danica tab. 1836, 1825.

Polysiphonia strictoides Kützing Tab. phyc. 14, 1864, Tab. 10.

α, typica.

β, Schuebelerii (Foslie) nob. (Plate V fig. 2).

Comp. Børgesen and Jonsson, The distribut. of the Mar. Alg. of the Arctic Sea etc. Appendix to the Botany of the Færöes. 1908 p. XII.

P. Schuebelerii Foslie, Nye arct. havalg., Christiania Vidensk. Selsk. Forh. 1881 Nr. 14 p. 3, tab. I fig. 1—3. Kolderup Rosenvinge, Grønl. Havalg. 1883 p. 798, pl. I figs. 1—2.

γ, baltica nob. (Plate V fig. 3).

The morphology of the frond has been described by Kny and Falkenberg.

The trichoblasts are arranged in a regular spiral turning to the left, each joint bearing a trichoblast with the exception of the first 5 or 4, rarely of a greater number of joints in the branches, which bear no lateral organs. The divergence of the trichoblasts in the spiral is a little greater than 1/4. The cells of the trichoblasts contain one nucleus. In f. *baltica* the trichoblasts are simple or very feebly branched and usually contain well developed rose-coloured chromatophores. The branches appear in the places of trichoblasts in the spiral, and are usually separated by 5 joints, more rarely by 4 or 6. Upwards the branches often become rarer, in particular in the tetrasporiferous and the antheridia-bearing shoots, which in their upper parts are entirely branchless. The branches usually appear singly; branches on two consecutive joints may, however, sometimes occur.

Fig. 355. *Polysiphonia elongata* f. *Schuebelerii*. Tip of shoot. The first pericentral cell in the 4th segment has been cut off to the right of the trichoblast. 560 : 1.

Adventitious shoots from the basal cells of the fallen off trichoblasts (secondary axillary shoots) appear not rarely, in particular on the lower part of the shoots. In specimens of f. *baltica* from Flensborg Fjord adventitious shoots appeared abundantly and early, before the trichoblast had been shed (fig. 364). The adventitious branches, however, usually reach only a slight degree of development in the first season. On the other hand, adventitious shoots appear normally in the shoots of wintering plants. When the growth ceases at the end of summer, a number of shoots and tips of shoots are thrown off, and next spring numerous new shoots are produced, partly from the surfaces of the wounds, partly from the basal cells. Frequently a shoot is produced from each joint. When the new shoots are principally given off from the upper part of the wintering ones the form appears which J. AGARDH has named f. *microdendron* (l. c.). This form I have only found once (Klørgrund South of Hjelm in May).

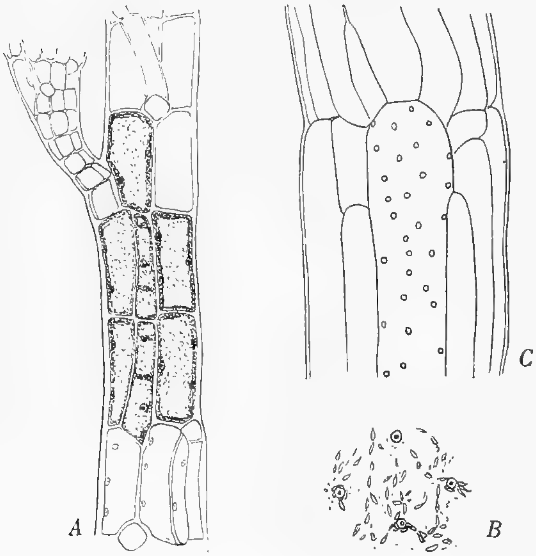


Fig. 356.
Polysiphonia elongata. *A*, portion of shoot showing the formation of the first cortical cells. *B*, nuclei and chromatophores of a pericentral cell. 270 : 1. *C*, portion of a branch showing the upper end of a pericentral cell with nuclei and cortical cells. 95 : 1.

In the usual form with short joints the branches are to a considerable extent connate with the following joint (fig. 356). In this form the branches are as a rule thin at the base and become thicker upwards. In f. *baltica* this is not so or only in a slight degree.

The cortication begins early, especially in the typical form. The primary cortical cells are here often of the same length as the pericentral cells, being cut off by a longitudinal wall (fig. 356). In the forms with longer joints, f. *Schuebelerii* and f. *baltica*, the primary cortical cells are shorter and cut off by an inclined wall (fig. 361). The pericentral cells contain numerous nuclei and the primary cortical cells are also plurinucleated (fig. 356), while the central cell contains one large nucleus, at least for a long time.

In the typical form, the pericentral cells of the thick main shoots are connected with several secondary pits traversing the transversal walls. In a transverse section one pit is found in the middlemost part of the wall and a number of up to ten in the periphery. The central pit is probably the first, arisen at a very early moment, while the others have only been formed in the following year. The cortical cells may also be connected by several pits in the same wall, in particular in the transversal walls. The secondary pits of the pericentral cells are much smaller than those of the central axis, but bigger than the pits between the pericentral cells in the other species of *Polysiphonia* and bigger than the primary pits connecting the central cells with the pericentral cells in *Polysiphonia elongata* (fig. 357).[1] Such multiple pits were not met with in f. *baltica*. On the other hand, the central cells of this

[1] Dr. LILY BATTEN figures three pits connecting two pericentral cells which are erroneously said to be central cells (1923 pl. 22 fig. 1).

form were often filled up by hypha-like cells, a phenomenon which, according to FALKENBERG, frequently occurs in the pericentral cells of *P. elongata*.

The attachment organ of the frond is conical, built up of numerous densely crowded descending filaments forming the continuation of the filaments of the cortication, and of rhizoids mostly given off from the latter (comp. L. BATTEN 1923 pp. 279, 297, fig. 47).

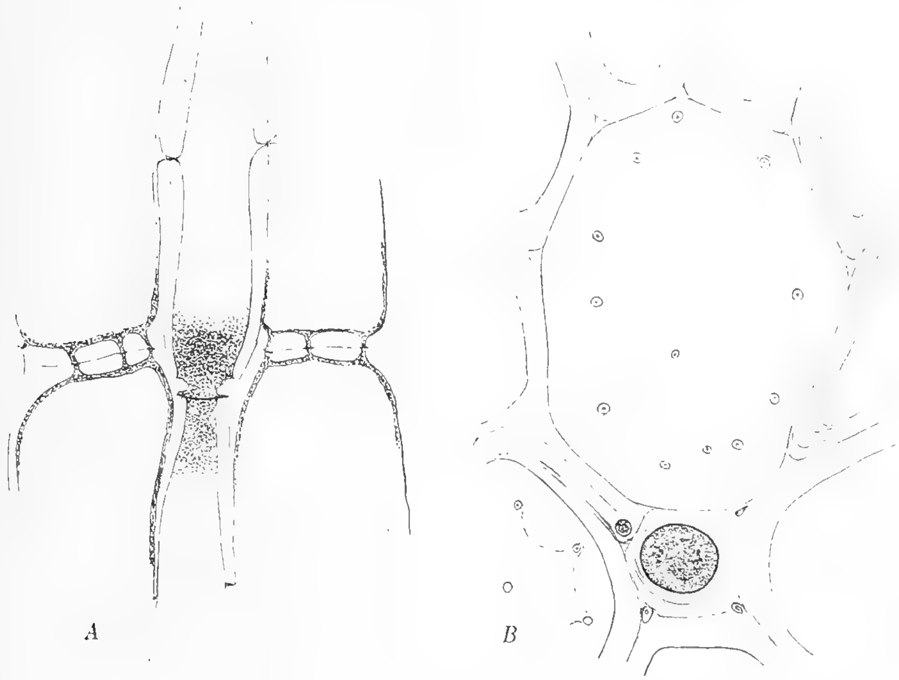


Fig. 357.
Polysiphonia elongata. A, longitudinal section through the central part of an old stem, showing the central cells and the pericentral cells connected with multiple secondary pits. 100 : 1. *B*, transverse section of a similar stem, at the level of a transverse septum, showing the pits. 290 : 1.

The antheridia occupy the main axis of the trichoblasts except the two first joints, the upper of which bears a sterile branch on the right side. Sometimes the third cell is also sterile and then bears a sterile branch on the left side. In the first case it happens that the branch becomes fertile and the trichoblast thus bears two antheridial bodies (fig. 358 to the right), and trichoblasts bearing three antheridial bodies were met with too (fig. 358 above). In the branch shown in the same figure an antheridial cushion even occurred on the stem (comp. L. K. R. 1903, p. 465).

In the procarp-bearing trichoblasts the first branch is seated on the 4th joint but not always on the right side, frequently on the left side. The ostiole of the cystocarp is fairly broad, not protracted and directed obliquely upwards, but more upwards than forwards (fig. 359, comp. Harv. pl. 292, 293). I have, however, met with cystocarps thicker than those figured by HARVEY and me and provided with a short spout.

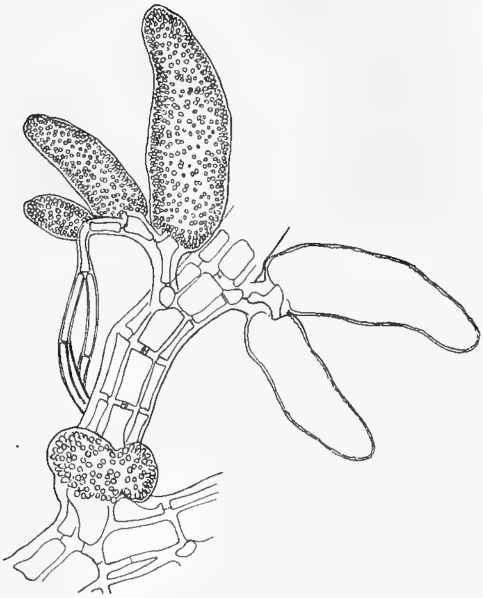


Fig. 358.
Polysiphonia elongata. Portion of male plant, showing trichoblasts with two or three antheridial bodies and a cushion of antheridia on the surface of the stem. 124 : 1.

The sporangiferous joints have 6 pericentral cells, 4 of which cover the sporangium. As shown by FALKENBERG (l. c. p. 128, pl. 21 fig. 9), a small peripheral cell situated to the right of the trichoblast of the foregoing joint is usually to be found (fig. 362); it is, however, not always present (fig. 360). When going from one trichoblast to the next two pericentral cells are passed.

The sporelings grow out to a vigorous straight primary shoot with early developed cortication, much bigger than the lateral branches.

J. AGARDH distinguishes two main forms of the species: I. *Lyngbyei* and II. *Ruchingeri*, the first thinner, with flagelliform filaments and the upper branches tapering upwards from a broader base, the latter thicker and more fleshy, with straight branches and the upper ones attenuated upwards and downwards. F. *Lyngbyei* is said to be most frequent at the coasts of Sweden and Denmark ("in sinu Codano"), while the other occurs on the shores of the Atlantic Ocean. The characters mentioned seem, however, to be inappropriate as distinctive characters; thus in most specimens from the Danish waters not referable to f. *baltica*, branches attenuated towards the base may be found. Nor has KYLIN considered this character as conclusive, having described under the f. *Lyngbyei* a new subf. *gelatinosa* with the branches attenuated downwards. This character is most prominent in the specimens from the North Sea, the Skagerak and the Northern Kattegat.

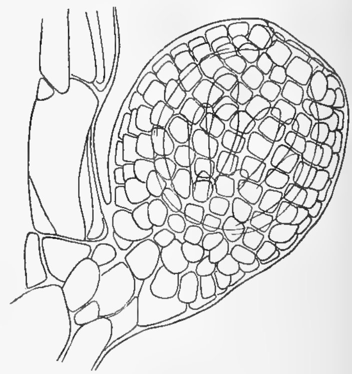


Fig. 359.
Polysiphonia elongata. Ripe cystocarp. 100 : 1.

Most of the specimens found in the Danish waters have been referred to f. *typica* though they are somewhat variable according to the localities. When growing in slight depth and exposed to light they become breviarticulate, the joints in the upper part of the plant having only half the length or the same length as the breadth, and the main axes become at least 1 mm thick. In greater depths the joints become longer. The typical form is common in the Danish waters from the North Sea to the western Baltic Sea, descending to 19 meters' depth. The innermost places where it has been met with near low water mark are Svendborg (Sf), Kerteminde (Sb) and Hellebæk (Su). In the Great Belt south of Kerteminde the minimum depth of its occurrence is 6,5 m, in the western Baltic Sea it is 5 m and in the Sound south of Helsingør 10 m.

In the inner Danish waters *P. elongata* appears in more slender forms which, however, are closely connected with the typical form by intermediate forms. In the

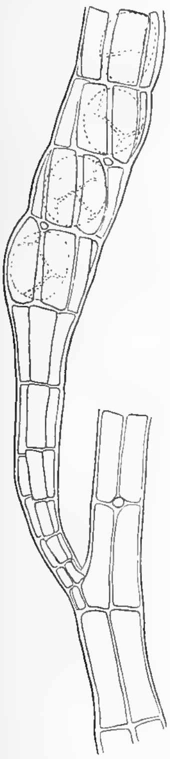


Fig. 360.
Polysiphonia elongata f. *typica* (from Frederikshavn). Portion of tetrasporiferous plant. 75 : 1.

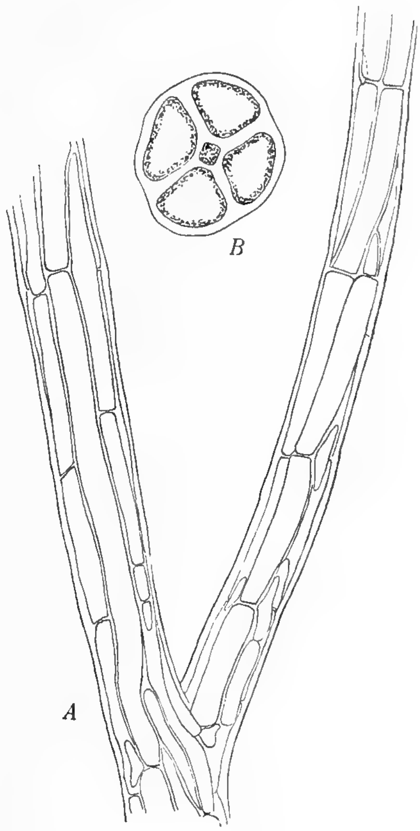


Fig. 361.
Polysiphonia elongata f. *Schuebelerii*, from Bolsaxen). *A*, portion of frond showing pericentral cells and cortication. 70 : 1. *B*, transverse section of stem not yet corticated. 200 : 1.

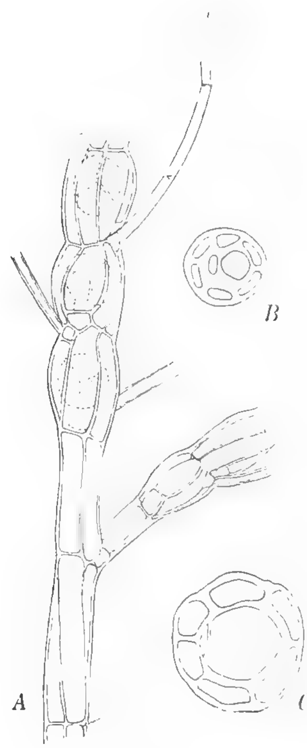


Fig. 362.
Polysiphonia elongata f. *Schuebelerii*, from Bolsaxen). *A*, portion of plant with tetrasporangia. *B* and *C*, transverse sections of tetrasporiferous joints. *A* 95 : 1. *B*, *C* 200 : 1.

Great Belt (Sb) a form agreeing exactly with *P. Schuebelerii* Foslie (see above) has been met with in several places in 6,5 to 19 meters' depth. It differs from the typical form principally in the longer joints, being up to 4 times as long as broad or longer where the cortication begins, and in the feebler cortication which entails a smaller diameter of the main axes (300—660 μ). The first cortical cells are comparatively small and cut off by oblique walls. The pericentral cells occupy a great part of the transverse section of the old stem; they produce no new pits or a small number of multiple pits in the transverse walls. On the other hand, in some cases I found the central cell

Fig. 363.
Polysiphonia elongata f. *baltica*. *A*, upper end of shoot; trichoblasts with chromatophores.

filled with hypha-like filaments. The trichoblasts are branched, in greater depths provided with feebly rose-coloured chromatophores. The frond may be 30 cm long or more.

In the Baltic Sea around Møen (**Bm**) and around Bornholm (**Bb**), where the salinity is much feebler, the species occurs in a still slenderer form which at first I judged identical with f. *expansa* (Ag.) which J. Agardh first found at the coast of Blekinge. An examination of the original specimen of *Hutchinia expansa* Agardh in Agardh's herbarium in Lund showed me, however, that Agardh's species cannot be referred to *P. elongata* as its branches arise in the axils of the trichoblasts, but that it is a form of *P. violacea*. I have therefore given the here described form of *P. elongata* from the Baltic Sea the name f. *baltica*. The frond of this form is very slender, up to 20 cm long, and has an intense red colour. The joints are 4—7 times as long as broad where the cortication begins. The branches are not attenuated towards the base. The cortication often begins rather late and advances more slowly downwards so that the pericentral cells do not become entirely covered by the cortical cells. The main axis is only 140—280 μ thick. The trichoblasts are unbranched or slightly branched with well developed, feebly rose-coloured chromatophores; they are usually long kept. When adventitious shoots occur they may arise before the trichoblasts have been shed (fig. 364). This form is confined to localities with feeble salinity and rather feeble light (9—24,5 meters depth). Specimens from the deepest localities in the outer waters with high salinity may resemble f. *baltica* in some characters, but are so different in other respects that they cannot be referred to it. In the Limfjord, in depths of 7 to 10 meters, where the light is very feeble, owing to the very turbid water,

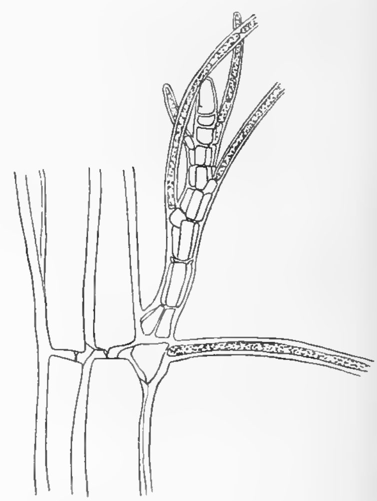


Fig. 364.
Polysiphonia elongata f. *baltica*, from Flensborg Fjord. Secondary axillary shoot. 230 : 1.

the specimens of *P. elongata* agree with the typical form in all respects. Specimens from the Kattegat collected in 17—19 meters' depth were certainly a little slenderer than those from higher levels and usually showed longer joints, 1—3 times as long as broad, but the branches tapered downwards and the trichoblasts were branched.

P. elongata occurs in all the Danish waters and also enters in the fjords. It descends to 20 meters' depth but has been recorded in 27 meters' depth in the eastern Kattegat and in 24,5 meters' depth near Bornholm (f. *baltica*). It grows on various substrata, stones, moles, shells of mollusks, various Algæ, as *Fucus serratus*, *Laminaria digitata*, etc. and *Zostera*. It occurs in very different plant associations but usually not as a dominant constituent. In oozy bottom it is frequently met with on mollusk shells. It is remarkable that it may occur rather abundantly in places where the flora is poor in species, f. inst. Fanø and Løgstør. It often attains a length of 23 cm, more rarely 35 cm, but only in protected localities. In autumn many specimens die but others are only denudated and recommence the growth in winter. New shoots may appear already at the end of December, and in January they are usually present though the growth is slow. Thus, new shoots more than one cm long were found in a specimen gathered on January 25th in the Great Belt; but it must be said that other specimens gathered in other localities in the same water were still in a resting stage. The growth is intense in April and May, it continues in June and July but in the latter month it decreases and usually ceases. The trichoblasts may remain still for some time, but in several specimens they are thrown off already in August. Otherwise this takes place in autumn, and at the same time a number of shoots, principally the fructiferous ones and the ends of the shoots are shed.

Antheridia were met with in January (unripe), April, May and July, and once even in August, ripe cystocarps in May to September, most frequently in July and August, unripe in April and May, ripe sporangia in May to August. The sporelings arising from the spores disseminated in summer continue their development, after wintering, the next year; but it is doubtful whether they can winter more than once.

Localities. *α, typica.* **Ns:** Nordby, Fanø; Esbjerg; Thyborøn, harbour and groins; off Ørhage, 5,5—7,5 m. — **Sk:** YU, Hanstholm, 2 m; within Bragerne, 2—10 m; off Løkken, 13 m; Dana St. 2900, 9 m (C. A. J.); FK[2], off Lønstrup; Hirshals mole and off Hirshals, 2—11 m; Højen, within first and second shoals, 2—5 m. — **Lf:** LV, Nissum Bredning; MH, Thisted Bredning; Oddesund; Nykøbing (Th. Mortensen, !); four localities east of Mors; north of Fur, Lendrup Røn, Løgstør, Aggersund (Ostenfeld). — **Kn:** Skagen; fC, S. of Skagen, 15 m; FG, Herthas Flak; off Hulsig (Boye Pet.); Krageskovs Rev (KC and TV); Hirsholmene; Fladstrand (Hornemann); harbour of Frederikshavn and reefs off Frederikshavn, off Marens Rev, 20 m; harbour of Sæby; BP, off Sæby; Nordre Rønner; TL, NG, VT, fF, UC, UB, GM, north of Læsø; harbour of Østerby; TO (17 m), TP, TQ, NI, FF, FE, fG, Dana St. 3891, near Trindelen. — **Ke:** FC, FD, XA, east of Læsø; VY, ZE, fH, Fladen; Groves Flak, down to 26,5 m; IK, ET, Lille Middelgrund; HX, Store Middelgrund, 17 m; GI, Ostindiefarer Grund; OO, Søborghoved Grund; Gilleleje, Nakkehoved (Lyngbye). — **Km:** Læsø Rende; Dana St. 2619, 2884 (C. A. J.); YY, XD, XF south of Læsø; BN; TS; VQ, Svitringen; BM; BL; VP; bK, N.W. of Anholt, 15 m; BK, VM, near Tangen; NC; BI, Gjerrild Flak; Gjerrild bay (Lyngbye). — **Ks:** EP, Pakhusbugt, Anholt; OP, HQ, EJ, Lysegrund;

RL, N.W. of Gilleleje; Grenaa harbour; HS, Briseis Grund; OS, Hastens Grund; OU, Schultz's Grund; FO, NB, Havknudeflak; FP, Jessens Grund; GF, Sjællands Rev; aU; D, Grønne Revle; EJ, entrance to Isefjord; NL and EH, off Lynæs; Lamme Fjord; Holbæk Fjord. — **Sa:** Very common, found in numerous places from 1 to 15 meters' depth. — **Lb:** Several places from 2 to 17 m. — **Sf:** Harbour of Svendborg, 1 m; BY; UV, 13 m; DZ. — **Sb:** 1 to 19 m.: DL; GT; DM; MN; GV; LM; harbour of Kerteminde; bay of Kerteminde; GQ; NU; AB; NP; NQ; NN, 19 m; UE; DN; Y; LH; LB, 17 m. — **Sm:** GZ; HA, Agersø Sund, 11 m. — **Su:** CS, off Aalsgaarde; Hellebæk (Budde Lund); Helsingør (Liebman); HK; PZ, east of Hveen; RZ, 13 m: bM, south of Hveen, 22,5 m; OH, off Vedbæk, 10 m. — **Bw:** bY, off Sønderskov by Sønderborg, 11 m; cD, dO, 5 m, dK, south of Als; LF, Vodrups Flak, 9,5 m; DV; LC, 11,5 m, south of Langeland.

β, Schuebelerii. — **Sa:** DK, Bolsaxen, 14 m. — **Sb:** Off Refsnæs, 19 m (Ostenfeld); LK, Elefantgrund (transitional form); UE, near Vresen, 7 m; UF, near Hov Sand, 8,5 m; DN, Vengeance Grund, 11,5 m. — **Bm:** 11,5 miles S. by E. 1/4 E. of Møens light-house, 19 m, (○ 6, C. A. J.).

γ, baltica. — **Su:** SA, Flinterenden. — **Bw:** dN, Flensborg Fjord, 9 m; KX, Femerbelt, 19 m. — **Bm:** QY, Bjelkes Flak, 10 m; VG, north of Møens Klint, 17 m; bO, south of Møen. — **Bb:** SQ, south of Broens Rev, 8,5 m; YE, off Øleaa, 10,5 m; YC, 24,5 m and YD, 19 m, near Salthammer Rev; 3 miles S.S.E. of Nexø harbour (C. A. J.); (12 miles N. 1/2 E. of Arkona light-house 46 m (○ 6, C. A. J.); the specimens much resemble that represented in Lakowitz, Algenfl. Danz. Bucht, Taf. II Fig. 5 under the name of *P. violacea* forma *tenuissima* which is perhaps identical with it).

4. **Polysiphonia violacea** (Roth) Greville, emend.

Hooker, Engl. Flora, Vol. II part I. 1833, p. 332; Harvey, Manual, 1841, p. 92; Phyc. Brit. II. 1849, plate 209; Areschoug, 1850, p. 51; J. Agardh, 1863, p. 988; Kützing, Tab. phyc. **13**, 1863, pl. 97, 98; Kolderup Rosenvinge, 1884, p. 27, pl. 1—2, figs. 33—47; Reinke, Algenfl. d. westl. Osts., 1889, p. 30; Falkenberg, 1901, p. 115, pl. 1, figs. 17—19; S. Yamanouchi, 1906, p. 401—449, plates 19—28; Kylin, 1907, p. 140.
Ceramium violaceum Roth, Catal. bot. Vol. I, p. 150.
Hutchinsia violacea Ag., Lyngb. Hydr., 1819, p. 112 ex parte (tab. 35, fig. B, 1).
Hutchinsia stricta Lyngb. Hydr., 1819, p. 115 ex p. (test. specim.); Fl. Dan. tab. 1666, 1819.
Hutchinsia divaricata Fl. Dan. tab. 2312, 1840.

α, violacea Aresch. l. c. p. 53, Alg. sc. exs. Nr. 65.

P. violacea β, sub-Brodiaei Aresch. 1850, p. 52, Exs. Nr. 5 (89).

β, fibrillosa (Dillw.) Aresch.

Areschoug, 1850, p. 52.
Conferva fibrillosa Dillw., Brit. Conf. 1809, p. 86, pl. G; Flor. Dan. tab. 1545, 1816.
Hutchinsia fibrillosa Ag., Lyngb. Hydr. 1819, p. 113.
Polysiphonia fibrillosa Grev. Harvey in Hook. Brit. Flora Vol. II p. 334, Phyc. Brit. Vol. III pl. 302, 1851. J. Agardh 1863, p. 991; Kny 1873, p. 104; Reinke, Algenfl. p. 31, Kylin, 1907, p. 141.

γ, tenuis.

Ceramium violaceum β, tenuis Roth Catal. III p. 151 (?).
Polysiphonia bulbosa Suhr, Aresch. Alg. sc. exs. Ser. I n. 9.
Polysiphonia violacea δ, bulbosa Areschoug 1850, p. 53.

Polysiphonia violacea ε, *tenuissima* Aresch. l. c. p. 54, Hauck, Meeresalg. p. 227.
Polysiphonia roseola Kützing Tab. phyc. Bd. 13 Taf. 80.

δ, *aculeata* (Ag.)

Hutchinsia aculeata Agardh Synopsis Alg. Scand. p. 59.
Polysiphonia aculeata J. Agardh, 1863 p. 947, Kützing Tab. phyc. Bd. 13 Taf. 71.
Polysiphonia aculeifera Kützing Tab. phyc. Bd. 13 Taf. 71.
Hutchinsia implicata Lyngbye Hydr. p. 111, Flor. Dan. tab. 1955.
Hutchinsia divaricata Ag. Syn. Alg. Scand. 1817 p. 59.
Polysiphonia divaricata Kützing Sp. Alg. p. 822, J. Agardh, 1863, p. 947.

Polysiphonia violacea is here taken in a larger sense than by earlier authors, not only *P. aculeata* (Ag.) but also *P. fibrillosa* (Dillw.) being included in it, while the latter has hitherto been regarded as a distinct species.

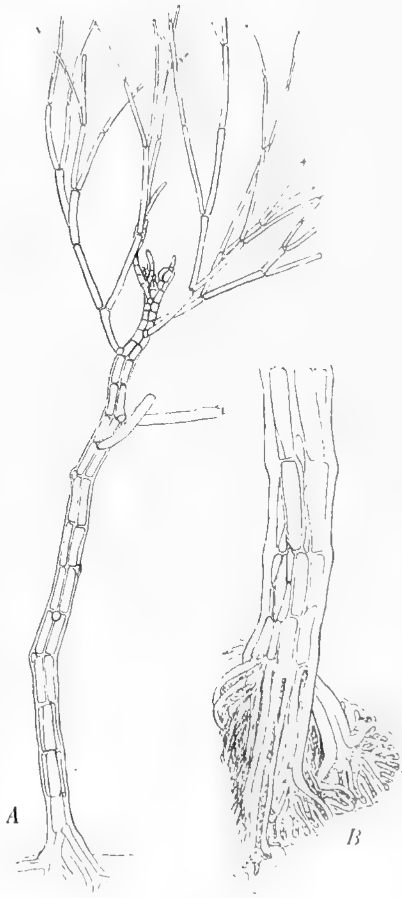


Fig. 365.
Polysiphonia violacea. *A*, young plant growing on Polysiphonia elongata, June 15th; a procarp is developing in the trichoblast on the 20th joint. *B*, base of a hardly one cm high plant. 100 : 1.

The morphology and development has been described by Kny (1873, p. 104, *P. fibrillosa*), myself (1884) and Falkenberg (1901). The primary axis is usually very distinct; in the f. *tenuis* only it is very thin and not easily discernible from the longer branches. The basal disc is composed of numerous densely crowded rhizoids terminating in attachment discs (fig. 365, comp. L. Batten 1923 figs. 55, 59). According to Falkenberg (1901, p. 116) adventitious, partly creeping branches are later given off from the base of the plant. This may be so, as I have convinced myself, but usually such adventitious shoots are not produced (comp. Harvey Phyc. Brit. Plates 209 and 302). In some cases, however, I found a great number of small adventitious shoots arising from the basal disc, being first creeping and then ascending and producing erect branches, and I also found erect shoots issuing directly from the basal disc. Such adventitious shoots are perhaps more common in f. *tenuis*.

The trichoblasts are arranged in a regular spiral, with a divergence varying between $^1/_4$ and $^2/_7$ of the circumference. Each joint of the shoots bears a trichoblast with the exception of the lowermost joints of the primary axis and of the branches. The first trichoblast on the branches is most frequently placed on the third joint, the basal joint included, more rarely on the 4th, very rarely on the second joint; in a specimen collected at Gjellegrund in the Great Belt in November it was, however, placed on the 5th or 6th joint. The trichoblasts are usually much branched, showing two generations of branches, particularly in the vigorous forms growing in shallow water (fig. 369 *A*). In other specimens the ramification is feebler, the trichoblasts bearing only one or two simple branches, or they may be entirely unbranched. Such simple trichoblasts are particularly found in slender specimens belonging to or approaching to f. *tenuis*, generally in specimens growing in deeper water or in shaded localities. They were met with in most of the specimens collected in November, at a season when the growth is very feeble. They occurred too in several specimens collected by Bornholm in July and August. The trichoblasts are usually hyaline; in specimens from deep water, however, they may contain feebly rose-coloured chromatophores. The cells contain one nucleus. The trichoblasts may be shed early, in other cases they may persist for a fairly long time; thus in several specimens from the Baltic Sea they were still present on the 40th to the 42nd joint from the top.

Fig. 366.
Polysiphonia violacea. Tip of shoot treated with glycerine. *I—IV*, trichoblasts; pericentral cells numbered according to age; *b*, basal cell of trichoblast. 390 : 1.

The primary branches arise at the base of the trichoblasts and develop simultaneously with them. They do not, however, occur at all the trichoblasts but are usually separated by 4 or 5 joints; yet, two or even three primary branches often follow immediately after each other. The basal cells of the trichoblasts which are not accompanied by primary branches generally produce later branches which may be named secondary axillary branches. These branches arise at a considerable distance from the top, usually only when the trichoblast has fallen off, but not rarely before this has taken place; they may attain a considerable length but always remain much feebler than the primary axillary branches. Very often all the basal cells produce branches, though some of them reach only a small size. As an example is here given a diagram of a shoot, where *t* signifies trichoblast, $\underline{t}$ basal cell of a trichoblast fallen off, *b* primary branch and *s* secondary axillary branch:

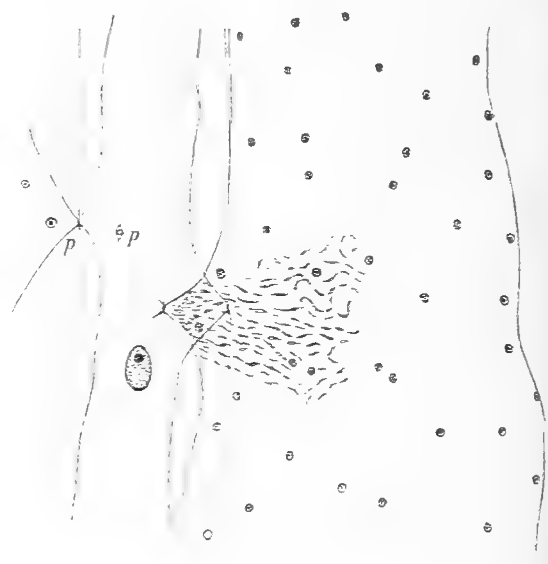


Fig. 367.
Polysiphonia violacea. Portion of central and pericentral cell showing nuclei, chromatophores (partly) and pits, *p*, connecting the central with the pericentral cells. 230 : 1.

s s s s b s s s s s s b b $\underline{t}$ *s s s s b s s s s b b* $\underline{t}\,\underline{t}$ *s s b s s s s b b s s t s b s s s s s b b s s s s b b t t t t b b t t t b t t t t b b* (top).

These secondary branches can be distinguished in the drawings of HARVEY (Phyc. brit. Plate 209) and KÜTZING (Tab. phyc. Vol. 13 Taf. 97 e, 98 e). They are very conspicuous in f. *aculeata* (fig. 374).

As in other species of *Polysiphonia*, torsions may occur in the long branches with the consequence that the primary branches may be placed in a longitudinal row over a long stretch (Plate VI fig. 1).

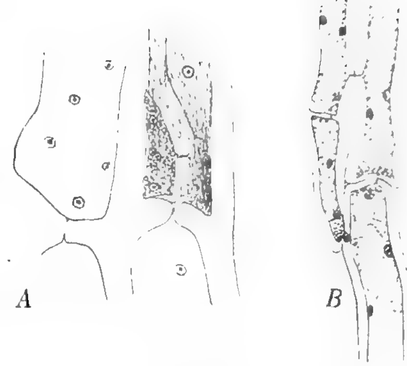


Fig. 368.
Polysiphonia violacea. *A*, cortical cell with three nuclei cut off from a pericentral cell. *B*, downward growing cortical filament on the point of establishing a secondary pit connecting it with another corticating filament. 230 : 1.

The central cell always contains a single nucleus; in the older cells it is rather large and situated in the middle of the cell. The pericentral cells after the formation of the secondary pits contain two nuclei which by continuous bipartitions produce the numerous small nuclei contained in the older pericentral cells. In one case c. 100 nuclei with a diameter of 5—6 μ were counted in one pericentral cell, while the nucleus of the central cell measured c. 30 μ in the greatest diameter (fig. 367). The central cell contains no chromatophores; the protoplasm shows a fine longitudinal striation.

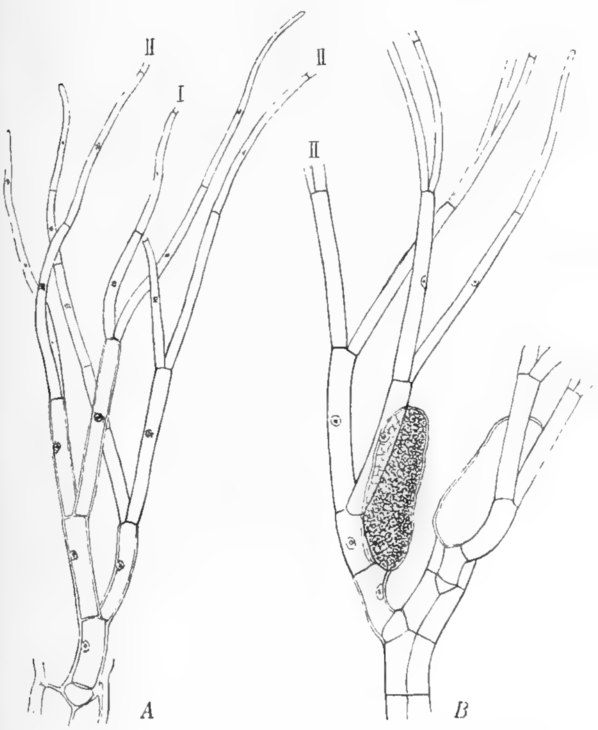


Fig. 369.
Polysiphonia violacea. *A*, trichoblast. *B*, trichoblast with antheridia. 200 : 1.

Cortical cells are always produced, but the cortication occurs in various degrees; it is most developed in f. *fibrillosa*, least in f. *tenuis*. It is usually not more pronounced than that the pericentral cells are visible between the cortical filaments; in the lower part of the main stem, however, the pericentral filaments may be completely covered, in particular in f. *fibrillosa*. The primary cortical cells are cut off from the undermost part of the pericentral cells by an oblique wall and originally contain more than one nucleus (fig. 368). They early begin to grow downwards in the outer wall between two pericentral cells, dividing by transversal walls. At their upper end they may also grow upwards under segmentation. The descending bark-

Fig. 370.
Polysiphonia violacea. Ripe cystocarp. 76 : 1.

filaments become connected with each other and with the pericentral cells by secondary pits (fig. 368 *B*). Two pits in the same wall may even occur.

The antheridia occupy the main axis of the male trichoblasts except the two lowermost cells, and the second cell bears a sterile branch on its right side. A torsion takes place, however, in the second joint with the consequence that the sterile branch issues on the outer side of the trichoblast and thus serves to protect the antheridial body (fig. 369).

Fig. 371.
Polysiphonia violacea. Branch with tetrasporangia. 200 : 1.

As regards the development and the structure of the cystocarps reference may be made to YAMANOUCHI (1906). A ripe cystocarp is shown in fig. 370.

In the tetrasporiferous shoots a considerable number of joints, usually without interruption, contain each one sporangium. As the sporangia always arise to the left of the trichoblast of the same joint, the sporangia are thus arranged in a spiral. The fertile joints have 6 pericentral cells, two of which are cut off from the cell which gives rise to the sporangium and which corresponds to the second pericentral cell in the sterile joints (figs. 372, 373, comp. fig. 366). One of these secondary pericentral cells does not reach the base of the joint, and a small peripheral cell (*p*) is here later cut off from the inner cell which is thereafter divided by a horizontal wall in a short stalk-cell (*s*) and the mother-cell of the sporangium. The stalk-cell is then connected through pits with the central cell, the sporangium, the two secondary pericentral cells and the small peripheral cell, *p*.

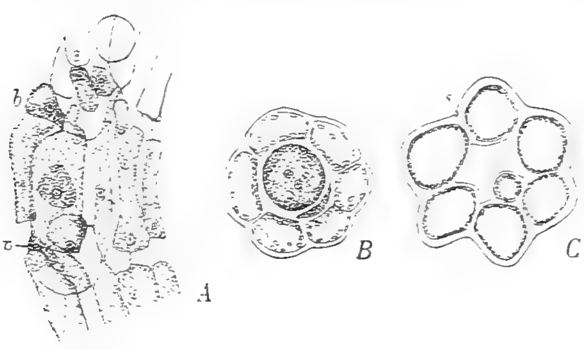


Fig. 372.
Polysiphonia violacea. *A*, tetrasporiferous joint; *b* basal cell of trichoblast; *p*, small peripheral cell. *B*, transverse section of tetrasporiferous joint. 390 : 1. *C*, similar after evacuation; *s*, split through which the tetraspores have escaped. 230 : 1.

P. violacea which is one of the most common species of Algæ in the Danish waters is very variable. The single characters distinguishing the different forms, as the length of the joints, the degree of cortication, the degree of branching of the trichoblasts and the frequency of the secondary axillary shoots are evidently dependent on the outer conditions. *P. fibrillosa* has hitherto been regarded as a distinct species though in its morphology it exactly agrees with *P. violacea* and only differs by very variable characters such as those mentioned. HARVEY indeed observes of *P. fibrillosa* (Phyc. Brit. Pl. 302, 1851): "It is most nearly related to *P. violacea*, with which alone can it well be confounded, and from which it chiefly differs in its shorter and less multified ramuli, duller colour, and shorter articulations; but there are specimens occasionally found which seem almost to connect these two species together". J. AGARDH, REINKE and KYLIN admit too the relation of the two species but nevertheless consider them as distinct. After having examined a great number of specimens from numerous localities in the Danish waters I have arrived at the apprehension that it is impossible to draw a natural line of demarkation between them. In too many cases it depends on an arbitrary estimate whether a specimen may be referred to the one or the other of the two species, and I have therefore arrived at the conclusion that *P. fibrillosa* must be regarded as a form of *P. violacea* distinguished principally by shorter joints and stronger cortication. The trichoblasts are strongly developed and much branched, at the base up to 28 μ thick. The straw-colour of the frond emphasised by REINKE is entirely due to an intense light. It grows only in slight depths and in rather light places, and usually also in more agitated water, and these conditions undoubtedly produce the characters mentioned.

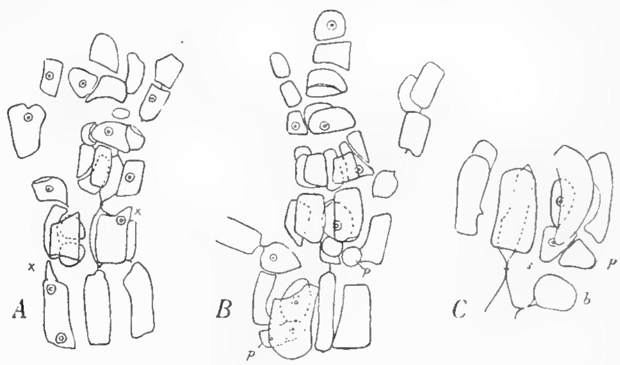


Fig. 373.
Polysiphonia violacea. Division of tetrasporiferous joints. *b*, basal cell of trichoblast; *p*, small peripheral cell; *s*, stalk cell of sporangium; × small cell establishing the secondary pit between the pericentral cells. 636 : 1.

In f. *fibrillosa* the joints in the upper part of the frond are about $1^1/_2$ (1—2) times as long as the diameter. In f. *typica* they are longer, usually 3—5 times as long as broad. In this form the main axis is distinct as is the case also with f. *fibrillosa*. But the thickness of this axis is variable, and in the finer forms it is scarcely thicker than the principal branches. In f. *tenuis* the principal axis is thin and not discernible from the branches; the joints are longer, c. 6—9 times as long as broad, the cortication almost wanting, the secondary axillary shoots are scarce, and the trichoblasts simple or feebly branched, often with rose-coloured chromatophores. This form grows in localities with feebler light and less agitated water, principally in fjords and in great depths.

F. *aculeata* is a loose sterile form characteristic by its squarrose branches and by wanting cortication. It has usually numerous secondary axillary branches which in spreading at right angles give to the plant a characteristic appearance (fig. 374). Sometimes, however, the secondary branches occur only rather sparsely, and the plant might then be referred to *P. divaricata* Ag. which is otherwise not sufficiently different from f. *aculeata* to be distinguished from it as a different form. F. *aculeata* occurs in shallow water. It must be assumed that loose individuals of *P. violacea* drifted in shallow water may go on growing there and by the altered condition, in particular the stronger light, assume the appearance characteristic to this form. Specimens of f. *fibrillosa* growing in very sunny localities, e.g. the stony reef in Kalø Vig, may take an appearance reminding one of f. *aculeata* by squarrose branchlets.

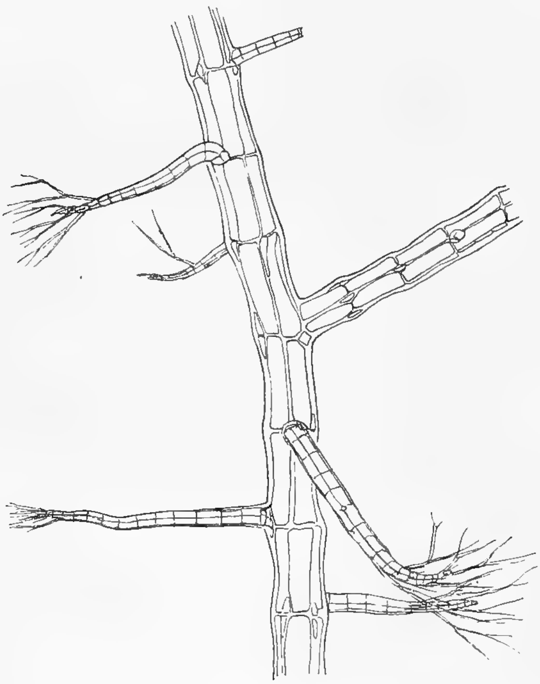


Fig. 374.
Polysiphonia violacea f. *aculeata*. Portion of shoot with one primary and 6 secondary axillary branches. 36 : 1.

P. violacea may complete its development in a short period. Most of the individuals probably only reach an age of a few months. This is at least the case with the specimens which grow on annual species of Algæ, e. g. *Chorda Filum*; they must have germinated in spring (May) or later, are fully developed in summer, and perish with the host plant in autumn. In favourable localities more than one generation may probably be produced in one summer. In the plant shown in fig. 365, collected June 15th, which was certainly only a few weeks old, a young procarp was already discernible in the trichoblast of the 20th joint of the plant, and another young plant of about the same size bore almost ripe antheridia. Most of the specimens certainly perish in autumn after fructification, but other individuals endure the winter and recommence in spring the growth arrested during the winter.

The growth ceases or is at least much diminished in August, and several individuals then begin to lose the trichoblasts. In the following months the growth is likewise stopped or extremely feeble. In November all or most of the trichoblasts are thrown off, and that is also the case with the tips of many of the shoots. In December and January the species appears in the same stage (fig. 375). In the last part of December 1890, however, I found on the bottom of Holbæk Fjord, which at that time had been covered with ice during a month, specimens with well preserved growing points and trichoblasts. The growth recommences in the last part of the winter. In the wintering specimens new shoots are found in spring growing out from the basal cells of the decayed trichoblasts, while the tips of the wintering shoots have fallen off. It seems, however, to be only a small number of specimens which endure the winter in a more advanced stage of development. In the northern part of the Kattegat, in the neighbourhood of Frederikshavn, I did not find any specimen of this species when collecting Algæ in December 1894 and Januar 1895, while it is very common there in summer. On the other hand full-grown specimens more frequently endure the winter in the inner waters, for I found such specimens in several places in the Little Belt and in the Great Belt in December and January. In the northern Kattegat it probably passes the winter in very small specimens arising from spores germinated in autumn.

P. violacea fructifies in summer. Ripe sporangia occur in May to September; in May the sporangia are frequently unripe. Ripe antheridia were met with in May to September and in November. Ripe cystocarps occur in July to September. The spores germinate immediately; sporelings are frequently met with on various Algæ in summer. Three days old sporelings from tetraspores and carpospores sown in vessels with sea-water showed about 10 tiers of cells.

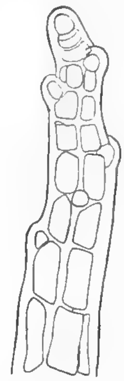


Fig. 375. *Polysiphonia violacea.* Tip of shoot in January. The trichoblasts have been shed; only the basal cells are to be seen. The two uppermost ones are perhaps rudimentary trichoblasts. 230 : 1.

The frond usually reaches a length of 7—14 cm, not unfrequently up to 20 cm, more rarely up to 30 cm. *β, fibrillosa* does not reach the same length as *α, violacea,* it scarcely grows over 13 cm in length. The longest specimens have been found in the following localities: Knollen, Øresund, 11—14 meters' depth, July, over 30 cm; Øresund east of Hveen, 10—19 met., July, 25 cm; N.E. of Sejerø light-house, 11—14 met., July, 22 cm; Lille Belt off Stenderup wood, 13—15 met., July, 20 cm. The maximal size is not very different in the various waters. Outside Skagen, however, the species does not reach the same size as in the more protected waters. It grows on all kind of firm substrata, stones, wood, but principally on various Algæ e. g. *Chorda Filum, Fucus, Furcellaria, Polysiphonia nigrescens, P. elongata* etc., further on *Zostera.* It occurs in depths of 0—19 meters, rarely deeper. *β, fibrillosa* grows principally on stony reefs in 0—7,5 meters' depth.

Localities. **Ns:** Does not occur at Fanø and Esbjerg. ZQ, jydske Rev, 24,5 meters (*α*). — **Sk:** *α*: Lønstrup, near land; *β*: Hanstholm; Bragerne; Hirshals mole. — **Lf:** Very common in all parts of the fjord, most frequently *α*, in deeper water *γ*; *β* at Rønnen by Lemvig, Oddesund and Nykøbing (Th. Mortensen). — **Kn:** *α* and *β* very common near land; wanting on Herthas Flak. Trindelen, FE, NI and dT[1], 9,5—11 m (*α*). — **Ke:** *α*, common to a depth of 28 m (ER east of Læsø. *γ*: ZE, Fladen, 15 m. — **Km:** *α* and *β* common. bK, N.W. of Anholt, 15 m, approaching to *γ*; *δ*: BO, BM, BL east of Jutland, 5,5—9,5 m, with Zostera. — **Ks:** *α* common, also in Isefjord: Holbæk Fjord, Frederikssund, PQ, near Boserup. *β*, several places. *δ*, Lammefjord. — **Sa:** *α* common to 14 meters' depth; *β* on stony reefs near land; *δ* Hofmansgave (Hofm. Bg., C. Rosenberg). — **Lb:** Principally *α*. *β* off Langore near land. — **Sf:** *α* most frequent. *β*: CT and Skaarup Ør (Rostrup). *γ* UX, Skjoldnæs, 9,5 m. — **Sb:** *α* common. *δ*: AC, off Knuds Hoved, 17 m. — **Sm:** *α* common. *δ* common: off Orenæsgaard, Petersværft, Kragevig, Guldborgsund. — **Su:** *α* common. *β*: Kronborg (C. Rosenberg); QD, south of Saltholm; Dragor (not typical). ♂ Kronborg (f. divaricata, C. Rosenberg). — **Bw:** α Egernsund; Pøls Rev; LC, off Gulstav. — **Bm:** α common. γ Præstø Fjord, Tromnæs, Falster (O. Paulsen). — **Bb:** α: 0—11 m depth, up to 8,5 cm long; in several places with tetrasporangia, sexual organs and cystocarps not observed.

5. **Polysiphonia Brodiæi** (Dillw.) Grev.

Harvey in Hooker, Brit. Flora Vol. II part I, 1833, p. 328; Harvey, Phyc. Brit. Vol. II, 1849, Pl. 195; J. Agardh, 1863, p. 993; Kützing, Tab. phyc. 14. Bd., 1864, Taf. 1; Kny, 1873, p. 103; Schwendener, Monatsber. d. Ak. Wiss. Berlin 1880, p. 333; Falkenberg, 1901 p. 34 Taf. 21 Fig. 12; Kolderup Rosenvinge 1902, p. 342, Taf. VI Figs. 1—2; id., 1903, p. 444 and p. 457; L. Batten, 1923, p. 303, figs. 61—63.

Conferva Brodiœi Dillw. Brit. Conf. 1809, pl. 107.

Hutchinsia Brodiœi Lyngb. Hydr. 1819, p. 109, pl. 33 B; Flora Dan. 1840, tab. 2312 (?).

Polysiphonia penicillata (Ag.) Kützing, Tab. phyc, 14. Bd., Taf. 1.

The erect shoots, with the exception of the primary shoot, issue from a system of creeping filaments with short articles, partly as continuations of these, partly as endogenous branches of them. The creeping shoots bear no trichoblasts but numerous rhizoids, and such organs may also be produced in abundance from the lower part of the erect shoots. These shoots, which are very flexible, on the Danish coasts attain a length of more than 20 cm; in almost their whole extent they bear a number of penicilliform shoots which are mostly much shorter than the main shoots. Long shoots are principally given off from the lowermost part of the primary axis; they are usually shorter than this, and transitional stages between the long and the short shoots frequently occur.

The trichoblasts of the erect shoots are arranged in a spiral almost always turning to the left. As shown by me (1902, p. 342), the spiral in 165 sporelings in 160 cases turned to the left, in 4 or perhaps 5 cases to the right (2,5 and 3 per cent respectively), and in the numerous full-grown plants examined I have met with one shoot only with a spiral turning to the right. According to Kny, the angle of divergence was, in plants from Cherbourg, $^1/_7$ of the circumference, between the first trichoblasts of the shoots, however, $^1/_6$. In the Danish specimens I found the divergences varying about $^1/_6$, from a little greater than $^1/_7$ to a little smaller than $^1/_5$, most frequently nearly $^1/_6$, and that not only at the base of the shoots. In the sporelings the divergence was $^1/_5$. The first trichoblast appeared on the 5th to the 8th joint, and henceforth each joint bears a trichoblast (fig. 384).

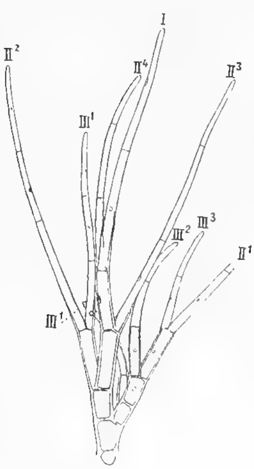


Fig. 376. *Polysiphonia Brodiœi.* Trichoblast seen from the back. 200 : 1.

The trichoblasts show the usual structure; they are well developed and are kept comparatively long. The primary branches (*II*) are alternate in two lateral series converging towards the axis, the branches of the second order (*III*) are likewise alternate in two series converging towards the primary axis of the trichoblast; the first branch of the second order III^1 is directed towards the stem (fig. 376). Each cell of the trichoblasts contains one nucleus. For a transitional stage between a trichoblast and a stem comp. K. R. 1903, p. 457.

The number of pericentral cells is, as shown by J. AGARDH, 7—8, more rarely 6, in the full-grown plant. The first pericentral cell is cut off exactly under the first leaf or, more frequently under its right side (fig. 377). The cortication begins rather early, the primary cortical cells being cut off at the lower angles of the pericentral cells and growing downwards and dividing. A cortex of considerable thickness, consisting for a great part of hypha-like filaments, early covering the pericentral cells, is then formed. At the same time a plexus of hypha-like filaments appears between the central cell and the pericentral cells (fig. 378). It was detected by J. AGARDH (1863, p. 993), who thought that it arose by division of the central cell. Later on it was figured by FALKENBERG who rightly shows (1901, p. 34, Taf. 21 Fig. 12) that the hyphæ arise from the pericentral cells, which I can confirm. Secondary pits are produced in considerable number through the longitudinal walls between the cortical cells mutually and between these and the pericentral cells.

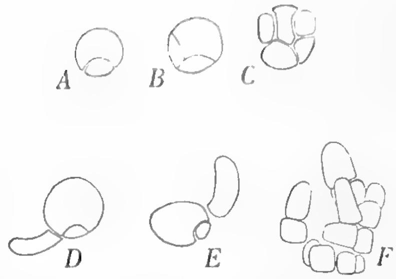


Fig. 377.
Polysiphonia Brodiæi. *A*—*C*, segregate young segments of sporeling seen from the face, showing the successive divisions. *D*, *E*, similar segments, from older plant, the fourth from the top, showing the relation of the first pericentral cell to the trichoblast; *D* seen from above, *E* from below. *F*, young segments seen from the side. 626 : 1.

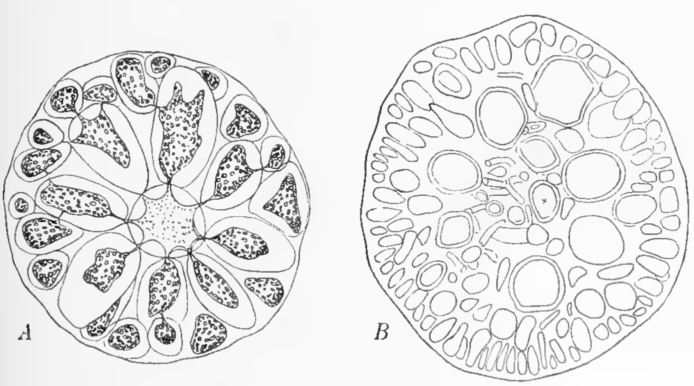


Fig. 378.
Polysiphonia Brodiæi. Transverse sections of stem. *A* rather young. 200 : 1. *B* older with hypha-like filaments in the interior of the stem. × the central cell. 63 : 1.

The branches arise, as shown by KNY (1873), in the axils of the trichoblasts, however, not exactly in the median plane, but they are somewhat displaced to the left. The joint common to the trichoblast and the branch has 3 pericentral cells, two of which are situated to the left and one to the right of the median plane of the trichoblast, as shown by KNY. The pit connecting the second cell of the trichoblast with the central cell of the basal joint appears at the upper end of the longitudinal wall between the middlemost pericentral cell and that to the right (fig. 379). The ordinary (primary) branches do not arise in the axils of all the trichoblasts. In the lower part of the long shoots none or only few are present, upwards they increase in number but decrease again in the fertile region, in particular in the tetrasporiferous and male plants. In the upper part of the plant two or three or even more branch-bearing joints may follow consecutively; on the other hand, the number of interjacent branchless joints may vary from one to many. The basal cell of the originally branchless trichoblasts frequently later on gives rise to a secondary shoot which, however, as a rule attains only a small size. As examples some diagrams of shoots may here be presented: *t* signifies a trichoblast without primary branch, *r* a primary branch, *s* a secondary branch, (*t*) a basal cell of a shed trichoblast, ♂ a male trichoblast.

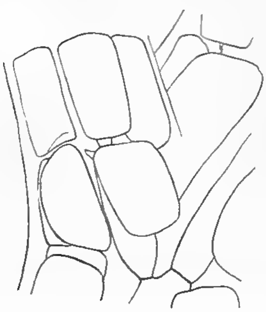


Fig. 379.
Polysiphonia Brodiæi. Basal portion of branch showing the pit connecting the central cell of the basal joint with the rest of the trichoblast. 390 : 1.

long shoot: *s s s s s s s s s* (*t*) (*t*) *r r s r s r* (*t*) (*t*) *r t* (*t*) *r t t r t t r r r r t r*
tetrasporiferous plant: *r s r r* (*t*) (*t*) *r* (*t*) (*t*) *r* (*t*) *r* (*t*) *r* (*t*) *r* (*t*) (*t*) *r* (*t*) (*t*) *r t*
similar: ...*t t r t t t r t t t t t t t*
male plant: ...*t r t t t r t t*♂ *r t*♂ *t*♂ ♂
similar: ...*t t r t t*♂ ♂ *r*

The first lateral organ (trichoblast) of the branches is usually in the Danish specimens placed on the second joint; in specimens from Cherbourg, Kny found it on the second to the fifth joint.

As in most other species of the genus the antheridia are produced in the main axis of the trichoblasts except the two lowermost joints. At the right hand the upper of these cells bears a sterile branch which projects more than the antheridial body and may thus protect it. A sterile cell does not occur at the top of the full-grown antheridial body.

The carpogoniferous trichoblasts frequently show a curious aberration, some of the cells of their primary axis bearing two branchlets each (cp. K. R. 1903 p. 444). The fertile trichoblast shown in fig. 380 bears two branchlets on the fourth joint to the right and two on the fifth joint to the left. In other cases one joint only (the fourth) bears two branchlets, and in one case the 3rd joint, which normally bears no branch, bore one branch on the left side, the 4th two branchlets on the right side, the 5th one branchlet on the left side. The second joint of the female trichoblasts may even in rare cases bear a branch; such cases are shown in fig. 381. In fig. *A* the second, fertile, joint and the fourth bear each a branch to the right, the third bears no branch. In fig. *B* the second joint bears a branch to the right, the third one to the left and the fourth one to the right. In the latter case the first joint of branch 2 bears no branch as if it were a basal cell of a trichoblast; its second joint bears two branchlets. Branch 3 bears two branchlets on its first joint. In all cases where a joint bears two branchlets, the last-formed branchlet is placed

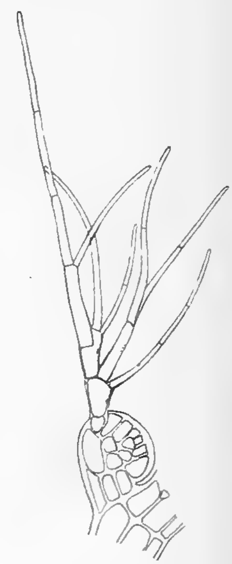


Fig. 380.
Polysiphonia Brodiæi. Young female trichoblast. 220 : 1.

under the first and feebler than it. Accessory branchlets do not occur in all the female trichoblasts, and in some specimens (f. inst. from Thyborøn) they were not met with at all.

In the ripe cystocarps the orifice is enlarged and funnel-shaped, consisting of large cells (fig. 382).

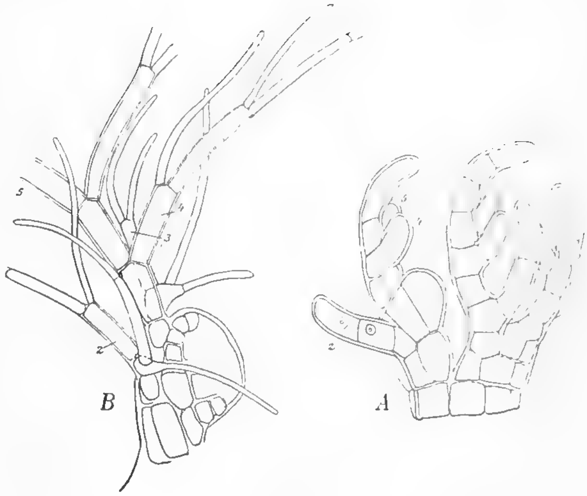


Fig. 381.
Polysiphonia Brodiæi. Female trichoblasts with supernumerary branchlets. The figures indicate the branches of the first order according to the joints of the primary axis of the trichoblast. (See texte). *A* 560 : 1. *B* 350 : 1.

The tetrasporangia arise at the left side of the trichoblast borne on the same joint; they are produced by the second pericentral cell (comp. fig. 377). Two secondary pericentral cells are cut off from this cell and the most remote of them is usually a little shorter than the other, a small peripheric cell being later cut off from the basal cell of the sporangium. This small cell may, however, be wanting, the second secondary pericentral cell continuing to the base of the article (fig. 383).

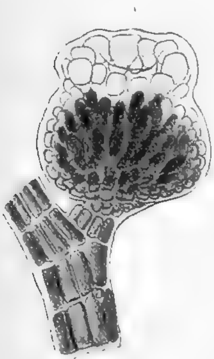


Fig. 382.
Polysiphonia Brodiæi. Ripe cystocarp. 63 : 1.

Germination is easily realised in cultures (comp. K. R. 1902 p. 342). In August sporelings consisting of 6 joints or more and bearing trichoblasts were produced in two days. The lowermost article or the two first joints produced no pericentral cells but only feebly coloured rhizoids. The following one to four joints had 4 pericentral cells, the following 5, and shortly afterwards joints with 6 or 7 pericentral cells appear, the same number which is found in a transverse section of the lower part of the stem of a full-grown plant. As mentioned above, the angle of divergence in the sporelings is $^1/_5$ of the circumference. — Abnormal sporelings, showing two opposite rhizoids or two opposite vegetative poles were not unfrequently met with in my cultures.

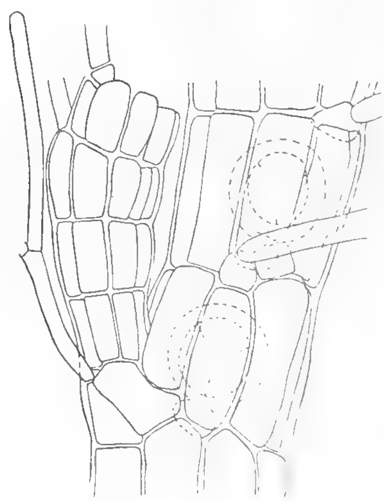


Fig. 383.
Polysiphonia Brodiæi. Portion of tetrasporiferous plant with branch. 350 : 1.

This species has only been collected in the months of May to September. It has the appearance of being annual on the Danish shores. In May small specimens only were met with at Hirshals, and in April I did not find it at all in the same locality. Further it was not contained in the samples of Algæ from the groins of Thyborøn collected and sent to me in March. It therefore seems probable that the plants die in autumn or in winter, leaving only the young plants produced by the germinating spores and the basal parts of some of the older plants, which pass the winter in a resting stage and again take up the

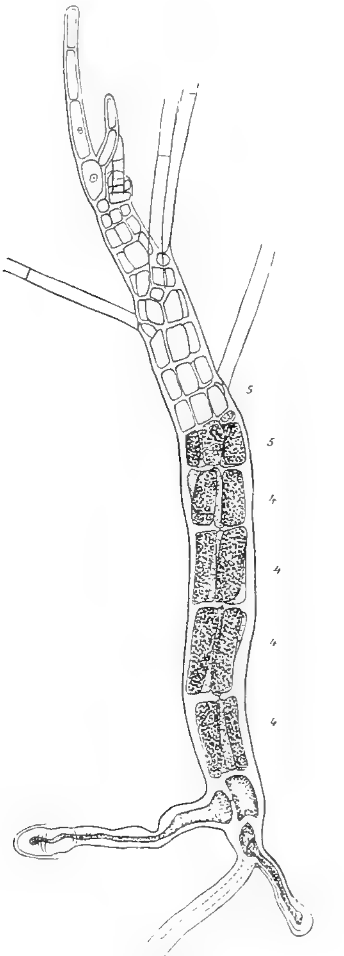


Fig. 384.
Polysiphonia Brodiæi. Sporeling. The figures denote the number of pericentral cells in the joints.

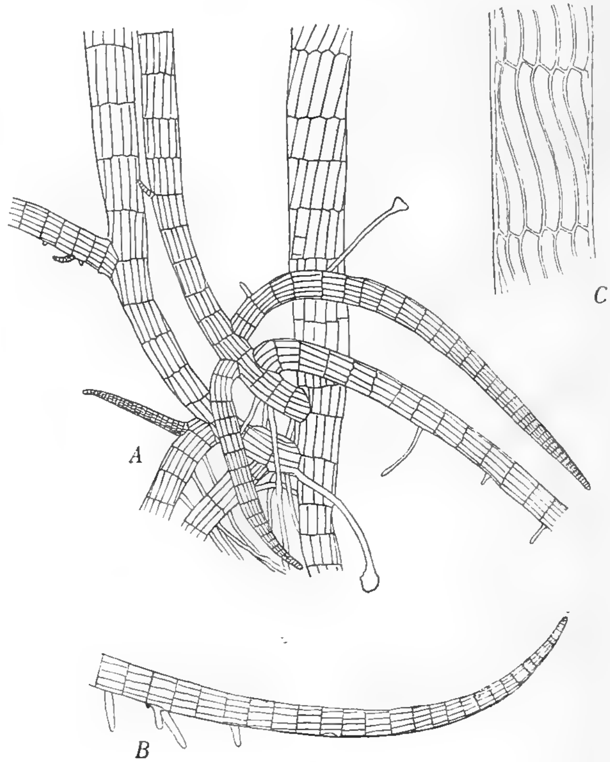


Fig. 385.
Polysiphonia atrorubescens. *A*, portion of plant near the base; numerous rhizoids and endogenous branches. *B*, decumbent branch. *C*, joint of stem. *A*, *B* 26 : 1. *C* 68 : 1.

growth in spring. Antheridia were met with in all the months mentioned, cystocarps and tetrasporangia only in July—September. It grows in exposed places on moles, stones and wrecks at middle sea level. In moles and groins it forms a continuous vegetation at the ordinary limit of the sea.

Localities. **Ns:** Groins at Harboøre and Thyborøn; harbour of Thyborøn, outside. — **Sk:** Hanstholm, Roshage, stone on the shore; Lønstrup, stones on the shore, Hirshals, mole and reef; wreck by Skiveren; Højen, on pebbles within the innermost shoal and between the first and the second shoal, 1—4 meters. — **Kn:** Harbour of Skagen, outside eastern mole.

6. **Polysiphonia atrorubescens** (Dillw.) Grev.

Greville, Flora Edinensis, 1824, p. 308; Harvey, Phyc. Brit. Vol. 2, 1849, pl. 172; Kützing, Tab. phyc. 13. Band, 1863, Taf. 82; J. Agardh, 1863, p. 1035; Farlow, Mar. Alg. N. Engl. 1881, p. 174; Kuckuck, Bemerk. I, 1894. Wiss. Meeresuntersuch. N. Folge I. Bd., p. 253, Fig. 21; L. Batten, 1923 p. 289 fig. 26—29.

Conferva atrorubescens Dillwyn, Brit. Conf. 1809, pl. 70.

Polysiphonia Agardhiana Greville, Scottish Cryptog. Flora Vol. IV, 1826, plate 210; Kützing Tab. phyc. 13. Band, 1863, Taf. 49.

A number of vigorous endogenous creeping shoots are given off from the base of the primary shoot and from the long branches issuing from its base (fig. 385).[1] These shoots produce numerous rhizoids (comp. KUCKUCK, BATTEN) and such organs are also given off in number from the lowermost part of the erect shoots. The rhizoids are separated from the pericentral cell by a wall and contain numerous nuclei. The creeping shoots bear no trichoblasts but produce endogenous shoots; they are not much branched, most of the branches issuing from their proximal part. Some of these shoots, arising from the upper side, become erect, others, given off from the flanks or from the under side of the shoots grow out in a horizontal direction. The branches arising at a greater distance from the base of the creeping shoots attain only a small size. The creeping shoots are usually somewhat incurved at the top, but not always upwards; they seem not to change from the horizontal to the vertical direction of growth, being transformed into erect shoot.

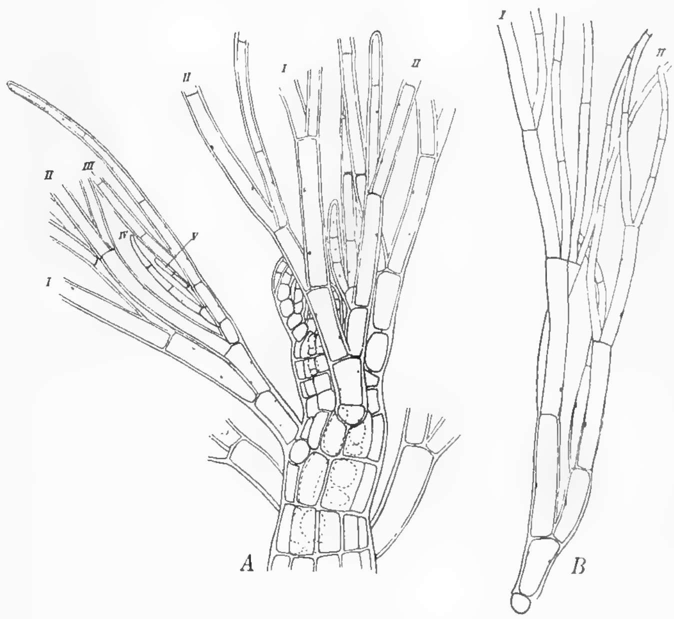


Fig. 386.
Polysiphonia atrorubescens. *A*, tip of tetraspore-bearing shoot with trichoblasts. *B*, trichoblast. 200 : 1.

The long erect shoots are densely tufted, issuing endogenously partly from the lowermost part of the erect filaments, partly from the innermost part of the creeping shoots. They bear no trichoblasts from the base to a comparatively great distance upwards; often more than the first twenty joints are without trichoblasts, but endogenous branches may occur in this part of the shoots. The trichoblasts are as a rule separated from each other by more than one joint, frequently by two or three

[1] HARVEY incorrectly ascribes a scutate root to this species (Phyc. Brit. l. c.).

joints, sometimes even more. In the upper parts of the plants, however, in particular of the sex plants, the trichoblasts may follow immediately after each other on the consecutive joints. In the male plants, the fertile trichoblasts are usually densely crowded at the upper end of the shoots, each joint bearing a trichoblast.

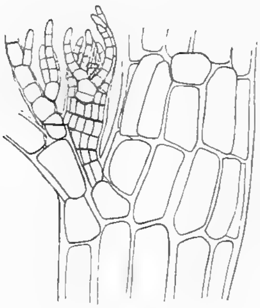


Fig. 387.
Polysiphonia atrorubescens. Basal portion of trichoblast with axillary shoot. 200 : 1.

The angle of divergence of the trichoblasts must be determined at the upper end of the shoots, for torsions take place later. It is usually $^1/_5$ or nearly so. In a male shoot I found it $^1/_6$. On the other hand, in short branches I found a divergence of $^1/_3$. The spiral always turns to the left; in one short shoot only I found a spiral turning to the right. The trichoblasts have the same structure as in the other species; they are much branched. The cells of the fully developed trichoblasts contain two or more nuclei; two nuclei most frequently occur (fig. 386), but four were repeatedly met with.

The branches arise as axillary buds to the trichoblasts, but only part of the trichoblasts, mostly those of the lowermost part of the shoots, are accompanied by shoots; these are placed at the left side of the trichoblasts. The first joint of the branches common to the branch and the trichoblast has three or four pericentral cells. The pit connecting (the second joint of) the trichoblast with the central cell in the basal joint is situated in the longitudinal wall between the outermost pericentral cell to the right and the cell next to it (fig. 388 *A*). The branches are given off from the axes under a rather acute angle, and they are often connate with the joint above to some extent. It may even rarely occur that the second joint of the branch is entirely connate with the mother shoot. The first trichoblast of the branch is always situated on the left side of the 3rd to the 6th joint (fig. 388 *B*). The basal cells of the shed trichoblasts often produce secondary axillary shoots, developing into short shoots, sometimes fructiferous but often reaching only a very slight degree of development. In these shoots, as in the primary ones, the first trichoblast arises on the left side. As mentioned above, endogenous adventitious shoots,

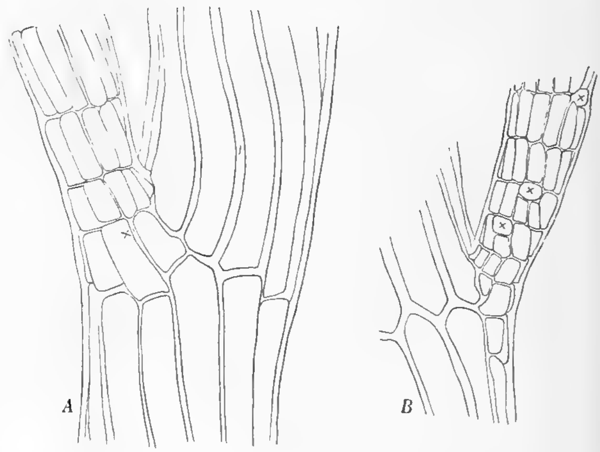


Fig. 388.
Polysiphonia atrorubescens. *A*, portion of branch showing the pit× connecting the central cell of the basal joint with (the rest of) the trichoblast fallen off. *B*, portion of branch showing the basal cells (×) of the three first trichoblasts. 150 : 1.

produced from the central cells, further occur on the creeping shoots and the undermost part of the long upright shoots, but they may also arise at the base of the normal branches in the upper part of the plant. They usually appear on the inner side of the branch, most frequently between the 2nd and the 3rd or between the 3rd and the 4th joint.

The upper trichoblast-bearing end of the shoots is curved, each trichoblast causing the axis to change direction. Later on, when the longitudinal growth takes place, the shoots are strengthened and each trace of bending is effaced. The number of pericentral cells is 11—13 in the long shoots, lower in the short shoots (about 9). The older joints, in particular of the longer shoots, usually show a more or less marked torsion, the pericentral cells being spirally curved, an appearance already observed by the first observers of the species. The torsion is undoubtedly caused by the pericentral cells growing more in length than the central cell. The coherence between the first and latter and between the ends of the pericentral cells in consecutive joints must, however, oppose resistance to this torsion, and this resistance may sometimes cause that the pericentral cells have a sigmoid curvature (fig. 385 *C*). The torsion may go to the right or to the left, and the direction may change in various joints of the same shoot. — Cortication does not occur.

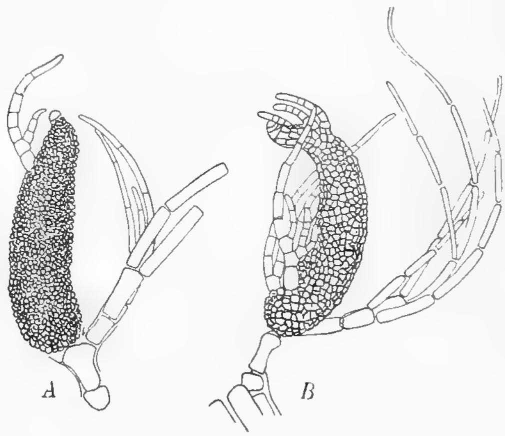


Fig. 389.
Polysiphonia atrorubescens. Male trichoblasts with sterile branches. 200 : 1.

The antheridia have been met with only once in a specimen from Hirshals (July 1914). The male trichoblasts may have the same appearance as in most other species, the antheridial body occupying the main axis of the trichoblast except the two first joints, the upper of which bears a sterile branched branch to the right.[1] But the fertile part of the trichoblast, which is always curved inwards, often bears sterile branches on the flanks in varying number (1 to 3 or more), issuing from the inner central axial cell-row (fig. 389). The antheridial bodies may then be a little irregular in shape and sometimes slightly branched. It also happens that the lower sterile branch is transformed into an antheridial body. The sterile branches of the antheridial bodies occurred in so great a number that they seemed to be a normal appearance.

The ripe cystocarps are nearly globular, about 400 μ in diameter, with a short stalk, the ostiole is small, situated in a slight depression and surrounded by small cells. The outer cells of the cystocarpial wall are connected with secondary pits, the formation of which is easily studied in this object.

[1] According to THURET (Et. phyc. p. 86) the male trichoblast in this species bears no sterile branch on the coast of France.

The tetrasporangia occur in the upper ends of the long shoots and in the fusiform short shoots. They are situated to the right of the trichoblast in the trichoblast-bearing segments, in the foregoing trichoblast-less joints the sporangia are situated under the sporangium in the trichoblast-bearing joint. The sporangia are covered by two secondary pericentral cells. A small peripheric cell is never found under one of these.[1]

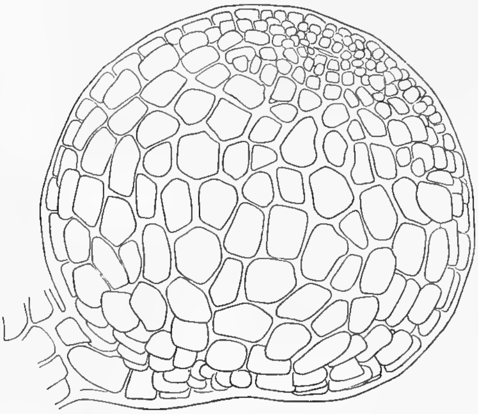


Fig. 390.
Polysiphonia atrorubescens. Ripe cystocarp. 150 : 1.

P. atrorubescens occurs only in waters with a high salinity. It grows on stones and shells of mollusks at from one to 23 meters' depth or deeper. In the Skagerak it has mostly been found near land in 1 to 4 meters' depth growing on stones, in the northern Kattegat in 11,5 to 23 meters' depth or deeper in soft bottom growing on *Aporrhais, Turritella* a. o. mollusks. Its non-occurrence in the upper regions of this water is probably due to the slighter and more variable salinity. It has only been collected in the summer months (June—August) and thus it cannot be stated whether the species is annual or perennial on the Danish shores. In October it was only met with once in a denudate state. GREVILLE and HARVEY mention it as annual, while BATTERS states that it is to be found "all the year". In the Skagerak and the Limfjord it attains a length of 18 cm, in the Kattegat 13 cm. In the Danish waters it has been found with cystocarps and tetrasporangia in June to August, with antheridia in July. It must be supposed that the spores germinate in summer and that the plants pass the winter in a feebly developed state.

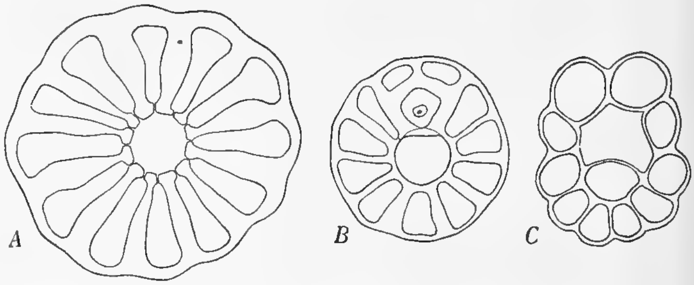


Fig. 391.
Polysiphonia atrorubescens. *A*, transverse section of stem. *B*, *C*, transverse sections of tetrasporiferous joints, *C* emptied. 200 : 1.

Localities. **Sk:** YT[3] and YT[5], Hanstholm 5,5 and 13 meters and YM, Roshage, near land, 2 m; Bragerne, YM[1], 1,5—2 m; Grønhøj Strand, Miss Ellen Möller; Lønstrup, on stones near land, 1 m;

[1] J. AGARDH states (l. c. p. 1037) that he has found two sporangia in each joint in a densely branched specimen from Tanger collected by SCHOUSBOE. As this species has not been found near Tanger (comp. BORNET, Les Algues de Schousboe. Mém. soc. sc. nat. Cherbourg 1892 p. 315) it must be supposed that it has been confounded with another species, f. i. *Ophidocladus Schousboei* (Thuret). (Comp. DE-TONI Syll. Alg. IV, p. 1073).

Hirshals, on stones near land, 1—2 m; off Højen, on pebbles within the first shoal and between the first and the second shoal. — **Lf:** XY, at Mullerne, Thisted Bredning, 6,5 m; XV, north of Rønnen at Lem Vig; Oddesund, 6,5 to 10 m or deeper. — **Kn:** South of Skagens Gren, 13—15 m (Kramp); fC, 3 miles S.W. by S. of Skagen light-house, 15 m, denudate in October; YS², north of Græsholm, Hirsholm, 15 m; YX, east of Nordostrev, Hirsholm, 23—28 m; south of Hirsholm, 13 m; XH and XL, east of Marens Rev, 11,5—15 m. — **Ke:** FC, east of Flyndergrund, east of Læsø 17—18 m.

7. **Polysiphonia nigrescens** (Engl. Bot.) Grev.

Harvey in Hooker, Brit. Flora II, 1833, p. 332; Phyc. Brit. III, 1851, Plate 277; J. Agardh, 1863, p. 1057; Kolderup Rosenvinge, 1884, p. 13 (Résumé p. 2), plates I—II figs. 15—29; Hauck, Meeresalg. 1884, p. 244; Falkenberg, 1901, p. 129; Svedelius, Östersj. Hafsalg., 1901, p. 121; Kylin, 1907, p. 143; Lakowitz, Alg. Danz., 1907, p. 20; Kylin, 1923, p. 116; L. Batten, 1923, p. 306.

Conferva nigrescens Smith, Engl. Bot. 1806 Plate 1717.

Hutchinsia nigrescens Lyngb. Tent. 1819, p. 109 Tab. 33.

Hutchinsia violacea Lyngb. Tent. 1819, p. 112 ex parte, tab. 35 A.1—2. B.2.

f. *pectinata* J. Agardh, l. c., p. 1058; Aresch. Exsicc. No. 63 and 57 (*Polys. Brodiæi*).

f. *fucoides* J. Ag., l. c.

f. *flaccida* Aresch., 1850, p. 49; Kylin, 1907, p. 143, Taf. 5 Fig. 1.

f. *reducta* Svedelius, 1901, p. 121.

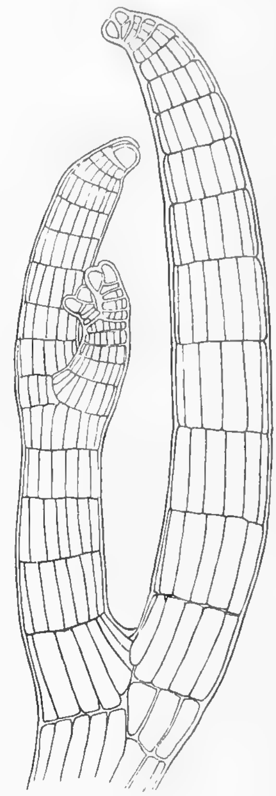


Fig. 392. *Polysiphonia nigrescens.* Frederikshavn December 31st. Tip of shoot without trichoblasts. 200 : 1.

The morphology of this very common species has been described at length by me (1884) and later by Falkenberg (1901). The trichoblasts are arranged in a spiral with rather large angles of divergence, about $^2/_5$. They may occupy all the consecutive joints, including those bearing branches which may take the place of some of the trichoblasts in the spiral (comp. K. R. 1884 fig. 24). But it also happens that "sterile" joints occur between the trichoblast- or branch-bearing ones, e. g. that every second joint only bears a lateral organ, or the sterile joints may occur more sparsely and more irregularly. In other cases the shoots are entirely or almost entirely devoid of trichoblasts; the branches are then placed in a spiral or they are biseriate, alternate, separated by a varying number of joints bearing no lateral organs. The latter occurs particularly in the f. *pectinata* J. Ag. but also in the other forms (fig. 392, comp. Falkenberg, p. 129). The main branches often begin by bearing only branches, no trichoblasts. Endogenous branches normally arise at the base of the primary axis and of the main branches (fig. 396), and at the base of almost all later well developed branches, mostly at their inner face (fig. 393, K. R. 1884, figs. 25—28); these endogenous branches may reach a considerable length. Secondary axillary shoots developed from the basal cell of trichoblasts also frequently occur, but these shoots usually reach only a small size (K. R. 1884 fig. 29); they sometimes arise before the trichoblast has been shed (fig. 395 *A*).

Fig. 393.
Polysiphonia nigrescens. Endogenous adventitious shoot at the limit between the second and the third joint of the branch. Small cortical cells have been cut off from the lower end of the pericentral cells. 220 : 1.

The trichoblasts show the usual structure; they have at least three generations of branchlets. The older cells contain a number of nuclei each (fig. 395 *B*). In specimens collected in April the trichoblasts had in a living stage a feeble rose tinge due to the cell sap, but the small round chromatophores were also feebly coloured. Later in the year the cell sap may have a brownish tinge.

The first joint of the branches is short and has only pericentral cells on its outer side, in a number of 4—6, the second joint of the branch being at the base in connection with the following joint in the mother axis. It may happen, however, that the first transversal wall of the branch does not reach the mother axis, but the first joint of the branch is at all events shorter than the following ones (fig. 394 *A*). A peculiar case is shown in fig. 394 *B*, where the third joint bears at the back the basal cell of a trichoblast whereafter follows a bifurcation, the two branches being of equal strength and diverging equally from the original direction of the axis. This must probably be because the apical cell, after having produced a trichoblast-bearing segment, has been divided by a vertical wall in two equal parts, each giving rise to a branch, a true dichotomy thus occurring here.

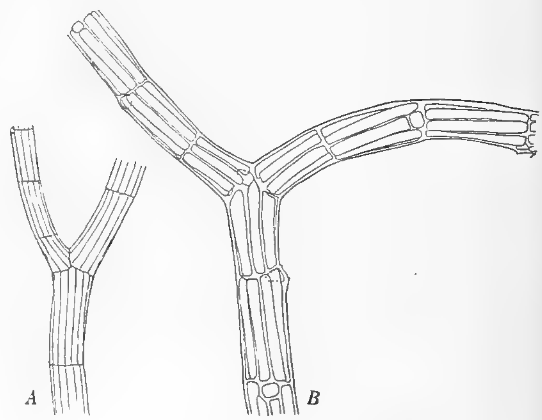


Fig. 394.
Polysiphonia nigrescens. *A*, pseudodichotomy; the first joint of the branch (to the left) is long, with pericentral cells all round, though shorter than the following joints. 50 : 1. *B*, portion of young plant; probably true dichotomy (see text).

In the upper part of the plants the first lateral organ on the branches usually occurs on the 3rd to the 5th joint, in the season of vegetation. The basal joint of the trichoblasts may sometimes produce pericentral cells, as if it were the basal joint of a branch (fig. 395 *B*). These trichoblasts must be apprehended as transitional forms approaching to the branches. A further transitional stage is shown in fig. 295 *C*, where the two lowermost joints are provided with pericentral cells and the upper of these has produced a tetrasporangium, while the upper part of the lateral organ has the character of a trichoblast, though it is unbranched. In winter (January) the plants as a rule bear no trichoblasts (fig. 392). The growth seems to begin slowly in February. In April, specimens with corymbiform shoots and well developed trichoblasts are met with, in May the trichoblasts have in great part attained their definitive size and in the two following months the growth gradually ceases. As the fully developed trichoblasts are shed early, hairless specimens may be found already in July; in September such specimens become more frequent, and in the following months they are almost exclusively met with.

The number of pericentral cells varies from 10 to 20, or more frequently between 12 and 17, but the average number is different in the different parts of the Danish waters as may be seen in the following table showing the numbers of pericentral cells found in cross sections of primary axes or principal long branches below the middle.

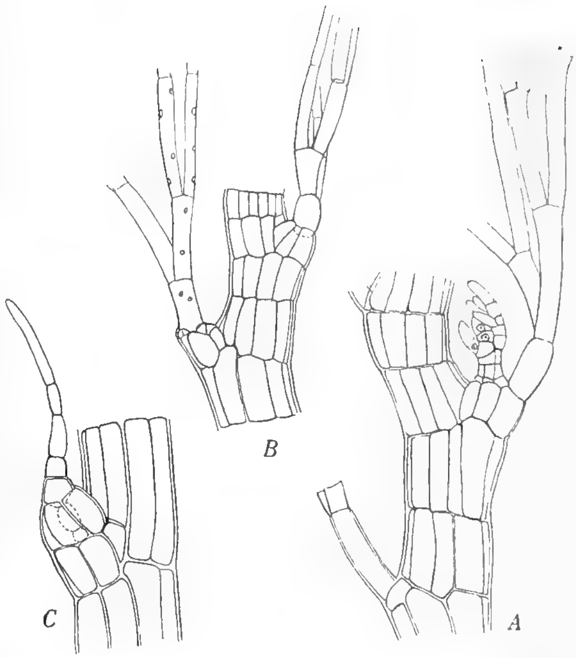


Fig. 395.
Polysiphonia nigrescens, from Søborghoved Grund off Gilleleje. *A*, a shoot has developed from the basal joint of the trichoblast. *B*, the basal cells of the trichoblasts have produced pericentral cells but no shoot. *C*, the two lowermost joints of an unbranched trichoblast have produced pericentral cells; the second joint a tetrasporangium. 200 : 1.

Number of pericentral cells.

	Localities over 11 meters' depth			Localities deeper than 11 meters		
	average number	numbers varying between	number of observations	average number	numbers varying between	number of observations
North Sea and Skagerak	15,1	12—18	26	..	..	..
Northern Kattegat	15,3	11—20	21	14,2	12—17	6
Southern Kattegat	14	11—17	19	13	12—14	2
Samsø Waters, the Belts and Sydfyn Waters	14,2	10—19	30	13,3	10—16	12
Smaaland Sea and Sound	13,7	12—15	17	..	..	..
Western Baltic and Baltic around Møen	13,1	11—16	16	12,2	11—14	5
Baltic around Bornholm	12,1	10—14	9	11	10—13	3

The table shows that the average number gradually decreases on going from the North Sea to Bornholm, and it is also a little smaller in deeper than in shallow water. In a specimen from the deepest locality where the species has been met with, US, Store Belt, in 33—45 meters' depth, 9—10 pericentral cells were found. The number of the pericentral cells is for the rest rather variable in different parts of the same plant. In the sporelings the first joint after the primary rhizoid-cell has no pericentral cells but gives rise to numerous rhizoids; the following two or perhaps more have 4, and in the next following the number gradually rises to the number normal to the species (fig. 396). In the branches of the latest order, the number may be much lower; in a tetraspore-bearing specimen I found it reduced to 6 (fig. 401 *C*).

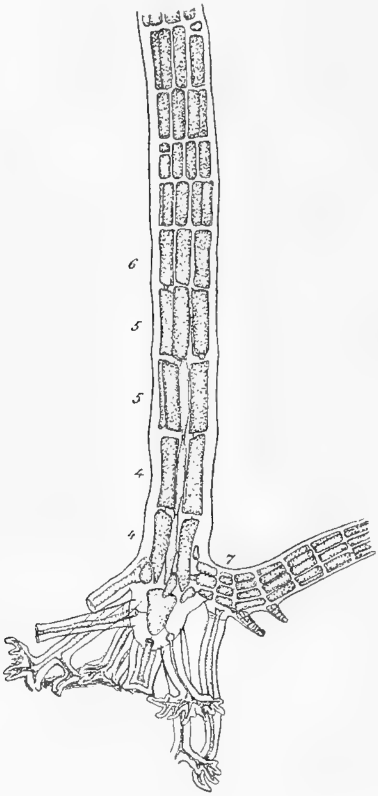


Fig. 396.
Polysiphonia nigrescens. Young plant. The lowermost cell of the primary axis is the short primary rhizoid-cell fixed to the substratum; the second has produced no pericentral cells but several rhizoids. The following joints have produced pericentral cells, the numbers of which are indicated by the respective joints. A vigorous branch of endogenous origin is given off from the lower end of the third joint. 70 : 1.

The pericentral cells usually contain numerous large starch grains. The nuclei were found situated at the inner and radial walls, not at the outer wall. The pericentral cells often contain peculiar star-shaped bodies with curved rays which are probably a sort of crystalloids (fig. 397 *B*). They take a brown tinge when treated with iodine. They are very resistent to chemical reagents; they were not dissolved by KOH, HCl and Eau de Javelle, nor by boiling water. They seem to disappear at a later moment, for in older pericentral cells they were not met with. The inner and radial walls of older pericentral cells are transversely striped. In a tetrasporiferous branch I found two nuclei in the central cells (fig. 401). At the level of the transversal walls between the joints, intercellular bodies like those described by me in *Polysiphonia fastigiata* as intercellular cuticular bodies (1884, p.10 (2), figs. 11—14) occur; they occupy the angles between the central cell and the pericentral cells, but are sometimes confluent and show some resemblance to cells (fig. 398).

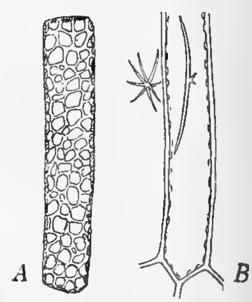


Fig. 397.
Polysiphonia nigrescens. A, pericentral cell showing chromatophores lying at the outer wall, January. 435 : 1. *B,* star-shaped bodies, probably crystalloids in pericentral cells. 300 : 1. After living plants.

The older parts of the long shoots are usually covered by a continuous cortex. The cortical cells arise as small cells cut off from the lower end of the pericentral cells.

The antheridia, as in the other species, usually occupy the principal axis of the fertile trichoblast except the two first joints; the antheridial bodies are usually pointed (comp. HARVEY l. c. and BUFFHAM) and terminate in a short row of sterile cells, but that is not always the case (comp. KYLIN 1923 p. 122). A sterile branch given off from the second joint is in many specimens normally present, in other specimens it is normally wanting, and the trichoblast is then unbranched. For the rest various arrangements may occur, as shown in fig. 399. As regards the development of the spermatia see KYLIN (l. c.).

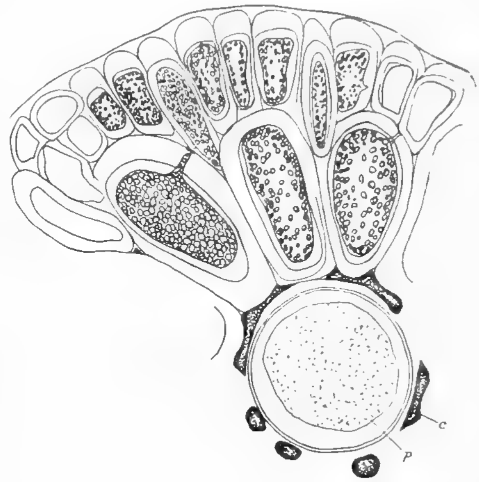


Fig. 398.
Polysiphonia nigrescens. Transverse section of stem, at the level of the transverse wall between two central cells. *p*, callus plate of the pit between the central cells. *c*, intercellular "cuticular" bodies. 200 : 1.

The development of the cystocarp from the second joint of the female trichoblasts and the position of the branches of the upper sterile part of these trichoblasts in relation to that of the sterile trichoblasts have been mentioned by me in 1884. The development of the procarp and the cystocarp has recently been very carefully studied by KYLIN (1923 pp. 118—121). The ripe cystocarps have a conical upper part, tapering towards the orifice (fig. 400).

The tetrasporangia are, in the shoots bearing a trichoblast on each joint, seated to the right of the trichoblast (or branch) borne on the same joint. When the internodia consist of more than one joint, the position of the one following next to a trichoblast seems usually to be determined by the position of the following trichoblast. The tetrasporangia are covered in the front with two pericentral cells between which a split is formed through which the spores escape at maturity. On the flanks the sporangium is covered by two other pericentral cells. No short peripheral cell is produced as in several other species. A cruciately divided sporangium was once observed amongst numerous sporangia divided in the ordinary tetrahedrical way.

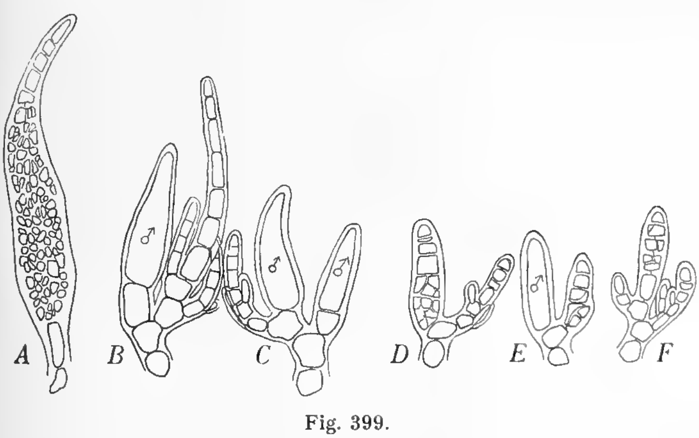


Fig. 399.
Polysiphonia nigrescens. Male trichoblasts, differing from the ordinary type, dorsal view. *A* without branches, *B—F* with one or two branches, sterile or fertile. *A* 230 : 1.

The species is very common in all the Danish waters. It is perennial and may be found in well developed and large specimens in all the seasons. In winter there is no or almost no growth, and the wintering shoots have no trichoblasts. In spring the plants are in full vegetative development with numerous hairs, and sexual organs occur. Thus antheridia and carpogonia were met with in April to June. Ripe cystocarps were met with in (May) June to September. Young tetrasporangia were found in April and May, ripe in May to September. The fructiferous branches seem to be thrown off in August and September, for in the following months the species was always found sterile. The denudate plants may produce new shoots in the following year as well as the young plants produced by the germinating spores in summer. The plants arising from early germinating spores may without doubt produce ripe spores in the same season while those germinating in the later part of the summer probably pass the winter in a sterile state. The denudate specimens bearing short remnants of the fructiferous shoots, may be referable to f. *senticosa*. Most of the specimens may be referred to f. *fucoides*. F. *pectinata* was met with in exposed localities in the North Sea and the Skagerak. In deeper localities in the inner waters slender specimens occur which may in part be referred to f. *flaccida* Aresch.[1] Other specimens from deeper localities were slightly branched and ought therefore to be referred to f. *reducta* Svedelius, described from the inner Baltic Sea. — The species thrives best in depths smaller than 15 meters, where it is very common, even in very light localities. Under that level it occurs rather rarely and only in small quantities.

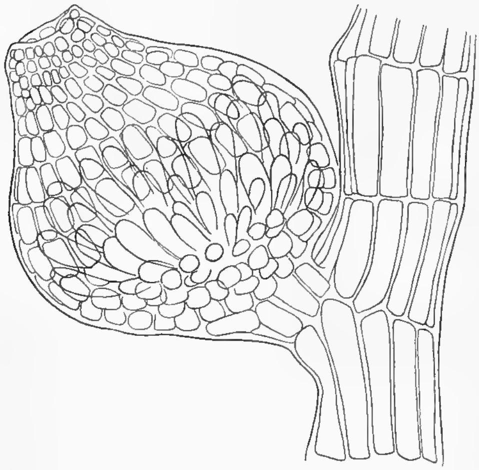


Fig. 400.
Polysiphonia nigrescens. Ripe cystocarp. 130 : 1.

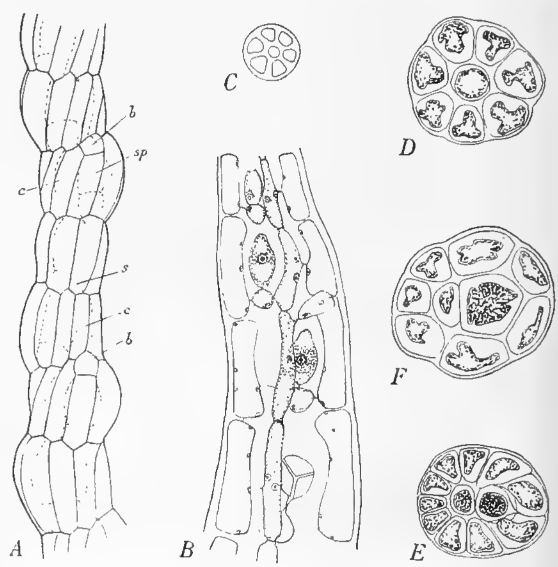


Fig. 401.
Polysiphonia nigrescens. *A*, portion of tetrasporiferous branch; *b*, basal cell of trichoblast; *c*, central cell; *s*, stalk cell; *sp*, sporangium. *B*, similar in longitudinal section. *C*, *D*, transverse sections of sterile joints, *E*, *F*, of fertile joints of tetrasporiferous branches. *A* 95 : 1. *B*—*F* 200 : 1.

[1] When Areschoug (l. c. p. 49) says that the branches and branchlets in this form are subhorizontal, it does not seem to be justified.

Thus in the North Sea it has only been found from low-water mark to 13 meters' depth, although several dredgings have been made in localities in deeper water. Further it was wanting in all the dredgings on Herthas Flak in the Northern Kattegat (19—22,5 meters), and in almost all the numerous dredgings made in the Eastern Kattegat. The species reaches a length of at least 20 cm; the largest specimens collected were 30 cm (Skagerak) and 35 cm (Lille Belt) long.

Localities. As the species is very common in shallow water, only localities deeper than 15 meters are recorded. In these specimens the joints were thrice as long as broad in the middlemost part of the frond. — **Ns:** From Esbjerg to Hanstholm, down to 13 m. — **Sk:** Down to 13 m. — **Lf:** — **Kn:** IX, near Trindelen, 19 m; YX, east of Nordøst-Rev, Hirsholm, 23—28 m. — **Ke:** Only in IN, Fladen, 15 m; EX, Groves Flak, 26,5 m; ET, Lille Middelgrund, 12 m; IA, Store Middelgrund, 16,5 m (f. *reducta*); GJ, Ostindiefarer Grund, 8,5 m and Søborghoved Grund, 8,5 m. — **Ks:** Hastens Grund, 16 m. — **Sa:** YV, 15 m. — **Lb:** Røgle Klint S. by E. 19—30 m; between Strib and Nederballe, 35—44 m; Fænø Sund, 28 m; dH[1], east of Hesteskoen, 18—19 m (f. *flaccida*); dQ, south of Lyø, 22 m. — **Sf:** — **Sb:** cN, 18 m; Z, off Skagbo Huse, 19 m; AA, north of Nyborg, 22,5—26,5 m (f. *reducta*); NN, S.W. of Sprogø, 19 m; US, Langelandsbelt 37,5—45 m (f. *flaccida*); LB, Langelandsbelt, 17 m. — **Sm:** — **Su:** bM, south of Hveen, 22,5 m (f. *reducta*). — **Bw:** KX, Femerbelt, deeper than 19 m. — **Bm:** VG, 17 m and QS, 20,5 m, North of Møens Klint. — **Bb:** SR, 15—16 m and ST, 18 m, Rønne Banke (f. *reducta*); YC, Salthammer Rev, 24,5 m.

Brongniartella Bory.

1. Brongniartella byssoides (Good. et Woodw.) Schmitz.

Fr. Schmitz, Die Gattung Lophothalia. Ber. deut. bot. Ges. **11**, 1893, p. 217; P. Falkenberg 1901, p. 542, Taf. 19 Fig. 8—10; Kolderup Rosenvinge, 1903, p. 469.

Fucus byssoides Goodenough et Woodward, Trans. Linn. Soc. III 1797, p. 229.

Hutchinsia byssoides C. Agardh, Synops. Alg. Scand. 1817, p. 60; Lyngbye, Tent. 1819, p. 110, Tab. 34 B, C; Flora Danica Tab. 1905_2, 1827.

Polysiphonia byssoides Greville, Flora Edin. 1824, p. 309; Areschoug, Phyc. Scand. mar. 1850, p. 56; Harvey, Phyc. Brit. **III**, 1851, Plate 284; J. Agardh, 1863, p. 1042; P. Magnus, Bot. Zeit. 1872, p. 253; L. Kny 1873, p. 106; G. Thuret et E. Bornet, Études phyc. 1878, p. 86; L. Kolderup Rosenvinge, 1884, p. 25 (4), Pl. 2 Fig. 30; Hauck Meeresalg. p. 238; Buffham, 1888, p. 263; Reinke, Algenflora 1889, p. 31.

Polysiphonia Dillwynii Kützing, Phyc. gen. 1843, p. 430; Tab. phyc. **14**, 1864, Tab. 23 (♂).

Polysiphonia vaga Kützing, Phyc. gen. 1843, p. 431; Tab. phyc. **14**, 1864, Tab. 24.

Polysiphonia asperula Kütz., Spec. Alg., p. 835, Tab. phyc. **14**, Tab. 25.

Polysiphonia Lyngbyei Kützing, Phyc. gen. 1843, p. 431 (Hofmansgave).

Polysiphonia Bangii Kützing, Spec. Alg. p. 1849, p. 835; Tab. phyc. **14**, Tab. 25 (Hofman Bang).

Lophothalia byssoides J. Agardh, Till Algernas Systematik, 6. Afdel. 1890, p, 59 (Lunds Univ. Årsskr. 26).

As first shown by Kny and confirmed by the writer and by Falkenberg, the trichoblasts are arranged in a spiral turning to the left with an angle of divergence of $^2/_7$ or nearly so. In luxuriantly growing shoots, the upper end of the axis is straight and overreaches the young trichoblasts which are curved upwards but not appressed to the axis (comp. Falkenberg l. c. fig. 8). The trichoblasts have usually not more than two branches (Falkenberg p. 544) but three branches are not unfrequently met with (comp. Kolderup Rosenvinge 1884 fig. 30). On the other hand

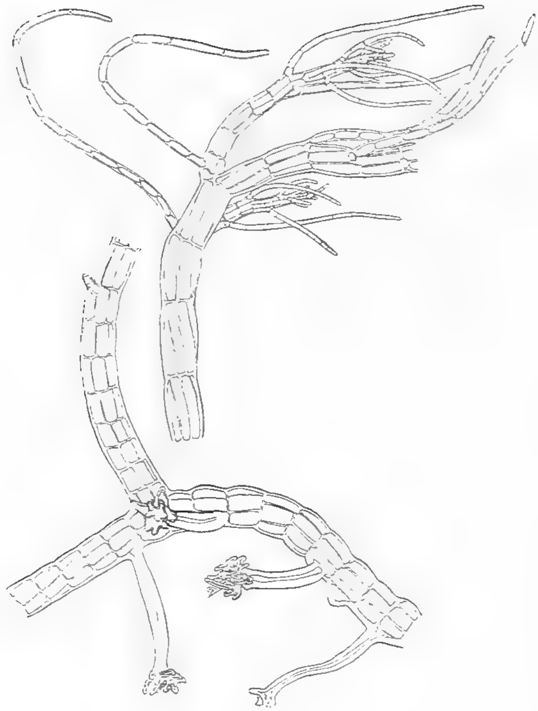


Fig. 402.
Brongniartella byssoides. Store Belt, May. Procumbent shoot giving off an erect shoot. The upper figure is the continuation of the lower, but eight joints without trichoblasts have been omitted; the lowermost joint in the upper figure is the 17th from the base. 50 : 1.

unbranched trichoblasts also occur, f. inst. on the lower part of the erect shoots (fig. 402). The cells of the full-grown trichoblasts contain a number of nuclei.

The long shoots have 7 pericentral cells but in the shoots of higher order the number is frequently only 6 or even 5, and in the creeping shoots, too, only 5 or 6 pericentral cells were found. Cortication is wanting.

In the long erect shoots an axillary shoot is usually given off from the basal cell of all the trichoblasts; the lowermost trichoblasts, however, are often not accompanied by axillary shoots, and the same may sometimes be the case with single trichoblasts among the usual ones. The first joint of the axillary shoot, common to this and the trichoblast, has usually 4 pericentral cells, as stated by Falkenberg (1901 p. 545), but the number may be smaller, e. g. 2, as described by Kny (1873, p. 106, comp. our fig. 404, 405 *A*). The normal axillary shoots arise comparatively late, on the kathodic side of the basal cell, according to Falkenberg at the 20th to the 30th segment of the mother shoot; they may, however, arise earlier, e. g. at the 8th to the 10th joint. The pericentral cells of the basal joint are cut off shortly after the formation of the axillary branch. The direction of these cells is usually very different from that of the pericentral cells of the following joints, coinciding with the direction of the trichoblast, while the direction of the axillary branch diverges almost at right angles from the trichoblast (fig. 405). As shown by Falkenberg, it happens that no axillary shoots are produced in feebler branches, but notwithstanding that four pericentral cells are cut off from the basal cells of the trichoblasts. The same has been found by me in *Polysiphonia nigrescens*

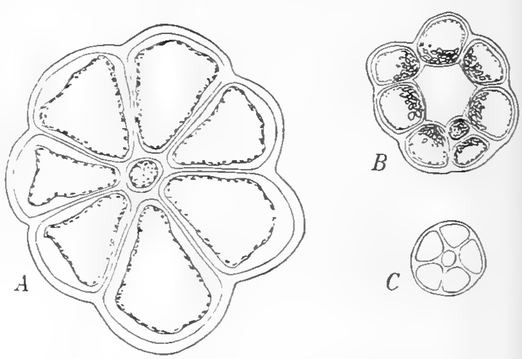


Fig. 403.
Brongniartella byssoides. *A*, transverse section of stem. *B* and *C*, transverse sections of tetrasporiferous branch. *B*, fertile joint after evacuation; *C*, sterile joint of tetrasporiferous branch. 200 : 1.

(see above p. 440). In normal axillary shoots the first trichoblast appears on the 3rd or 4th, more rarely on the 5th joint, the basal joint included.

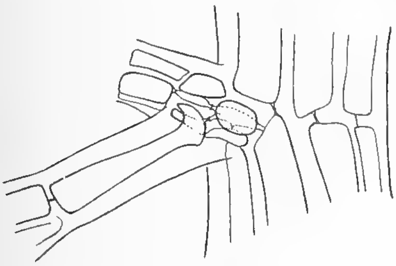


Fig. 404.
Brongniartella byssoides. Communication of the second joint of the trichoblast with the central cell of the basal joint. 220 : 1.

At the base of the plants endogenous creeping filaments are to be found which bear no trichoblasts; they may bend upwards and become erect, trichoblast-bearing shoots (fig. 410). Endogenous shoots arise from the creeping and the lowermost part of the erect shoots, emerging at the limit between two joints. Their first joint has pericentral cells on all sides. In these shoots a great number of joints is often without trichoblasts; but when the trichoblasts appear they occur on all the joints (figs. 402, 410).

FALKENBERG under the designation stolons describes certain shoots which bear no trichoblasts but are provided with rhizoids and have a long conical point. Such shoots are frequently met with in the Danish waters but they have not the character of stolons. They occur often indeed, mostly in the lower part of the plants, but they are not creeping, the numerous rhizoids are directed forward and not fixed to any substratum and therefore without attachment disc, and such shoots may also occur in the upper part of the plants. Their appearance is in correlation with a weakening of the growing power. In certain long shoots the trichoblasts become gradually feebler, finally their

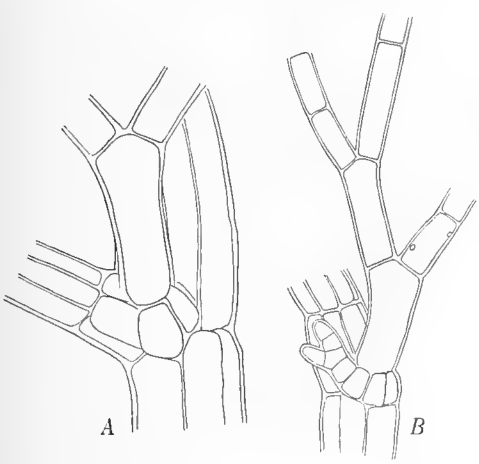


Fig. 405.
Brongniartella byssoides. Lower part of trichoblasts with axillary shoots. The pericentral cells of the basal joint parallel with the longitudinal axis of the trichoblast, the axillary shoot nearly perpendicular to this direction. 350 : 1.

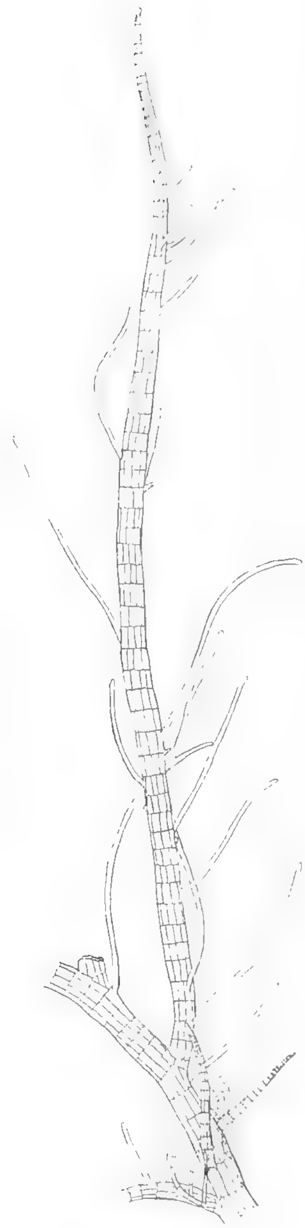


Fig. 406.
Brongniartella byssoides. Spiny shoot without trichoblasts but with rhizoids or hairs. 30 : 1.

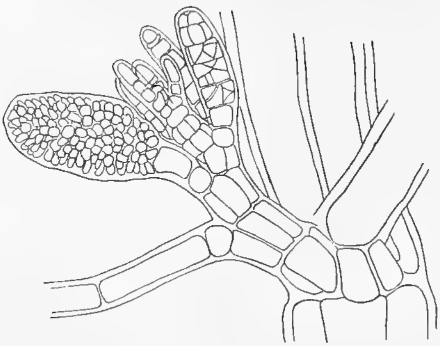


Fig. 407.
Brongniartella byssoides. Shoot with antheridia-bearing trichoblasts. June. 350 : 1.

production ceases and then the rhizoids appear and the shoot becomes pointed. Such spiny shoots have been met with in specimens from the different Danish waters from the North Sea to the Belts, gathered in July to November. The form described and figured by Kützing under the name of *Polysiphonia asperula* (l. c.) shows these spinous shoots in great number also in the upper part of the plant. The rhizoids mentioned ought perhaps rather to be compared with the unicellular hyaline hairs occurring in other Florideæ; they are like these separated from the pericentral cell by a wall. As I have had no occasion of examining them in a living state, it cannot be said with certainty whether they contain chromatophores or not.

The antheridia-bearing trichoblasts are simple with a two-celled stipe without sterile branch (comp. Kützing Tab. phyc. 14, Pl. 23 and Thuret 1878). They are borne on short branches which also bear sterile trichoblasts but are usually unbranched (fig. 407). I always found them on particular individuals, but Buffham found them intermixed with cystocarps on different branches of the same plant, and in another plant he found antheridia combined with tetrasporangia (1888, p. 263). Lyngbye found these organs in specimens gathered at Gjerrild 1825 and mentions them in his herbarium as corpuscula antheræformia.

The procarps arise as usual in the second joint of a trichoblast. The third joint remains short and the fourth bears a branch on the right side. The ripe cystocarp has a cylindrical spout consisting of parallel cell-rows. The sterile part of the trichoblast is kept till the maturity of the cystocarp (fig. 408).

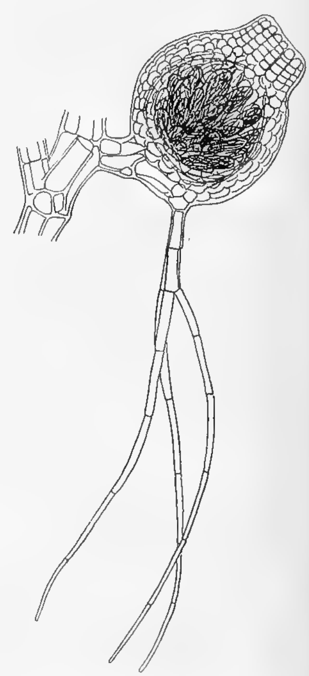


Fig. 408.
Brongniartella byssoides. Ripe cystocarp. July. 130 : 1.

The tetrasporangia arise in shoots with more or less limited growth of the two last orders of ramification. In transversal sections of tetraspore-bearing joints I found 7 pericentral cells whereas sterile joints of the same shoot often showed only 6 or 5 (fig. 403). A small peripheral cell under one of the secondary pericentral cells was not met with. The sporangia apparently always arise to the right of the trichoblast borne on the same joint.

The different organs of fructification were always found in distinct individuals. Antheridia were met with in June to September, carpogonia in June to July and even later, cystocarps in August to October and tetrasporangia in July to November; as late as December sporangia, partly emptied, were met with. The principal season for the production of ripe spores is August to September.

The spores are able to germinate immediately after dissemination. I have not myself observed the germination, but Mr. BOYE PETERSEN has kindly at my request sowed carpospores in vessels with sea-water and brought me slides with the sporelings raised in the cultures. After one day the globular spore-cell showed a feeble proeminence, the first step of the arising rhizoid. The following day an elongated rhizoid-cell was formed and the still globular spore-cell was divided by parallel walls perpendicular to the direction of the rhizoid. The sixth day a number of (5—9) segments were formed, the upper end of the lengthened sporeling had taken a shape reminding one of that of the full-grown plants, but lateral organs had not yet appeared. Most of the segments had formed pericentral cells, but the division of the first segments was somewhat irregular and the number of pericentral cells could not be determined with certainty (fig. 409). As the cultures had to be discontinued after 6 days, the further development is unknown, but it is probable that the sporelings produce early creeping filaments. Young sporelings were not met with in Nature, but in winter and spring I found only creeping filaments giving off short erect shoots (fig. 410). It has to be decided whether these creeping filaments originate from sporelings produced the last year or from older plants, or from both. In the first case the species would be annual like our winter-crops, in the second case it would be perennial.

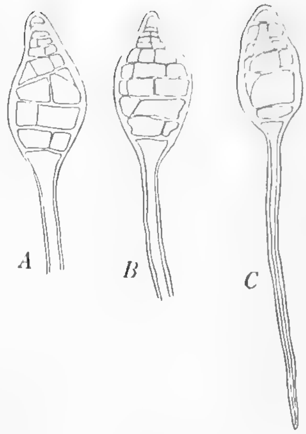


Fig. 409.
Brongniartella byssoides. Sporelings, 6 days old. 200 : 1.

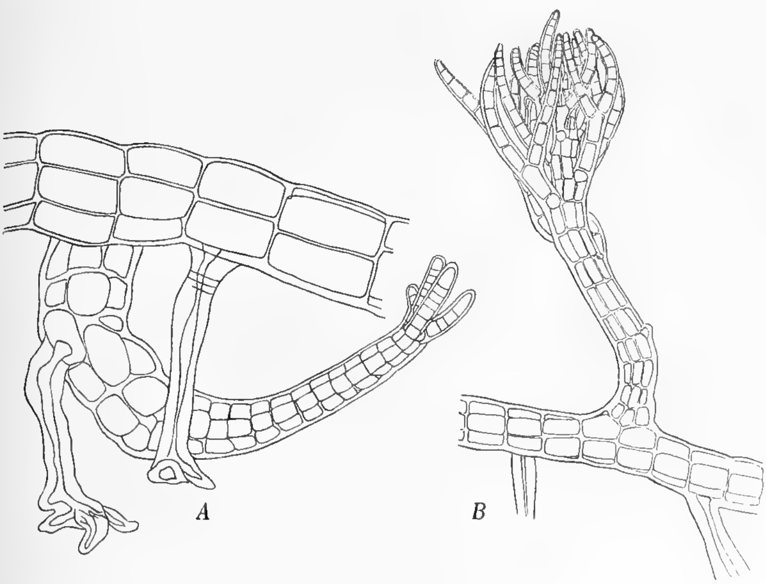


Fig. 410.
Brongniartella byssoides. Plants gathered January 3rd. *A* 200 : 1. *B* 95 : 1.

Brongniartella byssoides develops later as the species of *Polysiphonia.* In April the erect shoots are only 1 cm high, in May 1—3 cm, in June it is in active growth and in July it usually attains the maximal size (23 cm). The growth seems to cease towards the end of July or in the beginning of August, in September the trichoblasts begin to fall off, but as late as November specimens with well preserved trichoblasts may be met with. At the end of the year the plants die, in many cases with the exception of the creeping filaments from which new shoots are given off next spring. The new shoots in winter bear at the top a tuft of simple or feebly branched trichoblasts which are incurved over the upper end of the stem (fig. 410).

In the Danish waters from the Skagerak to the Belts the species reached a length of 20 cm or a little more. In the western Baltic Sea the greatest length observed was 12 cm and in the Sound south of Helsingør only 5 cm. It does not usually occur in the fjords; in the Limfjord it has only been met with once, and in the Isefjord only in the entrance. It occurs in the sublittoral region. At Hirshals it was found near land in about 1 meters' depth, and in the harbour of Frederikshavn it was found in the same depth, but otherwise it has not been met with over 4 meters' level, in the Great Belt and the western Baltic Sea not over 6 meters' level, and in the Sound south of Helsingør only in 10 meters' depth. It has been found most frequently in 7,5 to 15 meters' depth and descends to 38 meters' depth. It grows most frequently on various Algæ, in particular *Furcellaria*, but also occurs on shells of Molluscs and barnacles and on stones.

Localities. **Ns:** ZQ, jydske Rev, 24,5 m; aF, off Thyborøn, 31 m; aE, 16 m. — **Sk:** YN[1], YN[2], within Bragerne, 6,5—10 m; SY, off Løkken; ZK[12], off Lønstrup; off Hirshals, several places 11—15 m, near land, 1 m. — **Lf:** bU, Ejerslev Næse, 3—8 m, one specimen. — **Kn:** Off Skagen, 9,5 m; off Hulsig (Boye Petersen); Herthas Flak (Børgesen); around Hirsholmene, 5,5—7,5 m; Frederikshavn; off Frederikshavn; several places near Nordre Rønner; GM, Engelskmands Banke; TO, TP, ZA, Tønneberg Banke, 16—18 m; NI, FE, dS, a. o. pl., Trindelen, 8—16 m. — **Ke:** $4^1/_2$ miles S.W. $^3/_4$ W. of Fladen light-ship, 30 m (C. A. J.); FD, east of Læsø; VY, Fladen; ZJ, EX, EV, Groves Flak; XA; EU, Lille Middelgrund, 14 m; ER, Fyrbanken, 28 m; Store Middelgrund, 10 m (C. A. J.); Ostindiefarer Grund; OO, Søborg Hoved Grund; bR, Vesterlands Grund off Gilleleje, 7,5 m. — **Km:** 6 miles S.S.W. $^1/_2$ W. of Læsø Rende light-ship (C. A. J.); $5^1/_2$ miles N. by E. $^3/_4$ E. of Østre Flak light-ship (C. A. J.); XD, XC, south of Læsø; VP, south of Læsø; ND, NC, BH, off Gjerrild Klint; Gjerrild Bugt (Lyngbye). — **Ks:** FO, NB, off Havknude; EM, Lysegrund; RL, west of Ostindiefarer Grund; near Hesselø (Lyngbye); D, north of Grønne Revle, 11,5 m; Tisvilde (Lyngbye); GG, GF, Sjællands Rev; EJ, entrance to Isefjord; EH, west of Lynæs. — **Sa:** FU, Begtrup Vig; MY, FT, north of Samsø; BE, off Sletterhage, 10 m; FS, Vejrø Sund; GD, GE, north of Sejerø; MP, Falske Bolsax; AS, Mejlgrund; FX, west of Tunø; AT, Svanegrund, 5 m; MQ, south of Paludans Flak, 11,5 m; Hofmansgave (Lyngbye, Hofman Bang, C. Rosenberg); AJ[1], north of Æbelø, 4 m; AY, Ashoved; AX, Bjørnsknude, 9,5 m. — **Lb:** FZ, Kasserodde, 6 m; cX, between Strib and Nederballe, 35—44 m; Fænø Sund; north of Fænø Kalv; off Stenderup Skov, 13—15 m; Aarø Sund (Reinke); Lillegrund (Reinke); CD, Helnæs Hoved Flak, 4 m; CC, south side of Hornenæs, 7,5 m; dH[1], east of Hesteskoen, 18—19 m; CF, west of Lyø; dQ, south of Lyø, 22 m. — **Sf:** UV, north of Ærø, 13 m. — **Sb:** Off Refsnæs; MN, north of Asnæs, 11 m; GS, south of Asnæs; LH, Elefantgrund; cN, S.W. of Musholm, 18 m; AA, north of Sprogø, 23—26 m; XS, Kløverhage; GZ, north of Egholm; DP, UJ, north of Onsevig; US, Langelandsbelt, 38 m. — **Su:** Off Ellekilde, 5,5 m, cast ashore north of Helsingør and at Hellebæk (C. Rosenberg, Ørsted, Joh. Lange); PZ, east of Hveen, 10—19 m. — **Bw:** LG, off Vidsø, Ærø, 9,5 m; bV, bX, off Kobbel Skov, 6—13 m; cG, west of Kegnæs; south of Als (Reinke); cE, Middelgrund, south of Als, 13 m; dK, Pøls Rev, 6—7 m; Vodrups Flak, 9,5 m; DU, off Dimesodde, Langeland, 11 m; KX, Femerbelt, 19 m or deeper.

Rhodomela Agardh.

1. **Rhodomela subfusca** (Woodw.) Agardh.

C. A. Agardh, Sp. Alg. I, 1821, p. 378, emend.; Harvey, Phyc. Brit. Vol. III 1851 pl. 264; J. Agardh, 1863 p. 883; Areschoug, Obs. phyc. III 1875, p. 6. N. Act. R. Soc. Ups. Ser. III Vol. X; Kjellman, N. Ish. Algfl. 1883 p. 146 (113); Kolderup Rosenvinge 1884, p. 33; 1902 p. 360; 1903 p. 459; Falkenberg 1901, p. 593 Taf. 11 Figs. 2—17; Kylin 1907, p. 145; id. 1923 p. 114.

Fucus subfuscus Woodward, Linn. Transact. I, 1791, p. 131, tab. 12; Hornemann, Flor. Dan. tab. 1543, 1816.

Gigartina subfusca (Woodw.) Lamx.; Lyngbye Tent. 1819, p. 47, Tab. 10, 11.

Lophura gracilis Kützing Phyc. gen. 1843, p. 435, Taf. 53 IV.

Lophura cymosa Kützing Phyc. gen. p. 435; Tab. phyc. XV Tab. 36.

α, genuina.

Rh. subfusca Kjellm. l. c.; Kylin, l. c.

β, lycopodioides (L.) Gobi.

C. Gobi, Alg. weiss. Meeres. Mém. Acad. Imp. St. Pétersbourg VII^e sér. t. 26, 1878, p. 24.

Fucus lycopodioides Lin. Syst. Nat. ed. 12, tom. II p. 717.

Rhodomela lycopodioides Agardh Sp. Alg. I 1822 p. 377; J. Agardh, 1863, p. 885.

Gigartina lycopodioides Lyngbye Tent. p. 45.

Conferva squarrosa Oeder Flor. Dan. tab. 357, 1767.

γ, virgata (Kjellm.) nob.

Rhodomela virgata Kjellman N. I. Algfl. 1883 p. 143 (110) tafl. 7; Kylin, 1907 p. 147; id., Stud. üb. die Entw. v. Rhod. virg. Sv. bot. Tids. Bd. 8 1914 p. 33.

δ, tenuior (C. Agardh) Svedelius.

C. Agardh, Synops. Alg. sc. 1817 p. 32; Svedelius 1901, p. 124.

Rh. subfusca f. *gracilior* J. Ag. Gobi, Rothtange Finn. Meerbus. 1877 p. 11.

ε, abyssicola nob. Plate VI figs. 2—4.

From old time the *Rhodomelas* occurring at the shores of Northern Europe have been referred to the two species *Rh. subfusca* and *Rh. lycopodioides*, the near relation of which to one another has been emphasised by several authors. In 1883 Kjellman tried to show that the first of these species must be divided into two corresponding with the forms *extratæniensis* and *intratæniensis* distinguished by Areschoug in 1875. The latter, to which he gave the name *Rh. virgata*, is distinguished by the following characters: The vernal plant of the first year does not become black by drying and is flattened while *Rh. subfusca* becomes black and keeps cylindrical. The main axes are distinctly thickest in the middle and in their whole length bear branches gradually decreasing in length upwards, while *Rh. subfusca* has pronounced branchlets with limited growth. All these branches are shed in summer, the main axes only remaining. The organs of reproduction arise in winter on the branchlets which grow out on the long shoots from the previous winter, and which are shed after the fructification, while the corresponding branchlets in *Rh. subfusca* after fructification may develop as vegetative shoots, and the fructification in this species takes place later, in spring. KJELLMAN also found anatomical differences between the two species, the cells in the main axes of *Rh. virgata* decreasing gradually in size towards the periphery, while *Rh. subfusca* has a small-celled cortex rich in "endochrome", distinctly bounded towards the inner parenchyma consisting of large cells. *Rh. lycopodioides* is considered as a distinct species though nearly related to *Rh. subfusca.* Kjellman emphasises as distinctive characters the numerous curved branchlets having their greatest thickness a little below the middle; they are arranged without any distinct order and are supposed to be adventitious.

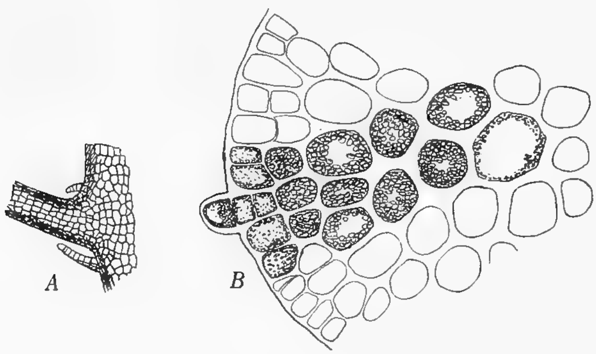


Fig. 411.
Rhodomela subfusca. A (f. *virgata*) adventitious shoots near the base of a primary branch. 64 : 1. *B* transverse section of stem with a young adventitious shoot. 206 : 1.

While REINKE and FALKENBERG do not adopt *Rh. virgata* as a distinct species, KYLIN follows KJELLMAN, laying particular stress on the different season of fructification (Nov. to Jan. for *Rh. virgata,* April and May for *Rh. subfusca*) and on the fact that the new shoots which in *Rh. subfusca* develop in the last part of the winter and in spring, are at first both vegetative and fertile but after fructification remain as vegetative, while the organs of reproduction in *Rh. virgata* are seated in particular shoots which are thrown off after fructification.

As to the branchlets of *Rh. lycopodioides* I have convinced myself, by examination of specimens from Iceland and Greenland, that numerous adventitious branchlets really occur in this species, arising from a single superficial cell growing out and dividing by a transversal wall, whereupon the outer cell becomes the apical cell of a branchlet. A similar formation of adventitious shoots has not only been met with in specimens from the Danish coasts otherwise fairly agreeing with *Rh. lycopodioides,* but also in specimens of *Rh. subfusca* and *Rh. virgata* (figs. 411 *A*). In the latter they were produced in particular near the base of the primary shoots. The occurrence of adventitious branchlets has thus no absolute value as distinctive character, and the same is, according to my experience, the case with the alleged shape of the branchlet and other characters, and I must therefore agree with the authors who have more or less distinctly suggested that *Rh. lycopodioides* might be considered a form of *Rh. subfusca.*

As to the two species *Rh. subfusca* and *Rh. virgata* as distinguished by KJELLMAN, to which most of the Danish species can be referred, it must be confessed, that in their typical shape they are so distinct as to habit and anatomical structure that they have the appearance of being distinct species. The examination of a great number of specimens, however, has led me to the conclusion that they are only marked types of a very variable species produced by the influence of the outer conditions. The first occurs in particular near the low-water mark, where it is exposed to the movement of the waves, whereas *Rh. virgata* grows in greater depth, in particular in streaming water but not exposed to the waves. In localities which are intermediary as to the outer conditions specimens intermediary as to the distinctive characters are also met with. In the outer characters it appears that e. g. individuals which if anything agree with *Rh. virgata* keep some branchlets which are not shed at the end of the period of vegetation, and do not show the above mentioned distinction between vegetative and fertile shoots. Further, the above-mentioned greater thickness on the middle of the long shoots is often wanting. When in doubtful cases the anatomical structure, which according to KJELLMAN seems to offer a very good distinction, is taken into consideration one finds that this also is not reliable. As a rule the anatomical structure in *Rh. virgata* is as described by KJELLMAN (fig. 412 *B*), but not rarely a more or less developed small-celled cortex is to be found in the lower part of the long shoots in specimens otherwise agreeing with typical *Rh. virgata*. Such a cortex may be found on one side of the branch but not of the other (fig. 413), or several more or less confluent proeminences with similar structure or even a continuous cortex all round may be met with. Usually then some long shoots are provided with cortex, others not.

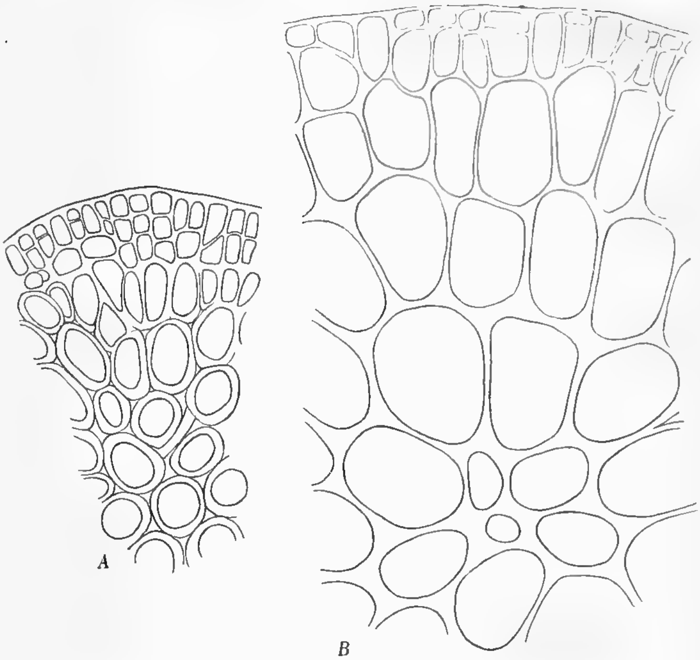


Fig. 412.
Rhodomela subfusca. Transverse sections of stems. *A*, *α genuina*. *B*, *γ virgata*. 160 : 1.

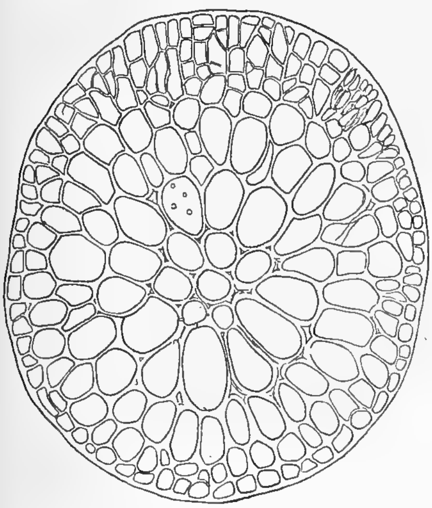


Fig. 413.
Rhodomela subfusca f. *virgata*. Transverse section of stem. 80 : 1.

Further, in some cases a feebly differentiated cortex may occur. Neither does the difference in the season of fructification emphasised by KYLIN seem to give a decisive mark, for both species were found with sex organs in January and were frequently found with ripe sporangia in April and May in the Danish Waters.

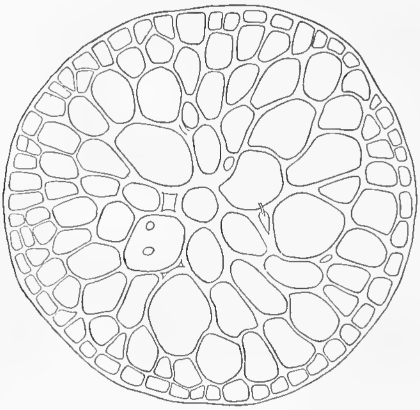


Fig. 414.
Rhodomela subfusca f. *abyssicola*. Transverse section of stem. 150 : 1.

In the inner waters, particularly the Baltic Sea, a fine form appears which in its extreme shape is very marked but which on the other hand is nearly related to the typical *Rh. subfusca* and to *Rh. virgata* as well. It is remarkable by its very thin and slender shoots and may be referred to f. *tenuior* Agardh, especially as it is characterised by SVEDELIUS (l. c.). In the ramification it usually resembles *Rh. subfusca*, the long branches bearing a considerable number of branchlets which are not shed, whereas in the anatomical structure it agrees better with *Rh. virgata* (comp. SVEDELIUS 1901 p. 125).

Another thin and slender form ε, *abyssicola* nob. was gathered in the southern Little Belt south of Lyø in 22 meters' depth. Some of the specimens resembled *Rh. virgata* in habit (Plate VI fig. 2), others had a very thin principal axis and very distant thin and slender branches which were only slightly branched, in particular towards the top (Plate VI fig. 4). The trichoblasts were kept at least 4 cm below the top. These plants were still fructiferous on June 20th and bore sporangia and cystocarps in elongated branchlets not different from the vegetative ones, thus behaving much as *Rh. subfusca*. A section of the main stem shows the same structure as in *Rh. virgata*, but the cells are smaller. The diameter of the stem was 320 μ (fig. 414). The plants are red and keep the colour when drying.

All the forms mentioned are thus here considered as forms of *Rh. subfusca* which may be divided in the following principal forms:

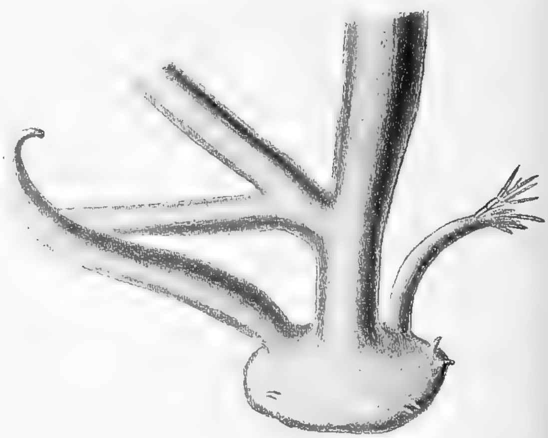


Fig. 415.
Rhodomela subfusca growing on Portunus. Basal disc with primary and secondary shoots. 38 : 1.

α, *genuina*.
β, *lycopodioides* (L.) Gobi.
γ, *virgata* (Kjellman) nob.
δ, *tenuior* (C. Agardh) Svedelius.
ε, *abyssicola* nob. F. axi primario distincto tenui, ramis remotis longis, parce præcipue apicem versus ramosis, trichoblastibus diu persistentibus.

The structure and development of the frond have been treated at length by Falkenberg and Kylin. Some supplementary remarks may be given here.

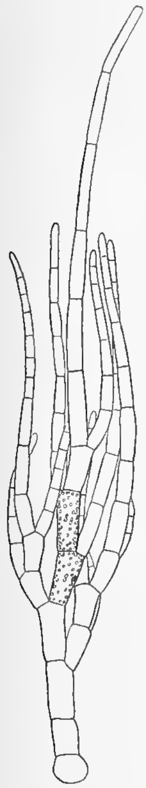


Fig. 416. *Rhodomela subfusca*. Fænø Sund February. Trichoblast. 150 : 1.

The fronds issue from a parenchymatous disc from which new shoots arise as adventitious buds without any order (fig. 415). According to Falkenberg the lateral organs produced by the branching of the fronds are only branches except at the tips of the shoots which are closing their growth, where numerous hair-leaves are produced, on long stretches one on each joint, and above this region of hair-leaves a formation of branches never takes place. The latter assertion, however, does not always hold good, for in the upper part of the branched shoots basal cells of shed trichoblasts are frequently found and single branches frequently occur between the trichoblasts still in function. The branches of the last order bear only trichoblasts. The trichoblasts and the branches are placed in a spiral with a divergence varying between $^1/_4$ and $^2/_7$ (often nearly $^2/_7$). When occurring between the trichoblasts the branches take the place of the latter in the spiral without a change of the angle of divergence. The spiral may be turning to the right or to the left, but there is no regular antidromy as stated by me in 1884 (p. 33 (5)). It seems that the spiral turns more frequently to the left than to the right, but my observations are not sufficient to ascertain that with certainty.

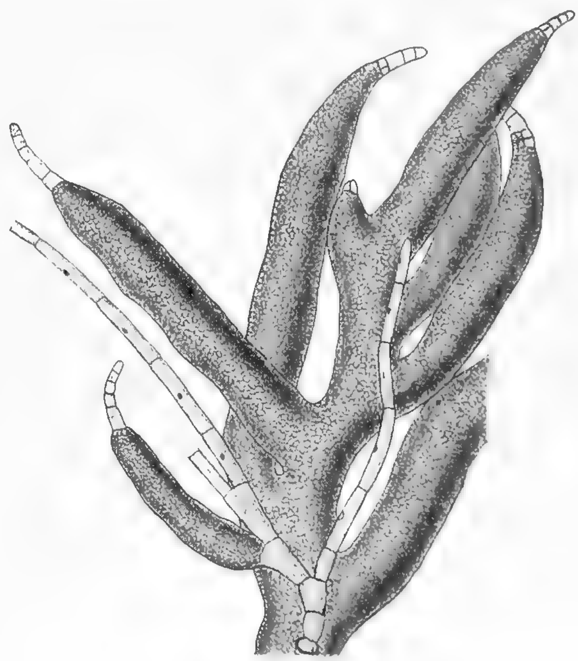


Fig. 417. *Rhodomela subfusca*. Upper end of male plant. 121 : 1.

The trichoblasts have the same structure as in Polysiphonia and other Rhodomelaceæ. The first branchlet of the trichoblast, however, is often given off from the third joint instead of from the second (fig. 416), or, though rarely, from the 4th, and unbranched trichoblasts may occur, e. g. in f. *tenuior*. The second joint is often shorter than the following ones whether it bear a branchlet or not. The cells contain a single nucleus and numerous chromatophores which are distinctly red. Falkenberg lays much stress upon this fact which he alleges

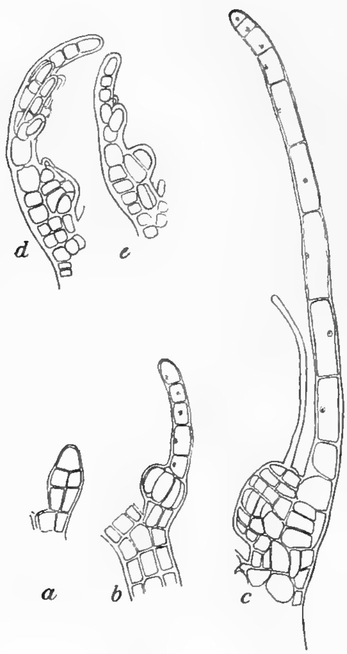


Fig. 418.
Rhodomela subfusca. Female trichoblasts. *a—c* of var. *virgata.* 220 : 1.

as supporting the opinion that "Die Blätter von *Rh. subfusca* stellen ein eigenartiges Mittelglied dar, über dessen Benennung man zweifelhaft sein kann" (l. c. p. 597). I cannot agree with the said author in this as there is only a slight gradual difference in the colour of the chromatophores in *Rhodomela* and in several species of *Polysiphonia* which have also rose-coloured chromatophores in spring and in deep localities. On the other hand the chromatophores of the trichoblasts in *Rhodomela* are often more or less decoloured during the spring, even in April.[1] The trichoblasts begin to develop in winter (January) and are fully developed in spring (March to May). In June they are shed at the same time as the growth ceases, and in the following months no trichoblasts are met with except the uppermost ones which are apparently without function. Vigorous trichoblasts with red chromatophores have been met with only exceptionally in mid-summer, in the beginning of August in a specimen found in great depth in the North Sea (31 m), and in specimens of the f. *tenuior* found at Bornholm (8,5—15 m).

As mentioned above, adventitious shoots may arise from superficial cortical cells of the stem in f. *lycopodioides* and other forms. The fasciculate branches occurring frequently in the long shoots of various forms of *Rhodomela* are probably due to the production of such adventitious buds.

The antheridia, as I have shown (1903 p. 462), arise on the stems and on the trichoblasts (fig. 417). The fertile organs form corymbiform tufts at the ends of the shoots, or lateral on the long shoots in f. *virgata.* In some cases the fertile organs are apparently only branches, in others they are principally trichoblasts, but in both cases the main axis is usually covered with antheridia, and the formation of antheridia may extend to three generations of branches

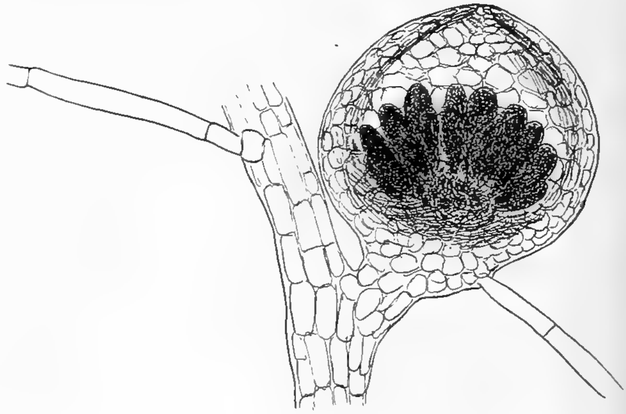


Fig. 419.
Rhodomela subfusca f. *virgata.* Cystocarp. May. 95 : 1.

[1] Further it must be remembered that the assimilating trichoblasts in *Brongniartella* are just as distinct from the stem as those in *Polysiphonia.*

(fig. 417, comp. FALKENBERG p. 597). As regards the development of the spermatia reference may be made to KYLIN's paper (1914, p. 55 pl. 3 figs. 13—18).

The procarps arise in the second joint of the trichoblasts (fig. 418, comp. K. R. 1903 p. 459, KYLIN 1914 p. 42). The sterile upper part of the latter remains for a shorter or longer time at the upper end of the developing cystocarp; it may still be found sometimes in the ripe cystocarp (fig. 419). It may be simple or branched. The development of the procarp and the cystocarp has been described at length in the important papers of KYLIN (1914 pp. 41—54 and 1923 p. 114).

The tetrasporangia arise in short branches forming small tufts at the ends or on the sides of the long shoots, the latter principally in the f. *virgata*, two in the same joint, in a number of consecutive joints. In the lower part of the branch, under the first lateral organ, they are arranged laterally, to the right and to the left of the median plane. The first trichoblast is inserted over one of them. In the joint following after a trichoblast (or a branch) the sporangia are arranged in a similar way to the right and to the left of it, and the orientation of the sporangia is thus constantly changing in the trichoblast-bearing region. The pericentral cells, from which the sporangia are produced, are first divided by two oblique walls by which two cover-cells are cut off (comp. KYLIN 1914 fig. 11). These cells are shorter than the mother-cell, the lower part of which therefore is free outwards and which afterwards is divided by a horizontal wall into two cells, the upper of which becomes the sporangium. The lower cell, the stalk-cell, is then divided by one or two periclinal walls cutting off one or two shorter peripheric cells that cover the stalk-cell. The other pericentral cells divide in the usual manner by horizontal walls in such a manner that the upper cell remains in pit-connection with the central cell while the cover-cells of the sporangia are connected with the stalk-cell (fig. 420 *A*, KYLIN p. 61). The pits connecting the central cell with the sterile pericentral cells are situated at a much higher level than that connecting it with the stalk-cell (fig. 420). At the stage of maturation the central cell, the stalk-cell and the pericentral cells contain several nuclei. For further details in the development of the sporangia see Kylin 1914.

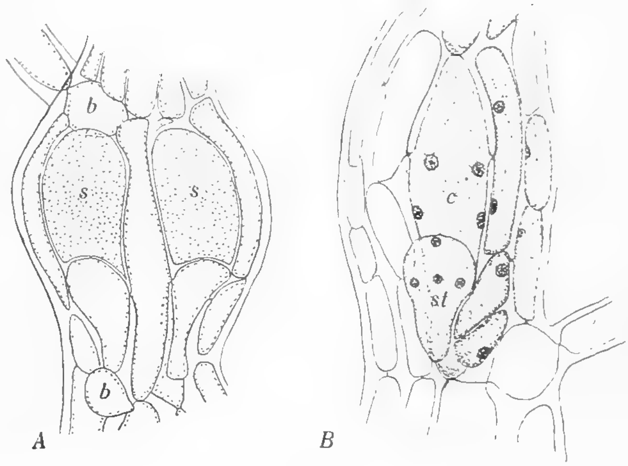


Fig. 420.
Rhodomela subfusca f. *virgata*. May. *A*, longitudinal section of tetrasporiferous joint before division of the sporangia. *B*, tetrasporiferous joint after evacuation of the tetraspores. *s* sporangia, *st* stalk-cell, *c* central cell, *b*, basal cells of trichoblasts. 200 : 1.

The germination has not been observed by me, but I have once found a sporeling on Callithamnion Hookeri, which is shown in fig. 421. The basal part was disc-shaped, as in the adult plant, but it was only developed on one side.

Rhodomela subfusca is widely distributed in the Danish waters, growing on stones and various Algæ (*Fucus, Laminaria*). It usually descends only to a depth of 20 meters, but it has been found once in the North Sea in 31 meters' depth (Jydske Rev, f. *α*), and f. *tenuior* has been repeatedly recorded in depths from 25 to 38 meters near Bornholm. The forma *α* occurs from low-water mark to a depth of about 15 m or a little more, but it is most typical near low-water mark. F. *lycopodioides* has only been met with rarely in the Skagerak, washed ashore or by dredging in slight depths near land. F. *virgata* has been met with in all the waters within Skagen in depths from 4 to 20 meters, most typical in the Belts. F. *tenuior* has been found in the Baltic Sea and particularly round Bornholm, in depths from 8,5 to 38 meters. F. *abyssicola* has only been met with once in the Little Belt in 22 meters' depth. — The vegetative development begins in winter (January) and is usually arrested in May or June whereupon the trichoblasts and fertile shoots are shed. The organs of fructification begin to develop in winter and the spores are evacuated in spring.

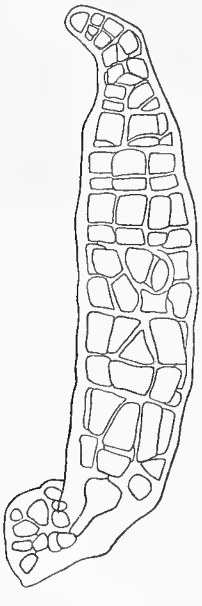


Fig. 421. *Rhodomela subfusca.* Plantlet growing on Callithamnion Hookeri. 210 : 1.

Localities. **Ns:** *α*: Jydske Rev 31 m and some other loc. off Lodbjerg light-house and off Ørhage, very sparsely. *β*: washed ashore by Klitmøller (Hornemann). — **Sk:** Several places from Hanstholm to Hirshals, from low-water mark (Hirshals) to 15 m, mostly *α*, more or less approaching to *β*, *lycopodioides* at Bragerne, Løkken and Hirshals. — **Lf:** Several places from Rønnen by Lem Vig to Løgstør Bredning, but not well developed, usually intermediary between *α* and *γ*, *virgata*. — **Kattegat:** *α* very common, *γ* very common, also in the Isefjord; here also f. *tenuior*. — **Sa:** *α* and *β* very common down to 17 meters' depth. — **Lb:** *α* and in particular *γ* very common, *α* from low-water mark to 15 m, *γ* from 7—30 m; *ε*, *abyssicola*: dQ, south of Lyø, 22 m. — **Sf:** *α*, *γ*. — **Sb:** *α*: LK, Elefantgrund; Kerteminde; GY, south of Sprogø; NN, 19 m. *γ*: in numerous places, 5—19 m. — **Sm:** *γ* in numerous places 4—12 m. — **Su:** *α*, off Aalsgaarde, Charlottenlund. *γ*, in several places, 5—10,5 m. — **Bw:** *α*, UP off Kramnisse Gab 8,5 m; KU, Schønheyders Pulle 7,5 m; KR, near Korselitze Grund. *γ* several places 7—20 m. — **Bm:** *α*, HG, Præstebjergs Rev. *γ*, several places from 7 to 20,5 m. ♂ SD, north-east of Møen, 23,5 m, loose. — **Bb:** The species is common at Bornholm in depths from 5,5 to 25 m, but descending to 40 meters' depth, more rarely near low-water mark, e. g. at Rønne (!) and at Rø (C. A. J.) in 1—2 meters' depth. Some specimens have been referred to f. *genuina*; their stem was provided with cortex. These specimens were found near land in 1—10 meters' depth. But also in great depth specimens were found which, though small and slender, most resembled f. *genuina* (Dana St. 3116, 5,5 miles N.N.E. ½ W. of Hammershus light-house, 35—40 m, C. A. J.); their stem had a well developed cortex. Most of the specimens from the waters around Bornholm may be referred to f. *tenuis* though they not rarely approach to f. *genuina* or to f. *virgata*. They are rather small; their height does not usually exceed 15 cm and the shoots are slender. The awl-shaped branchlets emphasised by Svedelius as characteristic to f. *tenuior* are not always present; in other cases they are very numerous. A small-celled cortex is wanting as in Svedelius' specimens. On all sides of Bornholm.

Odonthalia Lyngbye.

1. **Odonthalia dentata** (L.) Lyngbye.

Lyngbye Hydr. 1819, p. 9 tab. 3 A; Ørsted De reg. mar. 1844 p. 52; Harvey Phyc. brit. I 1846 Pl. 34; J. Agardh, 1863, p. 899; Wille, 1885, pp. 30, 50, Tab. IV figs. 48—49; id. 1887, p. 69 figs. 32—37; Buffham 1893, p. 297, Pl. XIV figs. 32—36; Falkenberg 1901, p. 604, Taf. X figs. 6—22.
Fucus dentatus Lin. Syst. nat. ed. 12, vol. II, p. 718.
Fucus pinnatifidus Oeder Fl. Dan. Tab. 354, 1767.
Rhodomela dentata Lyngb., Rar. cod. 1880 p. 225.

The morphology of this species shall only be mentioned here rather shortly as it has been treated at length by FALKENBERG (1901). As mentioned by this author, p. 605, the two-edged shape of the frond is caused partly by the formation of a wing on each side of the frond, partly by the congenital coalescence of the lower parts of the shoots The branch-bearing segments are, in the sterile parts of the frond, separated by 2—4 segments bearing no branch (fig. 422). The ectoblastesis (L. K. R. 1920 p. 20) is very prominent. As emphasised by FALKENBERG, there are no trichoblasts. The pericentral cells divide early and thus become covered by a layer of smaller cells which divide further and the outermost of which are so arranged that four transversal rows correspond to the height of a primary segment (comp. FALKENBERG p. 606, our fig. 422 *B*). It deserves further notice that triangular initial cells are to be found in the edge of the frond, in particular where the outline is convex, one for each secondary segment (fig. 422 *B*). There is thus resemblance with the edge of *Delesseria* but with the difference that the initial cell is seated in the lower (basiscopic) corner of the segment while in *Delesseria* it is to be found in the upper corner. In *Apoglossum ruscifolium*, however, I also found marginal initial cells with the same orientation as in *Odonthalia* (comp. p. 459). FALKENBERG has delineated these initial cells in *Odonthalia* (l. c. Pl. 10 Fig. 12), but he has not shown the produces of their divisions.

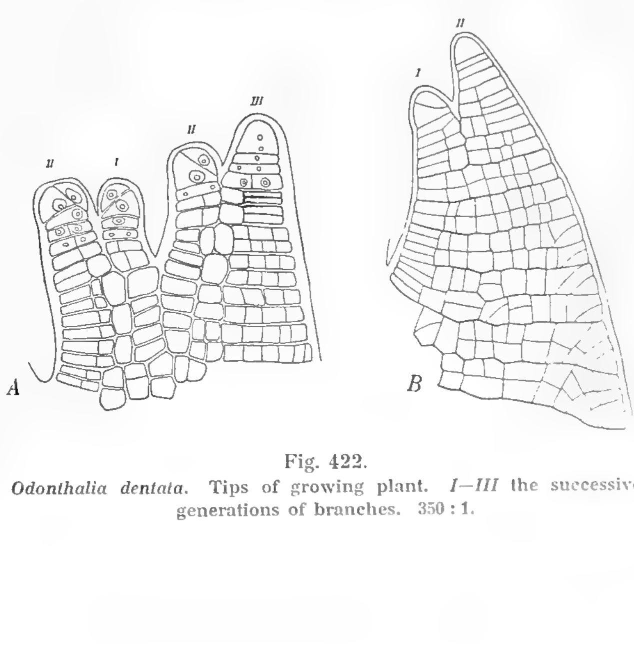


Fig. 422.
Odonthalia dentata. Tips of growing plant. *I—III* the successive generations of branches. 350 : 1.

The frond of the last year has a slightly projecting mid-rib which contains the central cell in the centre. This cell is comparatively narrow but becomes very long and is connected with the contiguous central cells through a large primary pit; it contains several nuclei but produces no starch. The other cells of the inner tissue have a larger diameter (fig. 423 *A*) but are

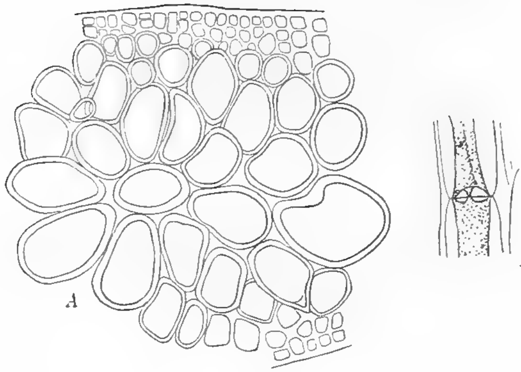


Fig. 423.
Odonthalia dentata. A, transverse section of frond from the last year. *B*, longitudinal section of cells of the inner tissue (pericentral cells or inner cortical cells), connected by three secondary pits. 150 : 1.

shorter and are connected with each other by one to three, mostly secondary pits in the transversal walls (fig. 423 *B*). They contain several nuclei and produce many starch grains when the growing period has ceased. The cells surrounding the central cell are longer and constitute together with it a conducting system (comp. Wille l. c.). The older, at least one year old parts of the frond are provided with a more distinct mid-rib projecting on both faces of the frond. Its appearance may be somewhat irregular, the rib being present on a certain stretch, disappearing further downwards and then reappearing definitely, and the two ribs are not always exactly opposite to each other. This rib is composed of cell-rows directed outwards and then in a bow obliquely downwards and united into a compact tissue, the surface of which is even. Wille's fig. 48 (1885) evidently represents a transverse section of such a mid-rib. He regards this tissue as belonging to the assimilating system; it has in my opinion rather a mechanical function.

The germination has not been observed, but young plants, about 3 mm high, were found in the northern part of the Sound off Aalsgaarde, on a shell of *Cyprina islandica* in a depth of 19 meters (fig. 424). The smallest one (*A*) which did not reach 2 mm in length was entirely unbranched. It had a terete stipe continuing in a narrow lanceolate lamina, the upper part of which is shown in fig. *D*. Numerous marginal initial cells similar to those shown in fig. 422 *B* are to be found in the edge. A couple of some-

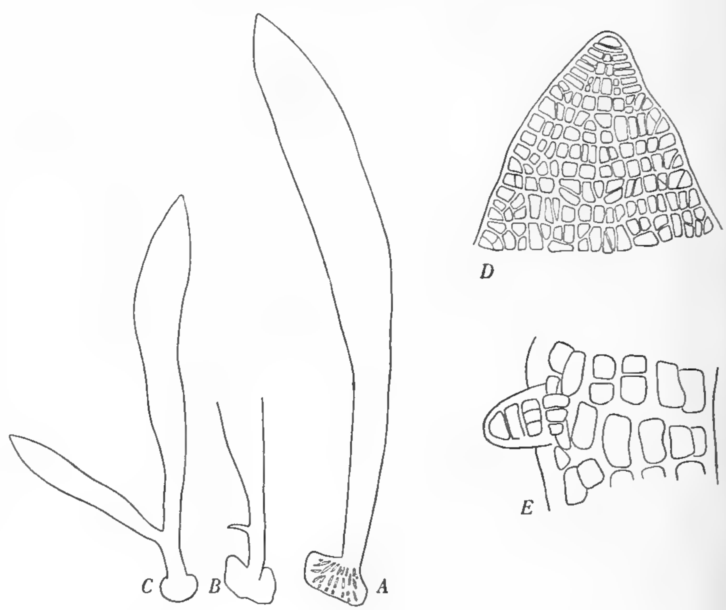


Fig. 424.
Odonthalia dentata. A—C, plantlets found growing on Cyprina islandica, *B* and *C*, with an adventitious hranch. *D*, upper end of *A* more highly magnified. *E*, young adventitious branch. *A* 50 : 1. *B, C* 18 : 1. *D, E* 260 : 1.

what more developed plants showed an adventitious shoot issuing from the stipe, produced from a superficial cell (fig. 424 *B, C, E*). The normal branching at the apex seems only to begin when the plants have attained a size of about 3 mm. In a young 7 mm high plant the primary shoot was terete at the base but a short distance upwards flattened and at a higher level branched in the usual way. The young fronds are fixed to the substratum by a circular basal disc composed of densely united radiating cell-filaments. In a more advanced stage the basal disc is a flat expansion having a circular or lobed outline; the regularly radiating filaments are united to the margin.

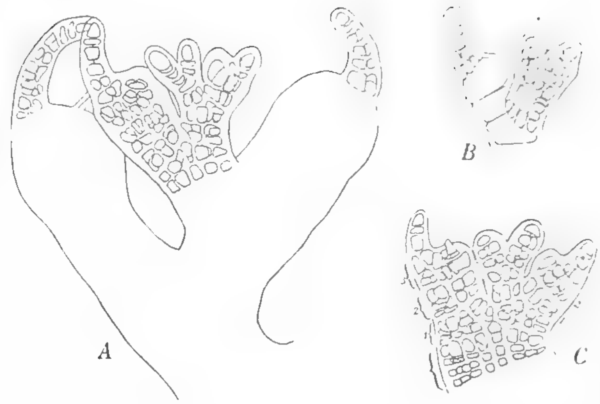


Fig. 425.
Odonthalia dentata. Female sexual shoots. The procarps arise partly in the third joint of the branches. In *B* a procarp will probably arise subterminally in the main axis *. 200 : 1.

The organs of reproduction are as a rule confined to small adventitious shoots borne on the margin of the frond.

The antheridial shoots are according to BUFFHAM (1893) and FALKENBERG (1901, p. 607) pale simple or bifid leaflets, the surfaces of which are covered with antheridia. They have hitherto not been observed in the Danish waters.

The female shoots are much branched, slightly winged or quite cylindrical. According to FALKENBERG (1901, p. 606) the procarps constantly arise in the second joint of the fertile shoot. That is, however, not always the case, for I not unfrequently found them in the third joint (fig. 425 *A, C*), and it seems that they may also arise in higher situated joints (fig. 426 *B*, to the right). The sterile upper part of the procarp-bearing shoots (the calcar) is as a rule unbranched, incurved, but it not unfrequently happens that it is branched and produces new procarps (fig. 426). It seems that the end of the shoot may also produce a procarp arising from the last segment cell (figs. 425, 426*).

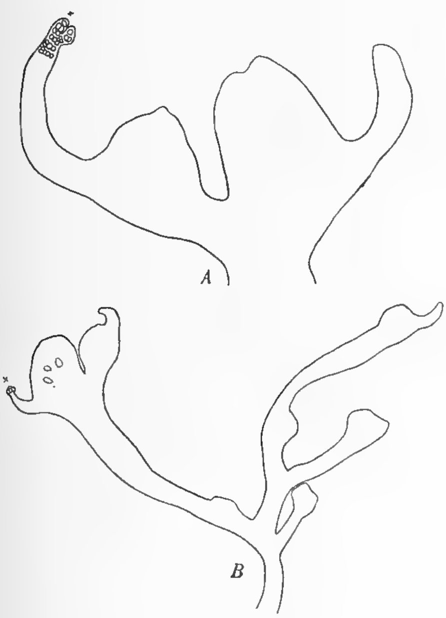


Fig. 426.
Odonthalia dentata. Female sexual branchlets with ripe and aborted cystocarps. See text. At * procarps are apparently developing in the last segment cut off from the apical cell.
A 95 : 1. *B* 50 : 1.

The tetraspore-bearing shoots are cylindrical, much branched, forming small fascicles of stichidia each containing two series of sporangia.

O. dentata is perennial; it attains a length of up to 20 cm, thus in the most southern locality recorded in the Sound. It has only been met with in the months of April to September. The new shoots must arise in winter; in spring they are of a fresh red colour in contrast to the shoots of the foregoing year. The organs of fructification must develop in winter. According to ARESCHOUG the species is fructiferous in winter (Dec. to March) at the west coast of Sweden, and that is probably also the case in the Danish waters, but tetraspore-bearing specimens have been met with as late as May, and cystocarp-bearing ones were collected in April and even in June (Store Belt). On the other hand, specimens were found in May with adventitious shoots having shed the outer fructiferous part.

The species is confined to the waters with high salinity and slightly varying temperature; it has therefore principally been met with in the deeper parts of the eastern Kattegat in 15 meters' depth and deeper. In slighter depth it has only been collected in one place in the northern Kattegat on the north side of Hirsholmene. In the Great Belt it has only been found in one place in 19 meters' depth, and in the Sound south of Helsingör only in one place in 22,5 meters' depth in the deep channel. It grows on stony or gravelly bottom and may be fixed to *Litothamnia*, barnacles or mollusks, has also been found on *Fucus serratus* and *Polysiphonia elongata*.

Localities. **Kn:** East of Tyskerens Rev, Hirsholmene, c. 11 m; VX, Böchers Banke, 29 m. — **Ke:** IL^1, IM, ZE^1, ZE^2, ZF, IP, IQ, Dana St. 2922 (C. A. J.), Fladen, 15—30 m; Groves Flak, 24,5 m; IK, Lille Middelgrund, c. 18 m; RU, 26,5 m; IA, Store Middelgrund, 17 m. — **Ks:** Lysegrund (Lyngbye, Rhodomela dentata, Rariora codana, p. 225); near Hesselø (Lyngbye); off Isefjord, buoy at Grønne Revle in S. 3 miles, 15 m (Biolog. Station). — **Sa:** The Herbarium of the Bot. Mus. of Copenhagen contains a denudate specimen of Polysiphonia elongata bearing in Hornemann's handwriting the following labelling: "hab. ad littus Hofmansgave saxis adnascens ded. Lyngbye". This bears some small specimens of O. dentata, c. 1 cm long. — **Sb:** Off Refsnæs, 19 m (C. H. Ostenfeld). — **Su:** Off Aalsgaarde (Th. Mortensen), off Hellebæk (Ørsted); frequently cast ashore at Julebæk and Hellebæk; bM, south of Hveen, 22,5 m.

General Remarks on the Morphology of the Danish Rhodomelaceæ.

The following remarks deal particularly with the genus *Polysiphonia* which has been most thoroughly studied as to the morphology. Further information on the morphology of this interesting family must be sought in the quoted papers of FALKENBERG, KYLIN a. o.

1. The hair-shaped organs which were named leaves by NÄGELI (1846) were repeatedly studied by various authors. I treated them in 1903 and gave them the name trichoblasts; they might also be named hair-leaves. Vegetative trichoblasts occur in all the Danish species of Rhodomelaceæ except *Odonthalia* and *Heterosiphonia*. In *Polysiphonia* they occur only in the erect shoots, not in the creeping ones. In this genus they are usually hyaline though provided with small colourless plastids.

In most of the Danish species, however, I have observed that in specimens gathered in spring or in great depths these bodies were true chromatophores giving to the trichoblasts a light rose colour. This phenomenon is particularly conspicuous in *Polysiphonia elongata* f. *baltica* which just occurs in deep water. In *Rhodomela* the chromatophores of the trichoblasts are distinctly rose-coloured, but they are finally decoloured in the adult trichoblasts which are shed at the beginning of the summer. In *Brongniartella byssoides* they are persistent and remain coloured during the life of the plant.

In *Polysiphonia nigrescens* the cell-sap of the trichoblasts may be rose-coloured in April, later brownish.

The ramification of the primary axis of the trichoblasts is regularly alternate, biseriate. The first branchlet is always given off on the anodic side (to the right when the spiral turns to the left), from the second joint, in *Rhodomela* often from the third. In the female trichoblasts the first branch is given off from the fourth joint and most frequently on the anodic side. In female trichoblasts of *Pol. Brodiæi* two branches were found on the same joint, one above the other (p. 381).

2. Unicellular hyaline hairs do not occur in the Rhodomelaceæ. Only in *Brongniartella byssoides* such organs may sometimes be met with in peculiar pointed shoots without trichoblasts (comp. p. 406); but they might perhaps better be interpreted as a sort of rhizoids.

3. The branches arise in different manners.

a) In *Polysiphonia urceolata, P. elongata, P. nigrescens* and *Rhodomela* they are produced directly from the youngest segment under the apical cell, usually in the place of a trichoblast in the spiral. In some species, at any rate, the branch-producing segments are higher than those which give rise to the trichoblasts or do not produce any sort of lateral organs (*P. urceolata*, fig. 344, *P. elongata*). To this group belongs *Odonthalia*, which is destitute of trichoblasts, and *Heterosiphonia* which has a sympodial growth.

b) In the other species of *Polysiphonia*, in *Brongniartella byssoides, Chondria dasyphylla* and *Laurencia pinnatifida* the normal branches arise as axillary buds of the trichoblasts. In *Brongniartella* they arise rather late when the trichoblast has reached a pluricellular stage. In *Polysiphonia* they arise much earlier, simultaneously with the trichoblast or nearly so, and it seems that the branch-producing trichoblasts are, at their first appearance, bigger than the sterile ones (comp. K. R. 1884 p. 29, rés. p. 5, figs. 34—40). The branches in *Polysiphonia* are thus not branches of the trichoblasts as Oltmanns thinks (Morph. u. Biol. d. Alg. 1904 p. 609). The basal cell common to the trichoblast and the branch belongs as to its lowermost part to the stem. The first joint of the branch, common with the trichoblast, cuts off pericentral cells on its outer surface, but the central cell of this joint keeps the protoplasma continuity with the trichoblast through a longitudinal wall between the pericentral cells or the segmental wall between the first and the second joint (figs. 379, 388, comp. K. R. 1903, p. 468).

c) Secondary axillary shoots arise from the basal cells of shed trichoblasts. They occur normally in *P. violacea*, giving rise to the shorter branches characteristic to this species, appearing between the longer primary branches, further in *P. elongata*, particularly in older, wintering plants, and in *P. Brodiæi*, more rarely in *P. nigrescens* (K. R. 1884, p. 19, rés. p. 3) while they have not been met with in *P. urceolata* and in *P. orthocarpa*. Thus they occur also in species having no primary axillary shoots. In some cases they appear before the trichoblasts have been shed (figs. 364, 394).

d) Endogenous branches produced from the central cell of older joints occur in particular in the species of *Polysiphonia* with creeping shoots and in *Brongniartella*. The creeping shoots always arise endogenously and produce new endogenous shoots; they issue normally near the base of the principal stems in *P. urceolata*, *P. orthocarpa*, *P. atrorubescens* and *P. nigrescens*. In the latter species an endogenous shoot often appears in the axil of the longer branches, near the base of the branch (fig. 393).

e) Adventitious branches arising from peripheric cortical cells occur in *Rhodomela* and *Odonthalia*; they have not been met with in *Polysiphonia*.

4. The rhizoids are unicellular. In *Polysiphonia* and *Brongniartella* they are produced from the pericentral cells or in the corticated species also from the cortical cells. In the sporelings, however, the first rhizoid originates from the lowermost cell of the plant and the next following from the first joints which do not produce pericentral cells (figs. 384, 396). The rhizoids are separated from the pericentral cells by a wall (comp. Derick 1899 p. 251). Dr. Lily Batten did not observe a wall at the base of a rhizoid in any species of *Polysiphonia* that she had observed (1923 p. 276). Such a wall is, however, really present in all of the Danish species. In *P. urceolata* only I found rhizoids in open connection with the pericentral cell. A shortening of the rhizoids was stated in *P. urceolata*. Rhizoids are wanting in *Laurencia pinnatifida*, *Rhodomela subfusca* and *Odonthalia dentata*, the organ of attachment of which is a continuous pseudoparenchymatous disc.

5. Torsion of the stems in *Polysiphonia* and *Rhodomela* frequently occurs. In *P. atrorubescens* it is a constant feature, but the direction of the torsion varies. The twisting may cause that the branches become uniseriate for a longer stretch (*P. violacea*, *P. Brodiæi*, *Rhodomela*).

6. In most of the species the central cell contains one nucleus which remains undivided, while the pericentral cells are always polynucleate. In *Polysiphonia nigrescens* and *Rhodomela subfusca*, however, it becomes plurinucleate by division of the primary nucleus.

7. By the germination of the spores (of *Polysiphonia* and *Brongniartella*) the cell is first divided by a transversal wall whereby a cell is cut off that becomes the first rhizoid cell. In *Brongniartella* the rhizoid was perceivable before the appearance of the wall. The sporeling is then divided by parallel walls into segments, the first one or two of which (in *Polysiphonia*) do not produce pericentral cells,

which only appear in the second or third and following joints. In *P. Brodiæi* and *P. nigrescens*, which have 7—8 and 12—17 pericentral cells respectively, the next following one to four joints had 4 pericentral cells (figs. 384, 396), an interesting fact when we remember that a great number of the species of this genus have constantly 4 pericentral cells. The normal number of pericentral cells in the said species is gradually reached in the following joints.

8. Secondary pits are produced not only between pericentral cells but also between the cortical cells and between these and the pericentral cells (*Pol. violacea*, *P. Brodiæi*). Cells connected with more than one secondary pit in the same wall occur in *Pol. elongata*, *Rhodomela* and *Odonthalia*. In *Pol. elongata* the pericentral cells are first connected by one secondary pit, but later on, in the following year, a circle of further secondary pits arises in the same wall (fig. 357).

9. The tetrasporangia arise in a pericentral cell. According to Falkenberg (1901 p. 88) they always originate in the *Polysiphoniæ* from the oldest pericentral cell in the segment. This is, howewer, not in accordance with my observations. As early as in 1884 I have ascertained that the sporangia in *P. fastigiata* take their rise in a lateral pericentral cell separated from the oldest one by two or three sterile pericentral cells (1884 p. 10, rés. p. 2, figs. 1—3). In *P. violacea* and *P. Brodiæi* I found that the first pericentral cell is cut off to the right of the trichoblast, while the fertile pericentral cell is always situated to the left of the trichoblast borne on the same joint, and is probably the second pericentral cell. The fertile cell cuts off two secondary pericentral cells, and the inner cell is then divided by a horizontal wall into a stalk cell and a spore-mother-cell or tetrasporangium. In the species of *Polysiphonia* with 4 pericentral cells a small peripheric cell is further cut off under one of the secondary pericentral cells which is a little shorter than the other, and this little cell is always situated beside the basal cell of the trichoblast of the foregoing joint, on its right side. This cell is always present in *P. violacea* and *P. orthocarpa*. In *P. urceolata* and *P. elongata* it may be present or wanting; in the first named species it was present in the trichoblast-bearing stems, while it was wanting in the stems without trichoblasts. It is further usually present in *P. Brodiæi* which has 7—8 pericentral cells, but it is wanting in *P. atrorubescens* and *P. nigrescens* where the number of pericentral cells is greater. In the species with 4 pericentral cells in the sterile joints the number of pericentral cells in the fertile joints is always 6, though there are always only two secondary pericentral cells.

Fam. 14. Delesseriaceæ.

J. G. Agardh, 1852, Species genera et ordines Algarum. Vol. II pars 2. Lundæ.

— , 1898, — Vol. III pars 3.

R. Kolkwitz, (1900), Beiträge zur Biologie der Florideen. Wissensch. Meeresuntersuch. Neue Folge. IV. Band. Abt. Helgoland Heft 1. Kiel und Leipzig.

P. Kuckuck, 1894, Bemerkungen zur marinen Algenvegetation von Helgoland. (I). Wissensch. Meeresuntersuch. Neue Folge. I. Band.
W. Nienburg, 1908, Zur Keimungs- und Wachstumsgeschichte der Delesseriaceen. Botan. Zeitung 1908, p. 183, Taf. VII.
R. W. Phillips 1898, The Development of the Cystocarp in Rhodymeniales: II. Delesseriaceae. Annals of Botany, Vol. 12.
N. Wille, 1885, Bidrag til Algernes physiologiske Anatomi. K. Sv. Vet. Akad. Handl. Bd. 21 No. 12. Stockholm.
— , 1887, Beiträge z. Entwickelungsgeschichte der physiolog. Gewebesysteme bei einiger Florideen. N. A Leop. Car. Ak. Bd. LII Nr. 2. Halle.
See further p. 297 and p. 402.

My investigations on the Danish Delesseriaceæ, which have been directed to the structure and development of the frond, were almost finished when I received Kylin's important paper (1923) which contributes so much to the morphology of this family. My observations are in full accordance with those of Kylin to which I can, however, give some additions. Two matters only must here be emphasized.

1. The presence of secondary pits, first pointed out by me (1888) in *Membranoptera alata*, was ascertained in all the species in question, both in the ribs and in the monostromatic frond. In the mid-ribs of the fronds multiple pits occur in the transverse walls of most of the long cells. These pits are in most cases all of secondary kind, arising at different moments between two pericentral or similar cells that were not before-hand connected by pits. In *Phycodrys rubens*, however, secondary pits are also formed between the cells of the axial cell-row, though these cells are from the first connected by a primary pit. The secondary pits are here formed in the periphery of the wall while the primary pit is central (figs. 429, 430).

2. The germination has only been observed in *Apoglossum ruscifolium* by Tobler, but young specimens of the other species were found in nature. In *Apoglossum ruscifolium*, *Delesseria sanguinea* and *Membranoptera alata* the primary axis of the plantlet becomes a typical frond provided with a mid-rib. In *Delesseria sanguinea* this primary frond seems to obtain only a moderate length, but in *Membranoptera alata* and probably also in *Apoglossum ruscifolium* it becomes the main axis of the frond, and in *Membranoptera* it early begins branching. In *Phycodrys rubens*, on the other hand, the primary axis of the young plant develops into a thorough monostromatic frond without mid-rib, reaching only a length of half a cm or a little more; the typical fronds arise as adventitious shoots from the stalk of the primary shoot. The accordance of this primary frond with the normal frond in *Nitophyllum* corroborates the opinion put forth by earlier authors, in particular by Kylin, that this species must be referred to the *Nitophylleæ*.

Subfam. Nitophylleæ.

Phycodrys Kützing.

1. Phycodrys rubens (Huds.) Batters.

Batters, Cat. Brit. Mar. Algæ. 1902 p. 76.
Fucus rubens Hudson Fl. Angl. 1762 p. 475 (not seen).
Fucus roseus O. Fr. Müller, Flora Danica tab. 652, 1775.
Fucus sinuosis Gooden. & Woodw., Linn. Transact. III 1797 p. 111.
Delesseria sinuosa (G. & W.) Lamour. Essai, 1813 p. 124, Lyngbye Hydr. 1819 p. 7 Tab. 2 B; Harvey, Phyc. Brit. III pl. 259, 1851; J. Agardh, 1852 p. 691; Magnus, Bot. Erg. d. Pommerania Exp. Kiel 1873 p. 75; Nägeli u. Schwendener, Das Mikroskop, 2. Aufl. 1877 p. 563; Wille, 1885 pp. 30, 51, fig. 51, 1887 pp. 65—69 figs. 21—31; Kuckuck, 1894 p. 255; Phillips, 1898, p. 189.
Phycodrys sinuosa (Huds.) Kützing. Phyc. gen. 1843 p. 444 Taf. 68 II; Tab. phyc. XVI 1866 pl. 20; Kylin, 1923 p. 64.

The apical growth of the frond has been studied repeatedly (Nägeli and Schwendener, Wille, Nienburg, Kylin). Nienburg has stated the occurrence of intercalary cell-divisions[1], but the succession of the divisions and the genetic connection of the cells has only been correctly described by Kylin (1923) who payed especial attention to the pits connecting the cells. In my figures 427 and 428 the pits connecting the cells have not been drawn. The sequence of the division walls can, however, to a certain degree be concluded from a comparison of the consecutive segments cut off from the apical cell, but the fact stated by Kylin, that the primary cell-row of the segment issues from the lowermost cell produced by intercalary division of the primary cell in the axial cell-row, cannot be recognized. Intercalary divisions occur early in the axial cell-row; they appear already in the second segment from the top (Kylin figs. 44, 45) or a little later, in particular in narrow fronds (figs. 427, 428), where the primary segments do not become so much deepened as in Kylin's fig. 44.

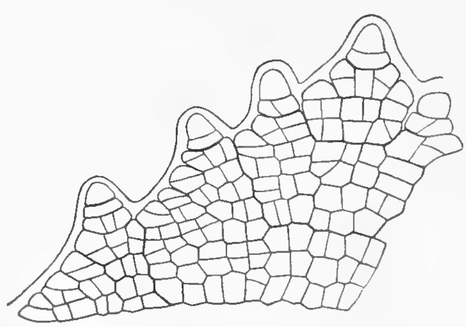


Fig. 427.
Phycodrys rubens. Tip of frond. April. 260 : 1.

The secondary initial cells situated in the upper edges of the primary segments are able to grow out into lobes, and as the two initial segments of a segment always behave in the same manner, the lobes are always opposed. In the frond shown in fig. 427 the three consecutive segments produced each a lobe on each side, and it seems to be normally so that the number of lobes in a normal leaf corresponds to an equal number of consecutive segments. The distance between two consecutive lobes or between the nerves belonging to them in an adult leaf thus indicates the height obtained by the primary segments which may be 3—6 mm.

[1] Schmitz has undoubtedly observed these cell-divisions in *Del. sinuosa*, but he has not expressly cited this species in this connection.

The border of an older frond shows numerous triangular initial cells (fig. 431) which are the end-cells of cell-rows of the third or fourth order, which really exist in spite of NIENBURG's assertion (comp. 1908 pp. 195, 206). These initial cells do not grow out except by producing adventitious shoots.

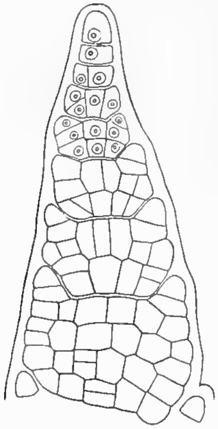


Fig. 428.
Phycodrys rubens. Tip of narrow growing frond. 260 : 1.

The structure and development of the mid-rib has been described by WILLE and KYLIN. The development begins with longitudinal divisions of the primary cell-row in the middle of the frond, and the cortication proceeds at both sides of it. A transverse section of the mid-rib shows a row of large cells with rather thick walls traversing the mid-rib (fig. 429). These cells are lengthened in the longitudinal direction of the frond and show multiple pits in the transversal walls. The cells situated on both sides of the median row have a similar character to these, but they have a smaller diameter and are shorter (comp. WILLE 1887 fig. 28, KYLIN 1923 p. 70 fig. 45); they are also provided with (secondary) pits in the transversal walls. The middlemost cell of the transversal cell-row must be designated as the central cell; its transverse walls contain the primary pit of the primary segment walls or of the intercalary walls; it is shown in the middle of the middlemost cell-wall (*c*) in fig. 429, but the same wall shows four secondary pits in the periphery of the wall by which the cell is connected with the next following central cell. The transverse walls of the other cells in the transverse cell-row are only provided with secondary pits, usually four, all situated near the periphery of the wall. Fig. 430 shows longitudinal sections of the inner cells in a mid-rib; *C* is a central cell showing at the upper end

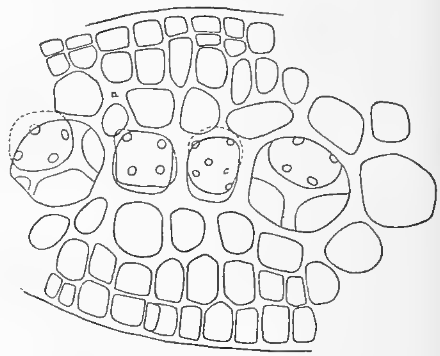


Fig. 429.
Phycodrys rubens. Transverse section of mid-rib. *c*, central cell with a central primary pit and four secondary pits. 150 : 1.

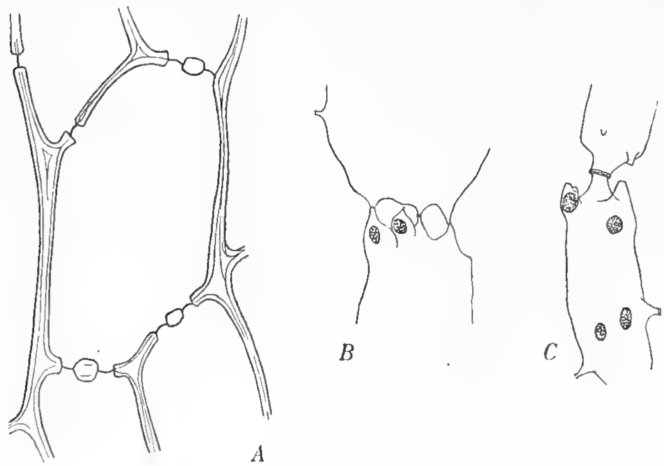


Fig. 430.
Phycodrys rubens. Longitudinal sections of inner cells in the mid-rib. *A* in the living state, *B* and *C* fixed and stained, showing the pits and the nuclei. *A* 200 : 1. *B*, *C* 450 : 1.

a primary and two secondary pits, *B* a transverse wall with four secondary pits. As pointed out by WILLE the inner cells of the rib have, a mechanical and a conductive function as well. This tissue is covered on both sides by an assimilatory system composed of radiating filaments of short cells (fig. 429, comp. WILLE 1885, fig. 51, KYLIN l. c.).

The lateral veins are opposed, in accordance with their origin from the primary cell-rows of the consecutive segments, and run out in the lobes. Lateral veins of the

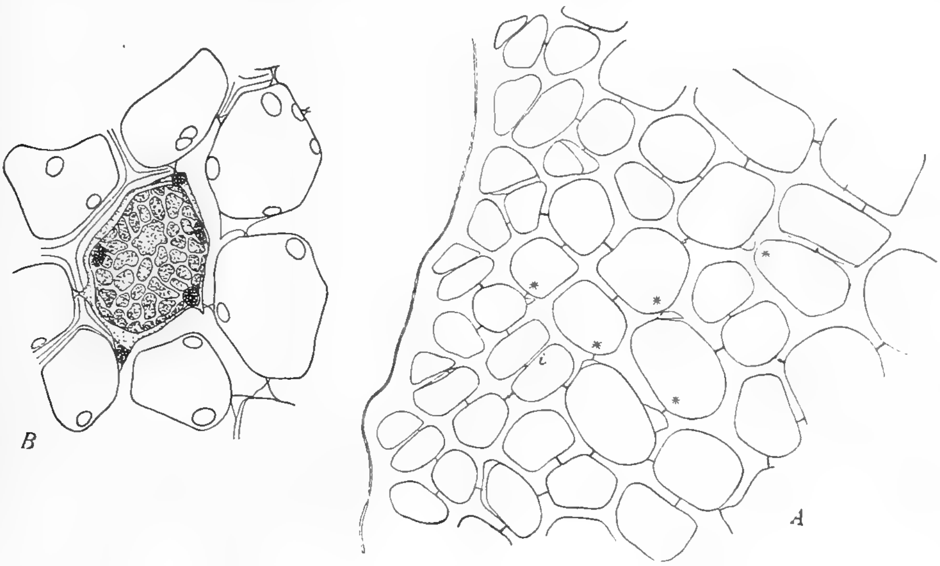


Fig. 431.

Phycodrys rubens. *A*, marginal part of frond showing formation of secondary pits (*). *i* intercalary division wall. 450 : 1. *B*, group of cells showing secondary pits. In the middlemost cell the inner contour is the outline of the cell at high level; the outer contour showing the pits is at a lower level. 380 : 1.

second order may also occur, but they are much feebler. The later arising marginal shoots give further rise to lateral veins in the leaves. By treatment with iodine the veins take a darker stain owing to their richer contents of starch (July).

Secondary pits are also produced in great numbers in the monostromatic part of the frond; but they arise only at a considerable distance from the top. In the living plant it is impossible to observe their formation, as it takes place only in the middlemost part of the walls while the parts of the cells situated at the surfaces of the frond do not participate in the process. The formation of the secondary pits seems to continue rather long; their number increases downwards and inwards from the border. In a leaf examined by me the cells situated near the border (not including the marginal cells) had averagely 2,5 pits, while the cells in some distance from the border had averagely 3,6 pits, a difference due to the greater frequency of the secondary pits. The secondary pits are recognizable by the transmigrating cell being not completely incorporated in the receiving cell but remaining at all events for a long time as a triangular projection, after the entrance of the nucleus in the receiving cell (fig. 431). No wall separating two cells in the monostromatic part of the leaf contains more than one pit.

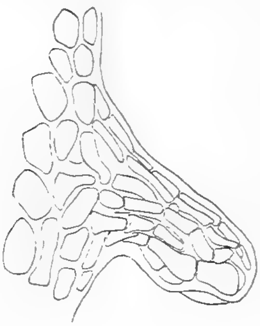


Fig. 432.
Phycodrys rubens. Multicellular papilla. 150 : 1.

The shape of the frond is rather variable according to the different length and breadth of the lobes and to the different manner in which the growth recommences after the rest of the winter. In some cases a number of the lobes resume the growth from a broad base and form new leaves as prolongations of the lobes of the old leaf. In other cases the apical cells of the lobes give rise to a leafy shoot with a narrow stipe, and it has then a similar character to the other marginal shoots arising from single marginal cells, probably principally from initial cells of the third order. Most of these shoots, which may be very numerous, reach only a small size and become fertile. Adventitious shoots may also arise, in older leaves, from the middle-rib and from the side-ribs. KYLIN found tetrasporiferous leaflets projecting from the veins (1923 p. 65); I found the same. Long narrow shoots are frequently produced, mostly at the base of the plants, but sometimes also from the upper end of the shoots. They often bear multicellular papillæ (fig. 432) which take the function of hapters when meeting a firm substratum, f. inst. other Algæ. Such papillæ, which have first been described by P. MAGNUS (l. c. p. 75), occur frequently in this species, also in the broader forms of the frond and frequently cause the fronds to be entangled with each other and with other Algæ.

Germinating spores have not been observed in cultures, but young plants have repeatedly been found in nature, principally in hydroids. The small plant shown in fig. 433 *A* is most probably a sporeling of *Phycodrys rubens,* as it has been found by dredging in April in company with adult specimens of this species while other species of *Delesseriaceæ* were not present. This young plant shows much resemblance to the sporelings of *Nitophyllum punct-*

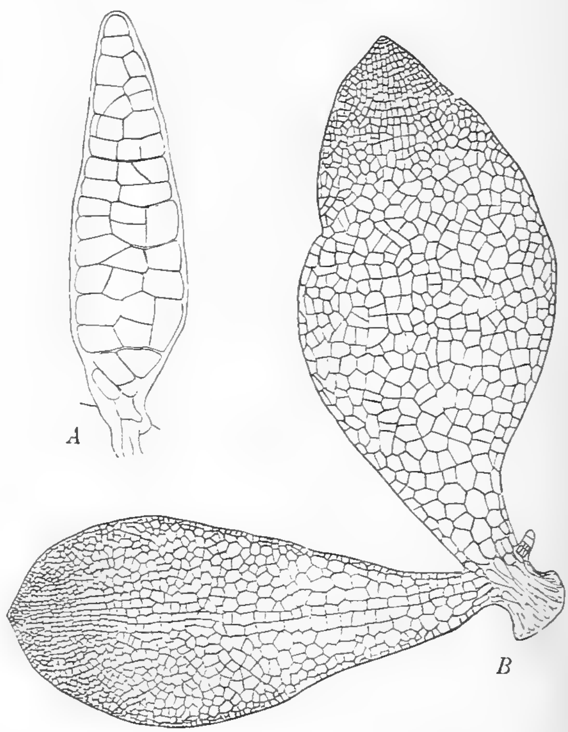


Fig. 433.
Phycodrys rubens. *A* sporeling found in April off Refsnæs (Store Belt). 270 : 1. *B* plantlet found in July in the Little Belt on Sertularia. 63 : 1.

atum described and figured by NIENBURG (1908 Taf. VII). Like these it lacks the regular apical cell-divisions characteristic of the older shoots of the *Phycodrys*-plants; the monostromatic frond is composed of uniform cells which are rather irregularly divided, intercalary divisions being very frequent, and no mid-rib is present. Our sporeling differs, however, from those described by NIENBURG in being erect, while the latter, according to the said author, are decumbent, growing along the substratum (l. c. p. 185). This primary shoot has been found again in a number of older plantlets collected in July; it had reached a considerable size, up to 6 mm long and 2 mm broad or more, and had a broadly lanceolate shape, but otherwise showed the same character as before. It was thoroughly monostromatic, composed of uniform, irregularly disposed cells becoming smaller upwards, and terminated in an apical cell divided by transversal walls, but showed no trace of a mid-rib. The base of the primary shoot was contracted in a short stalk fixed to the substratum by a basal disc. From the stalk one or more adventitious shoots showing the typical apical growth and a well developed mid-rib were given off; the mid-rib could be traced to the very base (fig. 433 *B*).

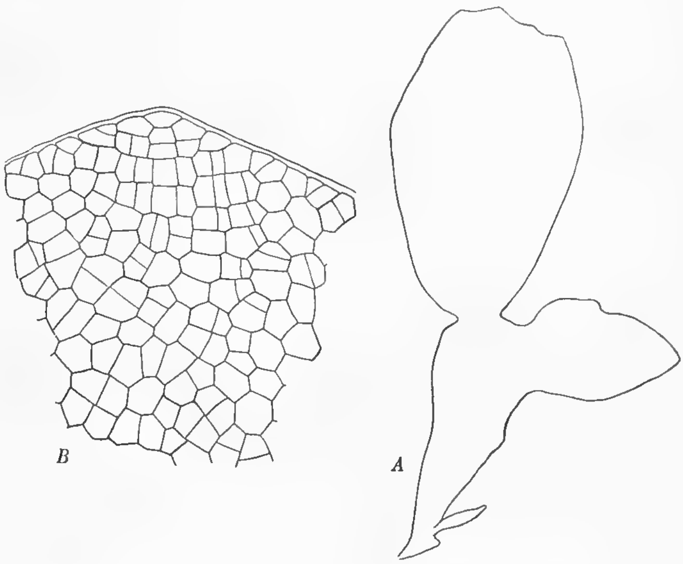
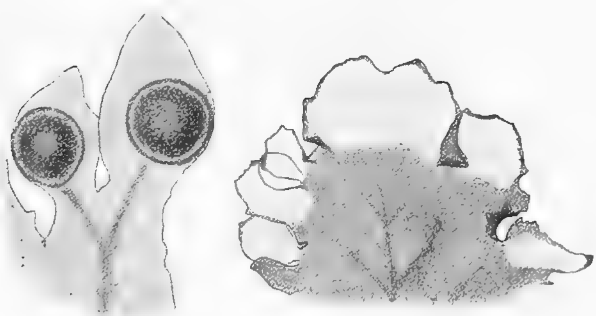


Fig. 434.
Phycodrys rubens. *A*, plantlet found in July in the Little Belt on Sertularia, with lobed primary frond; at the base a young adventitious shoot. 20 : 1. *B*, tip of the primary frond in *A*, showing the apical cell. 260 : 1.

The primary frond in an advanced stage terminates in an apical cell dividing like that of the typical fronds, and the first divisions of the primary segments are similar to those mentioned above of the normal fronds, but intercalary divisions occur early and continue in still greater number than in the ordinary leaves and cause the arrangement of the cells to become much more irregular than in these (fig. 434 *B*). The cells in the middle of the frond do not show any tendency to longitudinal arrangement and no divisions parallel to the surface of the frond occur. Secondary apical cells appear and may give rise to slight sinuosities of the outline (fig. 434 *A* above) but normally they do not occasion branching. Primary fronds with one lateral lobe such as that represented in fig. 434 may, however, sometimes be met with. Even in these fronds no rudiment of a mid-rib was discernible. The primary fronds thus agree perfectly well with the normal fronds in *Nitophyllum* (comp. NIENBURG 1908). The discovery of the primary frond in *Phycodrys rubens* is in good accordance with the opinion pronounced by earlier authors (SCHMITZ, PHILLIPS, NIENBURG), and recently more precisely by KYLIN, that this species must be referred to the *Nitophylleæ*.

Antheridia have been met with in one specimen collected in November in the Great Belt; it was well developed, 5 cm long, while KUCKUCK only found antheridia on dwarfy specimens at Helgoland. The antheridia were borne on marginal lobes and leaflets on the upper part of the plant, about 1 mm long. The antheridial patches are usually surrounded by a narrow sterile border (fig. 435 *A*). In young leaves KYLIN found the antheridial sori forming bands parallel to the margin (1923 p. 65). The development of the antheridia has been described by the same author (p. 77).



B A

Fig. 435.
Phycodrys rubens. *A*, part of male frond with antheridia in particular leaflets, November. *B*, two cystocarps in particular leaflets. 16 : 1.

The procarps arise in great numbers in the upper part of the fronds without any relation to the veins. The development and structure of the procarps and the cystocarps has been studied by PHILLIPS and recently most carefully by KYLIN (1923 p. 71) whose description may here be referred to. The cystocarps were, in the Danish waters, only met with in a few specimens dredged in the Little Belt; they were almost all placed in special marginal leaflets usually containing one cystocarp only (fig. 435 *B*), otherwise near the margin in the larger leaves.

The tetrasporangia arise in the Danish specimens only in small marginal adventitious folioles, never in larger leaves. The folioles, as shown also by KYLIN, may arise from the face of the frond, and sometimes even from old mid-ribs without membrane, much as in *Del. sanguinea*. They contain two layers of tetrasporangia which are only separated by one median layer of cells. Their development has been described by KYLIN (1923, p. 73) who emphasises that the mother-cells of the sporangia arise in the inner cortical layer, whereas in *Del. sanguinea* they are superficial cells.

Ph. rubens is rather variable in the size and shape of the frond, but the forms are connected with each other by intermediate forms. It is widely spread in all the Danish waters except the fjords, usually in the ordinary, rather broad form. In the North Sea and the Skagerak, however, it reaches only a moderate length (about 4 cm). In the northern Kattegat, too, it does not reach the full size (7 cm). In the inner waters it becomes larger, it not unfrequently attains a length of 10 cm and more. The largest specimens were found in the Great Belt and the Sound, in depths of 15 to 23 m, where they reach a length of up to 18 cm and a breadth of 1—2 cm excluding the lobes. These, the most well developed specimens can be referred to f. *quercifolia* Turn., distinguished by the outline of the frond resembling an oak-leaf and by the rounded lobes. In smaller depths the size of the frond is smaller; that appears very plainly when comparing the rather numerous specimens collected in the Great Belt. In those dredged in depths of 1 to 17 meters the length was at most 8 cm, the breadth at most 1 cm, while the specimens collected in greater depths, where the salinity is higher and the conditions less variable, reached a length of 10—18 cm and a breadth of 1,3—2 cm and analogous differences were found in the Sound.

A much branched loose form (f. *ægagropila*) was found in fast flowing water in Svendborgsund at 5,5 meters' depth.

As a noticeable form may be named f. *lingulata* Ag., characterized by its narrow frond with stalked lingulate almost entire marginal shoots. This form is, however, closely connected with the typical form through intermediate specimens. The smaller breadth of the frond is evidently an effect of the unfavourable conditions in the water with feebler salinity and great variations in temperature and salinity. In the Western Baltic Sea the frond still reaches a length of 10 cm and a breadth of up to 1 cm, but in **Bm** and **Bb** the frond is only 0,5—1,5 mm broad. The frond is then almost linear or lineari-lanceolate and reminds one of *Membranoptera alata* from which it is, however, distinct by the more or less lanceolate segments of the frond. The margin is for long stretches even or only provided with few feeble teeth (fig. 436). These specimens which may be named f. *sublinearis* usually seem to be loose; they occur together with *Furcellaria* and *Mytilus* and attached to these, but apparently only by lateral hapters, and it is doubtful whether they have arisen directly from spores.

Fig. 436.
Phycodrys rubens f. *sublinearis*. From Bornholm, east of Dueodde, 38 m. 2:1.

Tetrasporiferous specimens occur more frequently than sexual ones. Antheridia have been met with once only in November and cystocarps in two or three localities in March, while tetrasporangia have been found in numerous specimens collected in the months December to May. In the last-named month the sporangia were, however, usually entirely or partly emptied.

The species occurs in depths from 1 to 40 meters. In the southern parts of the Belts and the Sound and in the southern waters it has, however, not been met with in smaller depths than 5,5 m, and at Bornholm only in 19 to 38 meters' depth. It grows partly on stones, partly and principally on other Algæ as *Furcellaria*, *Laminaria*, *Halidrys* and many others, further on shells of mollusks, hydroids, *Hyas* etc.

Localities. **Ns:** ZQ, jydske Rev, 24,5 m; aF, off Thyborøn, 31 m; XR, off Klitmøller, 12 m; YT, Hanstholm, 15 m. — **Sk:** eV; Dana 2902; eY; eZ; several places off Lønstrup, off Hirshals, mole at Hirshals, everywhere were scarce. — **Lf:** Wanting. — **Kn:** Skagen harbour; Herthas Flak; Krageskovs Rev; around Hirsholmene; Frederikshavn, harbour and environs; UC, TL and ZP, at Nordre Rønner; several places near Læsø Trindel, 11—21 m. — **Ke:** Fladen, 16—30 m; Groves Flak, 19—32 m; Lille Middelgrund; ER, Fyrbanken, 28 m; IE; RU; RV; Store Middelgrund; Gilleleje. — **Km:** Læsø Rende: BN, off Asaa; Dana St. 2884 (C. A. J.). — **Ks:** Grenaa harbour; PF, Jessens Grund, 4 m; EJ, EM, Lysegrund; at Hesselø (Lyngbye); RL, 15 m; D, north of Grønne Revle, 11 m; aU, off Lumbsaas, 13 m; GF, GG, Sjællands Rev, 4—8,5 m. — **Sa:** GD, north of Sejerø; PC, MY, north of Samsø; stony reef in Begtrup Vig; Aarhus harbour; FV; FX; FY; GC, east of Æbelø; Hofmansgave (Lyngb., Hofm. Bang); AH[1], Lillegrund at Fyns Hoved, 13 m; Korshavn; MP; DK, Bolsaxen; PF, off Refsnæs. — **Lb:** AX; OB; AL (Baaring Vig); AN; Middelfart harbour; common in the belt at Middelfart; Fænø Sund; cX; DG; dC; DF; DD; DE; DA; CC; CY; dQ; dE; dH, east of Hesteskoen. — **Sf:** CU; UV; Svendborgsund several places, f. *ægagropila* at 5,5 m depth. — **Sb.** Very common: GT, off Asnæs; GU; GS; AG; GV; cN; Kerteminde harbour; NU; cL; GP; NN; Z; AB; AC; BS; BT; between Sprogø and Korsør (Magnus); UE; DN; UF; UH; UT; DP; UI; Spodsbjerg; LH; DQ; DR; US, over 38 m; US[1]; DS; DT; LB; UR. — **Sm:** HA, HB, Agersøsund; CK; Q. — **Bw:** bX, off Kobbel Skov; CD, CE, Middelgrund south of Als; dO; dP; dK, Pøls Rev; DX, Vodrups Flak; UY, Vejsnæs Flak; DV; DU; UL, Øjet, 20 m; LA; KX; KU; UM, 25 m. — **Bm:** HG, Præstebjergs Rev; VH, south of Møen; VG, n. of Møens Klint; QS; SD; QO; QM; PR, off Dragør. — **Bb:** F. *sublinearis*: Rønne; XZ[1], Davids Banke; SP, off Svaneke, 28 m; YD; YA, east of Dueodde, 38 m.

Subfam. **Delesserieæ.**

Apoglossum J. Agardh.

1. **Apoglossum ruscifolium** (Turner) J. Agardh, 1898 p. 194; Kylin 1923 p. 83.

Fucus ruscifolius Turner, Trans. Linn. Soc. t. 6 p. 127, tab. 8 figs. 1—2, 1801.

Delesseria ruscifolia (Turn.) Lamouroux, Essai 1813 p. 124; Harvey Phyc. Brit. II pl. 26, 1846; J. Agardh 1852 p. 695; Kützing Tab. phyc. XVI tab. 12, 1866; Buffham 1893 p. 296 pl. 14; Kuckuck 1894 p. 256 (antheridia); Phillips 1898 p. 188; Kolkwitz 1900 pp. 45, 46; Nienburg, Z. Entwickl. d. Florideenkeimlinge, Hedwigia Bd. 51, 1912, p. 299; Kylin, Keimung der Florideensporen, Arkiv f. Botanik 1917 p. 21.

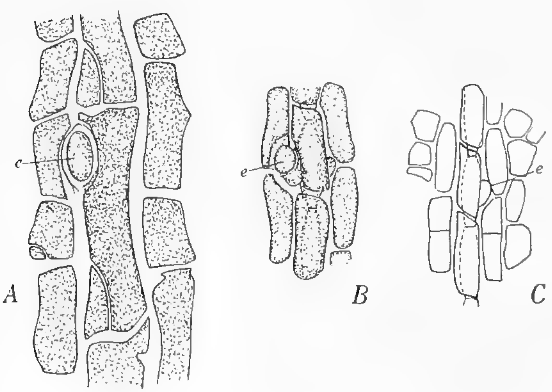


Fig. 437.
A, *Apoglossum ruscifolium* (Biarritz), part of mid-rib in superficial view. *e* endogenous branch budding from the central cell which is not visible. 700 : 1. *B* and *C*, *Hypoglossum Woodwardii*, similar views; the central cells are shown behind the cortical cells. 240 : 1.

Two specimens only of this pretty little Alga have been met with in the Danish waters, I must therefore refer the reader for the structure and development of the frond and of the organs of fructification to the recent paper of Kylin (1923). It must only be noted that, according to my observations many years ago at Biarritz, the adventitious branches do not arise from any superficial cell of the mid-rib, as maintained by Kylin (1923 p. 85), but by endogenous budding from the central cell. I have found the same in *Hypoglossum Woodwardii* Kütz. (*Delesseria Hypoglossum* (Woodw.)) (fig. 437).

The first stages of the germination have been observed by KYLIN (1917 p. 21). NIENBURG, who studied the further development, found that the sporeling is early divided by parallel walls into four cells. By irregular divisions of the two middlemost and partly of the lowermost and the upper of these cells, a flat body without mid-rib is produced which corresponds to the primary frond in *Nitophyllum* and continues in the primary frond, showing the typical structure.

Apoglossum ruscifolium has been met with in two localities in the northern and eastern Kattegat in great depths with salt water, 20—22,5 m, in July, in each place only in one specimen. They were both provided with tetraspores. The largest specimen was 2 cm high, 4 mm broad. According to KUCKUCK it accomplishes its course of life in scarcely more than four weeks. ARESCHOUG states, however, that it has been found fructiferous at the western coast of Sweden in July to September.

Localities. **Kn:** XJ, Herthas Flak, c. 20 m. — **Ke:** ZF, near Fladens light-ship, 22,5 m.

Delesseria Lamouroux.

1. Delesseria sanguinea (L.) Lamouroux.

Lamouroux, Essai 1813 p. 124; Lyngbye, 1819 p. 7 pl. 2; Flora Danica tab. 2198,2 1836 (f. *lanceolata* Ag.); Kützing, Phyc. gen. 1843 p. 445 pl. 67; Harvey, Phyc. Brit. II pl. 151, 1849; Buffham, 1893, p. 296 pl. XIV figs. 28—30; Kuckuck, 1894 p. 255; Kolkwitz, 1900 p. 41; Kylin, 1907 p. 136; Svedelius, Svensk Botan. Tidskr. Bd. 5, 1911 p. 200, Bd. 6, 1912 p. 239, Bd. 8 1914 p. 1; Kylin, 1923 p. 92.

Fucus sanguineus Linné Mantissa 1767 p. 136; Oeder Fl. Dan. tab. 349 1767.

Hydrolapathum sanguineum Stackhouse Tent. 1809 p. 67 (not seen); J. Agardh, Sp. g. ord. Vol. III 1876 p. 370; Le Jolis, Liste . . Cherbourg 1864 p. 133; Wille, 1887 p. 57 figs. 1—13; J. Agardh, Analecta alg. cont. IV 1897 pp. 22, 41.

Wormskioldia sanguinea Sprengel, Syst. veg. IV 1827 p. 331; J. Agardh, 1851 p. 408.

The cell-divisions in the tip of the frond are very regular (comp. WILLE, KYLIN). As emphasised by KYLIN (1923 p. 93), intercalary cell-divisions do not take place in the primary cell-row but in the cell-rows of the second and third orders. These divisions are marked with an * in my fig. 438 *B*. The cell-rows of the third order are given off from the lower side of those of the second order, and the cell-rows of the fourth order equally from the lower side of those of the third order (fig. 438, comp. KYLIN 1923 fig. 61). The pericentral cells cut off from the primary cell-row are early divided by a transverse wall (fig. 443). The cells surrounding the central cell-row are therefore of half the length of the central ones. As the central cells never divide by transverse walls they become very long. They are connected with one another by a broad pit in each transversal wall. The nucleus early divides into two, and the divisions continue, in consequence of which the older central cells contain numerous nuclei. The first transverse wall dividing the young pericentral cell is situated under the pit connecting it with the central cell (comp. KYLIN 1923 fig. 62 a) and this pit is later to be found near the upper end of the central cell. The lowermost cell resulting from this division is at first not connected with the central cell by a pit, but such a connection must later be established for in a more advanced stage the lower end of the central cell is also connected with the surrounding cells by pits (fig. 439 *A*, *C*). The pericentral cells are connected longitudinally by multiple, usually three pits of which all or at least two are secondary.

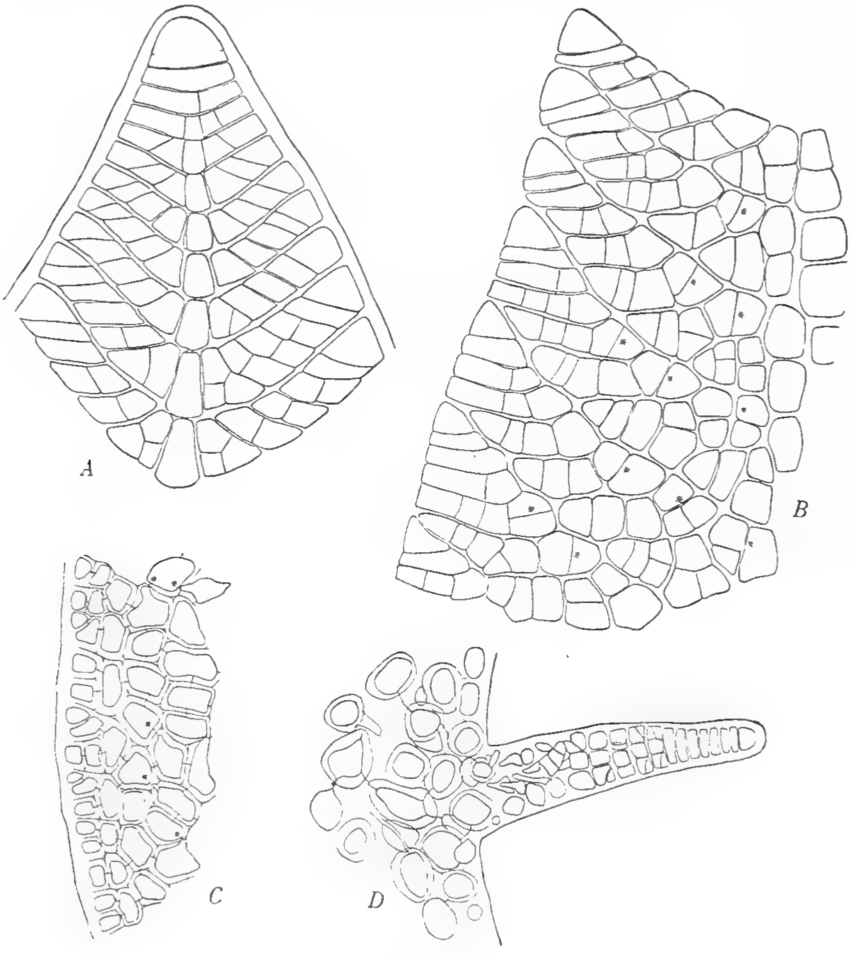


Fig. 438.

Delesseria sanguinea. *A*, growing point of young leaf; the division of the apical cell has begun. *B*, lateral part of the same leaf; the intercalary division walls are marked with an *. *C*, marginal portion of frond at a longer distance from the top, showing the secondary pits (*). *D*, young adventitious shoot given off from a mid-rib. *A*, *B* 560 : 1. *D* 200 : 1.

The lateral veins of the first order arise in the upper border of the primary segments. Lateral veins of the second order are given off from the lower side of the primary ones; only near the margin of the leaf small veins may also sometimes project from the upper side. Veins of the third order may be met with and anastomoses of the veins may occur near the border. The branching of the veins is wrongly represented in Flora Dan. pl. 349.

The leaves do not normally branch, and branched leaves do not seem to have been mentioned in the literature. I have, however, observed some cases of branched leaves; as they have been met with in three different places, branched leaves may perhaps be found to be not quite uncommon. The branching is caused by a secondary apical cell becoming a primary one. When the branch has arisen at an early moment it may give rise to a pseudodichotomy (fig. 440 *A*); if it arises later, it becomes feebler and the branching more distinctly monopodial (fig. 440 *B*, *C*). Opposite branches have never been observed.[1]

Secondary pits are produced in great numbers, not only in the veins but also in the monostromatic frond (438 *C*). Two pits may exceptionally occur in the same wall between two cells in the latter.

The new leaves, as is known, arise as adventitious shoots from the mid-rib. The first stages of development have not been observed, but the new leaves seem to arise from a superficial cell. They are at first almost filiform (fig. 438 *D*) but soon become flat. In the lower part of the young leaves several cells early grow downward giving rise to rhizine-like filaments that strengthen the connection with the mother axis and establish a union of the conductive systems of the two axes which does not exist to begin with (comp. fig. 444). A small number of adventitious leaves may arise early, in spring, and grow out in the summer (comp. HARVEY l. c.), but most of the leaves arise in autumn (or perhaps early in winter). In January they have only a small size, they grow out in early spring and reach a considerable size already in April and the growth ceases in the beginning of summer, usually in June or perhaps already in May.

In the mid-rib the inner cortical cells are segregated by numerous rhizoids or conductive hyphæ (WILLE 1887 p. 59; KYLIN 1923

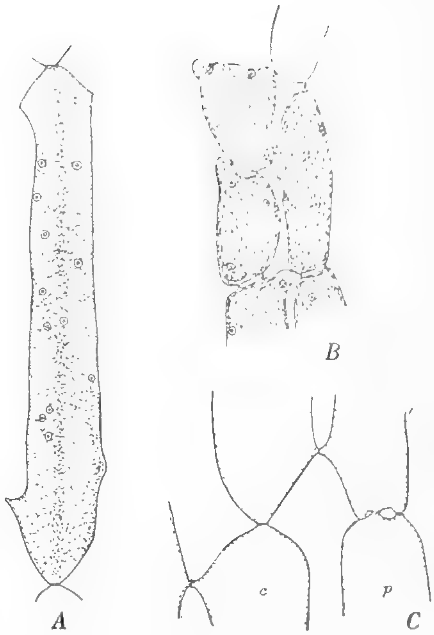


Fig. 439.
Delesseria sanguinea. Cells from the mid-rib in longitudinal sections. *A*, central cell. *B*, inner cortical cells showing secondary pits. *C*, central (*c*) and pericentral (*p*) cells, the latter showing three secondary pits. *A*, *C* 350 : 1. *B* 560 : 1.

Fig. 440.
Delesseria sanguinea. From the Baltic, south of Als. Branched leaves. $1\frac{1}{4}:1$

[1] As mentioned by KYLIN (1923 p. 92), SCHMITZ and HAUPTFLEISCH's fig. 238 *B*, which shows a ramification, does not represent *Delesseria sanguinea*. Fig. *A* according to KYLIN is a *Hypoglossum*, probably *H. Woodwardii*; fig. *B* is probably *Membranoptera alata*.

p. 95). As shown by KOLKWITZ (l. c.) starch is deposited in the mid-rib of the new leaves in June, and in summer and autumn they are densely filled with starch grains. The lateral veins are also filled with starch and therefore become dark brown by treatment with iodine.

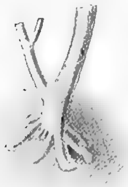


Fig. 441.
Delesseria sanguinea. Basal part of frond consisting of several cylindric hapters. Natural size.

The basal portion of the frond is disc-shaped or conical and composed of densely united rhizines (KOLKWITZ p. 45). It may, however, also be branched, composed of cylindrical members resembling the hapters of the Laminariæ (fig. 441). The basal portion is, according to KOLKWITZ, filled with starch in August and September; it gives rise to new adventitious shoots.

The germination has not been observed, but plantlets which could be identified with this species were repeatedly met with in summer, mostly growing on Hydroids, often in company with plantlets of *Phycodrys rubens* but easily distinguished from them by the lanceolate outline of the primary frond which is provided with a very distinct mid-rib from the base to the top (fig. 442). As shown in fig. 443, the cell-divisions at the top of the frond agree exactly with those of the later fronds and the mid-rib has also the same structure as in these (comp. KYLIN 1923 fig. 61). Near the base, however, the cortication of the mid-rib is less advanced than in the middle of the young frond (fig. 442 *B*). As in the later fronds, the margin shows a number of secondary apical cells, but while these are otherwise always situated so that the right angle of the cell is directed upward, the marginal apical cells of the primary frond often show the inverse situation, the wall by which they have been cut off being inclined upwards and the right angle of the cell therefore being directed downward. It not rarely happens that two marginal cells situated beside one another show different orientation, the one directed upward, the other downward (fig. 443 *B*). The downward directed apical cells remind one of those described above (p. 459) in *Odonthalia dentata*. Adventitious shoots early arise in the lowermost part of the primary frond, which has the character of a stipe, probably produced by a superficial cell (figs. 442, 444).

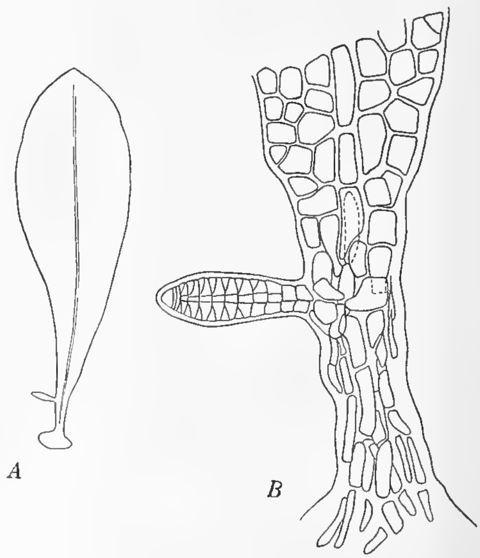


Fig. 442.
Delesseria sanguinea. A, plantlet from the Little Belt, July, 1,7 mm long. 43 : 1. *B*, lower part of the same showing adventitious branch. 200 : 1.

The laminæ of the leaves begin to disorganise in September, and this process advances more or less quickly during the autumn and winter and so that only the mid-rib remains. In exposed localities the disorganisation may begin earlier and the mid-rib may be denudated in September, whereas in sheltered localities, e. g. in the belts the laminæ keep till the next spring, having then a brownish colour.

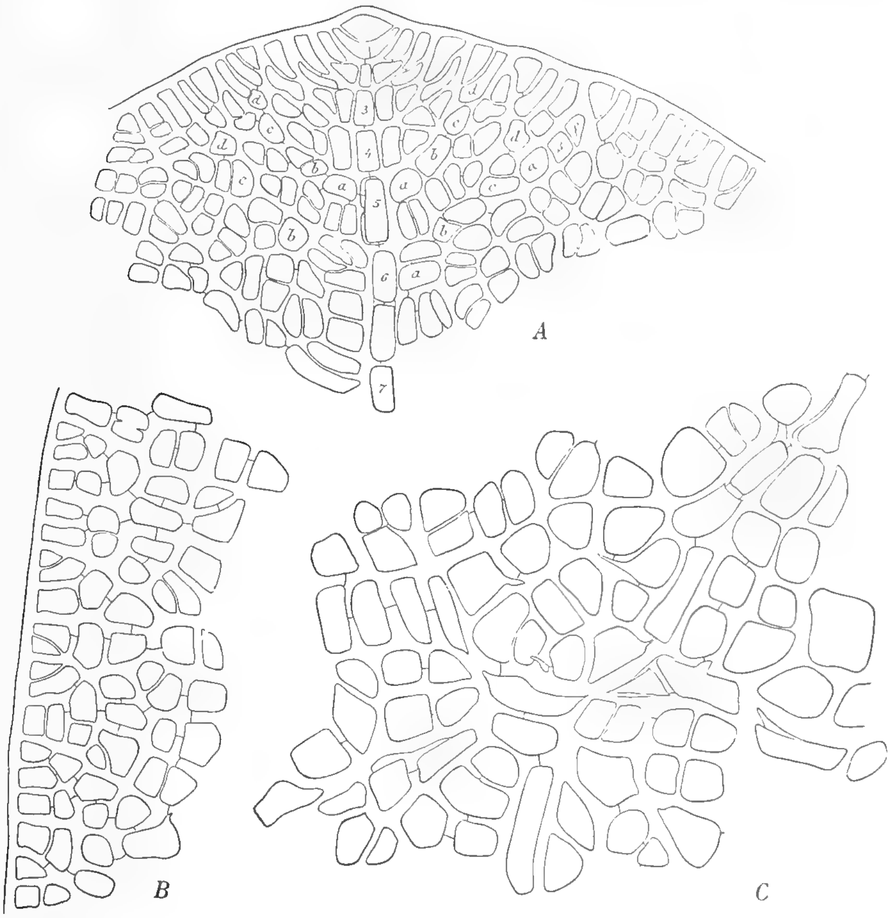


Fig. 443.

Delesseria sanguinea. Parts of 7 mm long plantlet, primary shoot. *A*, apical part showing cell-divisions. *B*, marginal part showing secondary, variously orientated apical cells. *C*, lateral veins and secondary pits. 560 : 1.

The fertile folioles arise in the autumn as adventitious shoots on the mid-ribs of the leaves from the foregoing winter. The development and structure of the organs of fructification has been thoroughly described by Svedelius and Kylin and will not therefore be mentioned here. The three kinds of fructification always occur in separate individuals. The antheridia-bearing leaflets were met with in September and October; they reach a length of 5 mm. The procarp-bearing leaflets produce a great number of procarps situated on the mid-rib, but one cystocarp only is developed in each shoot. Ripe cystocarps were met with in January and may certainly also occur in December and in the following months. Still in May numerous cystocarps may be found. Ripe tetrasporangiferous leaflets were met with in January to May, but the dissemination of the spores apparently takes place mostly in winter. The sporophylls reach a length of 20 mm.

The age reached by the individuals of this species is not easy to determine with certainty, not only because the basal disc is able to produce adventitious shoots, as emphasised by Kolkwitz (1900, p. 45), but also owing to the fact that new vegetative shoots may be produced not only in the autumn or in winter, but also in spring or early in summer on the new leaves, and there may thus possibly be produced two generations of shoots in one year. When in single cases, in specimens from the Little Belt, I have ascertained the presence of 7 generations of shoots in one specimen, it is therefore not permitted to conclude that it was 7 years old, though it is not improbable that it was really so. Kolkwitz thinks that *D. sanguinea* becomes "kaum älter als einige Jahre". I estimate the maximal age to be 4—5, perhaps 7 years.

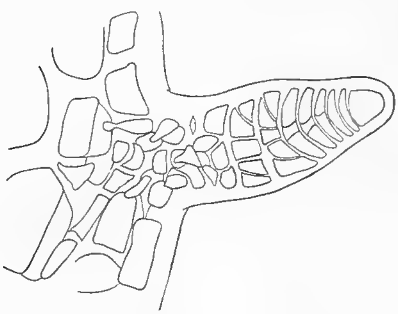


Fig. 444.
Delesseria sanguinea. Adventitious branch of plantlet producing downward growing filaments at the base. 420 : 1.

Delesseria sanguinea reaches its greatest frequency and the best development in comparatively deep water with fresh flow, as in the eastern channel of the Kattegat and in particular in the Belts and the Sound, where it is often predominant. In such places it often attains a length of 30 cm or a little more. In the open waters as **Ns** and **Sk** and in **Kn** it does not thrive by far so well and only reaches a length of up to 20 cm. Still in the western Baltic (**Bw**), in the deep channel between Lolland and Fehmern it reaches the maximal length. But in **Bm** it reaches only 18 cm and at Bornholm only 9 cm in length. The maximal length of the leaves varies about 10 cm in most of the Danish waters, in **Kn** and **Ke** between 7 and 18,5 cm, in **Sb** between 6 and 17 cm, in **Su** and **Bw** between 7 and 14 cm. In **Bm** it is only 5—8 cm and at Bornholm 2—5 cm. The greatest breadth of the leaves is reached in the Northern and Eastern Kattegat where it is 1,5—7,5 cm, most frequently 2,5—4,5 cm. In **Sb** the breadth is 1,3—4 cm, in the Sound 1,4—3 cm, in **Bw** only 0,8—1,5 cm, in **Bm** 0,3—1,3 cm and in **Bb** only 0,3 cm (comp. Plate VII figs. 1—4). The breadth of the leaves seems therefore to be more influenced than the length when the salinity of the water is diminished.

D. sanguinea occurs in all the Danish waters except the Limfjord and other fjords. It does not grow in depths smaller than 4—5 meters and descends to 30 meters' depth at least; in **Sb** it has been met with in 40 meters' depth. It prefers water with a salinity of 20 $^{0}/_{00}$ or higher and with rather low summer temperature. It is characteristic to stony bottom in the deep channels in our inner waters, where it occurs in great specimens with several generations of shoots.

Localities. **Ns:** ZQ, jydske Rev, 24,5 meters; aF, 31 m; XR, off Ørhage; cT, 34 m; YT, off Helshage, Hanstholm, 5,5—13 m. — **Sk:** eX, N.W. of Bragerne, S.E. of Bragerne, 10,5 m; washed ashore at Svinkløv; Dana St. 2900, 2899 (C. A. J.); several places off Lønstrup, 7,5—19 m; Bredegrund and Møllegrund off Hirshals; bF, Skagbanken. — **Kn:** Herthas Flak, c. 22 m; around Hirsholm; Frederikshavn; VT and GN, near Nordre Rønner; VT; common at Læsø Trindel, 10—24 m. — **Ke:** Fladen, several places, 16—30 m; Groves Flak; several places, 19—30 m; XA; RU, 26,5 m; Store Middelgrund (Børgesen, !); GJ, Ostindiefarer Grund; OO, Søborghoved Grund, 8,5 m; bR, Vesterlands Grund at Gilleleje, 7,5 m. — **Km:** Læsø Rende, Dana St. 2884 (C. A. J.); XC, south of Læsø, 7 m. — **Ks:** Lysegrund (Lyngbye, HQ, OP !); OT, Hastens Grund, 9,5 m; near Hesselø (Lyngbye); RL; D; GG, GF, Sjællands Rev; FP, Jessens Grund, 4 m. — **Sa:** PA, GD. GE, PC, near Sejerø; PG, near Hatter Rev; Koldby Kaas, outer side of mole; aV; MP, DK, Bolsaxen; AH[1], Lille Grund; Hofmansgave (Hofm. Bang); entrance to Odense Fjord (C. Rosenberg). — **Lb:** Middelfart; off Kongebro; Fænø Sund, 19—34 m; off Stenderup; DA, off Bøjgden; dH, dH[1], east of Hesteskoen; CF, dQ, south of Lyø, 22 m; LG, off Vidsø, Ærø. — **Sf:** BY, BX, Svendborgsund; UV, north of Ærø. — **Sb:** GT, off Asnæs; GU; LK, Elefantgrund; cN; NU; cL, 25—27 m, NO, NN, near Sprogø; GP; DN, Vengeance Grund; UE; UF; UG; LH, West Side of Langeland; UH; UT; DQ; US, c. 40 m; US[1]; DR; LB; UR. — **Sm:** HA, Agersø Sund; VC; HC; CR; KQ. — **Su:** Hellebæk; north of Kronborg cast ashore (Liebman, C. Rosenberg a. o.); bM, south of Hveen, 22,5 m. — **Bw:** bV, N.E. of Kobbel Skov; cD, cE, dO, 5 m, south of Als; Pøls Rev; DX, Vodrups Flak; UL, Øjet, 20 m; LA, UQ, KY, KV, KU, south of Lolland; KT, Gedser Rev; Kadetrenden, 24,5 m. — **Bm:** KS, KR, HG, east of Falster; bO, 15 m (O. Paulsen); VG, QS, N.E. of Møen; 7,5 miles E. of Hellehavns Nakke (C. A. J.); 20 miles E. by N. of Møens light-house (C. A. J.); 13,5 miles E.S.E. of Møens light-house, 24 m (C. A. J.); QN, QM, Køge Bugt. — **Bb:** Adler Grund, 20 and 30 meters (C. A. J.); SH, Rønne Banke; YH, off Rønne, 24,5 m; 8 miles S. $^1/_2$ E. of Rønne harbour, 11—19 m (C. A. J.); XZ[1], Davids Banke, 29 m; 3 miles S.S.E. of Nexø harbour, 21 m (C. A. J.); YC, near Salthammer Rev, 24,5 m.

Membranoptera Stackhouse.

1. **Membranoptera alata** (L.) Stackhouse.

Stackhouse, Tentamen marino-cryptogamicum. Mémoires de la soc. imp. des Natur. de Moscou, Tom. 2, Moskwa 1809 p. 85 (teste Kylin); Kylin 1923 p. 108.

Fucus alatus Hudson, Fl. Angl. 1st ed. 1762 p. 578 (not seen); Oeder Fl. Dan. tab. 352, 1767.

Delesseria alata (Huds.) Lamour. Essai 1813 p. 124; Lyngbye 1819 p. 8 pl. 2; Hornemann Fl. Dan. tab. 2129, 1836; Harvey Phyc. Brit. III 1851 pl. 247; J. Agardh 1852 p. 683; Wille 1885 pp. 31, 64, id. 1887 p. 62 figs. 14—20, 79; Kny Wandtaf. Taf. 77. 1886, Erläuterungen p. 334; Buffham 1893 p. 296 figs. 22—24; Phillips 1898 p. 183 figs. 17—19; Kolderup Rosenvinge, Sporeplanterne 1913 p. 112 fig. 158.

Hypoglossum alatum Kützing, Phyc. gen. 1843 p. 445, pl. 66; Tab. phyc. Bd. 16 tab. 16, 1866.

Pteridium alatum J. Agardh 1898 p. 225.

The apical cell-divisions of the frond have been described and figured by Kny (1886), Wille (1887), myself (1913) and recently by Kylin (1923). The latter author shows that the structure of the tip of the frond resembles that of *Delesseria sanguinea* but differs from it 1) in the absence of intercalary divisions, 2) in that the lateral pericentral cells do not divide by transversal walls, and 3) by the branching of the frond by the secondary apical cells transforming into primary ones. After the division of the primary segment cut off from the apical cell by two longitudinal walls, the two lateral cells are divided by inclined walls in a number of segments of

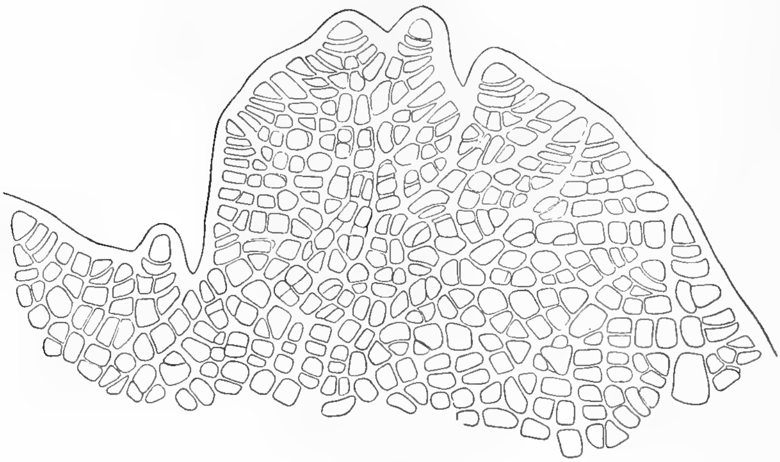


Fig. 445.
Membranoptera alata. Tip of frond from Frederikshavn, May.

the second order, the first of which are included, the outer end meeting the lower primary segment wall, while the younger segments of the second order reach the border of the frond. The number of included segments of the second order is variable, it is greatest in the broader forms (comp. KNY l. c., K. ROSENVINGE 1913 p. 22 (from Cherbourg) and KYLIN 1923 fig. 70), while in the narrow forms from the Baltic Sea it may be only 1 or 2 (fig. 447). Their number can be recognised in the older parts of the frond by the aid of the lateral veins of the second order arising in the upper border of the segment of the second order (fig. 446 *A*), just as the lateral veins of first order arise in the upper border of the primary segments. In the branch-producing segments one segment of the second order only is as a rule included (fig. 445, lower branch on the right hand; comp. KNY l. c., second branch from the top on the right; K. R. 1913 fig. 158 last branch; KYLIN 1923 fig. 70 *a*). But it also happens that the first segment of the second order reaches the border of the frond (fig. 445 last branch on the right, comp. KNY l. c. last branch on the right, KYLIN 1923 fig. 70 *c*). When the first segment of the second order of the branch-producing

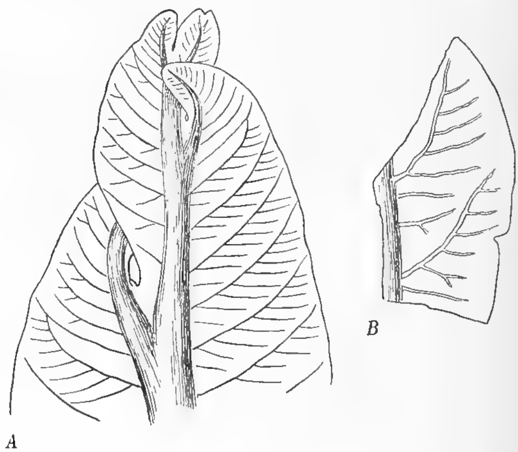


Fig. 446.
Membranoptera alata. *A*, tip of frond showing the mid-rib and the lateral veins. *B*, portion of membrane showing the veins. 19 : 1.

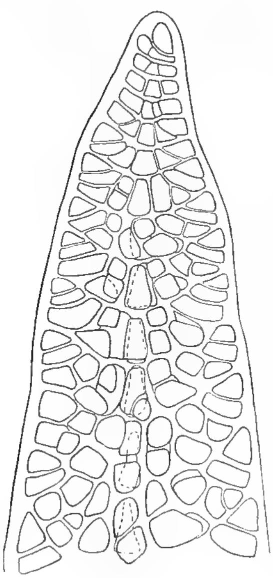


Fig. 447.
Membranoptera alata f. *baltica*, from Bornholm. Tip of frond. 350 : 1.

segment is included the vein situated in its upper border anastomoses with the vein of the foregoing primary segment (fig. 446 *A*). The primary segment situated immediately over a branch may sometimes be included (fig. 452, segm. 9). The branches are as a rule regularly alternate, but superposed branches may occur (fig. 445).

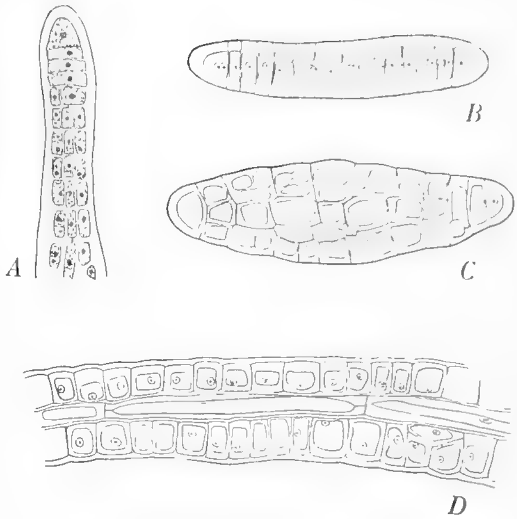


Fig. 448.
Membranoptera alata. *A*, longitudinal section of young shoot. *B*, *C*, transverse sections of shoots. *D*, longitudinal section of lateral vein. 390 : 1.

The mid-rib arising by tangential divisions, not only of the median cell but also of the adjacent parts of the primary segments, early attains a considerable thickness and the lateral veins are also early developed, the cells in the upper border of the primary segments lengthening and dividing by walls parallel to the flat, in consequence of which the inner conducting cell becomes covered by a short-celled layer on both sides (fig. 448 *D*). Lateral veins of the second order are also early developed in the upper border of the segments of the second order. According to HARVEY (Phyc. Brit. pl. 247 fig. 8) the lateral veins of the second order spring upwards and downwards as well from the primary ones; this is, however, not correct, they are only given off from the lower side (fig. 446). Lateral veins may also spring from the mid-rib between the primary lateral veins (fig. 446). The divisions parallel to the flat of the frond extend from the mid-rib towards the margin, so that the greater part of the frond consists of more than one layer of cells; the margin itself, however, is always monostromatic (fig. 448 *B*, *C*, comp. KYLIN 1923 p. 111). The veins are rather close owing to the want of growth beyond the apical portion of the frond.

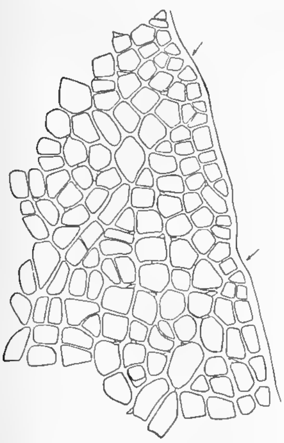


Fig. 449.
Membranoptera alata. Portion of membrane showing two lateral veins and secondary pits. The limits of the primary segments are marked with an arrow. 260 : 1.

Secondary pits are produced in great numbers and, in the membranaceous portion of the frond, in particular in the walls perpendicular to the longi-

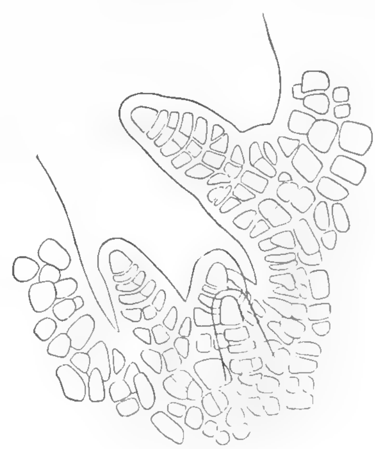


Fig. 450.
Membranoptera alata. Adventitious shoots from an axil. 350 : 1.

tudinal axis of the frond, thus establishing a longitudinal connection between the cells of the flat. A longitudinal arrangement of the cells not agreeing with the distribution corresponding to the succession of the cell-divisions then frequently appears (fig. 449).

Adventitious shoots arise in various number from the axils of the branches; they have no fixed position but develop from marginal initial cells or from other cells near the margin (fig. 450).

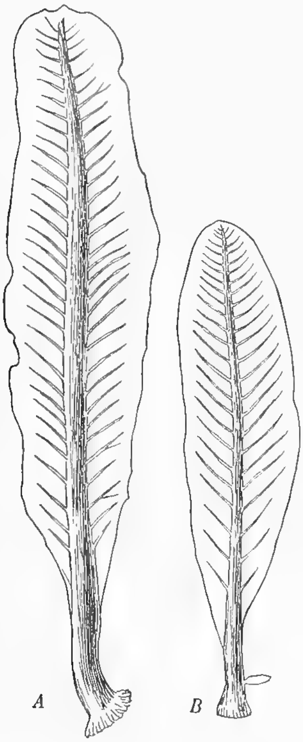


Fig. 451.
Membranoptera alata. Young plants growing on Membranipora pilosa. *A*, with a young branch near the top. *B*, with an adventitious shoot near the base, 19 : 1.

In the Baltic Sea a very narrow form occurs, the frond of which is only c. 1 mm broad, at Bornholm even only c. 0,3 mm broad (Plate VII fig. 7). While in the typical form the frond is rounded above with two or three branches near the top, the frond from the Baltic is much less branched; the shoots are pointed, frequently without any branch near the top (fig. 447). The frond is polystromatic almost to the margin. Of the segments of the second order only one or two are included; sometimes even the first one reaches the margin of the frond (fig. 447, 7th segment from the top).

The mid-rib becomes very convex on both sides. Within a thin assimilatory cortex it is built up by 1) primary longitudinal cell-rows, the cells of which are principally jointed by secondary pits, often three in each transversal wall, 2) conducting hyphæ given off from the former (comp. Wille 1887 p. 62 figs. 14—20, 79). In a cross section a transversal row of primary cells is present, the middlemost of which, the primary axial cell, may have a smaller diameter than the others. All the inner cells of the mid-rib contain several nuclei.

Sporelings produced in cultures were not obtained and very young plantlets were not met with in Nature, but young plants that could be referred with certainty to this species were collected in July, e. g. growing on *Membranipora pilosa* at Herthas Flak. They were $^1/_3$ to $^1/_2$ cm long, not branched, with a terete stipe continuing in a vigorous mid-rib from which opposed lateral veins were given off (fig. 451). The apical cell-divisions agreed exactly with those of the adult plants (fig. 452). In one of the larger plants the ramification had begun, the first branch having been formed near the top (fig. 451 *A*). As shown in fig. 452, this branch differs from those of the older fronds in that it is more symmetrical, the first segments being equally developed in the anterior and the posterior side; the following segment of the primary axis is therefore included, and the rib of the branch is not as usual in its outer part situated in the anterior border of the segment of the mother axis from which it has arisen. The primary axis appears to develop into an ordinary branched frond. The stipe is fixed to the substratum by a conical disc formed by densely united rhizines. Adventitious shoots early appear in the stipe.

The antheridia occur, as shown by BUFFHAM (1893 p. 296 figs. 22—24) in minute leaflets arising from the apices of the plant and, especially, in groups from the axils (comp. KYLIN 1923 fig. 69a); they cover the whole surface except a marginal zone which is sometimes very narrow, and the lower portion of the leaflet may also be sterile (fig. 453). According to KYLIN, the development and structure of the spermatangia and the spermatia is similar to that in *Apoglossum ruscifolium*.

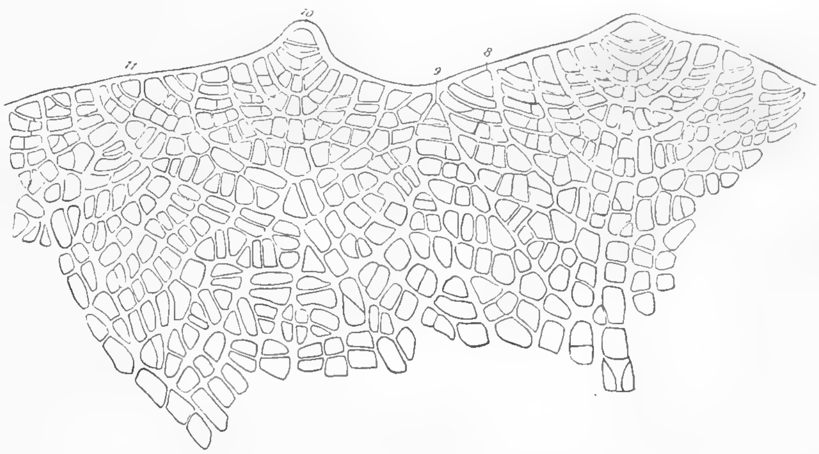


Fig. 452.
Membranoptera alata. Tip of the plantlet represented in fig. 451 *A*. The figures indicate the number of segments from the top. 350 : 1.

The procarps arise in the mid-rib in adventitious shoots or in the upper part of the frond; their development has been described by PHILLIPS (1898) and KYLIN (1923). The cystocarps occur singly on the mid-rib in the said parts of the frond.

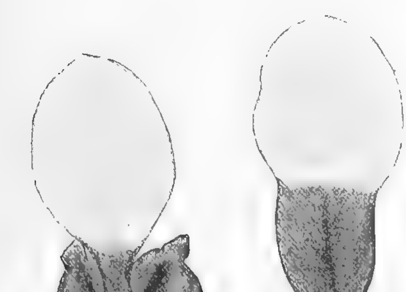


Fig. 453.
Membranoptera alata. Male leaflets. 2,7 : 1.

The tetrasporangia occur in sori in adventitious branchlets or in the ultimate branches of the frond. According to KYLIN (1923 p. 113), they develop from superficial cortical cells in the same way as in *Delesseria*.

Membranoptera alata occurs in all the Danish waters except the fjords and perhaps the waters around Bornholm where it has only been met with as washed ashore. It reaches a length of 14 cm in the Northern Danish waters, 12 cm in the Sound and the Belts, 8 cm in **Bw**, 7 cm in **Bm** and 5 cm in **Bb**. The breadth is rather variable. In the northern waters it usually varies about 2 mm, it frequently amounts to 3 mm more rarely to 4,5 mm. In the Great Belt and the Sound a breadth of 3,5—4 mm may still be reached in deep salt water. In **Bw** it is rarely more than 2 mm broad, in **Bm** $^1/_2$—1 mm (in one specimen 1,5 mm). A specimen from Bornholm was only 0,3 mm broad (comp. Plate VII figs. 5—7).

The narrow Baltic form (fig. 447, Plate VII fig. 7) is much feebler and less branched than the typical form and thereby rather characteristic. It is, however, connected with the typical form by transitional forms. It may be named f. *baltica*. Some of the specimens of this form were loose on the bottom, especially those found north of Møen.

The vegetative growth begins in winter and ceases in summer. Antheridia were met with in October and November, cystocarps and tetrasporangia in January to April. The species has been found growing on stones and on various Algæ (*Furcellaria, Fucus serratus, Halidrys, Ahnfeltia, Laminaria* etc.). It has been met with from low-water mark to 27 meters' depth.

Localities. **Ns:** Rømø, cast ashore (Møller); YT, off Helshage, Hanstholm, 13 m. — **Sk:** Roshage, Hanstholm, near land, 2 m; Dana 2902 (loose?) (C. A. J.); eY, 15 m; Bragerne, 1—2 m; Dana 2900 (loose?) (C. A. J.); off Lønstrup, 7—9 m; off Hirshals, 12—15 m (Børgesen, !); Hirshals mole and stones near land, 1—2 m. — **Lf:** Wanting. — **Kn:** Herthas Flak; Hirsholmene; Krageskovs Rev, 5 m; Strandby, 1 m; Frederikshavn, harbour and stony reefs; GM, north of Læsø; Trindelen, FE, IX. — **Ke:** fH, Fladen, 17 m; Store Middelgrund (!, C. A. J.); GI, Ostindiefarer Grund; OO, Søborghoved Grund; Gilleleje (Lyngbye). — **Km:** Læsø Rende, Dana 2884, 9 m (C. A. J.). — **Ks:** Grenaa harbour; Jessens Grund, 4 m; OP, EM, HQ, Lysegrund, 6—10 m: RL; near Hesselø (Lyngbye); GF, Sjællands Rev, 8 m. — **Sa:** GD, GE, north of Sejerø; FT; FS; PG; YV, 15 m; MP, Falske Bolsax; DK, Bolsaxen; AH[1], AH, Lillegrund north of Fyns Hoved. — **Lb:** NV, Middelfart; LG, off Vidsø, Ærø. — **Sf:** Ærø, Kjærbølling. — **Sb:** GT, off Asnæs; cN, S.W. of Musholm; Kerteminde harbour; GP, off Halskov; near Sprogø (Magnus); NN; NO; NP; Nyborg (Hofm. Bang); UE; DN, Vengeance Grund, 12 m; UT; US[1], 20 m; DR, off Albuen; DT; LB, 17 m; UR. — **Sm:** HA, Agersø Sund, 11 m; VC; HC, off Knudshoved Odde; Q; KP, 3 m; HI and KQ, 4 m, Grønsund. — **Su:** Hellebæk (Ørsted), washed ashore north of Helsingør (C. Rosenberg a. o.); bM, south of Hveen, 22,5 m: OG, Taarbæk Rev; TB, off Skovshoved, 5 m; OG[1]; RH, Knollen; PR, off Dragør. — **Bw:** cE, south of Als; UY, Vejsnæs Flak; UY; UL, Øjet, 20 m; KY; KX; KU, KV, Schønheyders Pulle. — **Bm:** (f. *baltica*) KR, KS, HG, east of Falster; VH, QY, south of Møen; QZ, RC, VG, east side of Møen; 7,5 miles east of Hellehavns Nakke, 27 m (C. A. J.); QS; QR; VD; SD; QN; QM, off Køge; QF, south end of Flinterenden. — **Bb:** (f. *baltica*) washed ashore at Rønne (R. T. Hoff).

EXPLANATION OF PLATES

All figures are photographs of dried specimens, $^4/_5$ nat. size.

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Plate V.

1. *Polysiphonia orthocarpa*, from Amtoft Reef, Limfjorden.
2. *Polysiphonia elongata* f. *Schuebelerii*, from the Great Belt north of Langeland (UF).
3. *Polysiphonia elongata* f. *baltica*, from YC, east of Bornholm, 24,5 meters' depth.

Plate VI.

1. *Polysiphonia violacea*, from Hirsholm 11 meters' depth showing secondary axillary shoots and torsion.

2—4. *Rhodomela subfusca* f. *abyssicola*, from dQ south of Lyø 22 m, June; fig. 3 with tetrasporangia.

Plate VII.

1. *Delesseria sanguinea*, from N.E. Reef by Hirsholm, July.
2. — , from Øjet (Bw) 20 m, May 21st. With cystocarps.
3. — , from VG, north of Møens Klint, 17 m, May 28th.
4. — , from YC, east of Bornholm, 24,5 m, July.
5. *Membranoptera alata*, from Læsø Trindel, April, Børgesen.
6. — , from Frederikshavn, outside of harbour, May.
7. — , from Præstebjergs Rev, east of Falster, 7,5 m, November.

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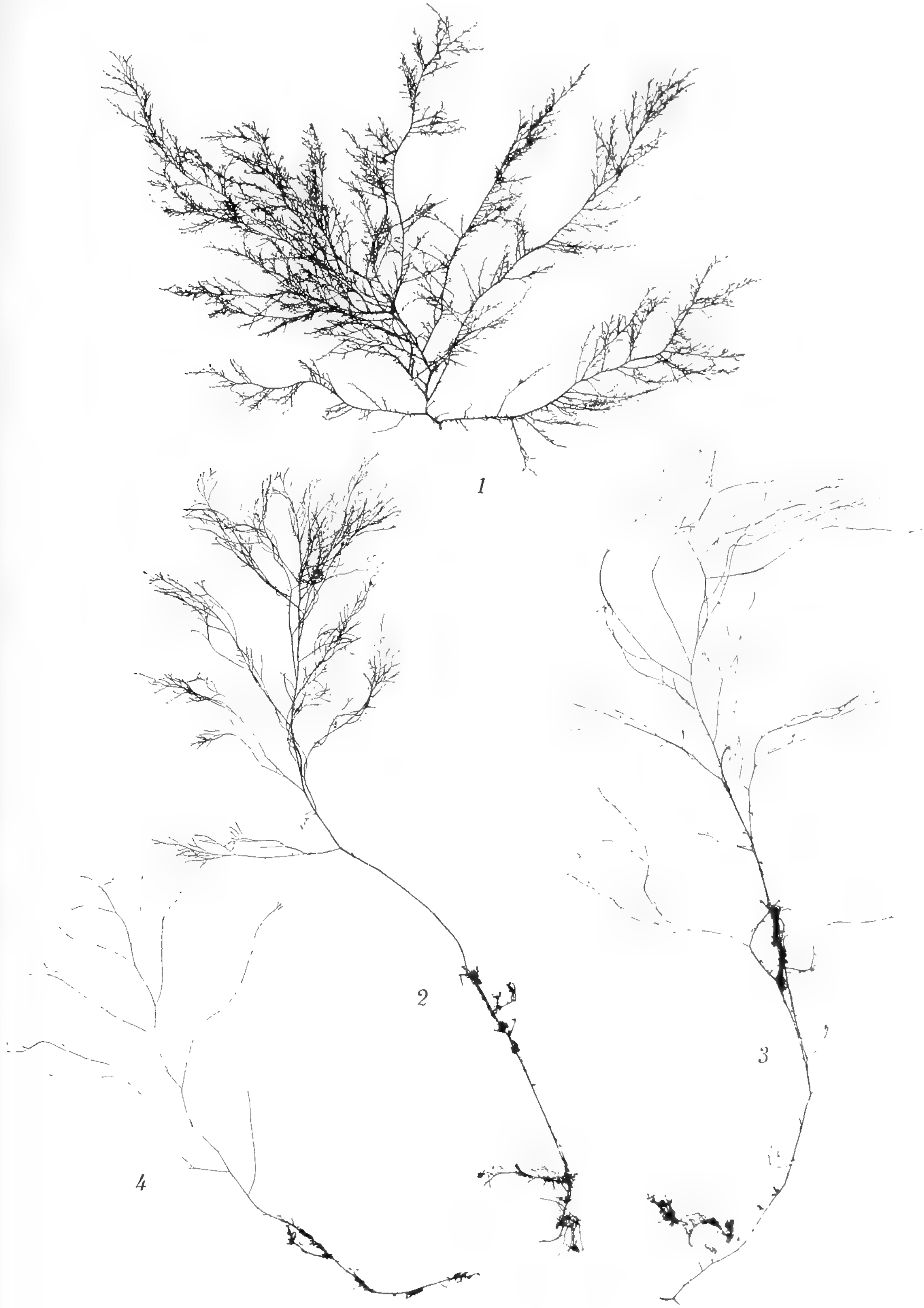
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THE MARINE ALGÆ OF DENMARK

CONTRIBUTIONS TO THEIR NATURAL HISTORY

PART IV

RHODOPHYCEÆ IV.

(GIGARTINALES. RHODYMENIALES. NEMASTOMATALES)

BY

L. KOLDERUP ROSENVINGE

WITH ONE PLATE

D. Kgl. Danske Vidensk. Selsk. Skrifter, 7. Række, naturvidensk. og mathem. Afd., VII. 4.

KØBENHAVN

HOVEDKOMMISSIONÆR: ANDR. HØST & SØN, KGL. HOF-BOGHANDEL

BIANCO LUNOS BOGTRYKKERI A/S

1931

INTRODUCTION

Though a comparativety small number of species, belonging to the *Gigartinales, Rhodymeniales,* and *Nemastomatales,* are treated in the present part, seven years have been spent in completing it. This is partly due to the fact that some of the species offered problems that demanded thorough investigations. Two of these problems have been treated in particular papers, viz. (1) the question of the reproduction of *Phyllophora Brodiæi* and the nature of *Actinococcus subcutaneus*[1]), and (2) the question of the reproduction of *Ahnfeltia plicata*[2]).

In the years elapsed since the publication of the third part of this work, numerous gatherings have been made in several places on the coasts, and dredgings have been made in many new stations which are recorded below. Many new localities have been stated for species recorded in the foregoing parts, but these are not named here; only a few species belonging to the orders treated in the foregoing parts but not named there are mentioned here under *Addenda.*

List of new Dredging Stations arranged according to the different Waters.

Kattegat, Northern Part. (Kn)

gR. $^{17}/_{7}$ 29. Midway between Hirsholm harbour and Kølpen. — 8 m. — Boulders (picked up). On the upper side mostly *Halidrys siliqu.*, on the other sides many others, e. g. *Deless. sangu., Polys. viol., Phylloph. membr., Codium toment.,* (young plants), *Rhodym. palm., Bryopsis plum.* and many others.

gI. $^{5}/_{7}$ 28. Midway between Hirsholm and Deget. 7.5 m. — Soft bottom with stones. — Scarce vegetation: *Desmarestia aculeata, Acrothrix gracilis, Desmar. viridis.*

gK. $^{5}/_{7}$ 28. Hirsholm light-house in N.W., Frederikshavn Church in W. S. W., 19 m. — Soft bottom, no Algæ.

gQ. $^{15}/_{7}$ 29. East end of Hjellens Rev by Frederikshavn. — 4—6 m. — Stones. — Abundant vegetation: *Halidrys siliqu.*, the three *Laminaria* species, *Fuc. serratus, Furcellaria, Laurencia pinn., Polyides, Ahnfeltia, Corallina offic.*

[1]) L. Kolderup Rosenvinge: Phyllophora Brodiæi and Actinococcus subcutaneus. K. D. Vid Selsk. Biolog. Meddel. **IX**, 4, 1929.

[2]) L. Kolderup Rosenvinge: The Reproduction of Ahnfeltia plicata. K. D. Vid. Selsk. Biolog. Medd. **X**, 2, 1931.

gL. 25/7 28, 22/5 29, 19/9 29. Off Friis' Sten W. side of Læsø. 2—3 m. — Sand with stones. — *Fucus serratus, Fuc. vesic., Phylloph. Brodiæi,* further *Brongniartella, Zostera, Phylloph. membranifolia.*

gK[1]. 25/7 28. Vesterø harbour in S. E. by E. 10—11 m. — Sand. — *Acrothrix gracilis, Striaria* and others on dead *Zostera* leaves.

Samsø area. (Sa)

fN. 5/8 25. Off Ballen, east side of Samsø.

1) East of the channel, 13 m. — Stony bottom — *Laminaria saccharina, Lithothamnion glaciale, Corallina off., Ectocarpus silicul., Brongniartella byss.*
2) In the channel, 22.5 m. — Soft bottom with stones. — *Lithothamn. glaciale.*
3) Within the channel, 13.5 m. — Sand.

gT. 27/5 30. Paludans Flak, near the broom. — 10—11 m. — Sand with small stones. — *Fucus serratus, Lamin. digit., Furcell. fast., Polys. viol., Chondrus crispus.* — 6—8 m, further *Ahnfeltia plicata, Corallina off.* and many others.

gH. 1/8 27. South side of Hesbjerg Grund, near land, 3 m. — Gravel. — *Furcellaria fast., Zostera, Ascophyllum nodosum scorpioides, Halidrys sil.* loose, *Asperococcus echinatus, Ectocarpus conferv., Rhodomela subfusca, Chorda Filum.*

The South Fyen Waters. (Sf)

fX. 15/8 25. South side of Svelmø. 7,5 m. — Soft bottom. — Broad-leaved *Zostera.*

— Same place, nearer to land, 4 m. — Narrow-leaved *Zostera marina, Potamogeton pectinatus, Cladophora.*

fV. 15/8 25. At the East side of Avernak Ø, near land, 3—4 m. — Stones with *Fucus vesicul.* and *Chorda Filum.*

Great Belt. (Sb)

gU. 27/5 30. East side of Lille Grund, North of Hindsholm. — 10—11 m. — Sand with stones. — *Fucus serratus, Fuc. vesic., Furcellaria, Laminaria digit., Phylloph. Brod.* and *Ph. membranif., Corallina off., Ahnfeltia plic.* and many others.

gS. 19/11 29. Elefant Grund, north side and middle. — 6—7.5 m. — Stones and *Mytilus edulis* abundantly. — *Phylloph. Brodiæi, Rhodomela subfusca, Ahnfeltia plic.* etc.

gV. 27/5 30. At the broom S. E. of Romsø, 11 m. — Stones. — *Laminaria digitata, Furcellaria fast.*

(LP) 18/5 27. Off Stavreshoved, 7 m. — Stones. — *Fucus serratus, Fuc. vesicul., Laminaria digitata, Lam. sacchar.,* several Florideæ.

gX 27/5 30. Off Stavreshoved. — 8 m. — Sand with spots of *Zostera* vegetation. — *Fucus serratus, Laminaria sacch., Furcellaria, Halidrys.*

gY. 27/5 30. Møllegrund. — 8 m. — Sand with stones. — *Laminaria digitata, L. sacch.*

gG. 18/5 27. Off Bovense, 6.5—8 m. — Stones. — *Laminaria digitata, Furcellaria fast., Phylloph. membranifolia* and many others.

gF. 18/5 27. Off Teglværksskoven, 7.5—10 m. — Stones. — *Laminaria saccharina, Lam. digit., Fucus serratus,* several Florideæ e. g. *Phycodrys rubens, Cystoclonium purp.*

fY. 24/11 25. Sprogø light-house in N. W. 3/4 W., Halskov Rev light-ship in N. E., 9—10 m. — Stones. — *Furcellaria, Fucus serratus, Laminaria digitata,* several Florideæ.

fY[1], — near the foregoing place, 12—14 m. — Stones. — Same vegetation.

fZ. 24/11 25. Sprogø light-house in N. W. 1/4 W., Halskov Rev light-ship in N. E. 3/4 N. — 20 m. — Soft bottom, stones. — *Phyllophora Brodiæi, Delesseria sanguinea, Phycodrys rubens, Furcellaria, Phylloph. membranifolia.*

gA. 24/11 25. Sprogø light-house in N. E. 1/2 N., Gjellegrund light-beacon in S. E. 1/4 E. — *Mytilus edulis,* few Algæ: *Laminaria digitata, Furcellaria fast.*

gC. (= NS) $^{24}/_{11}$ and $^{25}/_{11}$ 25. Between Knudshoved and Slipshavn. 5–6 m. — Stones. — *Fucus serratus, Chorda Filum, Fucus vesic., Phycodrys rubens, Laminaria digitata, Halidrys siliqu.* fructiferous.

gB. $^{24}/_{11}$ 25. Vresens Puller, the broom in E. by N. $^{1}/_{2}$ N., 0.4 mile to 0.2 mile. — 7 m. Stones. — *Fucus serratus, Halidrys siliqu., Laminaria digitata.*

gD. $^{25}/_{11}$ 29. The double broom for Kobberdyb in N. by E. $^{3}/_{4}$ E. 1.0 mile. — 9 m. — Soft bottom (?) — *Phyllophora Brodiæi* f., *Furcellaria fastig.*

gE. $^{25}/_{11}$ 25. Stokkebæks Flak. 5—7 m. — Stones. — *Zostera, Fucus serratus, Chorda Filum.*

fP. $^{13}/_{8}$ 25. $^{1}/_{2}$ mile E. of Hov light-house, 5.5 m. — Coarse sand with scattered stones, and firm clay. — *Zostera* leaves and abundant, partly loose Algæ: *Fucus vesicul., Furcellaria, Rhodomela, Phyllophora Brodiæi* and *Phyll. Bangii.*

fO. $^{13}/_{8}$ 25. S. S. E. of Vresen, E. of Langesand. 7,5 m. — Bottom? with a few stones. — Dead *Zostera* leaves, *Ascophyllum nodosum* f. *scorpioides*, loose *Furcellaria.*

fQ. $^{14}/_{8}$ 25. Off Spodsbjerg, 19 m. — Bottom with stones. — Mostly *Delesseria sanguinea*, further *Laminaria saccharina* and *digitata, Phycodrys rubens.*

fR. $^{14}/_{8}$ 25. Off Hjortholm Skov, Kjelsnor light-house in W. by N., $^{5}/_{6}$ mile from land, 21 m. — Stones. — *Laminaria digitata, Delesseria sanguinea, Phycodrys rubens, Brongniartella byss., Laminaria saccharina.*

fS. $^{14}/_{8}$ 25. East of Kjelsnor light-house, $^{5}/_{6}$ mile, 9.5 m. — Sand with stones, gravel. — Mostly *Furcellaria,* further *Laminaria digit., Mytilus edulis* abundant.

— Same place, 11.5 m. — Stones. — Similar vegetation, mostly *Furcellaria,* further *Rhodomela, Deless. sangu., Polysiph. elongata, Brongniartella byss., Phycodrys rubens.*

The Sound (Øresund). (Su)

gM. $^{25}/_{6}$ 29. Taarbæk Rev. One mile W. of the bell buoy. 8—9 m. — Stones and *Mytilus.* — In particular brown Algæ, *Ectocarpus silicul., Chorda Filum, Stictyosiphon tort., Rhodomela subf., Polysiph. nigr., Dumontia incrassata* etc.

gM¹. $^{25}/_{6}$ 29. Just outside the bell buoy. 12 m. — Stones. — *Laminaria saccharina, L. digitata, Rhodymenia palmata, Fucus serratus,* etc. as in the foregoing place.

gM². $^{25}/_{6}$ 29. Same place, 500 m N.E. of the bell buoy. 15 m. — *Striaria attenuata, Rhodymenia palmata, Ceramium Areschougii.*

gN. $^{25}/_{6}$ 29. Taarbæk Rev, $2^{1}/_{2}$ miles N. by W. of Middelgrundsfort. — 7 m. — Sand with scattered stones. — *Chorda Filum, Ectocarpus, Polysiph. violacea, P. urceolata, Dumontia incrassata.*

gP. $^{25}/_{6}$ 29. $2^{1}/_{2}$ miles E. of Skovshoved. — 11 m. — Sand with stones. — *Mytilus. Desmarestia viridis, Polysiph. nigrescens, Laminaria sacch.* etc.

gO. $^{25}/_{6}$ 29. Skovshoved in W. by N. 3 miles. 14 m. — Clay-mud. — *Mytilus. Laminaria sacchar., Desmarestia aculeata.*

Baltic, Western Part. (Bw)

fT. $^{14}/_{8}$ 25. South of Marstal, Fakkebjerg light-house in S.E. by E. $5^{1}/_{2}$ miles. 7.5 and 11 m. - Gravel. — *Fucus vesicul., Chorda Filum, Rhodomela subfusca, Zostera.*

fU. $^{14}/_{8}$ 25. South of Ærø, off Drejet. 7 m. — Gravel with stones. — *Fucus vesicul., Fuc. serratus, Furcellaria, Rhodomela subf., Phylloph. Brodiæi* and *membranifolia,* numerous loose forms of *Phylloph. Brodiæi,* and *Phyll. Bangii.*

V. Gigartinales.

Fam. 15. Gigartinaceæ.

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H. C. Lyngbye (1819), Tentamen hydrophytologiae danicae. Hafniae.
R. W. Phillips (1925), On the genera Phyllophora, Gymnogongrus and Ahnfeldtia and their parasites. The New Phytologist. Vol. 24, No. 4.
Henrik Printz (1926). Die Algenvegetation des Trondhjemfjordes. Skrifter utgitt av d. Norske Videnskaps-Akademi i Oslo. Math. naturv. Kl. 1926. No. 5. Oslo.
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See further pp. 79. 297. 465.

Harveyella Schmitz and Reinke.

1. **Harveyella mirabilis** (Reinsch) Schmitz et Reinke.

Reinke Algenfl. westl. Osts. 1889 p. 28: Buffham (1893). p. 292, Pl. XIII figs. 3, 4, Pl. XIV figs 40—42; Kuckuck, Bemerk. II. 1897, p. 395. H. H. Sturch, Harveyella mirabilis. Annals of Botany, Vol. 13, 1899, p. 84 Pl. III. IV; id, on the life-history of Harveyella pachyderma and H. mirabilis. Ann.

of Botany, Vol. 38, 1924 p. 27. Kylin (1923) p. 134. E. Chemin, Sur le développement des spores et sur le parasitisme d'Harveyella mirabilis Schmitz et Reinke. Comptes rendus d. s. de l'Acad. d. sc. Paris t. 184, p. 1187, 1927.

Choreocolax mirabilis Reinsch, Contrib. 1875 p. 63, Taf. 53 et 54.

Choreocolax albus Kuckuck, Choreocolax albus n. sp., ein echter Schmarotzer. Sitzungsber. d. K. preuss. Akad. d. Wiss. 1894.

Although not described until 1875, this interesting parasitic alga was already observed by LYNGBYE. In Tent. Hydr. (1819, p. 47 tab. 11 B) he mentions and gives a drawing of some warts seated laterally on the branchlets of *Gigartina subfusca* γ, *tenuior* (*Rhodomela subfusca*). The "*puncta nigra*" mentioned (l. c. p. 48) which "potius pro massa interna hic illic magis condensata, quam pro seminibus sumenda sunt", were probably the large inner cells rich in starch-grains. Specimens in Herb. LYNGBYE of the named host-plant from Svinøer, Norway, collected by LYNGBYE in October 1817, bear several of these warts which are mentioned in the label in similar terms as in Tent. Hydr.; they proved on microscopical examination to be sexual specimens of *Harveyella mirabilis*, one with procarps and a young gonimoblast, another perhaps a young male specimen. LIEBMAN also met with this species in December 1838 at Helsingør but referred it to *Corynephora marina* (*Leathesia difformis*).

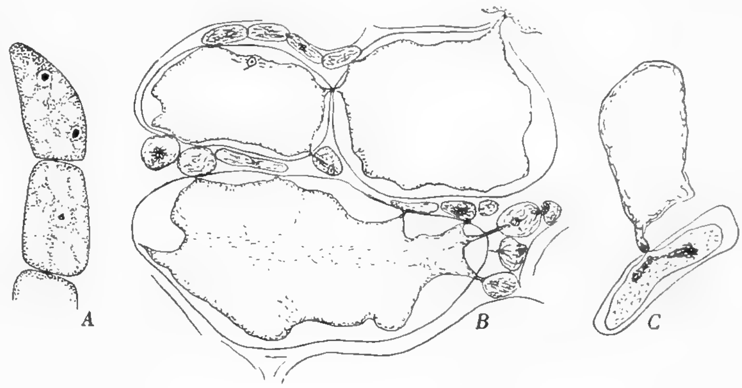


Fig. 454.
Harveyella mirabilis. *A*, end of intramatrical filament (May); the last cell in beginning division (to the right). *B* and *C*, longitudinal sections of Rhodomela with intercellular filaments of Harveyella, pit-connections between the host and the parasite. *A*, 560 : 1, *B*, *C* 350 : 1.

Our knowledge of the structure and development of this plant is principally due to the researches of SCHMITZ, KUCKUCK and STURCH cited above. The colour of the plant may be pure white in the living state, in particular in the large tetrasporiferous specimens collected in May, but other specimens were feebly rosy or yellowish, apparently owing to the isolated cells of the host plant interspersed among the cells of the parasite.

As pointed out by KUCKUCK, the cells are devoid of chromatophores; it would be of interest to ascertain whether leucoplastids are also wanting. The cells represented in fig. 454 A after treatment with NAWASHIN's mixture[1], showed filamentous bodies which are probably leucoplastids. The cells contain one nucleus as shown by STURCH

[1] See Karpechenko, The production of polyploid gametes. Hereditas IX, 1927, p. 349.

(comp. fig. 454 *A*, *B*). Floridean starch-grains are often very abundant, in particular in the inner large cells of the globular thallus. The statement of Sturch that there are no secondary connections between the cells of the gametophyte does not agree with my observations as I have repeatedly met with secondary pit-connections between the cells situated a little within the antheridia-producing cells (fig. 455).

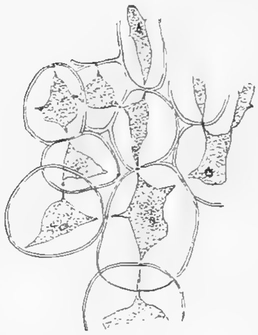


Fig. 455.
Harveyella mirabilis. Cells from the cushion of a male plant connected with primary and secondary pits (May). 350 : 1.

According to Schmitz (1889, p. 29), the cells of the intramatrical filaments are here and there connected with the cells of the host-plant through secondary pits. An immigration of a nucleus from the parasite into the host-plant or vice versa probably takes place, as in the ordinary formation of secondary pits, but I have not ascertained this with full certainty, as the nuclei were usually not distinct in the specimens examined when treated after Nawaschin. In some cases a nucleus seemed to have penetrated from the parasite into the host-plant.

As emphasized by Sturch (1924, p. 39), "the cystocarps, antheridia, and tetraspores are invariably developed on separate individuals". The three kinds of individuals may attain about the same size, in the Danish waters scarcely exceeding 1 mm.

The antheridia arise by oblique alternate divisions of elongated cells composing the outer layer of the external cushion of the male plants (Sturch 1924, fig. 20).

Numerous procarps arise in the female specimens, but one cystocarp only is produced, which occupies most of the cushion. As to the details of the development of the cystocarp, reference may be made to Sturch's papers. It shall only be stated that I found a four-celled carpogonial branch in accordance with Sturch. According to Sturch, the cystocarpial wall is composed of branched cell-filaments consisting of fairly short cells. In a cystocarp collected by Liebman December 1838 I found the filaments feebly branched and consisting of long cells (fig. 456).

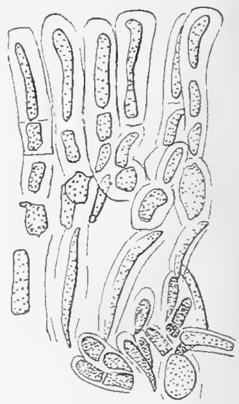


Fig. 456.
Harveyella mirabilis. Helsingør, December. Section through the cystocarpial wall; below, cells of the gonimoblast. 350 : 1.

The tetrasporangia are cruciately divided, as shown by Kuckuck and Sturch. In specimens preserved in spirit the nuclei in the dividing sporangia sometimes showed irregular lobed features that may perhaps be due to the imperfect state of preservation (fig. 457). This picture shows, moreover, that the division of the tetrasporangium does not consist in two consecutive bipartitions but that the transverse and the longitudinal divisions proceed almost simultaneously from the periphery towards the centre of the sporangium.

The relationship of the genus *Harveyella* is doubtful. Schmitz (Engler a. Prantl. I. 2, 1897 p. 344) classed it among the *Gelidiaceæ*, whilst Sturch referred it to the *Gigartinaceæ*. As emphasized by Kylin (1923, p. 124) it is not in accordance with the latter family, from which it differs among other things by a four-celled carpogonial filament and by the first gonimoblast-cell being cut off on the outer side of the auxiliary cell. In these characters it agrees better with the *Rhodomelaceæ*, but as, on the other hand, it differs very much from this family in the structure of the frond, it seems impossible to refer it to it[1].

E. Chemin in 1927 made the surprising communication that he had obtained the germination of the tetraspores of *Harveyella mirabilis* on a glass-plate. The ripe spores were without the slightest trace of pigment; they surrounded themselves with a membrane and were divided in 48 hours by successive bipartitions into a parenchymatous disc much resembling that of *Chondrus crispus*. The French author remarks that the germinating spore begins to produce phycoërythrine immediately after the fixation on the substratum, and the cellular disc taking its rise from it is coloured intensely red. This very interesting statement is so unexpected that it requires confirmation. If this can be obtained, a relationship with the *Rhodomelaceæ* is decidedly excluded[2].

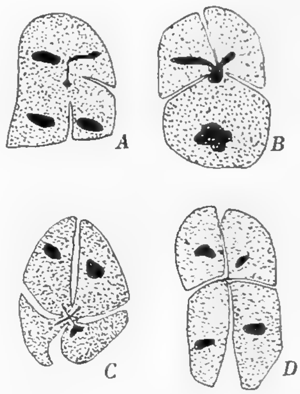


Fig. 457.
Harveyella mirabilis. Tetrasporangia in various stages of division. 835 : 1.

Harveyella mirabilis has been collected in all seasons in nearly all the inner Danish waters, most frequently in spring, always growing on *Rhodomela subfusca* (incl. *R. virgata*) at 4—26 metres' depth. Antheridia have been met with in July (**Bm** and **Bb**), September (**Kn**, **Lb**), October (**Ke**, **Su**) and once in January (**Kn**). Procarp-bearing specimens may probably be sought in autumn; I met with them once in October (**Su**) and once in April in one specimen together with tetrasporiferous ones, probably a retarded abortive specimen. Cystocarps were met with in December and January. Tetrasporiferous cushions were frequently found in April to June, in July once only in the Northern Kattegat, but several specimens at Bornholm, and finally once in August in the Great Belt and once in October in the Sound. The species is most frequently met with in spring (May) and then always with tetrasporangia.

It would be of interest to compare this occurrence with that on other coasts

[1] It is remarkable that Sturch in 1924 described another species, *H. pachydermus*, parasitic on *Gracilaria confervoides*; it differs by having a two-celled carpogonial branch and by numerous fusions of the ooblastema with cells of the gametophyte. As the number of cells in the carpogonial branch as a rule is a good systematic character, it ought to be examined 1) whether this number is really constant and 2) whether this species is rightly referred to the genus *Harveyella*.

[2] To verify the statement of Chemin, I searched for specimens with ripe tetrasporangia in May 1929 and in June 1930, but in vain. In June 1930 the season of fructification seemed to be closed for that year, for although I dredged in several places where I might reasonably expect to find fructiferous specimens of *Harveyella*, only few specimens were met with and none with well developed ripe tetrasporangia, and the examination of the germination of the spores could not, therefore, be made.

of North Europe. The cystocarps have everywhere been met with only in winter (Plymouth December to February, west coast of Sweden December (KYLIN), west coast of Holstein December (REINKE), Færõe Islands November (BØRGESEN)). The tetrasporangia were met with only in February and March at Plymouth (STURCH). At the Farõe Islands (BØRGESEN), in Kristiania Fjord (GRAN) and at the coast of Bohuslän, Sweden (KYLIN) they were met with in April or May, at Helgoland (KUCKUCK) at the end of May, at the coast of Halland sparingly in June and July (KYLIN), and at Gotland in the Baltic Sea at the end of June (SVEDELIUS). The sporangia thus generally develop on the North-European coasts in late spring, at Plymouth earlier, and in the inner Danish waters partly a little later (June, July, once in October). In the Arctic Sea, on the other hand, the biology of the species seems to be very different, for in Scoresby Sound (East Greenland) it was found with cystocarps in April and July, while tetrasporiferous plants were not met with at all.

KYLIN (1907 p. 128) has emphasized the fact that the tetrasporiferous specimens found in April grew exclusively on branchlets of the host-plant which had developed later than December and concludes that they must have arisen from the carpospores of the specimens occurring in December. It must really be supposed that the species at the coasts of North Europe offers a rare example of a regular alternance of a sexual generation in winter and a tetraspore-generation in spring (or summer), while in the Arctic Sea one sexual generation only is produced. The fact that *Harveyella mirabilis* has only been observed with tetrasporangia in the inner Baltic Sea (Bornholm, Gotland) must perhaps be explained by the lack of dredgings during the winter in these waters.

Localities. Not observed in **Ns, Sk** and **Lf.** — **Kn:** KA, Aalbæk Bugt, 13 m (+ 5[1]); TX, North of Hirsholm, 9 m (♂ 1); TL, West of N. Rønner, 7.5 m (♂ 9); FE, Læsø Trindel 9—11 m (+ 7). — **Ke:** fH, east of Fladen light-ship, 17 m (♂ 10). — **Ks:** OS[1], Hastens Grund, 16 m (+ 4): at Hesselø (+ 5); aU Lumbsaas mill in South 32° West, 13 m. — **Sa:** KM, east of Øreflippen, 9—17 m (+ 5); DK, Bolsaxen, 13—15 m (+ 5) — **Lb:** OB, at Stavrshoved, 9—11 m (unripe + 3); DF, Remmen east of Bogø, 5.5 m (+ 5); DE, by the broom at Thorø Rev, 5.5 m (+ 5); dH, east of Hesteskoen, 15 m (+ 6). — **Sf:** CC, south side of Hornenæs, 7.5 m (♂ 9); UV, north of Ærø, 13 m (+ 5). — **Sb:** gY, Møllegrund, 8 m; cL, NE of Sprogø, 25—27 m (+ 6); NN, Sprogø light-house i NE 3/4 E 3 1/3 miles 19 m (◯ 1); AB north of Nyborg, 7.5 m (+ 8); Nyborg (Lyngbye); UE, by the buoy of Vresens Puller, 7 m (+ 5); UF, by Hov Sand, 8.5 m (+ 5); UT, Langelands Belt, 19 m (+ 5); UJ, near Onsevig, 7.5 m (+ 5); DR, by the broom of Albu Triller, 8.5 m (+ 5). — **Su:** Off Hellebæk (+ 4); near Helsingør (Liebman), (◯ 12); OJ, Nivaa Flak, 6 m (+ 4, one sp. with ♀); OG, by Taarbæk Rev, 6 m (+ 4); east of Taarbæk Flak 12.5 m (S. Lund, + ♂ ♀ 10); Charlottenlund (Hoffmeyer). — **Bw:** dM, Flensborg Fjord, east of the broom at Krage Sand, 14 m (+ 6); dK, Pøls Rev south of Als, 6—7 m (+ 6); UL, Femerbelt, Øjet, 20 m (+ 5). — **Bm:** VJ, off Hjelm, Møen, 6 m (+ 5); VG and QS north of Møen (+ 5 and ♂ 7); VD at Bøgestrømmen, 7.5 m (+ 5). — **Bb:** Davids Banke, 15 m (♂ 7), 19—21 m (+ 7); near Salthammer Rev, 24.5 m (+ 7).

[1] + designates tetrasporangia, ♂ antheridia, ♀ carpogonia, ◯ cystocarps, the number added being the number of the month.

Chondrus Stackh.

1. Chondrus crispus (L.) Stackh.

Lyngbye, Hydr., 1819, p. 15, tab. 5, A, B; Greville Alg. Brit. 1830, p. 129, pl. 15 (cystocarp); Kützing, Phycol. gen. 1843, p. 398, tab. 73 III; Harvey Phyc. Brit. III, 1846, pl. 63; J. Agardh, Sp. g. ord. Vol. II, I, 1851, p. 246; Kützing, Tab. phyc. Bd. 17, 1867, tab. 49; Schmitz, Befr. d. Florideen 1883, p. 238; Wille, Beitr. 1887, p. 82, Taf. VII, figs. 70—71; Buffham, Notes 1896, p. 183; Darbishire, Chondrus, Liverpool Marine Biology Committee. Memoirs IX. London 1902; Oltmanns, Morph. u. Biol., I, 1904, p. 549; Kylin, Studien 1907, p. 123; id. Keim. ein. Florid., Arkiv för Botanik, Bd. 14, No. 22, 1917, p. 12; id. Entwickl. 1923, p. 19; Violet Grubb, The Male Organs of the Florideæ, Linn. Soc. Journal. Botany, Vol. 47, 1925, pp. 184—187.

Fucus crispus Linné Mantissa plant. 1767, p. 134.

Fucus polymorphus Lamour. Diss. sur plus. espèces de Fucus. I. Agen et Paris 1805.

The fronds arise from a flat expanded disc which originates from the primary cushion-shaped stage of the germling. It is in older plants a nearly orbicular rather thin plate with irregularly lobed margin, densely attached to the substratum up to 1 or 2 cm in diameter. Several upright shoots may be given off from the same disc, e. g. 30—40, and these shoots are of very different age, old and young ones intermixed without any distinct order, the youngest, however, for the most part at the periphery. The disc itself may attain an age of several years. In specimens collected in summer upright shoots from the foregoing year or perhaps older are found together with numerous shoots produced after the last winter, and the latter have evidently arisen at various times during the last period of vegetation, for all gradations are to be found from well developed repeatedly branched shoots to quite small ones, a few mm long only.

Fig. 458.
Chondrus crispus. Northern Kattegat at Læsø Trindel, about 10 m depth, July. Photo, nat. size.

Owing to the fact that the upright shoots produced in the last period of growth are in very different stages of development when the growth is arrested in winter, it is not always easy to distinguish the portion of an older shoot which was produced in the last year from that existing already in the foregoing year. A difference in the colour, however, is often very significant, in particular in spring and the first part of the summer, the new portions of the frond showing a brighter colour. But the difference often becomes more striking by the epiphytes covering more or less densely the portion of the frond produced in the foregoing year, whereas the new segments are destitute of epiphytes or bear only very young specimens of such (comp. fig. 458).

The upright fronds ordinarily attain an age of two years, and sometimes they continue growing in the third year. This seems to be the case with the specimen represented in fig. 459 which was gathered in May. This frond has probably in the first year produced the first system of fans, in the second year the branches of these have produced a new system of fans, and in the year when the plant was gathered some of the branches have continued growing but have only caused a slight prolongation of the frond, 1 cm at most; the growing power of this frond was evidently exhausted. In the cases where the frond has arisen late in summer and therefore has only a small size at the end of the first season, the chance for a considerable growth in the third year may probably be greater. The period of growth begins in spring in the Danish waters and ceases towards the end of summer. The old fronds finally decay and are thrown off, probably as a rule in autumn and winter; they are separated at the very base, leaving scars that are a little deepened and have a slightly elevated border. An attachment disc, gathered in spring, showed some 30 such scars and a few upright shoots. According to PRINTZ the growth of the frond begins in Trondhjem Fjord about February and mostly ceases in August and September.

Fig. 459.
Chondrus crispus Krageskovs Rev, 4 m, May. The short streaks above indicate the limit between the portions of the frond formed in the foregoing and the present year. Photo, $^3/_4$ nat. size.

The attachment disc has a parenchymatous structure of firm consistence (comp. DARBISHIRE p. 15, figs. 9—11), being built up of approximately quadrangular cells arranged in more or less vertical rows. The height of the cells is rather variable, from half to twice the breadth. The cell-walls are firm, not gelatinous, staining deeply with hæmatoxylin. The outer wall is very thick, showing a lamellate structure. The pits in the transverse walls are scarcely discernible except in the neighbourhood of the upright shoots. A stratification due to the periodical growth of the crust appears in older crusts, but it is rather irregular, probably depending on the production of the upright shoots. The cells are filled with starch grains.

The upright fronds arise as outgrowths from the basal disc. A vertical section of the lowermost portion of the frond issuing from the disc shows a marked difference between the frond and the disc. In the neighbourhood the cell-rows of the disc are bent outwards, the cell-walls, which in the normal disc are firm, swell, the intercellular substance becoming much developed and gelatinous, and numerous transverse secondary pits appear between the cells of the originally vertical cell-rows (Fig. 460). These cell-rows gradually pass into the cortical cell-rows of the upright shoot, where the transverse secondary pits are also numerous and very long. These secondary pits enable a more intense longitudinal conductive power between the frond and the disc.

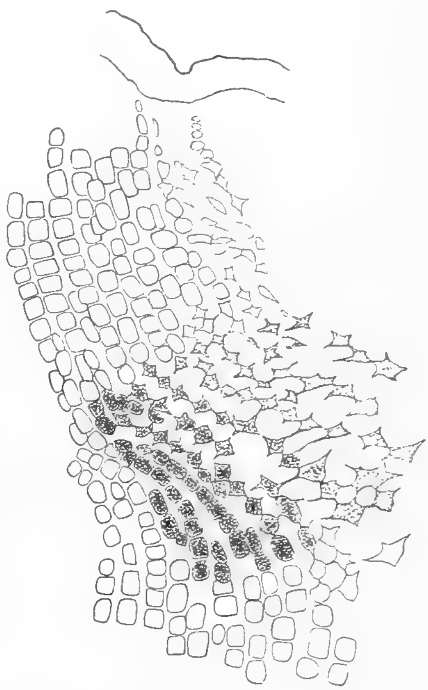


Fig. 460.
Chondrus crispus. Longitudinal section of an attachment disc at the base of an upright shoot; the latter issued to the right. 350 : 1.

The structure of the upright frond has repeatedly been described and pictured (KÜTZING 1843, WILLE, DARBISHIRE, OLTMANNS, KYLIN 1923). The tip of the frond has the structure designed by OLTMANNS as the fountain type (Springbrunnentypus) (KYLIN 1823, p. 20, fig. 10 a). The medullar or conducting tissue is built up of elongated cells arranged in longitudinal rows, 7—16 μ in inner diameter, connected with small pits in the end-walls and here and there also by transverse pits of secondary origin. The longitudinal cell-rows may be more or less bent, especially in the older parts of the frond. WILLE (1887, p. 83) thought that this might be explained by the supposition that the ends of the long cells slide past each other much as the bast-cells of the Phanerogams. This view, however, cannot be upheld, for the ends of these cells are connected by (primary) pits which persist and do not permit of such a sliding growth. The cells of the outer longitudinal cell-rows are much shorter than the inner ones, and gradually pass into the cortical layer which consists of branched cell-rows that are outward-directed and not unfrequently connected with secondary pits. The inner part of these cell-rows forms the storage tissue. The last 2 or 3 cells in the cortical cell-rows are very narrow and contain no starch, whereas the inner cells are more or less filled with starch-grains. For further details of the anatomy and cytology see the authors quoted, in particular DARBISHIRE. According to this author each cell contains only

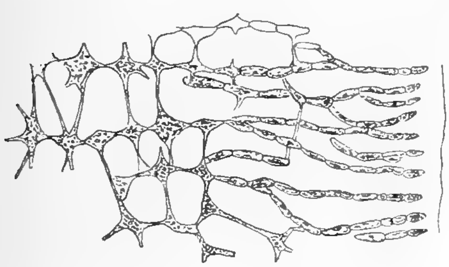


Fig. 461.
Chondrus crispus. Vertical section of the cortex at the base of an upright shoot. 560 : 1.

one chromatophore. In the outermost, assimilating cells it forms a plate lining the cell-wall, in the storage-cells the plate is divided into branched ribbons. According to the same author, the conducting cells of the medulla contain several leucoplastids.

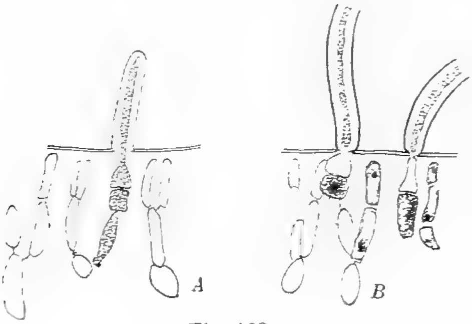


Fig. 462.
Chondrus crispus. Section of outer cortex of tetrasporiferous specimen showing hyaline hairs. Hirtshals, July. 835 : 1.

In 1911 (Hyaline hairs, p. 205) I have ranged this species among those which are devoid of hyaline hairs. I have, however, recently found such hairs in tetrasporiferous specimens collected at Hirtshals, Skagerak, in July 1914 and preserved in alcohol. They occurred scattered in the upper part of the frond. The basal portion of the hair-cell is swollen and sunk in the frond; this swelling is emptied when the hair has grown out, but still contains a thin layer of protoplasm lining the wall. The supporting cell is shorter and thicker than the surrounding cells and richer in contents (Fig. 462). The hairs attained a length of up to 250 μ.

The three kinds of reproductive organs are produced in separate individuals.

The antheridia have been examined by Buffham, Darbishire and more recently by Grubb. Darbishire found them in particular small and narrow white leaves (spermophores), while Miss Grubb describes them as whitish-pink patches or sori on the upper parts of the thallus of an otherwise normal vegetative plant. Buffham and Darbishire found them ripe in September and October, while Grubb found the material examined fully fertile in the spring, and she suggests that there are two seasons of spermatial production, spring and autumn. The outermost cortical cells, according to this author, give rise to two antheridial mother-cells from which two antheridia spring. For more details see Grubb's paper.

Fig. 463.
Chondrus crispus. North of Læsø, 9,5 m, January. With cystocarps (above). Photo, 3/4 nat. size.

The procarp was first described by Schmitz (1883, p. 238), later by Darbishire and recently by Kylin (1923, p. 20) who also followed the development of the gonimoblast. The three-celled carpogonial branch is borne on a large cell rich in protoplasm, which is the auxiliary cell.[1] After

[1] According to Darbishire, the large basal cell has a small cell cut off that is the auxiliary cell, l. c. p. 28.

fertilisation and fusion of the carpogonium with the auxiliary cell the latter gives off several sporogenous filaments penetrating between the vegetative cells of the frond and finally forming a large gonimoblast producing numerous carpospores. The ripe gonimoblast is composed of a number of more or less distinct glomeruli separated by shrunken hyphæ, as shown by Kützing (Tab. phyc. 17 Tab. 49 b). The whole cystocarp appears as an oblong or round swelling, up to 2 mm long, prominent on one or sometimes on both faces of the frond; in the first case the not swollen face of the frond may be concave. The cells of the inner layers of the cystocarpial wall are all connected transversally with secondary pits. In the narrow fronds only one cystocarp is present at the same level (fig. 463); in the broader ones several cystocarps may occur in the same segment (fig. 464), and it then happens that two are contiguous, but the limit between them is always distinct. No opening is preformed in the fruit wall but a hole is formed in the middle of the convex fruit wall by disintegration of the cells.

Fig. 464.
Chondrus crispus. West side of Hirtshals, low water, July. With cystocarps. Photo, nat. size.

Fig. 465.
Chondrus crispus. Hirtshals, mole, May. With tetrasporangial sori. Photo, nat size.

The tetrasporangial sori appear as dark-red elongated spots, slightly bulging on both faces of the frond, in particular in a dried condition; they are usually smaller, more irregular in outline and more numerous than the cystocarps and often confluent, and no limit can then be drawn between the fused sori. They occupy the younger portions of the frond, also the adventitious shoots, but may sometimes, in specimens growing near low-water mark, be met with in most parts of the frond (fig. 465). The production of the sporangial sori may persist during a long period and the development then proceeds from the base towards the top. Emptied sori may be met with in the middle of the frond or lower, while young sori are still in development at the top. The sporangia arise in branched cell-rows produced by the medullar cells, not only in the end-cells, but also from the intercalary ones. They are cruciately divided, first by a transverse wall, later by two longitudinal ones (fig. 466). In a specimen gathered in the eastern Kattegat in October I met with a sorus containing only two-parted sporangia.

Fructification occurs during the greater part of the year at the Danish coasts. Ripe sporangia and cystocarps were met with in all the months of March to October. In the winter months no well developed fructiferous specimens were met with, but some few with emptied cystocarps; but the species has only been gathered in small quantities at this season, and it is highly probable that it will be found fructiferous also in winter, so much the more as it may occur with ripe and partly emptied cystocarps and sporangial sori in March and April. The antheridia will probably be found on our shores at the same season as on the British coasts viz. spring and autumn, and it is probable that the development of the cystocarps usually begins in the autumn; it then continues through the following year. The production of the tetrasporangia has apparently a similar course. At the west coast of Sweden the fructification seems to take place at the same seasons as at the Danish coasts (comp. Areschoug Phyceæ, p. 86, Kylin 1907, p. 123). On the British coasts it has not, according to Batters and Darbishire, been recorded with fruit in the summer months, but that is perhaps only accidental, and will probably not be confirmed by further investigation, for it has been gathered with cystocarps at the Færöes in June and September by Børgesen (Mar. Alg. Fær. 1902, p. 357). According to Printz the cystocarps and the tetrasporangia begin to appear in August and September in Trondhjem Fjord, and the fructification continues during the winter and mostly ceases in early spring; he adds, however, that the species shows great power of variation as to the incidence of fructification.

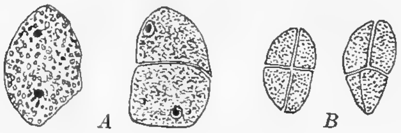


Fig. 466.
Chondrus crispus. Tetrasporangia. Hirtshals mole, *A* July, *B* August. 520 : 1.

The germination of the tetraspores has been shortly described and illustrated by Darbishire and Kylin (1917). I have observed the germination of the tetraspores and the carpospores in summer (July, August); they present the same features. The spore-cell is first divided by a perpendicular wall and then by rather irregularly orientated walls in a number of cells that are much smaller than the spore-cell. The germling is then hemispherical or cushion-shaped with a fairly regular outline, and increases slowly without changing in shape, or it becomes more flat, the vertical radius increasing less than the transverse ones. Sometimes one or two filaments are given off from the border; these filaments consist of a single cell-row rarely divided by a longitudinal wall (fig. 467, comp. Darbishire, fig. 29, Kylin, figs. g—i). Most of the sporelings in my cultures, however, were without such filaments. When two sporelings are developing close together, they may fuse together without any distinct limit. The oldest germlings in my cultures, 24 days old, showed no upright shoots. The young plants arising from germinating spores in summer probably only attain a small size before the following winter.

The variability of *Chondrus crispus* is well known, but it is impossible to draw any distinct limits between the numerous forms that may be met with. The most frequent and characteristic forms in the Danish waters are here recorded.

A. Forms occurring near low-water mark, down to 2 or 3 metres' depth. The uppermost specimens growing on stony reefs or moles left dry at low-water. Frond proportionally broad.

F. *typica.* The most common form near low-water mark. Frond regularly dichotomously divided, sometimes with proliferations, up to 14 (18) cm long, 6—10 mm broad, deep brown-red with a blue lustre. (LYNGBYE Tent. Tab. V A, LAMOUROUX, figs. 2—5, 8). The best developed specimens were found at Hirtshals, Skagerak, where the fronds are usually regularly flabellate and broad without proliferations (figs. 464, 465).

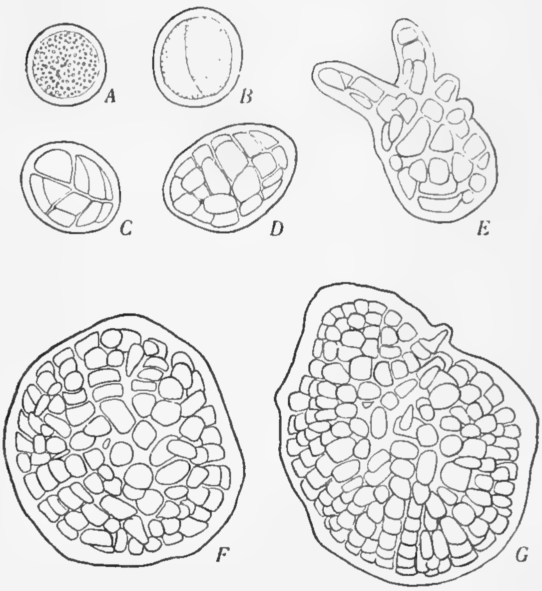


Fig. 467.
Chondrus crispus. Germination. *A—D*, germinating carpospores, 6 days old ($^{31}/_{7}$—$^{6}/_{8}$ 1928). *E*, germling from carpospore $^{13}/_{7}$—$^{25}/_{7}$ 1914. *F*, *G*, germlings from tetraspores, Hirtshals $^{9}/_{7}$—$^{2}/_{8}$ 1914. 625 : 1.

F. *abbreviata* KJELLMAN. KYLIN 1907. Only different from the foregoing by smaller dimensions. Frond up to 9 (13) cm long, up to 4 (6) mm broad. Same occurrence as the foregoing, in particular in the inner waters, on moles and stony reefs.

Fig. 468.
Chondrus crispus f. *densa.* Shallow water. Frederikshavn, July. Photo, nat. size.

F. *densa.* The frond short, broad, much branched, often taking a nearly globular form. The ramification may be apical (fig. 468) or, more frequently, chiefly marginal; in the latter case the frond is very broad and bears a very great number of longer or shorter, branched or unbranched marginal shoots. The number of branches and shoots is so great that the tips of the shoots point in all directions in the globular forms (fig. 468). This form grows on stones in shallow water protected against the waves, for instance at Frederikshavn at the north-side of the harbour. A less dense form with numerous proliferations is depicted in Flora Danica under the name of *Ch. crispus* var. *ciliatus* Suhr. It seems to be common at the isle of FÖHR at the west coast of Slesvig, and has also been collected at Blaavandshuk. (Specimens with numerous narrow branches or proliferations at the upper margin of a short broad thallus may be named f. *stellata*

Fig. 469.
Chondrus crispus, f. *densa* (*ciliata* Suhr). Shallow water, Frederikshavn, July. With tetrasporangial sori. Photo, nat. size.

Stackh., Lyngbye). Similar specimens have been met with in shallow, protected water at Frederikshavn (fig. 469).

B. The specimens growing at greater depths, more than 3 metres, are less variable than those growing near low-water mark. They are proportionally narrow, being usually at most 2—4 mm broad, and fairly long, up to 16 cm. Proliferations do not usually occur. The colour is more reddish.

F. *æqualis* Lyngb., Tent. Tab. 5 B, Lamour., figs. 12, 16, 22, Areschoug Exsicc. no. 156. Figs. 458, 463. Most of the specimens from deeper water may be referred to this form, characterized by the frond having almost a uniform breadth. The specimens from the greatest depths (13—20 m) are thinner but not otherwise different; they might be named f. *membranacea*.

F. *polychotoma* Kjellman, Kylin 1907, p. 123, Lamouroux tab. XII, figs. 31, 32. This form is represented by two year old fronds, with numerous branches in the upper part of the frond. Two systems of fan-shaped ramifications from two consecutive years may be found (fig. 459).

C. Specimens lying loose on the bottom. Fronds disengaged from the attachment disc may maintain life in the loose condition for a shorter or longer time. Such specimens may keep the original form for some time (usually f. *æqualis*); but upon continued life in a loose condition the shape of the frond becomes altered. The specimens that have lived for some length of time lying loose on the bottom and are carried along by the currents often show a swelling at the lower end where they have been loosened, like a feeble callus disc (fig. 470). The loose specimens are always sterile. They are only met with in sheltered localities in the inner waters.

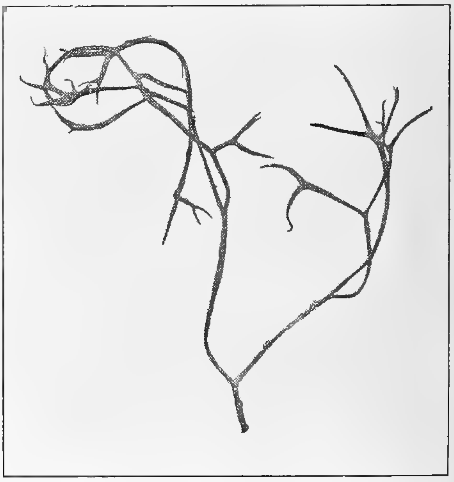


Fig. 470.
Chondrus crispus, f. *incurvata*. Off Vesterskovs Flak, north of Falster, 7,5 m. Photo, nat. size.

F. *incurvata* Lyngb., Tent. p. 16; *Chondrus incurvatus* Kützing, Sp. Alg. p. 735, Phyc. gener. p. 399, Taf. 73 II, Tab. phyc. Bd. 17, tab. 50 *c*, *d*.

Frond long, up to 20 cm, narrow, subterete, sometimes with proliferations, variously curved, often to one side. This is the most common loose form met with repeatedly at Hofmansgave (North Fyn) and further in **Sb**, **Sf** and **Sm**. Fig. 470, 471.

Fig. 471.
Chondrus crispus, f. incurvata. At Hofmansgave (Hofman Bang). Photo. 2/3 n. s.

F. *uncinata* LYNGB. Tent. p. 16. Frond small, cartilaginous, linear, cylindrical, complanated only at the bifurcations, at the ends recurved like the horns of a ram. This very characteristic form has only been found very rarely at Hofmansgave. It is so different from the typical form that an anatomical examination is needed for the identification (fig. 472).

F. *ægagropila.* A much branched specimen forming an irregularly rounded clump was found lying loose on the muddy bottom in shallow sheltered water at Frederikshavn in company with f. *densa.* The base was not visible, it was hidden in the interior of the clump the surface of which consisted on all sides of the irregularly outward directed ends of the shoots (fig. 473).

In the North Sea and Skagerak *Chondrus crispus* thrives only near land from a little over low-water mark to 2 metres' depth and only where the coast is stony, and the same can be said of its occurrence in the Limfjord. In the other waters within Skagen it occurs most frequently in similar localities (f. *typica* and *abbreviata*), but it also grows at greater depths among other Algæ on stones, down to 15 m, more rarely to 20 metres' depth. The boundary for its entrance into the Baltic is at Kriegers Flak and Saltholm, but in the most southerly part of its area it has only been met with at greater depths. At a higher level, near low-water mark, the southern boundary is more northerly, undoubtedly owing to the lower salinity of the surface water. In the Little Belt the southernmost locality known is at Sønderballe Hoved, at 2 metres' depth, but the specimens were very small, only 1—1,5 cm high. In the Great Belt it has not been met with near low-water mark south of Nyborg harbour, and in the Sound it has not been met with at this level south of Helsingborg.

Fig. 472.
Chondrus crispus f. *uncinata.* Hofmansgave, Car. Rosenberg. Photo, nat. size.

Chondrus crispus always grows on stones. Once only have I met with a small specimen growing on the stipe of *Laminaria hyperborea* in the Skagerak. It is often

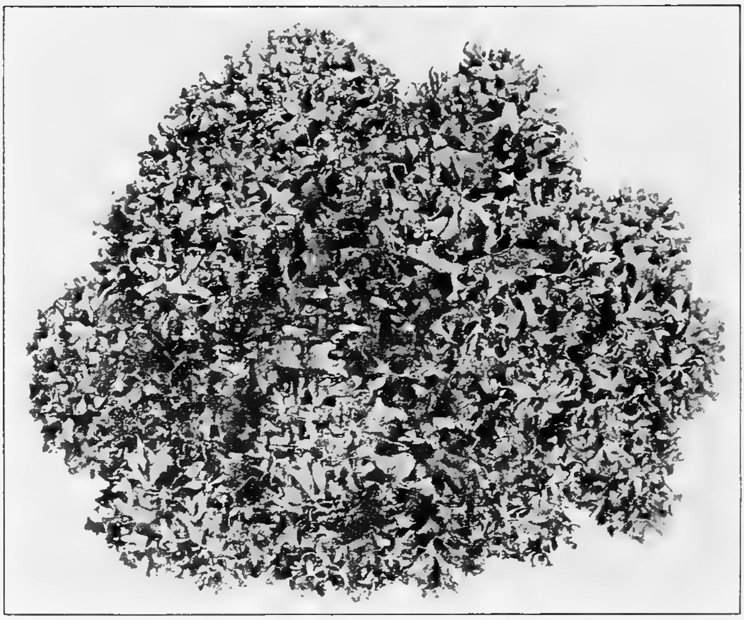


Fig. 473.
Chondrus crispus f. *ægagropila*. Shallow water, Frederikshavn. Photo, nat. size.

much overgrown by epiphytes, especially in Skagerak and Kattegat. The older parts of the frond may be totally covered by Bryozoans of the genus *Membranipora*, and incrusting Algæ as *Epilithon membranaceum* and *Melobesia limitata* may appear in the same way in the Kattegat, and further a number of other Algæ frequently occur as epiphytes, such as *Sphacelaria cirrosa*, *Ceramia*, *Polysiphoniæ*, *Brongniartella byssoides*, germlings of *Furcellaria fastigiata* a. o. At the coasts of the North Sea, Skagerak and the northern Kattegat the specimens of *Chondrus* growing in shallow water (1—2 metres', more rarely at 5,5 metres' depth) are often infested with the parasitic Pyrenomycete *Didymosphæria marina* (Rostr.) Lind, Danish Fungi as repr. in the herb. of E. Rostrup, 1913, p. 214 (*Leptosphæria marina* Rostr.), that gives to the sporangial sori and cystocarps a black colour and develops perithecia and pycnidia there. Another parasitic Fungus of the class Phycomycetes, *Pleotrachelus pollagaster* Henn. Petersen (Phycomycètes marins. Oversigt ov. d. K. D. Vid. Selsk. Forh. 1905), has repeatedly been found infesting the upper portion of fronds of *Chondrus crispus* growing at various depths in Kattegat and the inner waters.

Localities: **Ns:** Esbjerg harbour on muddy bottom with Zostera vegetation, f. *ciliata*; Blaavandshuk washed ashore, various forms, f. *æqualis*, f. *ciliata*, f. *incurvata*; Thyborøn, on a groin; Klitmøller, within Ørhage. — **Sk:** Hanstholm, Roshage 2 m, mole; Torup Strand, washed ashore (C. M. Poulsen); ZK[2] off Lønstrup, 8—9 m; Hirtshals, on the mole and on boulders, down to 2 m depth; Skagen, washed ashore on the North beach. — **Lf:** Common near low-water mark: Lemvig harbour; Mulle (J. P. Jacobsen); Thisted; Struer; Nykøbing, harbour and Ørodde; Ejerslev Røn; Knudshoved, Fur; off Lisehøj North side of Fur; Løgstør; Agersund (Th. Mortensen); Aalborg, large, very broad specimens with numerous proliferations (Th. Mort.); Hals (Børgesen). — **Kn:** Skagen harbour; Krageskov Rev; Hirsholmene; reefs and harbour at Frederikshavn; Bangsbostrand; Sæby; several places around Læsø Trindel, 8—19 m; several places North of Læsø; Vesterø. — **Ke:** IO, ZE, ZG, fH, Fladen, 11—17 m; Lille Middelgrund, 17—19 m; ES, S.W. of Lille Middelgr., 24.5 m; Store Middelgrund, 10—15 m; Gilleleje (Lyngbye); GJ, OO and Vesterlandsgrund north of Gilleleje. — **Km:** ZC, ZC[1] and XB, Kobbergrund; Asaa, mole; Anholt harbour; Gerrild bay (Lyngbye). — **Ks:** Grenaa harbour; at Hesselø (Lyngbye); RL near Ostindiefarer Grund; aU off Lumbsaas 13 m; Hastens Grund; GG Sjællands Rev; Holbæk harbour; on stones picked up near Roskilde. — **Sa:** Common on stony ground in 0 to 15 m depth, from KM, east of Øreflippen and the channel east of Sejrø to Endelave and DJ North of Fyn. Several specimens of f. *incurvata* from Hofmansgave (Hofm. Bang, Lyngbye). — **Lb:** Bogense harbour; Prins Frederiks Grund, Vejlefjord; FZ, Kasserodde; Fredericia harbour; Middelfart, harbour and 15 m; Assens harbour; at Sønderballe Hoved 2 m, 1—1.5 cm long specimens. — **Sf:** Faaborg harbour; UX at the North end of Ærø 9.5 m; CG, Skrams Flak, f. *incurvata*, loose. — **Sb:** Off Refsnæs (C. H. Ostenfeld); Kalundborg harbour; gU, east of Lille Grund 10—12 m; Elefantgrund 6—7 m; LP, Stavreshoved, 2—4 m; Kerteminde harbour; bay of Kerteminde; GY and fZ at Sprogø; AB off Teglgaardsskov; Knudshoved 5—6 m; Nyborg harbour; Palegrund 7,5 m; XS near Kløverhage; GZ North of Egholm 6,5 m; DN Vengeance Grund 12 m; gB, Vresens Puller; gE, Stokkebæks Flak 6 m, f. *incurvata*; fS, east of Kjelsnor ligthouse, 11.5 m. — **Sm:** Q, off Vesterskovs Flak, 7.5 m, f. *incurvata*. — **Su:** Off Ellekilde and Hellebæk (Ørsted,!); washed ashore at Helsingør (Liebman a. o.); PX, off Tibberup, 8.5 m, with *Zostera*; TF[1], Staffans Flak, 12—13 m; QD, east of the North end of Saltholm. — **Bw:** bY, off Sønderborg Nordskov, 11 m, f. *incurvata*; Sønderborg (Frölich according to Reinke); UL, Øjet, 20 m, attached to the bottom. — **Bm:** bP, Kriegers Flak, 15 m (O. Paulsen).

Gigartina Stackh.

1. **Gigartina mamillosa** (Good. et Woodw.) J. Agardh.

J. Agardh, Alg. mar. mediterr. p. 104 (1842); Sp. g. ord. Alg. Vol. II, pars. 1, p. 273, 1851; Harvey, Phyc. Brit. Vol. II, 1849, pl. 199; Buffham 1896, p. 84, plate X, figs. 4—8; Oltmanns, Morph. u. Biol. I, 1904, p. 547. fig. 331.

Fucus stellatus Stackhouse in Withering, Bot. Arr. ed. 3, vol. IV, p. 99, excl. syn. omn. (1796), sec. Batters. (Not seen by the author).

Fucus mamillosus Good. et Woodw., Trans. Linn. Soc. Vol. III, 1797, p. 174.

Sphærococcus mamillosus Agardh, Synops. Alg. scand. 1817, p. 25; Lyngbye Tent. 1819, p. 14, tab. 5 C; Flora Danica tab. 2011, Hornemann 1830 (from the Færöes).

Mastocarpus mamillosus Kützing, Phycol. gener. 1843, p. 398, Tab. 76 III, Tab. phycol. XVII, pl. 39, 1867.

Gigartina stellata Batters Catal. of the Brit. Marine Algæ. Suppl. to the 'Journ. of Botany' 1902, p. 64.

This Alga reminds one in habit of *Chondrus crispus*, a tuft of upright fronds of a similar shape as in this species springing from a flat disc. The latter is composed of densely united vertical cell-rows and shows several transverse lines indicating a periodical growth. The upright fronds are placed closely together; they are more or less canaliculate and bear numerous papillæ on one or on both faces. The papillæ seem to arise in spring (comp. 476 *B*).

The upright fronds have a cortex built up of outward directed cell-rows consisting of small oblong cells becoming smaller towards the surface, the outermost being only 2 μ thick. The number of cells in these rows may be 7—10. Within this dense assimilating cortex a few layers of somewhat larger almost isodiametrical cells form an inner cortex. These cells are more distant from each other, being separated by a hyaline intercellular substance, and are connected with primary and secondary pits (fig. 474, 475 A). They pass into the inner medullar cells which in a transverse section show almost the same aspect being only somewhat larger and still more distant from each other, while in longitudinal section they appear as long cells having their long axis parallel to the longitudinal axis of the frond. The cells of the inner cortex and of the medullar tissue may produce long thin cell-filaments consisting of long cells, which grow out in a transverse direction downwards between the primary cell-rows and may sometimes be connected with these through secondary pits (fig. 475).

Fig. 474.
Gigartina mamillosa. Transverse section of frond. 560 : 1.

The sex organs have not been observed by me. The antheridia were described by BUFFHAM in 1896. The male plant, according to this author, differs much from the female one, "for it is thickly beset from near the base with flattened leaf-like branches arising just within the edges of the main portions of the frond, and with smaller ones from

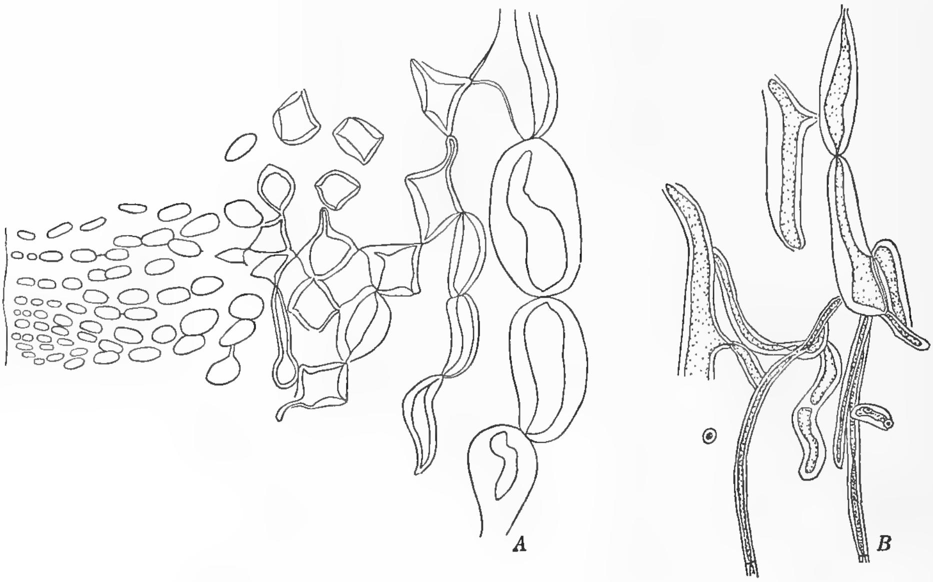


Fig. 475.
Gigartina mamillosa. *A*, longitudinal section of frond. 560 : 1. *B*, longitudinal section of medullar tissue. 350 : 1.

the other portions of the thallus". In some of these leaf-like branches the antheridia appear. The male plant was found in September; BØRGESEN found antheridia in June at the Faröes (M. A. Fær. 1902, p. 357). The cystocarps arise in the papillæ covering the flat frond. The procarps seem not to have been described; I have not observed them, perhaps owing to the fact that I have only examined specimens gathered in late summer (August, September). Ripe and partly emptied cystocarps were met with in August. According to the authors (J. Agardh, Schmitz and Hauptfleisch, Sjöstedt), the gonimoblast is surrounded in the genus *Gigartina* by an inner pericarp of medullary hyphæ. This pericarp, however, is not represented, or only feebly developed in Kützing's figures of this species (1843 and 1867) and I have not observed it on the outside of the gonimoblast. As shown by Kützing (1867), transverse secondary pits are very well developed in the inner part of the cystocarpial wall exactly corresponding to the inner cortical layer of the frond. Ripe and partly emptied cystocarps were met with at Thisted in August. Tetrasporangia are unknown. As they have been searched for by several phycologists, it seems most probable that they are really wanting. On the other hand one might imagine that they do occur in the papillæ, just like the cystocarps, and that the sori of tetrasporangia might have been confounded with the cystocarps, as has been the case repeatedly with *Chondrus crispus*.

Gigartina mamillosa has up to 1929 only been found in two localities at the shores of Denmark, namely at Thisted in the Limfjord and at Aarhus on the east coast of Jutland, in both places growing on moles of the harbour or on stony slopes near the harbour. As shown in an earlier paper[1], it must be supposed that it has been introduced into both localities by vessels. As to Thisted, where the species was first found by J. P. Jacobsen in 1869, this conclusion is almost certainly correct 1) since the salinity of the Limfjord before 1825, when the isthmus separating the fjord from the North Sea was broken through, was so slight that is was impossible for *G. mamillosa* to thrive here, 2) since the species has not been found elsewhere in the Limfjord and 3) since the part of the fjord (Thisted Bredning) where Thisted is situated is connected with the other parts of the fjord only by narrow channels with *Zostera* vegetation. The average salinity in the western part of the Limfjord is now 29 p. m. At Aarhus the species was found on a stony slope north of the harbour in 1911 or 1912. One might imagine that it might here be a relict from a time when the salinity was higher than now, when it varies probably about 20 p. m.; but that is quite improbable as the species has never been found elsewhere in similar localities in the Samsø waters or in Kattegat (except Skagen). It is therefore highly probable that the species has been introduced to this much frequented harbour by a vessel.

Gigartina mamillosa grows at low-water mark, at Thisted under the *Porphyra*-belt, over the *Fucus vesiculosus*-belt or partially in the upper part of this. It thrives well at Thisted, where it reaches a length of 5—8 cm, whereas at Aarhus it be-

[1] Om nogle i nyere Tid indvandr. Havalger i de danske Farvande. Botan. Tidsskr. Bd. 37, 1921, p. 126 and 133 (English abstract).

comes only 3—5 cm high, undoubtedly owing to the slighter salinity; here, however, it still produces ripe cystocarps.

In May 1929 I found *G. mamillosa* in the harbour of Skagen forming a continuous vegetation in the lover part of the tidal region and below the low-water mark. It was very well developed, reaching a length of 8,5 cm. There was a remarkable difference between the specimens growing over and below the low-water mark; the latter were broad, of a proportionally bright colour, without or only with very feeble papillæ appearing as low warts, whereas the littoral specimens were much darker, nearly black, and bearing numerous long, partly branched papillæ, mostly near the border (fig. 476). The sublittoral specimens were perhaps a year younger than the littoral ones.

A

B

Fig. 476.

Gigartina mamillosa. Harbour of Skagen. *A* in the littoral zone, *B* at low-water mark. Photo, 4/5 nat. size.

Localities. **Lf:** Thisted, first discovered by J. P. Jacobsen in August 1869, later found by me in Sept. 1890 and August 1893; it grew on the moles and on a stony slope east of the harbour. — **Kn:** Skagen, harbour, discovered May 1929. (The harbour was built in 1904—1907). — **Sa:** Aarhus, discovered in 1911 or 1912 by V. Petersson on a stony slope at the bathing-place "Kattegat" north of the harbour. I found it in 1917 and 1927 in the same place and on the outer side of the North mole, but it did not grow on the southern mole (at least 20 years old).

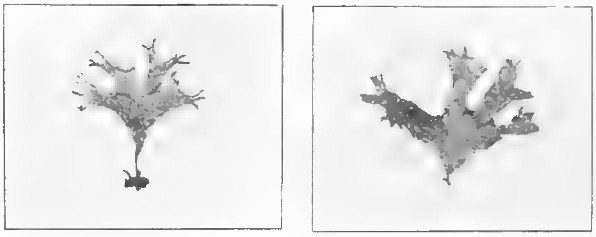
Phyllophora Greville.

1. **Phyllophora membranifolia** (G. & W.) J. Agardh.

J. Agardh, Alg. maris medit. (1842) p. 93; Harvey, Phyc. Brit. Vol. II (1849) pl. 163; J. Agardh, Sp. g. o. Vol. II, p. I (1851), p. 334; Wille, Bidrag (1885) p. 17, 32, 42, 65, 68, Tab. V, figs. 57, 58; Wille, Beiträge (1887), p. 79, Tab. VII, fig. 65; Buffham, Repr. Org. (1891), p. 248, Pl. 16 figs. 10—13 (antheridia);

B. Jönsson (1891, p. 19); Schmitz, Actinococcus (1893), p. 367; Darbishire (1895) pp. 5, 10, 20, 27, 31, 34; Kylin, Entwick. Florideenstud. (1928) p. 54, fig. 33.
Fucus membranifolius Good. et Woodw., Trans. Lin. Soc. III (1797), p. 120, pl. 16, fig. 1, 2.
Fucus crispatus Fl. Dan. tab. 826, fig. 1 (1778).
Fucus rubens Fl. Dan. tab. 827, fig. 1 (1778).
Sphærococcus membranifolius C. Agardh Synops. Alg. scand. (1817), p. 26; Lyngbye Tent., p. 10, tab. 3 C.
Sphærococcus Palmetta Lyngbye 1819, p. 11 ex parte.
Phyllotylus membranifolius Kützing, Phyc. gener. (1843) p. 412, Taf. 62 I (cystoc.), Tab. phyc. XIX (1869) Taf. 75 (c. nemathec.).

The shoots arise in various number from an expanded basal disc, of a similar structure to that in *Ph. Brodiæi* (comp. Darbishire l. c.). It has a very thick outer wall and is built up of densely united vertical rows of cells that are square or higher or lower than broad; the uppermost cells are usually low. The cells contain numerous grains of floridean starch that are stained blue by iodine. The outermost cells, however, contain no starch grains but similar refractive bodies that do not stain with iodine. They give no reaction with osmic acid, and take a feeble red colour with hæmatoxylin (Hansen), while the starch grains remain quite colourless. By treatment with caustic potash they swell somewhat and become less refractive; by the following washing out in water and treatment with iodine they stain feebly yellow; they give no reaction with bichromate of potassium nor with nitric acid and with ammonia after treatment with nitric acid. Their chemical quality thus remains unknown.



A *B*

Fig. 477.
Phyllophora membranifolia. Small specimens with short stipe Sallingsund, Limfjorden. July. Photo, nat. size.

Fig. 478.
Phyllophora membranifolia. Groves Flak, eastern Kattegat, April. Photo, 4/5 n. s.

The young shoots that may be met with in summer on the vertical faces of boulders and which have arisen after the last winter, have often a very short terete stipe while the flat part of the frond is broad and repeatedly bifurcate, and this is especially so in the first erect shoot of young plants; a lateral shoot then often arises from the short stipe (fig. 477 *A*). In other cases the stipe is long, in particular in older plants, where it may be 4—5 cm or longer. At the end of the first period of vegetation the frond has thus the shape of a well developed fan

Fig. 479.
Phyllophora membranifolia. Fladen, eastern Kattegat. May. Photo, $^4/_5$ n. s.

Fig. 480.
Phyllophora membranifolia. Limfjorden, at Jegindø. July. Photo, $^4/_5$ n. s.

at the end of a cylindrical stipe. The fan is not plane but convex, turning the convex face upwards, towards the light.

The growth of the particular segments of the frond may continue in the beginning of the next season (fig. 478), and the primary fan may thus be divided into secondary ones. But all the segments of the frond do not keep the growing power; several of them definitively cease growing at the end of the season, and, at least in older fronds, this may be the case with all the segments of a fan (fig. 479, the lowermost fans). In such cases the renewal of the fronds takes place only by proliferations arising from the cylindrical part or from the lower part of the flat frond. In the plant shown in fig. 478, gathered at the end of April, the difference in colour, and the absence of epiphytes characterized the new-formed portions of the frond. The proliferations arise as long cylindrical outgrowths that later become flattened and forked above. When given off from the flat frond they are usually placed on the border, but they may also frequently arise from the flat surface of the frond. These proliferations give rise to normal fan-shaped shoots that, however, only reach their full fan-shape in the season following their first appearance. Cylindrical proliferations without a blade are frequently met with in summer and autumn (fig. 480, 481). The production of proliferations may be repeated in the new-formed shoots, and 3 (or 4) generations of shoots are therefore easily recognized in the ordinary plants. In full-grown plants collected in summer, the fan-shaped frond from the foregoing year is fully preserved even when its growth has quite ceased (fig. 479), while the flat portion of the foregoing generation is often decayed; only a narrow strip connecting the base of the new shoot with the cylindrical part of the foregoing is kept and strengthened by secondary cortical layers. The named 3 (or 4) generations of shoots undoubtedly represent an equal number of years, and it must therefore be supposed that the upright shoots normally reach an age of at least three years. In the plant represented in fig. 488, gathered in April 1906, the first generation is represented by the short stem having a nearly horizontal direction, the second reaches the middle of the picture. The next generation (of 1905) is represented by two long shoots bearing cystocarps on the margin; the lowermost portions of these shoots, covered with *Membranipora pilosa*, were probably produced already in 1904. On the margins of these shoots a number of narrow proliferations are seen; it is however doubtful whether they would have been able to produce new fan-shaped segments. When more than three generations of shoots are produced, a greater total length of the plant is scarcely obtained; the new shoots do not usually overreach those of the third generation. New shoots may, however, arise from older portions of the upright shoots and from the basal disc, and the plants may thus become several years old.

Fig. 481.
Phyllophora membranifolia. Store Belt, At Kløverhage south of Nyborg, October. Photo, $^4/_5$ n. s.

The length of the shoots produced in a year is rather variable, varying from a few to 10 cm, and there seem to be no great differences between plants from the different waters in this respect. Only in the true Baltic Sea is it less, scarcely exceeding 5 cm, and at Bornholm 3.5 cm. On the other hand, the total length of

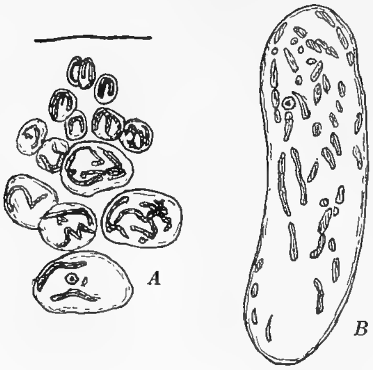


Fig. 482.
Phyllophora membranifolia. *A*, cortical cells, transverse section of frond. *B*, medullar cell. 840 : 1.

the plants exhibits considerable differences. The maximal total length observed in the North Sea and Skagerak is only 12 cm while in the Limfjord and most of the other inner waters it is usually 18 cm, and greater maximal lengths are observed in Eastern Kattegat (24 cm), the Little Belt (23 cm), the Great Belt (28 cm) and the western Baltic Sea (21 cm). Only in the true Baltic is the maximal length much less, **Bm** (12 cm) and **Bb** (5.5 cm). The specimens occurring in **Sb** are often very long and narrow with fairly slender stems (fig. 481).

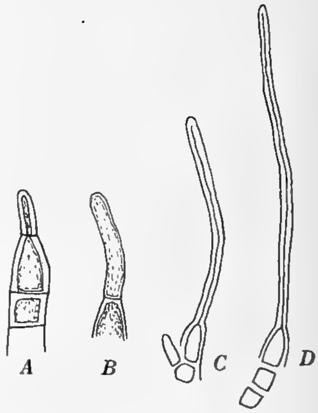


Fig. 483.
Phyllophora membranifolia. Hyaline hairs on carpophores. Prins Frederiks Grund, Vejle Fjord. 835 : 1.

The anatomical structure of the thallus has been treated at length by Darbishire, whose description (1895) may here be referred to. Wille has pictured a longitudinal section of the end of a frond showing the structure of the "Springbrunnentypus" (1887, pl. 5, fig. 65).

The cortical cells contain, according to Darbishire, each one chromatophore that may easily be observed in the outermost cells where it lines the outer and lateral walls. In the inner cortical cells it is much branched and appears as much bent ribbons that perhaps partly are separate chromatophores. In the inner cells a great number of rod-shaped or ribbon-like plastids are present which stain intensively with hæmatoxylin. A single nucleus in the vegetative cells may also be ascertained by this reagent (fig. 482). Hyaline hairs have only been observed in carpophores from a specimen gathered in Vejle Fjord in August (fig. 483).

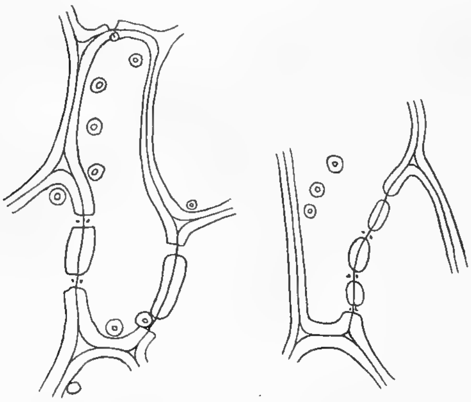


Fig. 484.
Phyllophora membranifolia. Longitudinal section of medullar cells showing numerous secondary pits. 520 : 1.

Secondary pits are produced in considerable number between the elongated cells of the medullary tissue with the effect that several pits are to be found in the same wall (fig. 484). A plug of callus is seen in the middle of each pit.

As shown by Jönsson (1891, p. 19) and Darbishire (1895), the lower portion of the stem has a thick cortex produced by secondary growth in thickness. The layers are, however, not regularly concentrical, the separate layers not usually continuing round the stem, for which reason the number of layers may be much greater on one side than on the other. The boundary of a layer may meet that of the foregoing layer or it may gradually disappear (fig. 485).

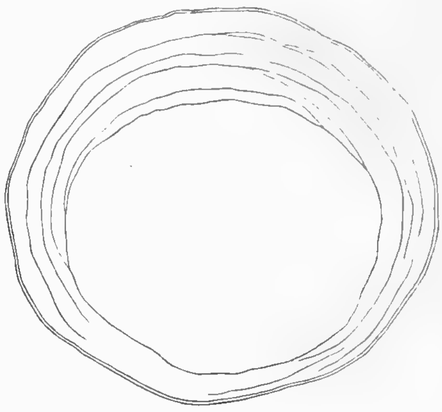


Fig. 485.
Phyllophora membranifolia. Transverse section of stem near the base. 86 : 1.

The **antheridia** are produced in particular yellowish or nearly colourless folioles borne on the border of the upper part of the flat fronds of the male plants. The androphores are up to 2 mm long, totally covered with spermatia-producing cells, sometimes with the exception of the outmost tip that remains sterile. The antheridia were first described by BUFFHAM (1891), later by DARBISHIRE (1895, p. 30) who showed that the spermatia are produced in conceptacles that are provided with an orifice in the roof. KYLIN (1928, p. 54) did not observe these orifices, but I can confirm their existence; they arise by dissolution of a distinct area of the outer wall. I found the conceptacles close together, not separated by sterile cells (fig. 487). The spermatia are about 6 μ long, 3 μ broad. Antheridia were observed from June to October.

Fig. 486.
Phyllophora membranifolia. Male plant with androphores. Nat. size.

The procarps arise in considerable number in particular oblong or nearly globular short-stalked carpophores borne on the upper part of the cylindrical and the lower part of the flat thallus of the female plants (fig. 488). In the latter case the carpophores are mostly placed on the border but often on the flat side too. In a short-stemmed specimen from the North-Sea (fig. 490) the carpophores were borne on the margin of the flat frond at a considerable distance from the cylindrical base. The carpophores arise in July. The carpogonial branch is three-celled (comp. SCHMITZ u. HAUPTFLEISCH p. 253, KYLIN 1928, p. 55, K. ROSENVINGE 1929, p. 12[1]). Fig. 491 shows carpogonial branches isolated by pressure and separated from the supporting cell which later functions as auxiliary cell. The carpogonium gives off downwards a prolongation that is connected with the second cell of the carpogonial branch through a lateral

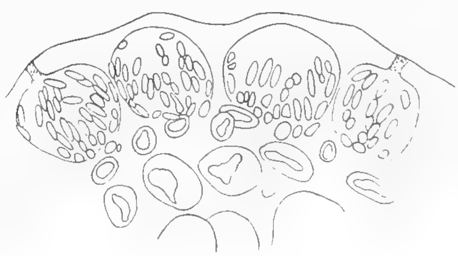


Fig. 487.
Phyllophora membranifolia. Transverse section of androphore showing four antheridial crypts. 625 : 1.

[1] According to DARBISHIRE 1895, p. 31 the carpogonial branch is four-celled; the first cell, however, does not belong to the carpogonial branch but is the supporting cell, the later auxiliary cell.

Fig. 488.
Phyllophora membranifolia. Specimen with ripe cystocarps. Hirtshals, April. $^4/_5$ n. s.

Fig. 489.
Phyllophora membranifolia. Specimen with nemathecia. Venø Bugt, Limfjord. September. $^4/_5$ n. s.

pit. The continuity of the protoplasm of the prolongation with that of the carpogonium was in all cases interrupted. The pit connection of the second cell with the first cell of the carpogonial branch is situated at the lower end of the second cell. A branch is frequently given off from the first cell; in fig. 491 *G* it has produced a complex of 7 cells. In fig. 492 similar stages are shown from sections through carpophores; the carpogonial branch is here seen borne on the auxiliary cell (*a*). In fig. 492 *B* a vegetative branch is given off from the auxiliary cell besides the carpogonial one, and this appears to be frequently the case (comp. KYLIN 1928, p. 55). In fig. 492 *D* the auxiliary cell has given off a prolongation apparently functioning by the transfer of the sporogenous nucleus. It appears that a great number of the procarps in a carpophore do not reach normal development (fig. 493 *A, B*); in many carpophores only few carpogonia are to be found, though there may be numerous supporting cells, but many of these bear only incompletely developed carpogonial branches or even no fertile branches at all.

Fig. 490.
Phyllophora membranifolia. Plant with short stem bearing carpophores on the border of the flat branched frond. North Sea, off Agger, 24 m, October. $^4/_5$ n. s.

To begin with the auxiliary cell contains one nucleus. In fig. 493 *C* is shown an auxiliary cell containing several small nuclei and four small protuberances at the lower face. It must be supposed that a sporogenous nucleus has entered into the cell, though a normal carpogonial branch could not be observed in this case. At all events the protuberances may be interpreted as the first stage of the gonimoblast. A similar stage is shown in fig. 494 *A* where a connection of the auxiliary cell with a normal carpogonial branch is not longer

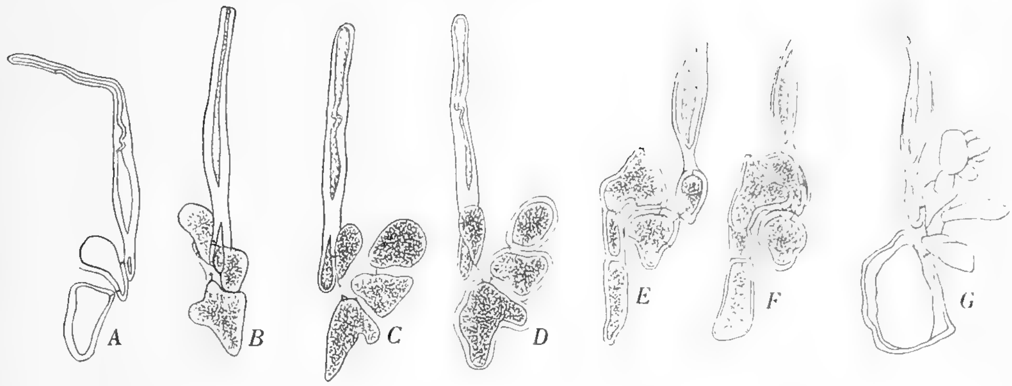


Fig. 491.
Phyllophora membranifolia. Carpogonial branches isolated by pressure, August. *D*, the same branch as *C* seen from another side. *F* the same branch as *E*. *G*, carpogonial branch in connection with the auxiliary cell. 390 : 1.

visible either. Later stages are shown in fig. 494 *B—D*, where the gonimoblast has arisen as several outgrowths from the lower and lateral sides of the auxiliary cell. The long cell or cell-complex at the upper face of the auxiliary cell probably derives from the carpogonial branch. It must be admitted that the fertilisation and the connection of the auxiliary cell with the carpogonium has not been ascertained. As to the first point reference may, however, be made to fig. 491 *A* where a pit in the wall of the trichogyne is undoubtedly the trace of a fusion with a spermatium. Kylin (1928, p. 54) has emphasized the accordance that exists in several respects between this species and *Stenogramme interrupta*; the development of the gonimoblast here pointed out is in good agreement with this conception. The carpogonium reminds one of that in *Iridæa cordata*

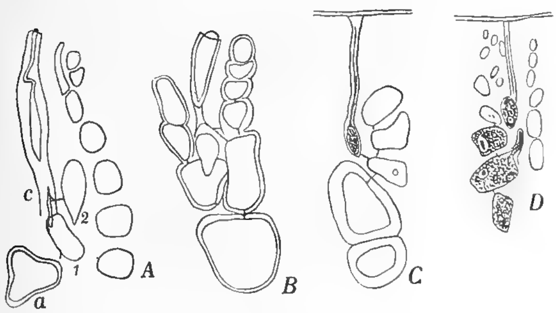


Fig. 492.
Phyllophora membranifolia Procarps from transverse sections of carpophores. In *B—D* the lower portion of the carpogonium is hidden behind the second cell of the carpogonial branch. In *D* the auxiliary cell has given off a prolongation towards the lower end of the carpogonium. *A*, *B*, Hanstholm, August. *C*, *D* Gilleleje, September. 390 : 1.

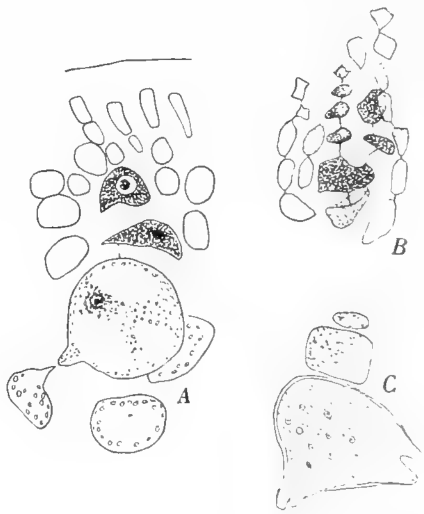


Fig. 493.
Phyllophora membranifolia. *A* and *B*, supporting cells with apparently not normally developed carpogonial branches. *C*, auxiliary cell containing several nuclei and producing four protuberances at the lower face. *A* 625 : 1. *B*, *C* 390 : 1.

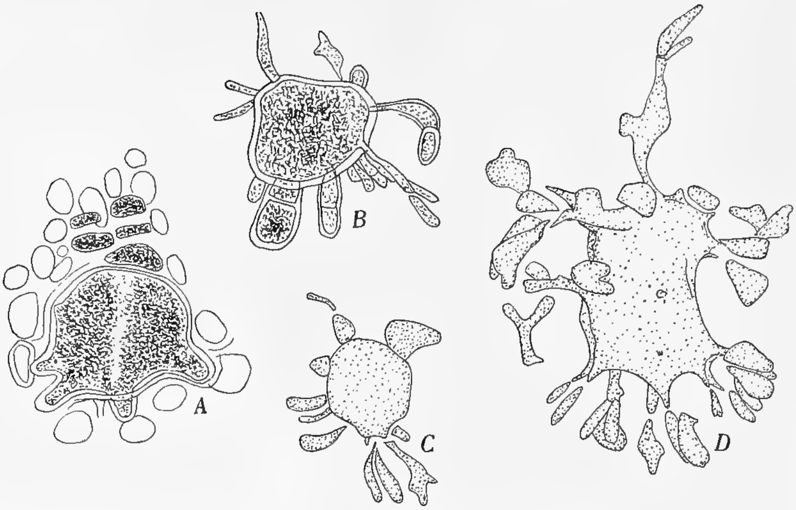


Fig. 494.
Phyllophora membranifolia. Auxiliary cells producing gonimoblast filaments in various stages of development. *B—D* isolated by squeezing. 390 : 1.

(KYLIN l. c. p. 47), being in both cases inserted laterally on the second cell of the carpogonial branch.

The gonimoblast filaments penetrate into the medullary tissue of cells rich in Floridean starch and produce numerous small carpospores. In the ripe cystocarps cell filaments consisting of long narrow cells are seen traversing the mass of carpospores (fig. 495, comp. KYLIN 1928, fig. 33 B). The cystocarps ripen in winter; they may still be met with in March to May, more or less empty.

The nemathecia arise in July, sometimes already in June (**Lf**, **Lb**) as deep-red wedge-shaped spots on both faces of the lower part of the flat frond (fig. 489). They are built up of parallel filaments, the cells of which develop slowly into tetrasporangia except the outermost cells (comp. DARBISHIRE 1895, p. 27). The division takes place in winter (December, January); in October I always found them undivided. The sporangium is first divided by a transverse wall, afterwards by two vertical walls perpendicular to the first.

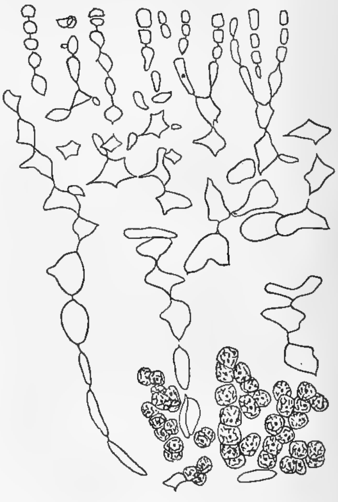


Fig. 495.
Phyllophora membranifolia. Portion of a transverse section of a ripe cystocarp. November. 390 : 1.

Phyllophora membranifolia occurs in all the Danish waters, from low-water mark or a little lower to at least 20 metres' depth. The greatest observed depths are 41 m (**Ns**) and 25.5 m (**Ke**). It grows on stones, in particular on the sides of boulders, more rarely on shells (*Astarte*). As mentioned above, it only attains a small size in the Baltic Sea proper (east of Gedser), and around Bornholm it is dwarfish, at most 5.5 cm in height (fig. 496); the specimens from this section of the Baltic were all sterile though they were collected in July, August (mostly) and November. The species has otherwise been recorded in the Batic Sea from Gotland (KROK, SVEDELIUS) and from the east coasts of Småland and Skåne, but also here it was always sterile. LAKOWITZ did not meet with it in the Bay of Danzig.

The species may be met with lying loose on the bottom in the inner Danish waters, but it is much less common in this state than *Ph. Brodiæi* and the loose specimens are slightly different from the normal ones.

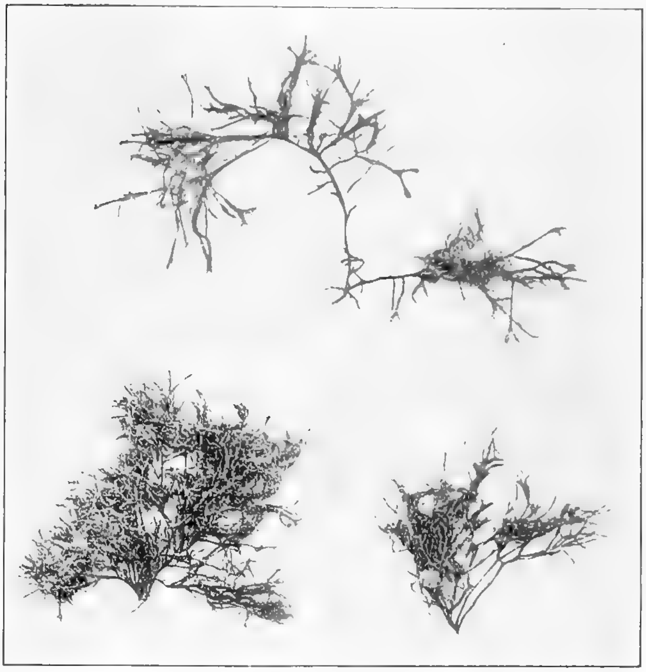


Fig. 496.
Phyllophora membranifolia. From the Baltic Sea. *A*, Gedser Rev 8.5m; *B* and *C* off Gudhjem, Bornholm. 5.5—11 m. August. Nat. size.

Localities. **Ns:** Jydske Rev ZQ, 24.5 m, several typical specimens but much overgrown with Hydroids and Bryozoa; eD, 41 m; aF, 31 m; eP, 24 m, (fig. 490); eQ, 27 m; eR, 27 m; eT, 34 m; XR, off Ørhage 5.5—13 m, small spec. In all localities except ZQ and aF only few and small specimens were met with. — **Sk:** Hanstholm, off Helshage, 5—13 m, on limestone, and off Roshage; eX north of Bragerne 16 m; eY, 15 m; YM, YN[2], Bragerne 2—10 m; Dana St. 2899, 14 m; SZ off Løkken 11 m; off Lønstrup, 7.3—13 m; Hirtshals, mole, Møllegrund 11—15 m and reef at Kjul, 5.5 m. — **Lf:** Nissum Bredning, XV Rønnen at Lemvig, ZY within Mullerne, 4.5 m; I, Venø Bugt; XT south of Jegind Ø, 6 m; MY Thisted Bredning; Sallingsund; Løgstør Bredning, Ejerslev Næse, Ejerslev Røn, off Fegge Klit, Amtoft Rev, Lendrup Røn. — **Kn:** Common everywhere on stony ground from Herthas Flak, 20—22 m, on the stony reefs from 1 m's depth. — **Ke:** Fladen, 16—18 m; Groves Flak, 19 m (F. Børgesen); Store Middelgrund, 25,5 m; Søborghoved Grund (OO); Vesterlands Grund; Gilleleje harbour. — **Km:** Sæby harbour; Several places south of Læsø; Gerrild Bay (Lyngbye). — **Ks:** Lysegrund; Hesselø (Lyngbye); RL, 15 m; NB, Havknude Flak; Briseis Grund; OS, Hastens Grund. — **Sa:** PA, near Albatros; KM, east of Øreflippen; PG near Hatterrev; Kyholm; PK, Norsminde Flak; Aarhus harbour. AH[1]; Korshavn; Hofmansgave (Hofm. Bang, Lgb. a. o.); aY; AY, Ashoved. — **Lb:** Bogense; Prins Frederiks Grund, Vejlefjord; Kasserodde; OB, Stavrshoved; Fredericia harbour (C. M. Poulsen); Middelfart, Snoghøj; Fænø Sund; off Stenderup; DC, Aakrog Bugt; Linderum, 1 m. — **Sf:** CC, Hornenæs; UX; Svendborg Sund. — **Sb:** Elefant Grund; AG W. of Romsø; Kerteminde, bay and harbour; several places around Sprogø; Halskov, Korsør; between Knudshoved and Slipshavn; Kløverhage (XS); GZ near Egholm; UE and gB, Vresens Puller; gE Stokkebæks Flak; Lohals; fR off Hjortholm Skov, 21 m; DP N. of Onsevig; DT, off Magleby; fS east of Kjelsnor lighthouse. — **Sm:** CK near Staalgrund. — **Su:** BQ, CS, Ellekilde; Hellebæk; PX off Tibberup; off Skovshoved, 5 m; QC east of Saltholms Flak. — **Bw:** bY near Sonderborg; bV, near Sundeved; cD, cE, cF, dO south of Als; fT south of Ærø; UY, Vejsnæs Flak; DU south of Langeland; KU Schönheyders Pulle; KT, Gedser Rev. — **Bm:** QT, QG south of Flinterenden; QH, Falsterbo Rev; SD; QS, VG, QZ east of Møen. — **Bb:** Bay of Arnager; SQ, Broens Rev; SL off Allinge; off Gudhjem; Christiansø (C. Rosenberg).

2. **Phyllophora Brodiæi** (Turn.) J. Agardh.

J. Agardh, Alg. maris medit. 1842 p. 93, Sp. g. ord. Alg. Vol. II, 1. 1851, p. 330; Harvey, Phyc. Brit. Vol. I, 1846; pl. 20 (excl. var. β); Wille (1887) p. 79, figs. 66—69; Schmitz Actin. 1893; Darbishire

1894, p. 361; id. 1895 pp. 6, 13, 15, 23, 29, 34; id. 1899. Gomont Actinoc., Journ. de Bot. 1894, p. 2; R. H. Phillips 1925, p. 244; H. Printz 1926, p. 60; L. Kolderup Rosenvinge, Phyllophora Brodiæi and Actinococcus subcutaneus. D. K. Vid. Selsk. Biol. Meddel. VIII, 4. 1929; Hugo Claussen, zur Entwicklungsgesch. v. Phylloph. Brodiæi. Ber. deut. b. Ges., Bd. 47, 1929, p. 544; Kylin 1930, p. 26.

Fucus Brodiæi Turn. Hist. Fuc. II. 1809, p. 1, tab. 72 (good pictures), Hornemann, Flora Danica, tab. 1476 (1813) (good picture with numerous nemathecia on narrow sexual shoots).

Sphærococcus Brodiæi Agardh Syn. Alg. Scand. 1817, p. 27; Lyngbye Tent. 1819, p. 11, tab. 3.

Chondrus Brodiæi Greville (1830), p. 133.

Coccotylus Brodiæi Kützing Phyc. gener. (1843), p. 412, Tab. phyc. Bd. 19, Taf. 74. (1869).

For the nemathecia:

Chætophora membranifolii Lyngb. ms. (Tent. 1819, p. 11).

Chætophora subcutanea Lyngb., Flora Danica, tab. 2135, 2 (1834).

Rivularia rosea Suhr mscr. (according to Kützing).

Actinococcus roseus Kützing, Phyc. gen. 1843, p. 177, Schmitz, Flora 1889, Flora 1893.

Actinococcus subcutaneus (Lyngb.) K. Rosenv. (1893), p. 822, Schmitz Flora 1893.

The fronds arise from the basal disc the development and structure of which are described at length by Darbishire (1895, pp. 15—20). In young plants a single frond is given off from the disc, later several fronds may spring from the same disc. As shown by this author, hapters may be produced from the under face of the disc and penetrate into the substratum, for instance shells of bivalves. The young fronds are to begin with cylindrical but early become flattened above. The flattening may begin near the base or there may be a long cylindrical stem before the flattening begins. Some of the fronds represented in fig. 497 show narrowings, often occurring in the species but in this case probably not due to the influence of the winter. The ramification by dichotomy may begin in the first year, but often the first branching does not take place till the second year (fig. 498 *c*). Lateral ramification of the flat frond as in fig. 497 *c* only rarely occurs in the first year. Only one or two dichotomies are produced in one season. Adventitious shoots or proliferations are later often produced from the cylindrical stem or from the flat frond.

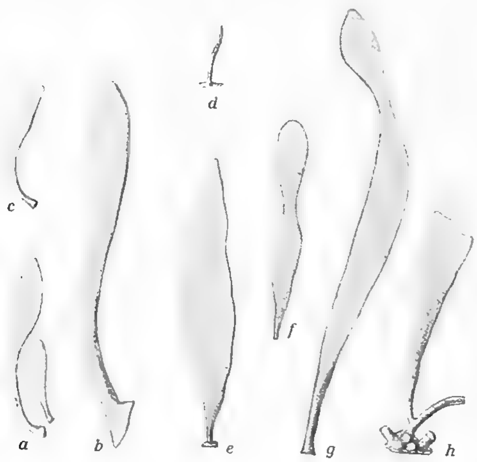


Fig. 497.
Phyllophora Brodiæi, young fronds, *a*—*c* from Holst's Banke north of Als, June; *d*—*h* from fR, Langelands Belt, August. 8 : 1.

The growth is arrested in winter (November to January). The young flat frond has then a growing zone in the upper margin of the frond or of each section of the frond. After the winter rest the growing zones resume their activity, and the difference between the old and the new frond is then very conspicuous, the first being darker, somewhat brownish, while the new segments are bright red. The growing margin may be long, and there is then only a feeble or no narrowing at the boundary between the old and the new frond (fig. 498 *b, c*); but when the segments are pointed at the end of the season, the growing zone is very short; the new segments are connected with the old ones by a narrow stalk (fig. 498 *a*). In both cases the periodicity of the growth is connected with a periodicity of the breadth of the frond, the latter becoming greatest in the middle of the growing period. The apical growth and dichotomy of the frond is usually not continued during more than two or three years. The growth then ceases and the upper portion of the flat frond is very often disorganised. This mode of growth occurs in particular in broad specimens reminding one of the arctic *f. interrupta* (fig. 488 *b*). In some cases new leaves arise as adventitious shoots from the cicatrized upper border of a flat frond (fig. 498 *b*, above in the middle, comp. Harvey Phyc. Brit. pl. 20, fig. 3).

Fig. 498.
Phyllophora Brodiæi, fronds branched by dichotomy. *a* from Litle Belt, March. *b*, Fænø Sund, April. *c*, from UK, Langelands Belt, May. *d*, Store Belt, November. *e*, Busserev at Frederikshavn, December. *a, b, e* $^2/_3$ nat. size; *c* 2 : 1. *d* $^4/_3$ nat. size.

Besides the apical growth and dichotomy, a branching by adventitious shoots or proliferations arising at a lower level are very characteristic of the species. The proliferations become long shoots terete below, upwards gradually flattened and more or less divided by dichotomy; they arise from the margin or, not rarely, from the flat side of the frond (figs. 499, 502). Their number is less than in *Phyll. membranifolia*, sometimes only one, and they may be entirely wanting. When the branching by proliferations is much pronounced, the apical ramification is often feeble; the growth of the upper border ceases at an early period. The growth of the single proliferations sometimes endures only one year; the growth is then taken up again by the new proliferations that may cease to grow in the next year, and so on, and a series of generations of proliferations may thus be produced. This takes place particularly in specimens growing in the inner waters in deep localities where the water is agitated by the current but not by the waves. In the specimen pictured in fig. 499 at least

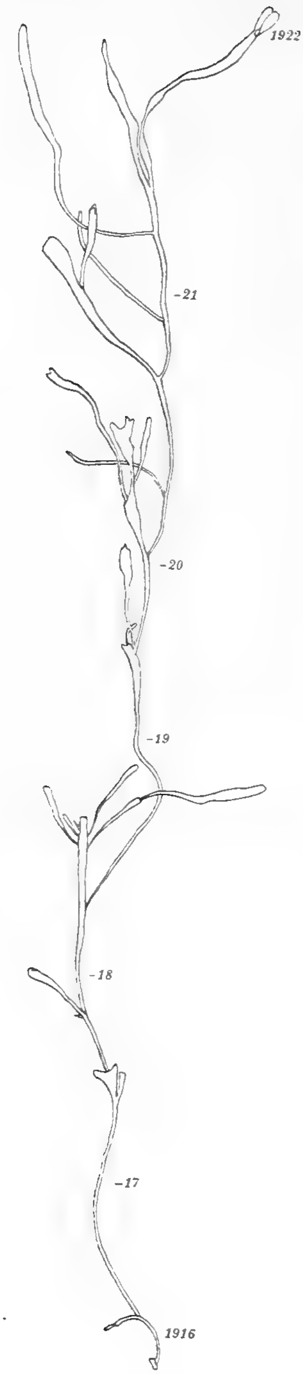


Fig. 499.
Phyllophora Brodiæi. Frond collected in June 1922 east of Hesteskoen NE of Als at 18—19 metres' depth. The oldest part of the frond has probably arisen in 1916. ²/₃ nat. size.

7 generations of shoots could be ascertained, undoubtedly representing an equal number of years. The specimens growing here attached to stones attained a length of 33 cm but had a very narrow frond, undivided or scarcely divided by dichotomy.

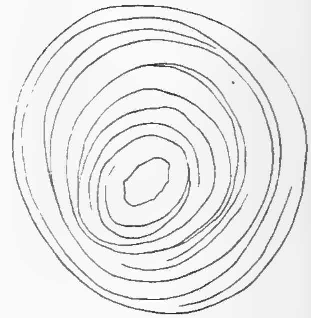


Fig. 500.
Phyllophora Brodiæi Transverse section of the stem near the holdfast.

A particular kind of shoots are the folioles, flat or nearly terete small shoots which arise at the upper margin of the leafy frond and which usually produce the sex organs (fig. 502). These shoots, however, are not always fertile, and in a loose form (*f. stellata*) similar shoots but sterile and often branched give to this form a characteristic habit (figs. 517 *D*, 518).

The anatomical structure will not be mentioned here, as it has been treated by Wille (1887) and Darbishire (1895). A transverse section of the stem of an older frond near the attachment disc is shown in fig. 500. There are a number of concentric cortical layers, partly incomplete, the limits between them often vanishing or merging. The central tissue has an elliptical outline. As shown by Darbishire (1895, p. 20, fig. 25,1), secondary cortical layers (sekundäre Verdickungsschichten) may also be produced at the base of branches, but they may further arise sometimes as local formations in the sexual shoots, as I, too, have observed. According to Darbishire, the young cells contain a single chromatophore. In the large cells in the interior of the frond several long ribbon-shaped chromatophores can be distinguished.

Fig. 501.
Phyllophora Brodiæi. Cells from the medullar tissue of leafy frond. 600 : 1.

According to H. Claussen the vegetative cells contain several small nuclei (1929, p. 546); the smaller cells of the cortex seem, however, to contain a single nucleus.

The reproduction of *Phyllophora Brodiæi* has been much disputed for more than a century. Turner, who described the species in 1809, interpreted the globular bodies

Fig. 502.
Phyllophora Brodiæi. *A*, from a dredging south of Als in June, 8.5 m's depth, nemathecia in leaflets, terminal or marginal. *B*, from 12 metres' depth off Ballen, Samsø in August; with nemathecia and new sexual leaflets. 1.8 : 1.

situated on the upper border of the frond, or on particular small shoots, as the fructification of the species, but LYNGBYE as early as 1819 was in doubt whether this was really so. He suggested that they might possibly be some parasite, and since then these bodies, which were later named nemathecia, have been the subject of various interpretations and much discussion. I have recently published a special paper on this question (1929), in which I have shown that the nemathecium does not belong to a particular parasite (*Actinococcus*), but that it is the nemathecium of the much reduced sporophyte of *Phyllophora Brodiæi* growing on the gametophyte. I shall therefore refer the reader to the historical survey given in that paper and here give only a short account of my own researches.

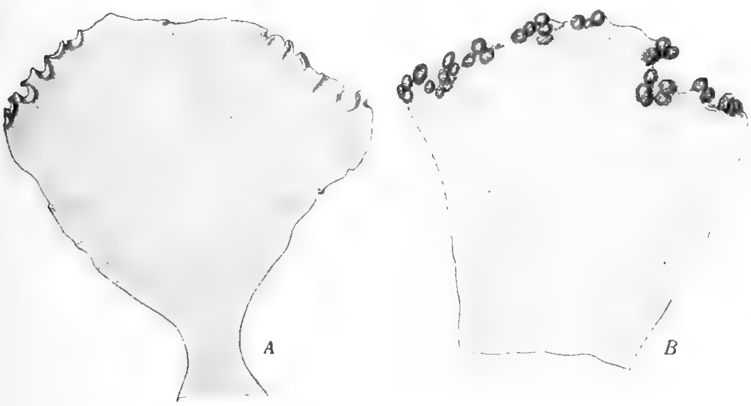


Fig. 503.
Phyllophora Brodiæi. Lille Belt, 18—19 metres' depth, June. *A*, upper end of frond with undulated fertile margin. *B*, similar with young nemathecia. c. 5 : 1.

The sex organs occur in particular sexual leaflets situated on the upper border of the flat frond (fig. 502) or in a marginal zone of the upper segments of the frond (fig. 503 *A*). DARBISHIRE, who observed the sexual shoots, maintained that the species is diœcious, and it may perhaps sometimes be so, but the two sexes usually occur in the same plant and often in the same organ. When the upper border of the frond is fertile, it is much undulated and finally lobed owing to increased transversal growth, and it also becomes incrassated. The small fertile shoots are narrow, nearly terete, angu-

Fig. 504.
Phyllophora Brodiæi, from Store Belt, near Nyborg, May. Fertile lobe of frond with a group of procarps made distinct by staining with hæmatoxylin. 47 : 1.

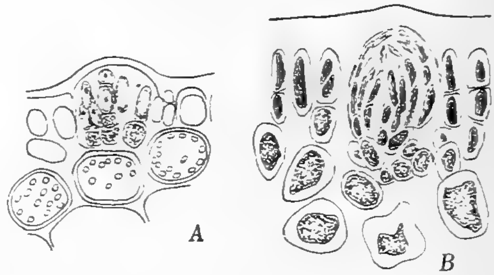


Fig. 505.
Phyllophora Brodiæi. Two antheridial crypts. *A*, not fully developed, June. *B*, ripe, partly emptied, August. 625 : 1.

late, flattened or canaliculate (fig. 502). The sex organs are irregularly distributed in the fertile portions of the frond, and it may happen that some of the small shoots are sterile. In fig. 504 is shown a lobe of an undulated margin of a frond containing numerous procarps, while most of the other lobes of the same margin were without procarps.

The antheridia are similar to those of *Phyll. membranifolia* (comp. Darbishire 1895, p. 29, 1899, p. 257, K. Rosenvinge 1929, p. 14). They are developed in small globular cavities in the sexual shoots and, when ripe, communicate with the exterior by an ostiole. Each cavity probably derives from one superficial cell (fig. 505 *A*). The crypts contain a number of short, often converging cell-filaments the end-cells of which become spermatia, but the spermatia-producing cells may also be situated at the surface of the shoot (comp. Kylin 1929, fig. 16 *E*). The antheridia were met with in the months of March and May to November.

Fig. 506.
Phyllophora Brodiæi, from Lille Belt, east of Hesteskoen, June 1922, from frond with crenulated border. *A*, procarp; a two-celled branch issues from the first cell of the carpogonial branch; *a*, the auxiliary cell, *1*, *2*, *c*, the cells of the carpogonial branch. *B*, two procarps, that to the left without trichogyne. *C*, carpogonial branch isolated by pressure. *D*, protruding trichogyne, the base of which cannot be distinguished. 560 : 1.

The procarps are situated in the inner cortex. When fully developed they are composed of a tricellular carpogonial branch and a large supporting cell (Tragzelle Kylin) which becomes an auxiliary cell, but it may happen that two carpogonial branches are borne on the same supporting cell (fig. 508 *D*). Darbishire (1895, p. 33) describes the carpogonial branch as four-celled, but he considers the supporting cell as the first cell of the carpogonial branch. — Numerous procarps were examined in specimens from various localities and gathered at different seasons; they showed considerable differences and the great majority of the procarps were not completely developed. The procarps are easily recognizable by their abundant protoplasmic contents and their staining power with hæmatoxylin. The supporting cell is larger than the cells of the carpogonial branch; it must be regarded as the auxiliary cell. In referring for details to my paper of 1929 and to the figures from there reproduced here, I shall only mention the principal facts. The carpogonial branches are often only two-celled (fig. 507), and the last cell is most frequently not developed as a carpogonium but roundish like the other cells of the branch, also in the three-celled carpogonial branches. The best developed carpogonial branches were met with in May and June, when long, projecting trichogynes were often observed (fig. 506). But most of the carpogonia observed had an abortive

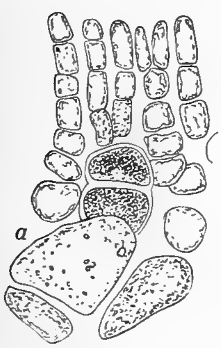


Fig. 507.
Phyllophora Brodiæi, from the same specimen as fig. 506. Tvo-celled carpogonial branch. 560 : 1.

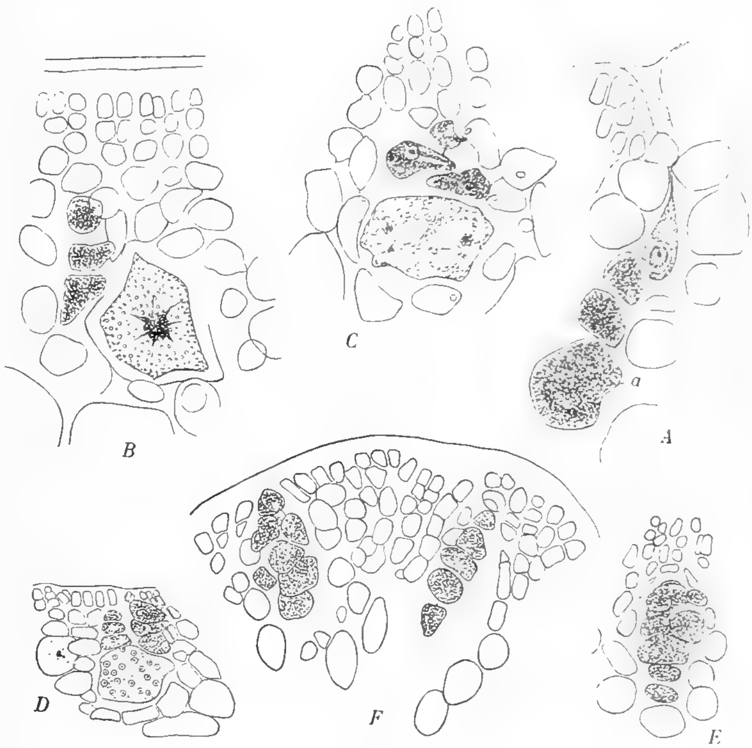


Fig. 508.
Phyllophora Brodiæi, collected by Dr. Henning Petersen at Ellekilde Hage, Oresund June 1910 and treated with Juel's solution. *A*, procarp; the carpogonium is attenuated towards the trichogyne channel but the trichogyne itself is wanting. *B*, the last cell has not the character of a carpogonium; the supporting cell seems to be uninuclear. *C*, the same, the supporting cell is plurinuclear. *D*, the supporting cell is multinuclear; it bears two carpogonial branches, but no carpogonium is developed. *E*, procarp showing more than the ordinary number of cells, without carpogonium. *F*, similar group to the left. *A*, *B*, 870 : 1. *C*—*F*, 480 : 1.

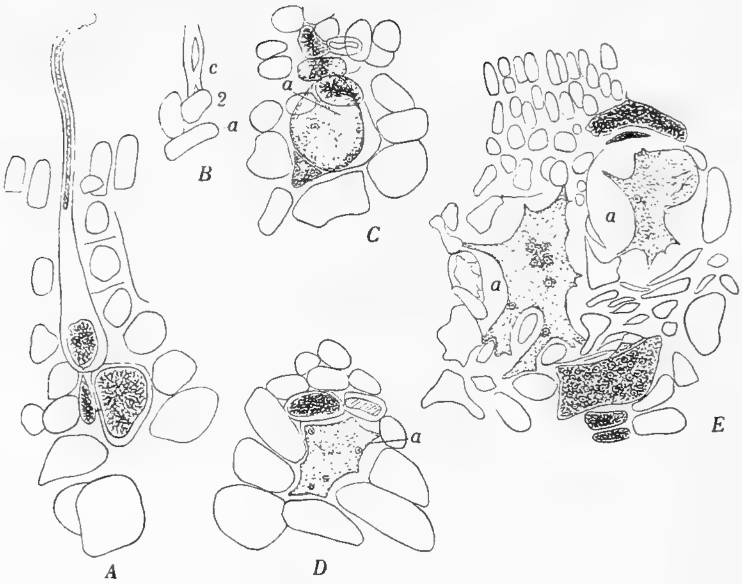


Fig. 509.

Phyllophora Brodiæi. From a specimen collected in Store Belt in May, fixed with formol-sublimate. *A.* Three cells only are to be seen in the procarp, the supporting cell seemed to be wanting in the section. *B,* procarp the interpretation of which was doubtful; no transverse wall was visible at the narrowing of the carpogonium. *C.* At least two nuclei were present in the supporting cell that is still round. *D.* The supporting cell is angular, plurinuclear. *E.* Three auxiliary cells, the two showing numerous nuclei, two producing prolongations forcing their way between the surrounding cells. *A,* 1000 : 1. *B—E,* 560 : 1.

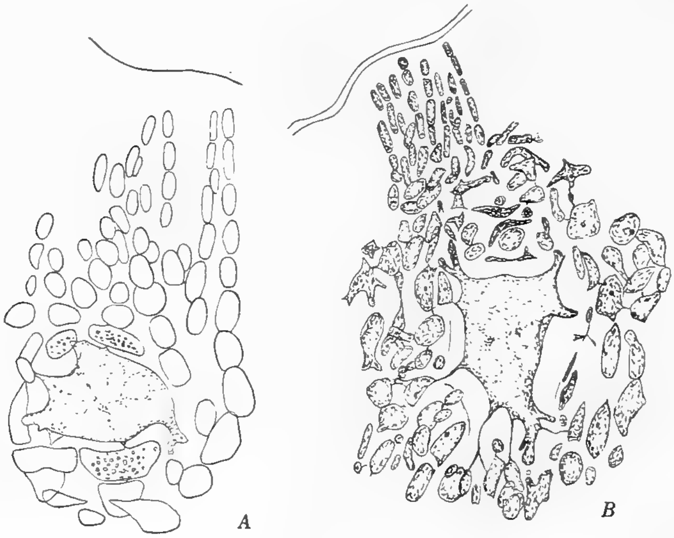


Fig 510.

Phyllophora Brodiæi. From Ellekilde Hage, Juel's solution. (Compare fig. 508). Auxiliary cells with protuberances. *A,* The protuberances penetrate between the surrounding cells. 625:1. *B,* more advanced stage. The protuberances have produced cells and cell-rows at their ends; some of these have begun to form a low tubercle, a young nemathecium. 390 : 1.

character (fig. 508). No spermatia were found adhering to the trichogynes and no other signs of a fertilization were observed. Furthermore, a transferring of a sporogenous, diploid nucleus from the carpogonium to the auxiliary cell could not be ascertained and I therefore concluded (1929) that it was uncertain whether or not a fertilization takes place in this species. The auxiliary cell, which originally seems to be uninucleate (comp. figs. 506 *B*, 508 *B*), later contains numerous nuclei (fig. 508 *D*). Such cells may increase in size and, at a certain stage of development, shoot out several protuberances (figs. 509, 510) which grow out to long branched radiating cell-rows forcing their way between the cells of the gametophyte and ending in nemathecial filaments. A globular body is then produced composed of radiating nemathecial filaments issuing from a system of more irregular cell-rows and containing in the middle a large central cell, the original auxiliary cell, from which they have all originated (Plate VIII figs. 1 3). These globular bodies have formerly by several authors (LYNGBYE, SUHR, KÜTZING, SCHMITZ, DARBISHIRE (1899)) been considered as a parasite (*Actinococcus subcutaneus* (LYNGB.) K. ROSENV., *Act. roseus* (SUHR) KÜTZ.), but have now turned out to be the much reduced sporophytic generation of *Phyllophora Brodiæi* growing as a parasite on the gametophyte.

The greater part of the globular bodies consists of nemathecial filaments and they can therefore be designated as nemathecia. They are placed either on particular sexual leaflets and are therefore often described as stipitate, or they are placed in great number in the undulated upper margin of flat frond segments (fig. 503 *B*). In the first case the fertile shoot usually remains short, but it may happen that it develops into a foliole of considerable size (fig. 502 *A*).

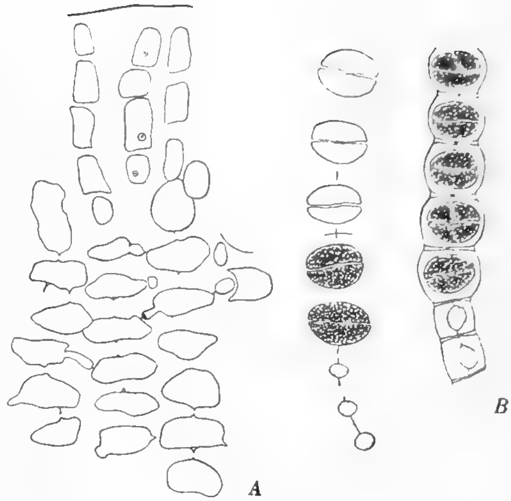


Fig. 511.
Phyllophora Brodiæi. *A*, specimen from Middelfart, April; radial section of young nemathecium, showing the outer sterile cells and the fertile ones, the latter connected by primary pits and partly by secondary pits with cells of the contiguous filaments. *B*, fertile filaments from specimen gathered in Store Belt. November 24th with sporangia in division 625 : 1.

The nemathecia can be met with at all seasons; they usually arise in the spring and may early attain a considerable size. The maximal size is 2 to 3.5 mm in diameter; it is reached already in June and July, while the nemathecia are only fully developed in winter. The sporangia begin to ripen at the close of November, and ripe sporangia are met with in December to February. As the nemathecia occurring in winter are of different sizes and as nemathecia of considerable size are to be found in early spring, it is probable that some nemathecia (sporophytes) which are

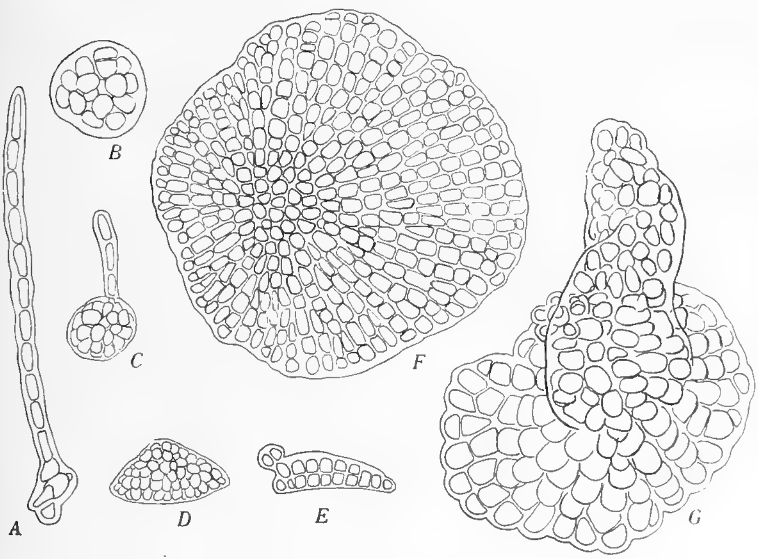


Fig. 512.
Germlings from tetraspores of *Phyllophora Brodiæi* sown in the beginning of December 1925. *A*—*B*, $3^1/_2$ months old, $^{22}/_3$ 1926. *C*—*F*, $6^1/_2$ months old, $^{29}/_6$ 1926. *G*, 7 months old, $^8/_7$ 1926. *E*, optical vertical section. *A*, *C*—*F*, 350 : 1. *B*, 410 : 1. *G*, 560 : 1.

small in December may be retained without producing tetrasporangia and continue their life in the following season, whereas most nemathecia perish in winter after the production of tetraspores. The 3 or 4 outermost cells in the nemathecial cell-rows are narrower than the other and remain sterile. It is remarkable that the young sporangial cells are sometimes connected with cells in the contiguous cell-rows by secondary pits (fig. 511 *A*). The fate of the nuclei transferred by the formation of these pits could not be followed. The sporangia are first divided by a transverse wall and later by two vertical or slightly inclined walls (fig. 511 *B*).

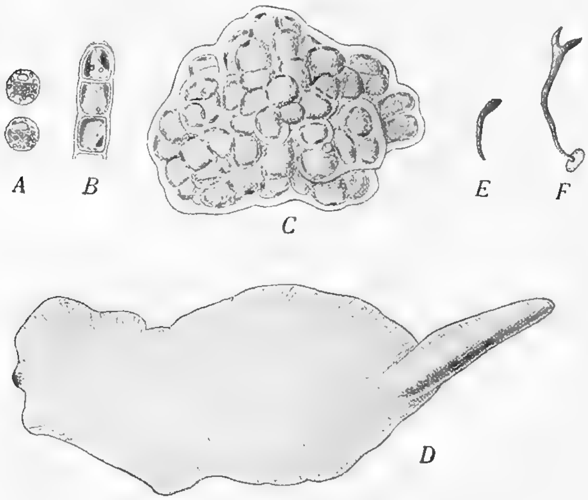


Fig. 513.
Phyllophora Brodiæi. Germlings from tetraspores sown in the beginning of December 1925. *A*, spores newly liberated. *B*, portion of filament from germling. *C*, eight months old germling, $^{14}/_{8}$ 1926. *D*, 14 months old germling with upright shoot springing near the border $^{10}/_{2}$ 1927, *E* and *F*, 20 months old germlings, $^{18}/_{8}$ 1927. *A—C*, 625 : 1. *D*, 70 : 1. *E—F*, 9 : 1.

The germination of the tetraspores was first observed by DARBISHIRE (1895); he found that the germlings were deep red bodies of various shape, filamentous, disc- or cushion-shaped, but they attained only a small size in his cultures. The germlings in my cultures from the end of November 1925 were kept alive for several months, up to more than two years and a half, and partly reached a much better development than in DARBISHIRE's cultures. In the best cultures orbicular, flat or more or less cushion-shaped discs, thickest in the middle, were produced, which after half a year began to give off an upright shoot, usually in the middle. The upright shoot is first terete but later becomes flattened, and in the older cultures ramification could be ascertained, partly by dichotomy, partly by lateral branching (figs. 513, 515). Owing to the unfavourable conditions in the old cultures, the germlings figured are not quite normal, but there can be no doubt of their identity with *Phyll. Brodiæi.* It must further be supposed that the germlings would have developed into gametophytes, as all fronds of this species are sexual plants, as far as we know.

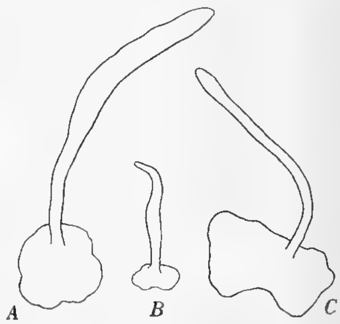


Fig. 514.
Phyllophora Brodiæi. Germlings from the bottom of a glass vessel in which a fructiferous plant was deposited at the close of November 1925, picked up $^{18}/_{6}$ 1927 (18 months old).

After the publication of my paper (1929) two authors have confirmed the general conclusions there advanced as to the relationship of *Actinococcus subcutaneus*, but they have both pointed out facts which suggest that a fertilization really takes place. HUGO CLAUSSEN (1929) studied the behaviour of the nuclei and found that the vegetative cells of *Phyll. Brodiæi* contain numerous small nuclei, about 2 μ in diameter, containing 4 chromosomes, whereas "In den Zellen des Karpogons [?] und im Gewebe des Parasiten" nuclei with 8 chromosomes are frequently to be found, which makes it probable that the formation of the sporophytic generation is preceded by a fertilization. This process however was not observed. Nor has KYLIN (1930, p. 26) observed the fertilization process, but he has found a carpogonium fusing together with an auxiliary cell, and he thinks that such a process only takes place when the carpogonium is fertilized.

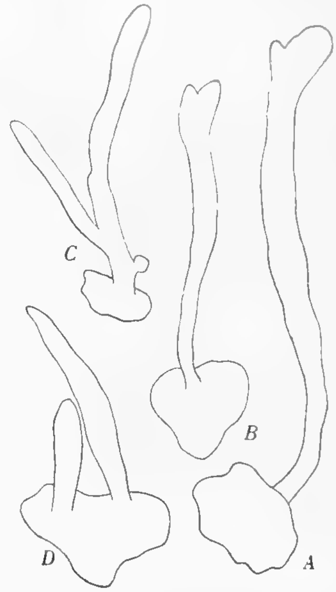


Fig. 515.
Phyllophora Brodiæi. 32 months old germlings from the walls and the bottom of the vessel mentioned in fig. 514. 64 : 1.

Phyllophora Brodiæi is spread in all the Danish waters from the North Sea to Bornholm, from 1 to 36 metres' depth, attached to stones and sometimes to shells of bivalves. In the North Sea and Skagerak there are only few places where it thrives well (Bragerne); the frond is here fairly broad but only attains a height of 10 cm. It scarcely becomes higher in the northern Kattegat where it is much less common than *Ph. membranifolia.* In the inner waters it attains its best development and is often abundant. Its maximal height increases considerably, as will be seen from the following figures indicating the maximal heights observed in the respective waters: **Ke** 15 cm, **Ks** 17.5 cm, **Sa** 24 cm, **Lb** 34 cm, **Sb** 29 cm, **Su** 23. In the Baltic it is much smaller: **Bw** 11 cm, **Bb** 8 cm. Its appearance varies not only as to the size but also otherwise, according to the different mode of ramification and the varying breadth of the frond. There is, however, no reason to describe special varieties because the differences seem to depend on outer conditions, and I am not able to point out types that might be supposed to be genotypically distinct. As mentioned above, there are two modes of ramification: dichotomy and proliferation, which are usually both in function; but it may happen that one of them is predominant. When the ramification is chiefly or exclusively dichotomous, which happens particularly with broad fronds (fig. 498), the shape may come near to the arctic f. *interrupta*, characterized by the frond being alternately broad and narrow, but the typical f. *interrupta* hardly occurs in the Danish waters; the specimen most resembling it was met with in a bank south of Lyø, Lille Belt, in 22 metres' depth. Specimens of the type nearly exclusively branched by proliferations so extreme as that represented in fig. 499 are rare; they occur too in deep water; the great majority of individuals are intermediary between the two extremes. The specimens growing in exposed localities in shallow water have a firmer texture than those growing in deep water. In specimens growing in light localities the upper, exposed portions of the frond are green in summer. In the Baltic around Bornholm the dimensions are small, the individuals often dwarfish (fig. 516). They are usually sterile; specimens with small sexual shoots, however, sometimes occur. In a specimen from Rønne Banke imperfectly developed procarps were met with, and once I found, in a specimen collected in August, what seemed to me to be a young nemathecium.

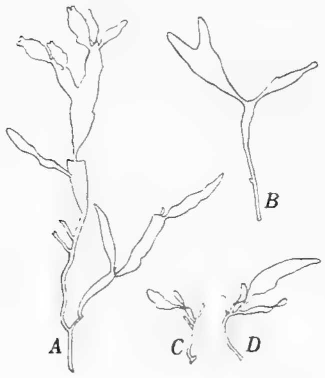


Fig. 516.
Phyllophora Brodiæi from Bornholm. *A*, *B* off Rønne 24.5 m. *C*, *D* off Gudhjem 5–11 m. Nat. size.

Localities: **Ns:** Not met with in a fixed state south of 56°48′ lat. N. aF, 31 m; dZ, 36 m; eS 25 m, scarce in all the localities. — **Sk:** Helshage and Roshage, Hanstholm 2—13 m; eX, north of Bragerne, 16 m; YN², S.E. of Bragerne 10.5 m, several broad specimens, 10 cm high, partly with nemathecia and new marginal leaflets; eY, 15 m; a small specimen; Hirtshals, near land c. 2 m, with Actinococcus 2 mm in diam.; August. — **Lf:** Found in several localities in the western Limfjord, but always without the basal part, so in most cases it must remain uncertain whether the species was growing on the locality in question. In most cases the specimens have certainly been lying loose on the bottom; they were usually found on soft bottom and bore no sexual leaflets. In two cases only did such leaflets occur and in one case Actinococcus. ZT, LX, LY and XV by Lemvig; LU, Thisted Bredning; XT; I; Sallingsund, several places, Th. Mortensen,!; MJ and LR, Løgstør Bredning; F, Skive Fjord. — **Kn:** Hirsholmene; Deget, Busserev, Frederikshavn, not abundant in the neighbourhood of Frederikshavn; Kummel Banke, (loose?) 38 m; several places near Læsø Trindel, 8—19 m; near Nordre Rønner; gL at Friis' Sten, south of Nordre Rønner, 2—3 m, abundant. — **Ke:** Inner side of Kobbergrund; several places 1—4½ miles of Fladens lightship, 15—30 m; Groves Flak (F. Børgesen,!), with Actin. April; GJ, Ostindiefarer Grund; OO, Søborghoved Grund and Vesterlandsgrund N. of Gilleleje; Gilleleje harbour; washed ashore by Gilleleje (Lyngbye). — **Km:** Usually loose; fixed on stones; N by E ¾ E of Østre Flaks light-ship 5½ miles (C. A. Jørgensen); ZC, XB and KF south of Læsø; Gjerrild Bay; Rygaard Strand (Lyngbye); KG near Anholt. — **Ks:** Grenaa harbour; FO, off Havknude; Jessens Grund; Hastens Grund; EJ, Lysegrund 4—5 m; D near Grønne Revle, 11 m; GF, Sjællands Rev; EH, Isefjord off Lynæs. — **Sa:** Common on stony ground at 1 to 15 m's depth from KM east of Øreflippen and PA, Albatros 7.5 m to Hofmansgave (ripe tetrasporangia in February (C. Rosenberg), aZ and OA, 7.5 m North of Fyn. — **Lb:** More than 20 localities, usually at depths from 6 to 15 m; off Stenderup and East of Hesteskoen (dH') at 19 m and at dQ south of Lyø at 22 m depth; at Linderum at 1 m depth. — **Sf:** Mostly loose; attached to stones at Hornenæs, 15 m; CV, Billes Grunde, 5.5 m; UV and UX North of Ærø; Svendborgsund, 7.5 m. — **Sb:** Numerous localities from Refsnæs to fS off the South end of Langeland at depths from 1 m (Kerteminde harbour) to 20 m. — **Sm:** CK, 9.5 m and HF West of Farø, 12 m. — **Su:** Common from BQ and CS near Ellekilde to QC and QD North of Saltholm, down to 13 m's depth, frequently with nemathecia. — **Bw:** Common from dL in Flensborg Fjord to KT, Gedser Rev and UM, Kadetrenden, at depths down to 25 m; deepest localities: UL, Øjet, 20 m; KX, more than 20 m, and UM, Kadetrenden, 25 m (small specimens). — **Bm:** Numerous localities. KS South of Falster, with nem.; VH South of Møen; several places East of Møen; VD, entrance to Bøgestrøm, with nem.; several places along the East coast of Sealand, partly with nem. — **Bb:** 14 miles SW ¾ S of Adler Grund light-ship, 30 m (C. A. Jørgensen); SF, Adler Grund c. 10 m (loose); SR, Rønne Banke, 15—16 m, on gravel and stones, with sexual shoots; YH, off Rønne 24.5 m; XZ, Davids Banke 10—29 m; off Gudhjem 5.5—11 m; off Svaneke; 3 miles SSE of Nexø, 21 m; Dueodde light-house in W 5¾ miles, 38 m; 5.5 miles NNE ½ W of Hammeren light-house, 35—40 m (C. A. J.); SV, North West Ground at Christiansø, 30—32 m.

Loose forms. *Phyllophora Brodiæi* very often occurs lying loose on the bottom in the inner Danish waters. It is able to keep living in this condition for a long time, growing continually in a sterile state, and it then usually takes a shape different from that of the typical species. Loose specimens occur in particular in the *Zostera*-associations and in other localities where the water is not too agitated by waves or by currents. They sometimes occur in great quantities in company with other loose Algæ. The loose forms are very variable, and distinct limits between the different forms cannot be drawn. In some cases they are only slightly different from the typical form, for instance those occurring in the Limfjord, in others they have a characteristic shape. The following types may here be distinguished.

f. *concatenata* Lyngb. (1819), p. 11.

Areschoug, Phyceae, 1850, p. 83, tab. III A.
β, elongata Hauck Meeresalg., p. 141.

Elongated often intricate frond repeatedly branched by dichotomy or by proliferations, the leafy portions lanceolate or bifurcate, above and below attenuated in cylindrical parts (fig. 517 *A*). The breadth is variable, the narrowest specimens merge imperceptibly into the following form. This form has usually few or no marginal shoots, but such shoots may sometimes occur, and may even be more numerous than in Areschoug's figure.

Very common in the inner waters, but also met with in the North Sea at Blaavandshuk, in the inner waters in particular in **Sa** (numerous specimens collected at Hofmansgave by Hofman-Bang, Lyngbye and Caroline Rosenberg), **Lb**, **Sf**, **Sb**, **Sm** and **Su**.

f. *filiformis.*

Frond cylindrical or here and there a little flattened, mostly branched by proliferations. It occurs in a robuster form, the cylindrical part of which is about 0.5 mm in diameter while the flat expansions are usually only 1 mm broad (fig. 517 *B*), and in a thinner form with a threadlike frond. The finest specimens are sometimes so thin that they are only $^1/_6$ mm thick and almost without flat expansions, and one would therefore be inclined to doubt that they belong to the form-cyclus of *Phyllophora Brodiæi* if other specimens from the same gathering did not offer intermediate forms connecting them with less aberrant forms. Moreover, even the finest specimens may be infested by *Ceratocolax Hartzii*, which is a specific parasite of *Phyllophora Brodiæi* (fig. 517 *C*). In its typical form it is only found in **Sf** and **Bw**.

Localities: **Sf:** Højen at Faaborg, between broad-leaved Zostera, very thin; DZ, Egholms Flak at Mørke Dyb, with Zostera. — **Bw:** cF south of Kegnæs lighthouse.

f. *stellata.*

Phyllophora parvula Darbishire ex p. (1895) fig. 10, 6—8.

The proportionally small flat frond bears at the top a bunch of radiating small, narrow, undivided or forked shoots. These shoots are similar to the sexual shoots in the normal plants but are sterile. They remain for the most part short, but some of the shoots in a bundle may grow out and develop into a long shoot like the mother shoot and bear a similar bunch of short shoots at the top (figs.

Fig. 517.
Phyllophora Brodiæi loose forms. *A*, f. *concatenata*, Store Belt. 3/4 nat. size. *B*, f. *filiformis*, at Kegnæs south side of Als, 3/4 nat. size. *C*, f. *filiformis* very thin, infested by *Ceratocolax Hartzii*, dredged near Faaborg. Nat. size. *D*, f. *stellata*, from ZC south of Læsø. Nat. size.

517 *D*, 518). This form is analogous to the f. *stellata* of *Chondrus crispus*, (comp. p. 505). The radiating shoots are sometimes repeatedly forked, and when, as will sometimes happen, they are partly reflexed, the plants may remind one of f. *uncinata* of the said species. Some of the specimens referred by Darbishire to *Phyllophora parvula* (see above), belong to this form, while the other figured specimens probably represent other reduced loose forms of *Phyllophora Brodiæi*.

Localities: **Kn:** Kummel Banke 38 m. — **Km:** ZC and EZ south of Læsø; 6 miles SSW 1/2 W of Læsø Rendes lightship 8 m (C. A. J.); BK, Tangen. — **Sa:** East side of Wulff's Flak; AO; Endelaves SE Flak, 7.5 m; Fyns Hoved in E 3/4 N 5 1/2 miles. — **Sf:** fV, south side of Svelmø, 4 m; — **Sb:** fP, E of Hov light-house, 5.5 m. — **Bw:** fU, south side of Ærø, 7 m.

Fig. 518.
Phyllophora Brodiæi f. *stellata*. South of Ærø. 2 : 1.

3. **Phyllophora epiphylla** (Fl. Dan.) Batters.

Batters, A Catalogue of the British Marine Algæ, 1902, p. 65.
Fucus epiphyllus O. F. Müller, Flora Danica, Tab. 705. 1777. (from Norway).
Fucus prolifer Lightfoot, Fl. Scot. II, p. 949, tab. 30. 1777.
Fucus rubens Good. et Woodw. Trans. Lin. Soc. III, 1797, p. 165.
Chondrus rubens Lyngb. Tent. p. 18.
Phyllophora rubens (G. & W.) Greville Algæ Brit. p. 135, pl. 15; Harvey Phyc. Brit. II, Pl. 131, (1849); J. Agardh, Sp. g. o. II, I p. 331, (1851); Kützing Tab. phyc. IX, tab. 76, (1869); Buffham, Antherid. (1893), p. 292, pl. XIII, fig. 5; Schmitz, Actinoc. 1893, p. 399 ff.; Darbishire (1894), p. 369, id. (1895), pp. 4, 7, 12, 21, 28, 30, 33, 34, 36).

The fronds arise from a basal disc that, according to Darbishire, may be 5—15 mm in diameter and up to 1.5 mm thick. The lowermost portion of the frond is cylindrical, but this stemlike portion may be extremely short; when it is more developed it may give rise to a considerable number of branches that take a similar appearance as the primary frond (fig. 519 *B*). The shoots gradually expand in a membranaceous linear frond which grows by the activity of an apical meristeme

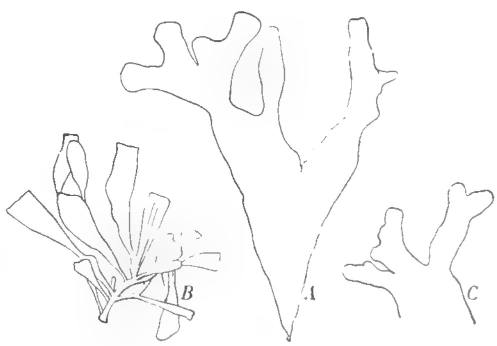


Fig. 519.
Phyllophora epiphylla. *A*, frond dredged off Lonstrup, Skagerak. *B*, lower portion of frond from the same locality. *C*, upper portion of frond dredged in the North Sea 15 miles off Hanstholm lighthouse. *A*, *C* 1/2 natural size. *B* natural size.

and may remain simple or branch by dichotomy. Sometimes the ramification is lateral as in fig. 519 *A*, C, which may perhaps be due to the checking of one of the products of the dichotomy. Besides this apical ramification a branching by proliferations regularly takes place. The latter, one or more, arise from the plane surface of the frond, usually near the end, and a series of generations of proliferations is consequently produced, representing probably an equal number of years (fig. 520). At least 5 or 6 generations are normally produced in the Danish individuals. The growth of the shoots normally ceases when a proliferation arises near its end. The ramification by proliferations is usually more pronounced than the apical forking in the specimens from the Danish waters, where the proliferations are very often simple, in particular from the waters within Skagen. The membranaceous frond reaches a breadth of 10 mm; in the southern Kattegat and the Sound it only becomes 5 mm broad at most. The thickness diminishes gradually from the middle towards the margin. As to the anatomical structure of the frond reference may be made to DARBISHIRE's paper (1895, p. 12). As shown by this author, small interstitial cells are wanting between the medullary cells. The shoots are often furnished with a midrib in their lower part. It is formed by local thickening of the cortex, produced by activity of the outer cortical layer on both sides (comp. DARBISHIRE l. c. p. 12).

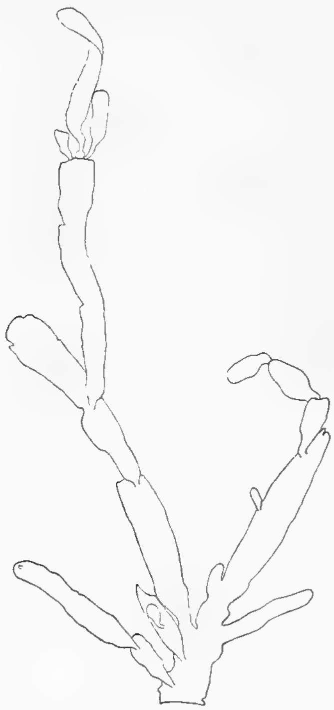


Fig. 520.
Phyllophora epiphylla. From the Øresund; north of Kronborg. Sept. 1848. Caroline Rosenberg. 2 : 1.

The antheridia are produced in small androphores on particular male specimens. The androphores are spherical or subspherical bodies, about 0.5 mm in diameter or a little more, borne on a short pedicel on the plane surface of the frond near the border (fig. 521). They were first pictured by DERBÈS et SOLIER[1] in the nearly related *Ph. nervosa* which is probably not specifically distinct from *Ph. epiphylla*, later on they were briefly mentioned by THURET (Et. phyc. 1878, p. 82) who found that "les corpuscules males sont contenus dans des cryptes tapissées d'anthéridies fort semblables à celles du *Gracilaria confervoides*". In 1883 they were described and figured by BUFFHAM (1883, p. 292, pl. XIII, figs. 5—7). This author observed the cavities, from the walls of which numerous tufts of thin filaments spring which produce at their extremities the spermatia, and he presumed that these bodies escape through one common issue at the top of the androphore (comp. l. c. fig. 7). My observations on the structure of the androphores however, are, not in accordance with those of BUFFHAM. A vertical section of an androphore shows a layer of cavities or crypts covering the whole surface of the globular body

[1] Ann. sc. nat. III. S. tome 14 p. 278, pl. 37 figs. 10—11, 1850.

and surrounding a globular parenchymatous medullary tissue (fig. 521). This parenchymatous columella seems not to have been observed by Buffham, but it has been distinctly represented by Derbès et Solier (l. c. fig. 10—11). The crypts are deep, 120—150 μ, nearly prismatic but somewhat irregular in a transverse section, and with rounded ends, 45—63 μ in diameter. The separating walls between these cavities are built up of very thin filaments from which the spermatia producing filaments spring. When the cavities are more irregular in transverse section, the separating walls may form folds in the cavity like incomplete septa, or the cavities may be partly confluent. The ostioles of the crypts were not observed by me but there is no doubt that the latter have each their particular opening, not a common one as supposed by Buffham, and this species is therefore in better accordance with the other species of the genus than must be supposed from Buffham's representation. The spermatia are very small, about 4 μ long, 2 μ broad; one nucleus was easily recognisable in the dried material. The antheridia were met with in September (**Kn** and **Su**). According to Kylin (1907, p. 125) antheridia-bearing specimens collected in May are present in the Riksmuseum at Stockholm.

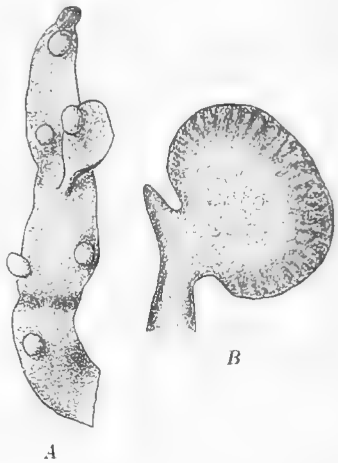


Fig. 521.
Phyllophora epiphylla. *A*, male specimen, September 5 : 1. *B*, vertical section of androphore. 30 : 1.

The procarps are developed in particular globular carpophores which have a similar position to that of the androphores. To begin with they are like these globular, sessile or furnished with a very short stalk but early become beset with anastomosing crests (comp. Harvey, l. c. and Darbishire 1895, p. 33). The procarps arise in the inner cortex in considerable number in each carpophore. The carpogonial branch is, as in the other species of the genus, three-celled and borne on a large cell that probably becomes the auxiliary cell (fig. 522). The trichogyne was observed to protrude through the surface in some cases; the narrowing between the ventral part of the carpogone and the trichogyne was very distinct at the level of the surface of the carpophore. The development of the cystocarp was not examined. A great number of the procarps observed in a carpophore collected in October were not fully developed and many of them would probably never have reached maturity. Carpophores with procarps were observed in September and October, cystocarps in winter (November to March); as late as May cystocarps may be met with but more or less empty.

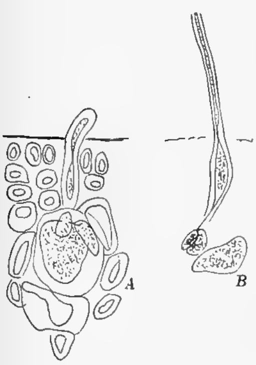


Fig. 522.
Phyllophora epiphylla. Procarps. *A*, with a young, *B*, with a fully developed carpogonium. 390 : 1.

The nemathecia are borne on the short stipe of peltate leaflets dispersed on the surface of the frond of separate asexual plants. They are flat broad bodies that cover a great part of the stipe, in a number of two or more. When several nemathecia are present, they may meet and jointly cover a great part of the surface of the stipe. The structure of the nemathecia has been well described and pictured by DARBISHIRE (1895, p. 28) who ascertained that the nemathecium is only connected with the supporting organ in the middle where it has arisen from the cortical tissue, while the basal layer of the nemathecium is for the rest appressed to the frond. The nemathecia increase at the margin by the formation of tangential walls. Two years before, SCHMITZ treated the nemathecia of this Alga in his paper on *Actinococcus* (1893, p. 399 et sequ.). DARBISHIRE's statements are in many respects in good accordance with those of SCHMITZ but as to the basal layer the two authors disagree. While DARBISHIRE describes this layer as consisting of one or two layers of cells and as distinct from the surface of the frond with which it is in contact, SCHMITZ found that the growing border of the nemathecium is separated from the surface of the supporting frond by a slit. At a certain distance from the margin, the basal layer appears in contact with the surface of the frond with which it becomes closely united, the cells of the basal layer giving off prolongations toward the superficial cells of the frond with which they are said to fuse, with the result that the slit entirely disappears, and finally almost all the superficial frond-cells are united with one or more cells of the basal layer, and the arrangement of the cells of the latter becomes very irregular. This fusing process takes place, according to SCHMITZ, even at the insertion of very young nemathecia and the author concludes from this that the nemathecia of this and some related species are particular parasitical algæ growing on the surface of the fronds of *Phyllophora* and fusing with the presumed host-plant through cell-fusions. SCHMITZ gave to the parasite the name of *Calacolepis incrustans*. If this interpretation were true, the parasite would only attack the asexual plants and these would then be devoid of tetrasporangia. As this is very improbable, particularly convincing facts must be demanded for supporting such an interpretation. It must be regretted that SCHMITZ has given no drawings illustrating the fusing process. DARBISHIRE has not succeeded in observing it (1894, p. 369); he declares (1895, p. 28) that the nemathecium only is in connection with the stipe in the place where it has arisen from the cortical cells. In this place the cortical cells first divide and grow out, and the young nemathecium thus formed breaks forth from the cortex; he can not, therefore, accept the view of SCHMITZ.

I, too, have not succeeded in observing the fusions recorded by SCHMITZ. In specimens collected in September the formation of the nemathecia is easily observed. In the youngest stages a small group of cells situated just within the surface are seen dividing and extending outwards, causing a vaulting and distending of the cuticle. This distending early involves a bursting of the cuticle, and the active cells protrude, surrounded by their thin special membranes (fig. 523 *B*, *C*). The bursting of the cuticle usually takes place in the middle, and the borders of the old cuticle are then later found surrounding the base of the young nemathecium (fig. 523 *D*). In other cases the bursting seems to take place at the periphery, and the nemathecium is then covered by a calotte of cuticle originating probably from the surface of the stipe (fig. 523 *E*).

In the young stages the arrangement of the cells may be rather irregular; sometimes a single cell is seen to be more active and rich in cell-contents than the others, and producing a great part of the cells of the excrescence (fig. 523 *A*). The diameter of the quite young nemathecia is small, corresponding only to the diameter of a very small number of cortical cell-rows, but the diameter early begins to increase, the marginal growth taking place by vertical division of the marginal cells. The insertion of the nemathecium is, however, not enlarged by this process, the growing borders of the nemathecium not being connected with the surface of the frond but separated from it by a slit (fig. 523 *E*, *F*) or in contact with it. The nemathecium at the same time increases in height and is then composed of parallel or radiating filaments which later, in winter, produce tetrasporangia. As mentioned above, I have never seen a fusing process like that described by Schmitz; at all events it did not take place in the younger stages such as those represented in fig. 523. From the above it must be concluded that the nemathecia are the true organs of *Phyllophora epiphylla* and do not belong to a parasite. The name of *Colacolepis incrustans* must therefore be abandoned.

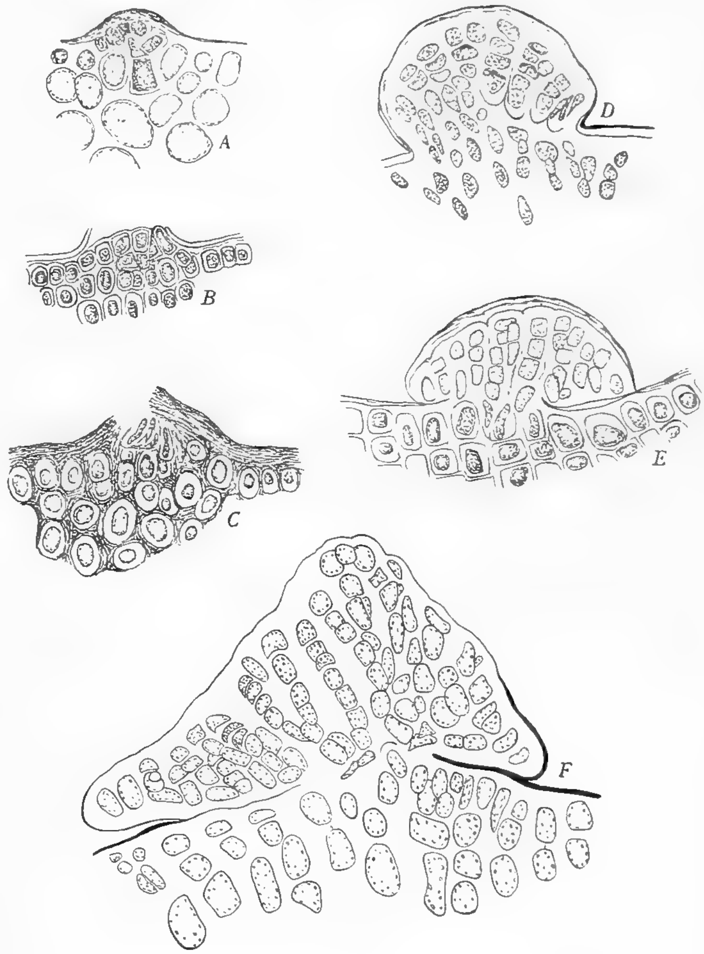


Fig. 523.
Phyllophora epiphylla. Young stages of nemathecia in September. 625 : 1.

The sporangia form long chains in the nemathecial filaments; only the ultimate cell is sterile, as shown by Darbishire (1895, p. 28, fig. 36). As late as April I found sporangia partly divided into four cells, partly only divided by a transverse wall; they measured 9—14 × 6—7 μ (9 × 7 to 14 × 6 μ).

The frond reaches a length of up to 20 cm. The breadth is variable; outside Skagen the maximum breadth varies from 5 to 10 mm, in the northern and eastern Kattegat from 4 to 7 (rarely 9) mm, in **Km**, **Ks**, **Sa** and **Su** from 2 to 4 (rarely 5) mm. As mentioned above, the ramification by dichotomy is less pronounced in the inner waters than outside Skagen (**Ns** and **Sk**).

Phyllophora epiphylla is confined to the waters with a comparatively high salinity: the North Sea, Skagerak, Northern, Eastern and Southern Kattegat. Outside these territories it has only been collected by dredging in one place (one specimen) in the central part of the Kattegat (**Km**). Further it has been found loose on the beach sparingly at Hofmansgave (**Sa**) and frequently in the Øresund north of Helsingør; to the latter places it is probably carried from the Swedish coast. It grows in rather deep water, on stony or gravelly bottom, in **Ns**, **Sk** and **Kn** in 5.5—41 m depth, in **Ke** at 15—25 metres' depth.

Localities. **Ns:** Jydske Rev, eD, 41 m; eC, 26 m; eO and eP off Agger; eR; eT; XR off Klitmøller. — **Sk:** Off Hanstholm 13 m; at Bragerne, 10.5 m; ZK[1], 7.5—9.5 m and ZK[6] 11.3—13 m off Lønstrup; Hirtshals, washed ashore; Skagen, washed ashore. — **Kn:** Herthas Flak, 19—22 m; Læsø Trindel, several places, 15—13 m; GM, Engelskmands Banke; UB, east of Nordre Rønner, 9—11.5 m; north of N. Rønner 7 m; east side of Hirsholmene; XG, east of Deget 4—5.5 m; Frederikshavn (Schmidt 1863). — **Ke:** Groves Flak, 19 m (!, Børgesen); HZ, Store Middelgrund 25.5 m; Gilleleje and Nakkehoved, washed ashore (Schouw, Lyngbye). — **Km:** HT, Fornæs lighthouse i SW $^5/_8$ W 7 miles, 16 m. — **Ks:** At Hesselø (Lyngbye); D, at grønne Revle; off Tisvilde Leje, 3 miles, 15 m (A. Otterstrøm); ad littus Vejbye prope fontem Helenæ et Raageleje (Lyngbye). — **Sa:** Hofmansgave, washed ashore (Hofm. Bang, Caroline Rosenberg), was not recorded from this locality by Lyngbye, seems therefore to be rare. — **Su:** Washed ashore at Hellebæk and at Helsingør (Ørsted, C. Rosenberg, Joh. Lange, Børgesen, !).

Loose form: f. *Bangii* (Horn.) Fries.

Fucus Bangii Hornemann, Flora Danica, tab. 1477 (1813).
Sphærococcus Bangii Agardh Synops. (1813) p. 24; Kützing, Phyc. gen. (1843) p. 410, Taf. 59 II, Tab. phyc. Bd. 18 (1868) Taf. 84.
Chondrus Bangii Lyngbye Hydr. (1819) p. 17, tab. 3.
Phyllophora Bangii E. Fries Summa veg. Scand. (1845—49) p. 126; Darbishire (1895).
Rhizophyllis ? Bangii J. Agardh. Sp. g. o. II.1 p. 223. (1851).

This pretty little alga, characterised by its much incised frond, was discovered by Hofman Bang at Hofmansgave at the North coast of Fyn, where it is frequently found washed ashore and from which locality innumerable specimens have been distributed, in particular by Hofman Bang and by his foster-daughter Miss Caroline Rosenberg. Lyngbye referred it to the genus *Chondrus* and described a fructification consisting in "tubercula subglobosa 4-granulata in substantia frondis remote et inordinate sparsa". This supposed fructification, however, does not belong to this Alga but is due to some alien organism, probably germinating spores of *Furcellaria* *fastigiata*, which frequently occur on this substratum (comp. KÜTZING, Phyc. gen. Taf. 59 II). The only later author who has considered them as tetrasporangia is J. AGARDH who on this basis, though with doubt, referred the Alga to the genus *Rhizophyllis*. E. FRIES transferred it to the genus *Phyllophora*[1], where it has since had its place, and with which genus it agrees well in the anatomical structure.

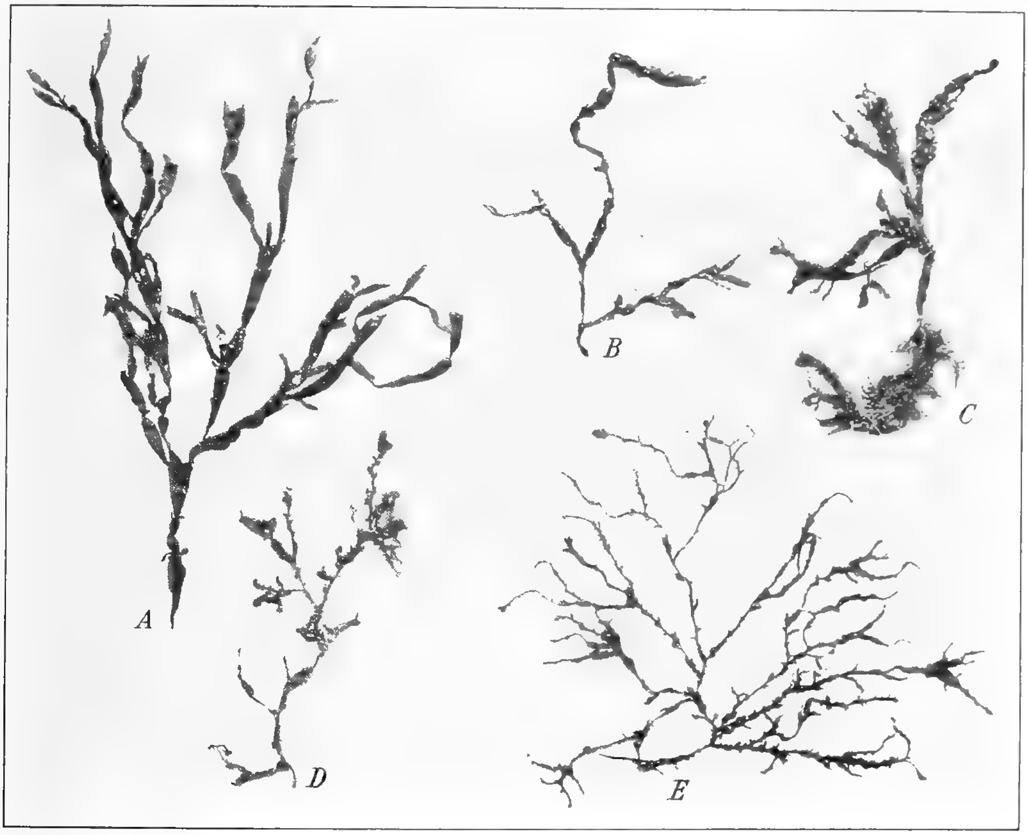


Fig. 524.
A, *Phyllophora epiphylla*, typical narrow frond from Helsingør. *B—E*, *Ph. epiph.* f. *Bangii*. *B*, off Gerrild Klint, 7.5 m. *C*, Silderøn south of Læsø, 2—4 m, together with *Ahnfeltia plicata* f. *D*, KF south of Læsø, 6.5 m. *E*, Hofmansgave (Caroline Rosenberg), large specimen. $^{6}/_{7}$ nat. size.

The plant has always been found loose, and reproductive organs have never been found.

During my dredgings in the Danish waters I have met with this Alga in numerous localities in the inner waters where the water is comparatively little agitated, on sandy bottom, very often in company with *Zostera marina*, entangled between its

[1] HAUCK, Meeresalg. p. 144 cites JENSEN as author of the combination *Phyllophora Bangii*, owing to the fact that he has only known it from Rabenhorst's Alg. Europ. exsicc. No 1299 where TH. JENSEN has communicated it with FRIES' name.

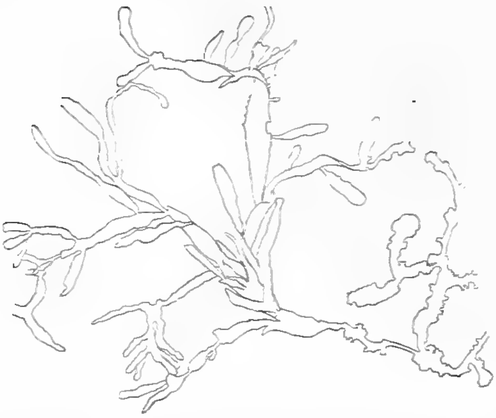


Fig. 525.
Phyllophora epiphylla f. *Bangii*, specimen from Baaring Vig, North side of Fyn, producing a branched shoot without crenulated border. $^1/_2$ nat size.

rhizomes and together with various other loose Algæ. As it has been found only in the inner Danish waters and the adjacent part of the western Baltic Sea and, according to J. AGARDH, at the coast of Bohuslän, it must be extremely probable that it might be a loose sterile form of any of the species of *Phyllophora* occurring in these or the adjacent waters, and I many years ago had arrived at the conviction that this species was *Ph. rubens*[1]. An examination of a large amount of material from various localities has fully confirmed this opinion. Firstly it must be pointed out that the colour and the consistency are identical in *Ph. epiphylla* and *Ph. Bangii*; and none of them adhere to the paper when drying. The area of the latter does not coincide with that of the genuine species but is situated outside it (ɔ: more to the south and west). Near the boundary between the two areas loose forms occur that are only little incised and then much resemble genuine specimens of *Ph. epiphylla* (comp. Fig. 524 *B—D*). The fronds of these specimens are partly linear with the border entire in part of its length. Similar specimens may also be met with in the waters north of Fyn. The specimen shown in fig. 525 has a great complex of shoots with entire borders springing from a shoot with the usual incisions; the first agrees exactly with a narrow specimen of *Ph. epiphylla*, 1 mm broad. The specimen represented in fig. 526 is also very instructive; it shows the proliferation characteristic of the species and a feeble mid-rib, and further the linear segments of the frond with border partly entire partly more or less incised. In the specimens agreeing with the typical *Chondrus Bangii* LYNGB. the broader parts of the frond are always present but are usually shorter and provided with feebler or deeper incisions, and a midrib is never present. Fig. 524 *E* shows a well developed specimen of this form; some of the lateral shoots are narrow without broader parts.

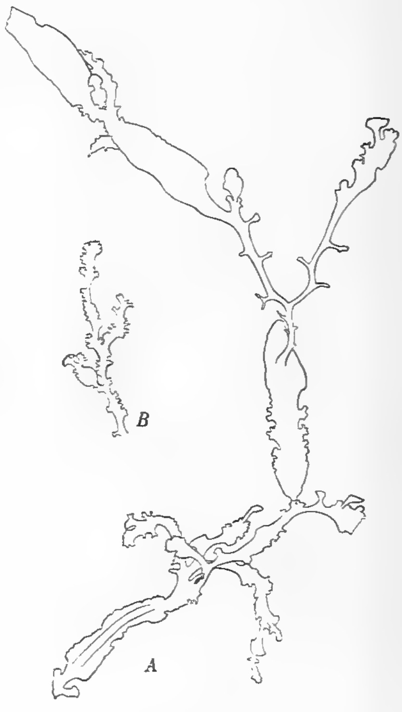


Fig. 526.
Phyllophora epiphylla f. *Bangii*. Hofmansgave, Caroline Rosenberg. **2 : 1.**

[1] Comp. WARMING, Oecology of plants. Oxford 1909, p. 178.

In other specimens the frond is much narrower than in the just named ones; the breadth of the frond is, indeed, variable, but 1—2 mm broad parts of the frond with feeble incisions as in the typical *Ph. Bangii* do not occur. Lyngbye named this form f. *tenuior* and numerous specimens from Hofmansgave are to be found in the herbarium. I have also found it in numerous localities and it is easy to distinguish from the broader form, and it is remarkable that f. *tenuior* is the only form occurring in the southern part of Lille Belt, in Store Belt and the western Baltic Sea. On the other hand it occurs together with the broad form in several localities in the waters north of Fyn. In the Western Baltic Sea it occurred in considerable quantities, in some localities together with other loose Algæ. Some of the specimens growing here produced shoots of a different character, being destitute of the numerous warts or lacinulæ but having long diverging branches with even borders. (Fig. 528 *C*). As these shoots are continuous with the usual crenulated form, their connexion with f. *tenuior* is evident notwithstanding the different shape. Likewise, the f. *tenuis* must be supposed to arise from the thinner shoots of the typical *Ph. Bangii*. F. *tenuior* does not branch by proliferations and is thus very different from the typical *Ph. epiphylla*.

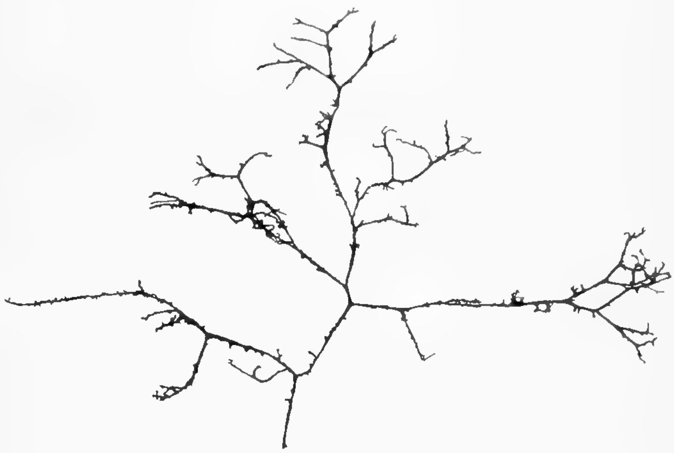


Fig. 527.
Phyllophora epiphylla f. *Bangii*, *tenuior*. Dredged south of Ærø, 7 m. 2:1.

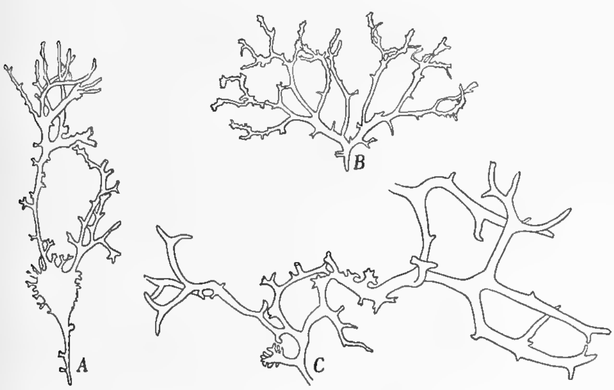


Fig. 528.
Phyllophora epiphylla f. *Bangii*, thinner form (f. *tenuior* Lyngb.). *A* with an expansion, *C* producing shoots without lacinulæ. *A* and *B* Hofmansgave; *C*, south of Ærø. *A* and *C* 3:1, *B* 2:1.

This species has thus the power of keeping alive in a loose condition, the shape of the frond being gradually much altered. In localities situated near the boundary of the genuine species specimens occur that are only different by the frond being partly more or less incised. In the typical *Ph. Bangii* he border is incised in its whole length, some parts of the frond being, however, broader, 1—2 mm broad, and only minutely crenulated; branching by proliferations may be met with. In the inner localities only a finer form, usually only 0.2—0.5 mm broad or less, is met with, f. *tenuior* Lyngb., without proliferations. The branches are alternate, divaricate, curved, with a varying number of branchlets.

The loose forms nearly always occur in water of lower salinity than that in which the typical species occurs; they often vegetate in water with a salinity of 20 ‰ or less.

Localities. α: *Ph. epiph.* f. *Bangii typica.* β: *Ph. epiph. Bangii* f. *tenuior.* — **Kn:** Frydenstrand by Frederikshavn, α. — **Ke:** FD, east of Læsø 9.5—11 m. — **Km:** ZC, 4—5 m, XE 2—4 m and KF, 6.5 m south of Læsø, all α; XF at Læsø Rende, 8.5 m, α and a little β; entrance to Mariager Fjord, Th. Mortensen, β; BH, off Gerrild Klint, 7.5 m, α. — **Sa:** PN, Kalø Vig, 5.5—11 m, β; PL, Wulffs Flak, 9.5—13 m, α; PK, Norsminde Flak, 5.5 m, β; MQ, south of Paludans Flak, 11.3 m, β; aV, east of Endelave, 10 m, α; aX south of Endelave 4.5 m, α; aH Lillegrund at Fyns Hoved, 7,5 m, α; aY, aZ and NZ, north coast of Fyn, α and β; Hofmansgave, washed ashore, α and β. (Hofman Bang, Lyngbye, Car. Rosenberg a. o.); NY, entrance to Odense Fjord, 6.5 m, α; Einsidelsborg (Car. Rosenberg); GC, east of Æbelø, 13 m, α; DJ, east of Æbelø, α; Æbelø (Lyngbye). — **Lb:** Off Bjørnsknude, 9.5 m, α; AL, Baaring Vig, 7.5 m, α; Flækøjet α (Biol. Station); DE, Thorø Rev. 5.5 m. β; DB, Lille Grund, 7.5 m; dH, east of Hesteskoen, 15 m, β. — **Sb:** Off Refsnæs, 19 m (C. H. Ostenfeld) β; Lerchenborg Strand, washed ashore, β (O. Smith); GS, Lysegrunde, β; LN, Stavreshoved, β; GQ, Slettings Grund, 7,5 m, β; NU, off Strandskov at Bovense, 13 m, β; AB, off Teglværkskov by Nyborg, 7.5 m, β; cL, NE of Sprogø, 25—27 m, β; BS, Palegrund, 7.5 m, β; VB Omø Tofte, 5.5 m, β; fP, east of Hov lighthouse, 5.5 m, β; DP and UJ at Onse Vig, 7 m, β; DQ, west of Nakskov Fjord, 5.5 m, β. — **Bw:** cF, south of Kegnæs, 8.5 m, β; dO, north side of Bredgrund, 5 m, β; dP, east side of the same, 7.5 m, β; fT, south side of Ærø, 7 m; off Drejet, 7 m, β; UQ, off Tillitse, 12 m, β.

4. **Phyllophora Traillii** Holmes et Batters.

Traill, Monograph of the Algæ of Firth of Forth. Proceedings of the Roy. Phys. Soc. of Edinburgh 1882, p. 13, sine descr., Holmes et Batters, A revised list of the Brit. Mar. Algae, Ann. of Botany Vol. V, 1890, p. 89, sine descr.; Batters, Mar. Algæ of Berwick 1899, p. 114, plate XI, figs, 6—11; id., A Catalogue of the Brit. Mar. Alg. 1902, p. 66.

At Fladen in the Eastern Kattegat I found in October 1922 at 17 metres' depth a small number of specimens of a little Alga which I think must be referred to the imperfectly known species *Phyllophora Traillii.* They were found growing on stones together with young plants of *Chætomorpha Melagonium* and *Chondrus crispus* and were only 3—6 mm high (fig. 529). They agree with Batters' description and drawings, and some of them bear small marginal leaflets which appear dark under the microscope. The fronds are feebly branched, laterally at the base or by dichotomy or they are still entire. They are contracted at the base in a short cylindrical stipe and issue from a well developed attachment disc. Owing to the very small number of specimens I cannot ascertain whether the leaflets contain procarps. According to Batters the cystocarps, which are entirely immersed in the leaflets, ripen in January and February at the British coasts. I have had for comparison original specimens from E. M. Holmes collected at Cumbrae, Scotland in March and April; they were small and sterile, without marginal leaflets.

In the harbour of Østerby on the north coast of Læsø in the Northern Kattegat three specimens were met with (July 1924) which must probably be referred to the same species. They are up to 1.5 cm high with a linear frond, partly bearing numerous marginal leaflets which are often longer and narrower than in the above mentioned specimens; the leaflets are all flat and sterile. These specimens are all without base; they were perhaps loose.

A specimen dredged in the North Sea NW of Thyborøn in 31 metres' depth was finally referred to this species, though with some doubt. It is 1.8 cm high, branched, with marginal leaflets, and sterile in August.

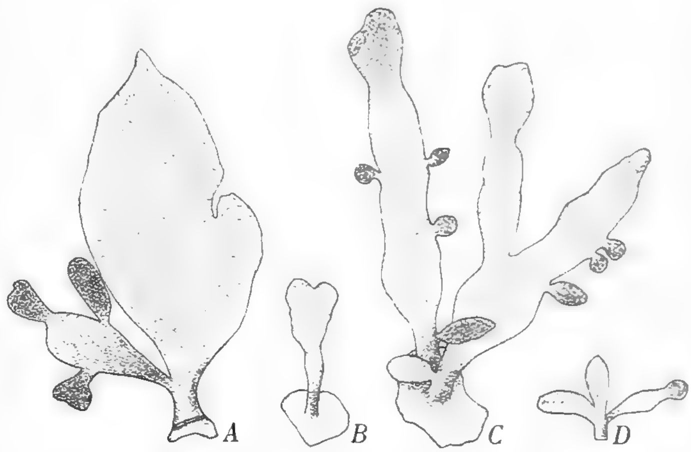


Fig. 529.
Phyllophora Traillii. Fladen, 17 metres' depth. 10 : 1.

The species has been met with at several places on the coasts of the British Isles (comp. Batters 1902), and it has also been recorded from the East coast of the United States by Collins. Tetraspores are unknown, and the structure and development of the cystocarps have not been examined.

Localities. **Ns:** aT Thyborøn beacon SE ½ E 14 miles, 31 m. — **Kn:** Østerø harbour, Læsö. — **Ke:** fH, Fladen, 17 m, October.

Ceratocolax K. Rosenv.

1. Ceratocolax Hartzii K. Rosenv.

Kolderup Rosenvinge, Deux. Mém. 1898, pp. 34—39.

When in 1898 I described a new Alga under the above name, growing parasitically on *Phyllophora Brodiæi* at the coasts of Greenland, I was not aware of the fact that the same or a nearly related species had long before been observed by Lyngbye (Tent. 1819, p. 11). In describing *Sphærococcus Brodiæi β, concatenatus,* this careful investigator characterized it as being set with "verrucis aggregatis, uvæformibus, pedicellatis, frondis e margine ortis". He did not take these bodies for fructifications, as they contained no "semina". Reinke directed the attention of Schmitz to these bodies and repeatedly sent him specimens of them from the Baltic Sea. Schmitz took much pains in examining them and finally arrived at the conclusion that they must be interpreted as "Produkte parasitischer Florideen". "Unter der Einwirkung eines ziemlich kleinen intramatrikalen Parasiten-Geflechts entwickeln sich traubenförmige Wucherungen des *Phyllophora*-Thallus: in diesen Wucherungen verbreiten sich intramatrical und langsam fortsprossend die intercellular kriechenden verzweigten Zellfäden des Parasiten; dann aber wachsen zu gegebener Zeit reichlich Zweigbüschel des Parasiten von den central gelagerten Parasiten-Geflechte auswärts hervor und bilden in analoger Weise wie bei *Act. roseus* an der Oberfläche je eines Höckers der *Phyllophora*-Wucherung ein fertiles flaches Polster, dessen antiklinfädige Zellreihen Ketten von Sporangien ausformen. Ich bin geneigt anzunehmen, dass diese traubenförmigen Wucherungen von *Ph. Brodiæi* durch eine eigenartige zweite Species von *Actinococcus* verursacht seien. Doch unterlasse ich es, schon jetzt diese Species durch Aufstellung eines selbständigen Namens zu unterscheiden" (Schmitz, Actinoc. 1893, p. 380).

These bodies have also been examined by Darbishire who found them at Helgoland as well as in the Baltic (Botan. Centralblatt, 1894, p. 369). He met with tetrasporangia which were usually quite colourless (white) and procarps with long, protruding trichogynes. On the other hand he did not observe the "intramatrical" filaments described by Schmitz. He concludes as follows: "Ich halte die ganze Erscheinung für eine pathologische Wucherung von *Ph. Brodiæi.* Hierfür spricht u. A. die weisse Farbe der Tetrasporen und ferner der Umstand, dass von den sehr zahlreichen Prokarpen aus nie ein Cystocarp gebildet wurde, obgleich ich öfters an den Trichogynen wohl erhaltene Spermatien haften sah".

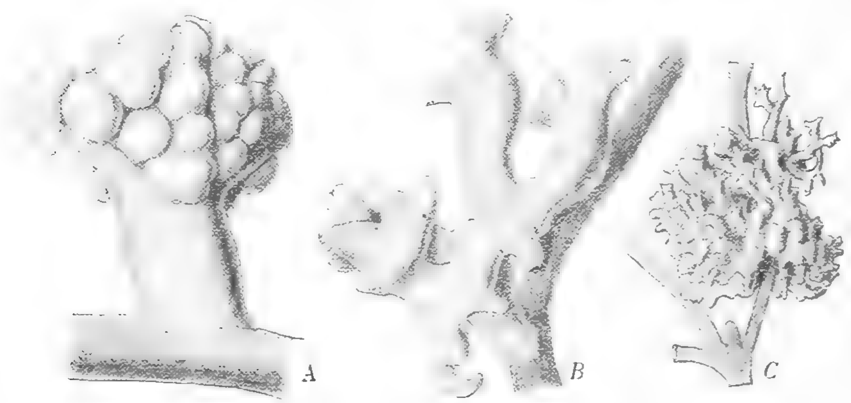


Fig. 530.
Ceratocolax Hartzii. A, from Hesteskoen east of Als. June. 11 : 1. *B*, from Højen near Faaborg. September. 11 : 1. *C*, from fN off Ballen, east of Samsø. August. 6 : 1.

The Greenland plant which I described in 1898[1] grows on the arctic form *interrupta* of *Phyll. Brodiæi*, on the flat side or on the border of the frond. It formed much branched bushes, 4—5 mm in diameter. At the base it penetrates a little way into the host plant, growing intercellularly. The cylindric branches bear globular nemathecia, while sex organs were not observed. The nemathecia remind one of those in *Phyll. Brodiæi.* The plants were not holoparasitic as they were red when living. The same species has later been met with at the coasts of Iceland (Jónsson) and in the Arctic American archipelago[2], on the same host-plant.

[1] On page 35 in my paper (Deux. Mém. 1898) l. 5 *fig.4* should be corrected into *fig. 7 A*.

[2] K. Rosenvinge, Mar. Alg. coll. by Simmons dur. the 2nd Norw. Arct. Exped. Oslo 1926.

The specimens from the Danish waters to be described below agree so well with the Greenland specimens that I think they must be referred to the same species. In describing them the differing views of SCHMITZ and DARBISHIRE will be taken into consideration.

Fig. 531.
Ceratocolax Hartzii. Vertical section of tetraspore-bearing plant. From Lille Belt, April. 30 : 1.

The organism in question, according to LYNGBYE, always grows on the loose, sterile f. *concatenata* of *Ph. Brodiæi*, and the specimens examined by SCHMITZ were probably also growing on this host-plant. It is, in reality, very common on this form in the Danish waters, but it also attacks the typical, fructiferous *Phyll. Brodiæi* and has the same appearance in both cases. It is much branched, the branches pointing in all directions. When the branches issue near the base, the outer outline of the plant becomes nearly globular, the ends of the branches reaching about the same distance from the centre (fig. 531). In other cases there is a cylindric stipe under the branched frond (fig. 530 *A*, *B*). The branches are repeatedly branched and often so crowded that the whole complex of branches is head-like. The branches are cylindric or a little complanated but never flat, often irregularly curved; in spring they usually end in a globular swelling, while later in the year the tips of the branches are not swollen but often much branched (fig. 530 *B*, *C*).

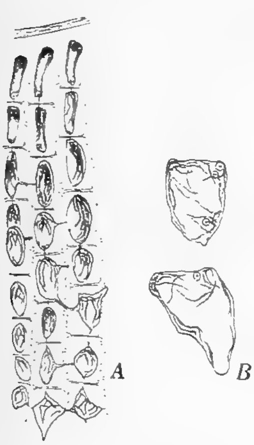


Fig. 532.
Ceratocolax Hartzii. A, section of cortex of the lower portion of the frond. *B*, medullar cells showing nuclei and chromatophores. 625 : 1.

The colour of the plant is pink, in particular in spring, or somewhat varying from yellowish to greenish according to the season and other external conditions, like that of the host-plant, but usually brighter, and brighter toward the tips of the branches.

The structure of the frond is somewhat similar to that of *Phyllophora Brodiæi,* but the consistency is softer. The cortex consists of outward directed cell-rows the innermost cells of which gradually pass into the medullary tissue. In the lower, sterile parts of the branches, the cortex is comparatively thick, consisting of regular parallel cell-rows, up to 6—8 cells long (fig. 532). In the upper, fertile regions, the cell-rows are shorter and not so densely crowded; the intercellular substance is here especially soft, and the arrangement of the cells is therefore often disturbed by microtomizing owing to the swelling of this substance (comp. figs. 537—539). The cortical cells are connected by primary pits in the transverse walls, but secondary pits may also occur in the longitudinal walls (fig. 532 *A*). The cells seemed often to contain a single calotte-shaped chromatophore, but in well-fixed material the cortical cells showed in some cases a system of narrow, thread-like bodies of which it was not easy to decide whether they were distinct chromatophores or branches of a much divided single chromatophore. In several cases a single nucleus was met with.

Fig. 533.
Ceratocolax Hartzii. Section of medullar tissue with smaller cells of secondary origin.

The inner tissue consists principally of isodiametric cells, increasing in diameter inwardly. The outer medullary cells have a structure similar to that of the inner cortical cells but they usually show two or three nuclei, and the inner cells a greater number. The medullary cells, in particular the larger inner ones, usually contain numerous small starch-grains and can be said to constitute a storage tissue (fig. 533). These cells are connected by numerous pits, primary and secondary ones, and it may happen that a wall separating two cells is traversed by two pits.

A system of smaller cells situated between the large storage cells and produced by budding from them is present in the interior of the frond; they are usually long and narrow and must if anything be regarded as representing a conducting tissue. Its cells are connected with the surrounding cells by secondary pits (fig. 533). It seems probable that these cell-rows have been interpreted by SCHMITZ as belonging to a parasite while the surrounding larger cells were supposed to belong to a hypertrophy of the host plant; nothing has, however, been found by me to support this interpretation.

In the paper (1898) where I have first described the species, I have stated that *Ceratocolax* penetrates into the medullar tissue of *Phyllophora* and sometimes even reaches the opposite face of the frond. In the Danish specimens I have never found the parasite penetrating so far into the host; usually the boundary line between the two organisms is situated nearly at the level of the surface of the host or is a little elevated towards the middle (Plate VIII, fig. 5). The limit is usually fairly distinct, though it is not always possible to say with certainty whether a cell belongs to the one or the other of the two organisms. This is in particular so in the central part of the limiting zone. The parasite has a softer consistence than the host, and its walls swell much more when treated with distilled water and various reagents; I also in some cases succeeded in obtaining a sharp boundary line when staining with hæmatoxylin after HEIDENHAIN and then with

Fig. 534.
Ceratocolax Hartzii. Vertical section of the marginal zone growing in the outer wall of Phyllophora. The walls of the parasite are hyaline. The undermost cells of the parasite penetrate into the cell-walls of the host. 670:1.

orange or safranine, the walls of *Phyllophora* staining intensely while those of *Ceratocolax* remain unstained or much feebler stained (fig. 534). In thin vertical sections it is then in some cases possible to observe, at the periphery of the insertion of the parasite, that the latter penetrates into the outer cell-wall under the cuticle, lifting the latter and sending thin haustoria from the lowermost cells into the cell-walls of the host (fig. 534). The cells are usually very small at the periphery of the insertion while they are much larger at the centre where it may sometimes be rather difficult to distinguish the cells of the two organisms from each other (Plate VIII, fig. 5, 6). But it is often evident that medullar cells of the host are separated from their neighbouring cells and incorporated in the tissue of the host as described already in 1898 (fig. 8 *A*).

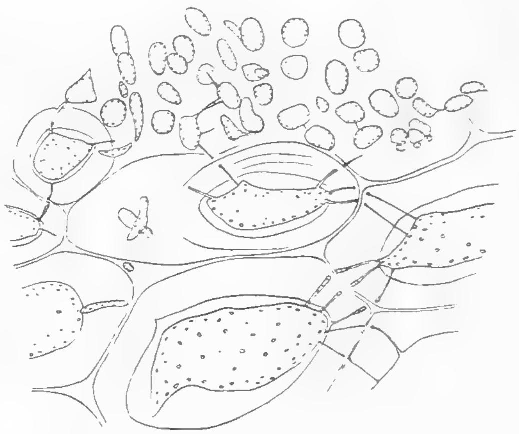


Fig. 535.
Ceratocolax Hartzii. Section through the limiting zone between the parasite and the host. 550 : 1.

In the plant represented in fig. 531 the lowermost part has the character of an attachment disc growing under the cuticle of the host plant (comp. Plate VIII, fig. 5), and such a disc may sometimes have a considerable extension. An unusually strong development of the attachment disc is shown in Plate VIII, fig. 8, where it is very thick and encompasses the marginal part of a frond of *Phyllophora.* More frequently, however, the limit between the parasite and the host is in the angle where the short cylindric stem meets with the surface of the host (fig. 530 *A*, Plate VIII, 4). It seems further to happen sometimes that the lowermost portion of the parasite is encompassed by a funnel-shaped outgrowth from the host consisting of a continuation of the cortical tissue of the latter, as shown in Plate VIII, fig. 7, where the medullar tissue of the host, too, extends considerably upwards in the centre of the stem. It is owing to the firm consistency and the high staining power of the cell-walls of the funnel-shaped cortex that it is assumed to belong to the host-plant. On the other hand the parasite may penetrate into the host-plant (Plate VIII, 4). When the small cells of the parasite meet with the large medullar cells of the host, they penetrate partly between, partly into the cells. The formation of secondary pits is very lively on both sides of the boundary line, and pits between the host and the parasite may be observed (fig. 535); but in other cases the medullar cells are invaded and often filled with the small cells of the parasite and then evidently killed (comp. fig. 535 to the right and Plate VIII, 4), and a number of the cortical cells must also have perished as a consequence of the attack of the parasite.

As mentioned above, nemathecia were observed by SCHMITZ (1893), DARBISHIRE

(1894) and myself (1898). They are very common in the Danish waters in spring. The branches of the nemathecia-bearing plants usually terminate in a globular swelling, and the nemathecia arise on the surface of these swellings. Nothing has been found to support the supposition of a genetical relation between the intercellular conducting tissue and the nemathecia, for the said tissue is only to be found at a certain distance below the young nemathecia. These arise by simultaneous division of the peripheral cells on a long stretch by periclinal walls, with the result that the surface on the stretch in question is covered with close anticlinal cell-rows (fig. 531, Plate VIII, fig. 9). The cells of these rows are rounded oblong or ellipsoidic and have an abundant plasmatic content; the thin plasmatic threads connecting the cells of the filaments are often easily visible in the young stages (fig. 536 *D*), later they could not be observed, and the regular arrangement of the cells is usually disturbed in the microtomized sections owing to the swelling of the intercellular substance.

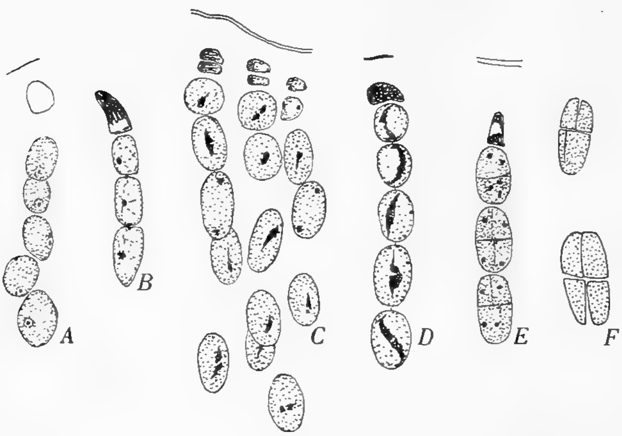


Fig. 536.
Ceratocolax Hartzii. Upper ends of nemathecial filaments. *A*, nuclei in the resting stage, February. *B—F*, April and May. *C—D*, nuclei in the first division. *E*, sporangia two- or four-parted. *F*, sporangia four-parted. 625 : 1.

The nemathecia have often a limited extent, but two or more young nemathecia may fuse together; the best developed ones form globular bodies at the end of the branches about $^{1}/_{2}$ mm in diameter (fig. 530 *A*, 531). In such cases the nemathecium occupies only the outer portion of the globular body while the central part is a parenchymatous tissue identical with the medullary tissue of the branches.

The last one or two cells of the nemathecial cell-rows are sterile, the others develop into sporangia. The number of the fertile cells in the cell-rows is usually only 6 or 7. Fig. 536 *A* shows young sporangia with nuclei in the resting stage, but without distinct chromatophores. Nor could the latter organs be distinguished in the later stages, perhaps with the exception of fig. 536 *B* where some of the seriate small bodies may possibly be reduced chromatophores. The dividing nucleus is lengthened with pointed ends, often curved and eccentric, sometimes of the same length as the cell. I regret that I was not able to observe the chromosomes in material treated with Flemming's weaker solution or with formalin-sublimate. The spindle-shaped bodies were often found divided in the middle, but the following divisions were not observed, so that it was not decided whether the next nuclear divisions take place before the first cell-division. At any rate, the sporangial cell is first divided by a transverse wall and afterwards by two longitudinal walls (fig. 536 *E*, *F*). The ripe sporangia are colourless; they contain a dense mass of protoplasm and numerous very small starch-grains. Chromatophores could not be detected, but colourless plastids are probably present. Young nemathecia with cells in the resting stage were met with in February, but as early as March four-parted sporangia were found, though most of them were still undivided, and in April and in particular in May numerous ripe sporangia were observed. Sporangia were rarely met with in June and never after that month. The ripe sporangia are 9—19 μ long, 8—11 μ broad, most frequently 14—15 μ long, 8,5—10 μ broad. — Single long sterile cells may occur between the sporangia; they are most easily observed in partly emptied nemathecia.

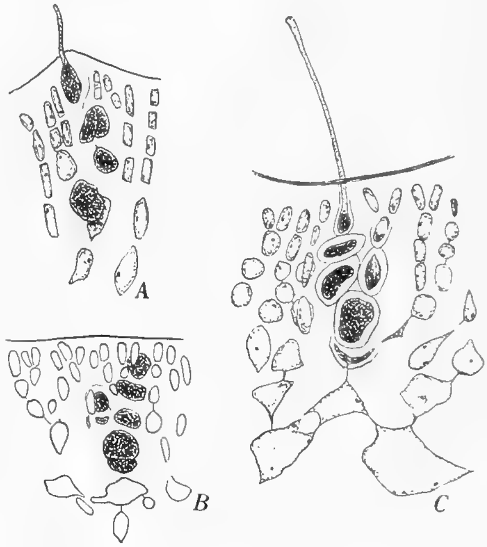


Fig. 537.
Ceratocolax Hartzii. Procarps, two with protruding trichogynes. August. 625 : 1.

The sexual plants differ from the sporangia-bearing ones by having no swollen globular ends. They are often much branched at the tips, but these branches have only the character of small warts (fig. 530 *C*). In sections of such irregular tips of the frond procarps may be found, often several together. A great number of procarps were observed in several plants, but only incompletely developed. The fertile character of these groups of cells is disclosed by their size and their abundance in plasmatic contents. When treated with hæmatoxylin after HEIDENHAIN they remained nearly black even after differentiation for a long time, so that the structure of the cells, in particular the presence of nuclei, could not be distinguished. Only in a specimen gathered in November and treated with formalin-alcohol it was observed that most of the cells of the procarps contained several small nuclei (fig. 539). The best developed procarps were found in specimens gathered near Samsø in August. Fig. 537 *C* shows such a procarp with long, protruding trichogyne; the carpogonial branch is here three-celled and borne on a large cell which is probably an auxiliary cell, much as in *Phyllophora Brodiæi.* Spermatia adhering to the trichogyne like those observed by DARBISHIRE, I have never observed. The other procarps from the same plant (fig. 537 *A*-*B*) can probably be interpreted in a similar manner, a trichogyne, however, being only developed in fig. *A*. In both procarps a lateral cell is borne on the first cell of the carpogonial branch. Feebly developed trichogynes are shown in fig. 538 but at any rate in some of the procarps here represented a three-celled carpogonial branch cannot be pointed out, and the procarps shown in fig. 538 *C*, too, can scarcely be reconciled with the type of a three-celled carpogonial branch. If the three-celled row of dark cells in fig. *A* is a carpogonial branch, a lateral cell is borne on its second cell. Fig. *B* apparently shows a supporting cell with two two-celled carpogonial branches. The interpretation of fig. *C* is difficult; to the left is shown what seems to be a three-celled carpogonial branch, but to the right of it two trichogynes are seen, the connection of which with carpogonial branches is doubtful. Nearly all the procarps observed had no well developed carpogonium and no trace of a trichogyne. Procarps were observed in nearly all the months of March to November, in particular from May to November. They thus occur partly at the same time as the nemathecia, partly (after May) alone.

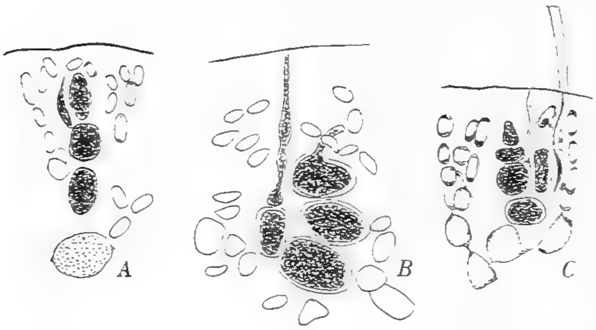


Fig. 538.
Ceratocolax Hartzii. Incompletely developed procarps. June. 625:1.

Any indication of a further development of the procarps, in particular from the auxiliary cells, was not observed, and cystocarps are unknown (comp. above).

As mentioned above, DARBISHIRE observed spermatia adhering to the trichogynes (1894, p. 369), but he did not describe the antheridia and spermatia. I have often seen what I supposed to be antheridia, most frequently in procarp-bearing specimens but I am not fully convinced of their sexual character. In sexual individuals the outer cortical cells are often disunited to a greater or less extent, in particular in specimens treated with FLEMMING's solution, and the outer cortex then consists of oblong or short cells imbedded in a hyaline gelatinous substance. The cells are not very different from the ordinary cortical cells but often contain a very distinct nucleus, situated near the lower end of the cell and stained intensely by treatment after HEIDENHAIN; the subjacent cells may then be the antheridia-producing cells (spermatangial mother-cells, SVEDELIUS). Comp. fig. 540 (Plate VIII, fig. 10). If the here described cells are really antheridia, the species is usually monoecious.

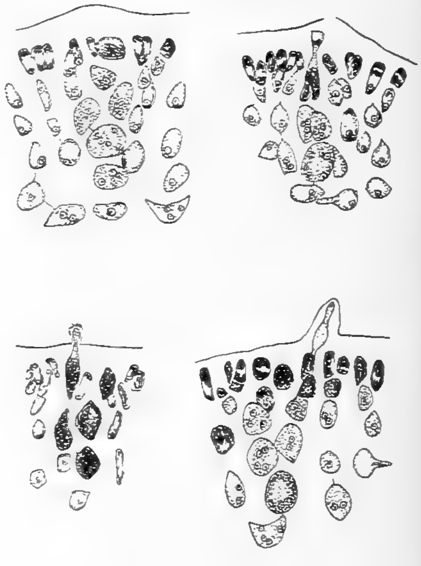


Fig. 539.
Ceratocolax Hartzii. Procarps with short trichogynes or without trichogynes. Nuclei visible in most of the cells. November. Sublimate-alcohol. 625 : 1.

Evacuated tetraspores have not been observed, nor their germination, but young plants raised in a culture were met with. On the 25th of May 1929 specimens of *Phyllophora Brodiæi* partly beset with *Ceratocolax Hartzii* bearing ripe tetrasporangia were placed in a glass vessel with sea-water and kept there for a long time. Three months later a number of young plants of *Ceratocolax* had arisen on other fronds or other shoots of *Phyllophora*, undoubtedly from tetraspores set free from the nemathecia, comp. fig. 541. In the middle of September these specimens contained no organs of reproduction. In April 1930 the tips of the branches of one of them were globular and turned out to be nemathecia, being composed of radiating cell-rows. Some of the cells of the latter were 4-parted, but the sporangia were not quite normal, probably owing to the unfavourable conditions of the culture. It must then be concluded that plants arisen by germination of tetraspores are able to produce tetrasporangia directly.

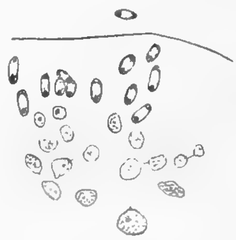


Fig. 540.
Ceratocolax Hartzii. Supposed antheridia. August. Formalin. 625 : 1.

The tetraspores seem to be the only reproductive cells which reach normal development, at any rate in the Danish waters. They are produced in spring, particularly in March to May. The sex organs are abortive and cystocarps are never produced. The specimens gathered after June never contain nemathecia but only sex organs, at least procarps, and might therefore be designated as gametophytes, but sex organs may also appear in the spring months, particularly in May, simultaneously with the nemathecia. It is possible that there exist distinct sexual and asexual individuals, resp. gametophytes and sporophytes, but at any rate in some cases procarps and nemathecia were found with certainty in the same individual, and this is perhaps a normal occurrence. It seems that sex organs normally arise in specimens first producing tetrasporangia, but this point deserves further investigation.

Fig. 541.
Ceratocolax Hartzii. Nearly 4 months old plants produced in culture in a glass vessel in which had been deposited in May specimens of *Phyllophora Brodiæi*, one of which bore a nemathecium-bearing *Ceratocolax*. Drawn in September. 2 : 1.

The Danish specimens have here been referred to the same species as the Greenland ones though there are or seem to be some differences. In specimens from East Greenland the parasite was found penetrating deeply into the frond of *Phyllophora*, deeper than in the Danish specimens, but I have later found Greenland specimens where the connection between the two organisms was much as in the Danish specimens. Another difference is that sex organs have not been observed in the Greenland specimens, but that may perhaps be due to insufficient investigation. Finally the sporangia seem to be larger in the Greenland specimens than in the Danish ones; in the former I found them 22—26 μ long, 12—16 μ broad, while in the latter they were only 9—19 μ long, 8—11 μ broad; but the dimensions of the sporangia seem to be variable.

In the Arctic Sea *Ceratocolax Hartzii* has been found with ripe tetrasporangia in spring (March, May), just as in the Danish waters. But it is remarkable that unripe nemathecia have been met with repeatedly in summer, June (West Greenland), August (East Greenland), July and September (Arctic America, K. Rosenvinge, 1926). It seems probable that nemathecia occur all the year round in the Arctic Sea.

The systematic position of the genus *Ceratocolax* remains uncertain so long as cystocarps are unknown, and the sex organs are only known as imperfectly developed and abortive. An affinity to the genus *Phyllophora* on which it is parasitic is highly probable.

The species is spread in nearly all the Danish waters, in particular the inner, more protected waters where it occurs at depths from 2 to 18 metres, perhaps most frequently on *Ph. Brodiæi* f. *concatenata*. It is met with in all seasons and reaches a diameter of from 2.5 to 5 mm. The greatest diameter, 5 mm, was met with in specimens gathered in May and September.

Localities. **Ns:** On *Ph. Brod.* f. *concatenata* at Blaavandshuk (C. M. Poulsen). — **Lf:** LY, on *Ph. Br. concat.*, between Gellerodde and Inderrön at Lemvig. — **Kn:** At Friis' Sten between Vesterø and N. Rønner, on *Ph. Br. typ.* 3 m. — **Ke:** HY, Store Middelgrund, 15 m, on *Ph. Br. typ.*; ad Nakkehoved (Lyngbye), on *Ph. Br. typ.*, washed ashore. — **Sa:** fN^3, off Ballen, Samsø, 11.3 m, on *Ph. Br. typ.*; Hofmansgave, on *Ph. Br. concat.*, numerous specimens gathered by Hofman Bang, Lyngbye, Car. Rosenberg. — **Lb:** Off Snoghøj; Fænø Sund; dE, Holst's Banke 8—13 m, on *Ph. Br. typ.*; dH and dH^1, east of Hesteskoen, 15—19 m, on *Ph. Br. typ.* — **Sf:** CA, Højen near Faaborg, on *Ph. Br. concat.* and *filiformis* (fig. 517 *C*). — **Sb:** Off Stavreshoved at Kerteminde; Bay of Kerteminde, on *Ph. Br. concat.*; NS, between Knudshoved and Slipshavn, on *Ph. Br. concat.*; XS, Kløverhage south of Nyborg, 5—6 m, on *Ph. Br. concat.*; fP, 1/2 mile east of Hov lighthouse, 10 m, on the same; UJ, near the broom at Onsevig, 7.5 m, on the same. — **Su:** OH, north of Lous' Flak, 10 m; at Dragør, on *Ph. Br. concat.* — **Bw:** bV, N. E. of Kobbel Skov, 7—13 m, on *Ph. Br. conc.*; bY, off Sønderskov, Sønderborg 11 m, on the same; cD, Middelgrund south of Als., 8—12 m, on *Ph. Br. typ.*

Ahnfeltia E. Fries.

1. Ahnfeltia plicata (Huds.) Fries.

El. Fries, Corpus florar. provincial. Sueciæ. I. Flora Scanica 1835, p. 310; J. Agardh, Sp. g. o. Alg. II pars I, 1851, p. 311; N. Wille, Bidr. (1885) pp. 13, 15, 50, plate II, figs. 11—12, plate V, fig. 52; B. Jönsson, Dickenwachst. 1891; Buffham, Anther. (1893), p. 302, fig. 43, 44; Schmitz, Actinoc. 1893, p. 397; Printz, Trondhjemsfj., (1926), p. 63; Gregory, New light on the so-called parasitism of Actinococcus aggregatus K. and Sterrocolax decipiens Schm., Annals of Bot. Vol. 44, 1930; Chemin, Ahnfeltia plicata Fries et son mode de reproduction. Bull. soc. bot. de France, t. 77, 1930, p. 342; Kolderup Rosenvinge, The reproduction of Ahnfeltia plicata. K. D. Vid. Selsk. Biol. Meddelelser, X, 2, 1930.

Fucus plicatus Hudson Fl. anglica, ed. alt. 1778, p. 589. English Botany, Vol. 16, 1803, plate 1089.

Fucus albus ? Oeder, Flora Danica, tab. 408, 1768.

Gigartina plicata Lamouroux, Thalass. 1813, p. 48; Lyngbye, Hydr. 1819, p. 42.

Gigartina Griffithsiæ Lyngbye Hydr. 1819, p. 43, tab. 11 C, (non Turner)[1].

[1] An examination of the specimens from Funen referred by Lyngbye to *Gigartina Griffithsiæ* has shown me that the "tubercula" interpreted by Lyngbye as "fructus" are not nemathecia but attachment discs of *Cystoclonium purpurascens* growing on *Ahnfeltia plicata*.

Gymnogongrus plicatus Kützing, Spec. Algar. 1849, p. 789; Tab. phyc. **19**, 1869, pl. 66; Harvey, Phyc. Brit. Vol. III, 1851, plate 288.
Sterrocolax decipiens Schmitz, Actinoc. 1893, p. 397.

The upright fronds spring from an expanded, thin firm disc intimately attached to the substratum, always stones, of a characteristic violet blue colour. By the colour it is usually easily distinguishable from other incrusting Florideæ, as for instance *Hildenbrandia prototypus*, which has a similar consistence but is either blood-red or yellow. The crust may reach a considerable extension before the first upright frond arises. Young fronds 1—5 mm high are often met with singly on the sides of stones picked up in summer at 1 to 2 metres' depth (fig. 542). But young fronds in greater number placed close together may also occur; then it is not always easy to decide whether they spring from one particular disc or from several fused together. Old specimens form light bushes composed of numerous fronds springing from an area of small extent. Such a case is shown in fig. 543 where about 100 fronds spring from an area with a maximal diameter of 1 cm whereas the basal crust from which they have arisen has a maximal diameter of more than 2 cm. In this case the crust has the appearance of being of single origin.

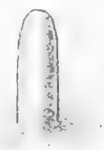


Fig. 542.
Ahnfeltia plicata. Young frond springing from an expanded disc. 10 : 1 (?).

Fig. 543.
Ahnfeltia plicata. Cluster of fronds springing from a thin disc appearing light in the photograph, extending as far as to the dark area to the right. Slettings Grund, Store Belt. November. 3 : 1.

The crust is built up of small almost squarish-cells, about 3 μ in diameter, arranged in vertical rows, with firm, not gelatinous cell-walls. The superficial cells are rounded outwards, but the outer cell-wall is scarcely thicker than the others (fig. 544). In older crusts this structure is sometimes interrupted by tissue with larger, more irregular cells.

The upright frond arises as a wart from the disc, a great number of the vertical filaments participating in it and showing divergence of the filaments, of which it is composed, and thus early showing conformity with the upper end of the cylindrical fronds.

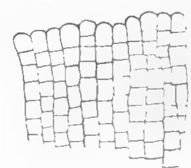


Fig. 544.
Ahnfeltia plicata. Vertical section of crust 625 : 1.

The fronds are cylindrical, rigid, horny, branched by dichotomy and by lateral ramification. They are usually forked at the top and later produce lateral branches, which have usually the character of adventitious shoots, but the lateral branches may also arise near the top. They appear in great number on the older fronds when the apical growth has been arrested by decay. A lateral branch often arises early near the dichotomy, and may then later suggest a trichotomy (fig. 545 *A*, *C*). HARVEY's figure (1851, pl. 288) shows a specimen branched throughout by dichotomy, whereas KÜTZING's picture 1869, pl. 66 represents a specimen almost exclusively branched by lateral ramification.

The thickness of the frond is nearly the same in its whole length, varying from 500 to 900 μ. It increases a little from the growing apex downwards, but the increase does not continue gradually from the growing apex to the base of the frond. From a short distance downwards the diameter varies irregularly between 400—500 μ and 900 μ. The branches are often thinner at the base than at a higher level. The cross section of the frond is circular or a little oblong.

Fig. 545.
Ahnfeltia plicata. *A*. frond branched by dichotomy. *B*. frond with dichotomous and lateral ramification. *C*. frond mainly with lateral ramification. $^4/_3$ n.s.

The frond may often reach a height of 16 cm but scarcely exceeds this size. It is unknown how long it takes before this size is reached. The growth of the perennial frond ceases in winter and begins again in early spring. In a specimen collected in the middle of May, the new portions of the frond were 1 to 1.5 cm, long, but I have not ascertained the annual increase in length of the frond. In a vigorous specimen from Frederikshavn (Deget) gathered in the middle of July I judged the increase of the year to be up to 3 cm, and I think that the annual increase in length will not generally exceed this figure. If this is correct, the tallest specimens should be at least 5 years old. But the specimens may certainly become much older, for many shoots die entirely or in part and are replaced by new lateral shoots. In autumn specimens may be met with in which a great number of the shoots have white tips, a sure sign of death and decay. The species often forms large carpets covering the upper or lateral faces of larger stones. Such carpets may certainly attain a great age, owing to the power of the expanded basal layer to produce new fronds.

The colour of the frond depends on the amount of light to which it is exposed. When growing in shady places it is lurid, showing a characteristic violet tint when observed against the light, and the same is the case with the lower parts of older fronds in the shadow of the younger ones, but the upper part of the fronds which are exposed to the full day-light in summer are prettily green, in autumn yellowish green. In winter the young portions of the fronds are much darker, not very different in colour from the older ones. JÓNSSON thinks that the darker colour of the older fronds is caused by the new cortical layers becoming darker than the foregoing ones, and that the lowermost parts of the fronds are the darkest because they contain the greatest number of cortical layers. In my opinion the dark colour of these portions of the frond is due to the fact that they are best protected against the destructive action of the light upon the phycoërythrine. I have once, at Frederikshavn (Borrebjergs Reef), met with a frond having the ordinary lurid-violaceous colour, but bearing a branched shoot, 6.5 cm long, having a pronounced blue-green colour contrasting with the colour of the rest of the frond. This shoot was at least 2 or 3 years old. It evidently contained much phycocyanin but not phycoërythrine.

The apical meristeme of the frond is built up of numerous thin, closely united filaments directed vertically towards the periphery and thus diverging. The outer cell-rows are gradually, by the growth of the frond, directed vertically to the longitudinal axis of the frond. The diameter of the outer cells is about 3.5 μ, and the superficial cells are scarcely thicker in the older parts of the frond. These rows of cells branch frequently in the meristematic portion of the frond, the apical cell dividing by an oblique cell-wall by which a new apical cell is cut off, while a branch is produced from the segment cell, the upper portion of which is cut off by a cross wall (fig. 546 *B*).

Fig. 546.
Ahnfeltia plicata. *A*, vertical section of apical meristeme. *B*, from a similar section showing ramification of the cortical cell-rows. 625 : 1.

The central part of the frond is built up of long cylindrical cells with very rigid refractive cell-walls, giving the central cylinder the character of a mechanical tissue (comp. WILLE, 1885, p. 13, 50, Plate II, fig. 12, V, fig. 52). The cells are terminated by transverse walls which are about as thick as the longitudinal ones; they do not, therefore, seem much adapted to the function of conducting substances, so much the more as the central pits are very thin and not easy to observe (fig. 547). The length of the cells is, however, great, though very variable; some cells were very long, up to 780 μ long, others much shorter, and it seems that a distinction can be made between very long-celled filaments and others consisting of short cells; the latter are perhaps of secondary origin. At the periphery the cells are shorter and gradually approach the inner cortical cells in size. WILLE (1885, p. 50) attributed *Ahnfeltia plicata* to the Florideæ with incompletely developed conducting tissue; he considered the last-named tissue, situated between the mechanical and the assimilatory systems, as such a conducting tissue. It, however, seems more adapted to a conduction between the assimilatory tissue and the central cylinder than for conduction in a longitudinal direction. The central cylinder has not only a mechanical function but also serves as storage tissue; I found the cells filled with starch-grains in summer and autumn (July to October) whereas in fructiferous plants they were without starch in spring (March to May). The intermediary

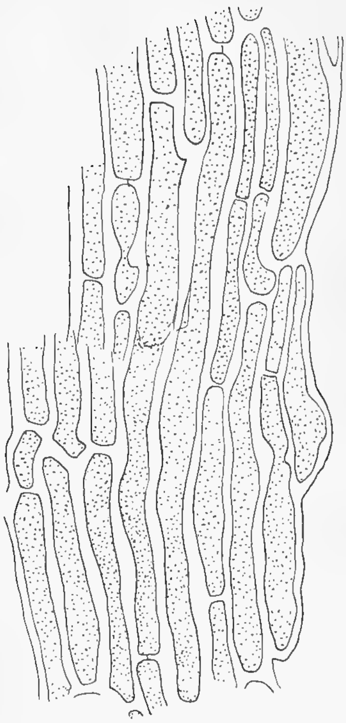


Fig. 547.
Ahnfeltia plicata. Longitudinal section of central tissue. 350 : 1.

tissue thus serves to convey the products of the assimilation to the central cylinder, and later to transport the dissolved nutrient media from the central tissue to the periphery.

The cortex has about the same structure as the basal disc; it is composed of small, nearly squarish cells with slightly rounded angles, arranged in radial rows having the same diameter in their whole length (comp. Kützing, 1869, pl. 66, fig. *e*, Wille, 1885, fig. 11). The cell-walls are moderately thick, the outer wall thicker, firm, not gelatinous. The whole cortex has a firm structure owing to the small diameter of the cells, and certainly contributes to the rigidity of the frond. The cortical cells contain one small nucleus. The chromatophores are not easy to distinguish owing to the small dimensions of the cortical cells. There often seemed to be one parietal plate at the upper end of the cells; but in a specimen treated with Flemming's weaker solution and stained after Heidenhain with erythrosin and examined under high power several disc-shaped chromatophores were observed in each cell, as shown in fig. 548 *B*, where also the primary pits are to be seen. Secondary fusions between cells of different cell-rows now and then appear (fig. 548 *A*). The cortex of the older fronds shows a stratification which is the effect of a periodical increase in thickness, which has been the subject of a thorough investigation of B. Jönsson (1891). The growth in thickness takes place in the outermost layer of cells which keep their dividing power. This, however, is not always in activity but is interrupted by resting periods leaving their trace in boundary lines characterized by thicker and more refractive membranes. Jönsson thinks these boundary lines arise because the walls of the outermost cells become thicker and more refractive than the inner walls during the resting period, whereas the new cells formed at the beginning of the growing period have comparatively thin walls. This explanation is certainly true but the figure (l. c. plate I, fig. 4) illustrating it does not give a true idea of the real structure. The boundary line is shown by Jönsson as a continuous thick wall corresponding to the outer wall of the frond,

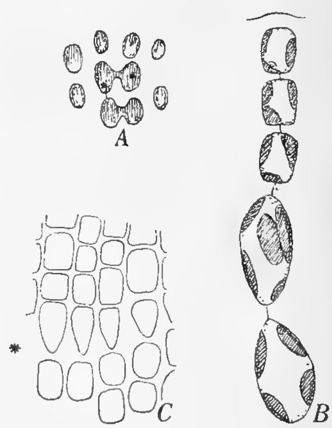


Fig. 548.
Ahnfeltia plicata. Transverse section of cortex. *A*, showing transverse fusion of cells. *B*, cell-row showing pit-connections and chromatophores 2100 : 1. *C*, section through the limit between two layers (*) 1200 : 1.

whereas the radial walls show no thickenings. This is undoubtedly due to the fact that the drawing has been made from a section which was not sufficiently thin. In examining a section only one cell thick it is evident that the thickenings in particular concern the radial walls. In the cells situated at the limit between two cortical layers the radial walls are much thickened at the base but the thickening diminishes upwards, with the consequence that the lumen of the cell is conical downwards and the area of the basal wall is very small. Thus no continuous thick transverse wall arises by the thickening of the transverse wall, but the thickened lower parts of the radial walls of the limiting layer of cells appear in thick sections as a thick refractive wall traversing the cortical tissue. The presence of a continuous thick transverse wall would not be easy to reconcile with the explanation given by Jõnsson, and it would be very unfavourable for the conduction of matter in a radial direction.

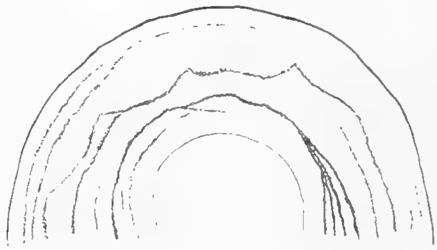


Fig. 549.
Ahnfeltia plicata. Cross section of older frond showing several irregular layers in the cortex. 83 : 1.

In older fronds, Jõnsson usually found from 4 to 6 cortical layers, once up to 12. The layers may be regular, but irregularities occur, the layers being incomplete, encompassing only a part of the stem, or secondary layers appear within the primary ones, dividing them, over part of their extent, into two or three subdivisions. Printz (1926, p. 63), who often found 6—8 layers, thinks that they indicate the number of years, while Jõnsson speaks with reservation of this question. I found the stratification so irregular in some cases that it was impossible to state the number of the layers. On one side of the frond the number of layers was high, e. g. 9, while on the other side it was much smaller owing to the fact that some boundary lines were vanishing, others confluent (fig. 549). Moreover, it was not always possible to distinguish the secondary layers from the primary ones. If the layers were regular annual productions like those of the ligneous Dicotyledons, one might expect to find the number of layers increasing from the top downwards; but that is, at any rate, not always the case. For in a large specimen I found about 3 layers near the base, at a higher level about 7. The diameter of the stem and the thickness of the cortex was also smaller than at a level one cm higher up, namely 530 μ and 130 μ against 670 μ and 248 μ. In the same frond the thickness of the cortex increased from the top to nearly one cm above the base (100; 125; 158; 178; 200; 248 μ). In this case the cortex has thus continued growing except in the lowermost part of the stem. A regular increase of the number of cortical layers could not however be ascertained in this case.

Fig. 550.
Ahnfeltia plicata. End of frond with nemathecia. December. $2^1/_2$: 1.

The older fronds are often beset with warts which have nothing to do with the fructification, nor do they seem to be undeveloped young branches, for they do not show the anatomical differentiation of the latter and must be considered as luxuriations of the cortex and may show stratification like this. Sometimes a cavity produced apparently by some parasite was found at the bottom of it, having its base at the inner limit of the cortex, and partly filled with what seemed to be decayed remains of the cells of the host which took a deep blue stain by methylen blue. They had an opening at the top of the wart and had been left by the parasite. It seems doubtful, however, whether the warts had really been caused by the supposed parasite, for in other warts no cavity seemed to be present, and similar cavities were found without causing such warts. In other warts the cavity was found filled with a granular matter which seemed to be small bacteria. The first described cavities have perhaps also been inhabited by bacteria which have left them later. The bacteria observed were very small; there seemed to be cocci and short rods. SCHMITZ has described tubercles containing bacteria in several other Florideæ (Botan. Zeit. 1892).

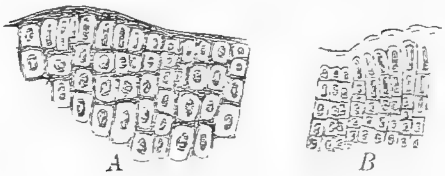


Fig. 551.
Ahnfeltia plicata. First origin of nemathecia. September. 670 : 1.

Reproduction. The reproduction of *Ahnfeltia* has been imperfectly known and disputed until quite lately. From the beginning of the ninetieth century, at least, cushions on the frond have been described and usually considered as the fructification of the species. LYNGBYE (Tent. 1819, p. 42) observed them in spring but did not meet with any spores. C. AGARDH (Spec. alg. 1822, p. 313) stated that they were composed of articulate filaments and named them nemathecia. KÜTZING (Tab. phyc. **19**, tab. 66, 1869) thought that the nemathecial filaments were transformed into seriate spores, but that has not been confirmed. The spores were first described by BUFFHAM (1893, p. 302) and SCHMITZ (1894, p. 397) who found that the spores are only produced in the end-cells of the nemathecial cell-rows, these cells each giving rise to one monospore. SCHMITZ submitted the nemathecia to an anatomical investigation and arrived at the conclusion that these bodies were not organs of the *Ahnfeltia* but that they were parasites, which he called *Sterrocolax decipiens*, growing on the surface of *Ahnfeltia* and penetrating into the cortex of the latter by numerous "Senker". But this inference was only founded on the presence of the said processes and not on the study of the development of the nemathecia or of the "Senker". Hence SCHMITZ's inference is not conclusive, and it would lead to the absurd conclusion that no kind of reproductive organs had ever been observed in *Ahnfeltia plicata.* To elucidate the question of the nature of the nemathecia I have examined their development and the germination of the spores. The results of my investigations have been published in a particular paper (1931) where I have also mentioned two smaller papers of GREGORY and CHEMIN treating the same question and published shortly before the publication of mine. Referring the reader for details to the latter, I shall here shortly give its substance, using again most of its illustrations.

The nemathecia form small cushions on the surface of the frond, orbicular or usually elliptical or oblong in outline (fig. 550). They arise in September from a group of superficial cells growing out simultaneously and dividing by cross walls (fig. 551). In September the cushions were only 1—2 cells high; in the middle of October the nemathecial cell-rows had grown longer, and the nemathecia had attained a larger extension by continued production of new nemathecial filaments at the margin (fig. 552). The continuity of the nemathecial filaments with the cortical cell-rows was stated in 1930 by GREGORY and CHEMIN. The first-named author maintained that the development of the cushion begins with a localized hypertrophy of the cortical tissue of *Ahnfeltia*. The nemathecial filaments are very thin, often only 2—3 μ broad. At this period (October) two kinds of cells different from the others appear. 1) flask-shaped cells, attenuated upwards, often appear in great number at the bottom of the nemathecium, arresting the growth of the filaments on which they are terminal (fig. 553). They have some resemblance to carpogonia but are not borne on particular cells comparable to carpogonial filaments and have only a small and feebly developed nucleus, and they cannot, therefore, be considered as true carpogonia but might probably better be interpreted as reduced hair-cells (comp. K. ROSENVINGE 1931, p. 8). 2) generative cells, thicker and richer in contents than the other cells, terminal or lateral, arise at the upper end of the nemathecial cell-rows, singly or in small groups which seem to arise by division of a single cell. The generative cells or some of them grow out, at first in particular in a horizontal direction, forming more or less irregular cell-rows, the cells of which are larger than the sterile cells. Some of them may be rather hyaline

Fig. 552.
Ahnfeltia plicata. Nemathecium, October. *A*, vertical section, 244 : 1. *B—D*, upper ends of nemathecial filaments with generative cells. 670 : 1.

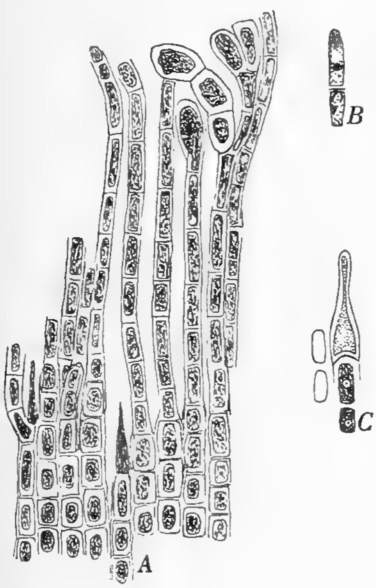


Fig. 553.
Ahnfeltia plicata. From a nemathecium, October. *A*, nemathecial filaments showing flask-shaped cells below and generative cells above. *B*, upper end of primary nemathecial filament. *C*, flask-shaped end-cell. 1080 : 1.

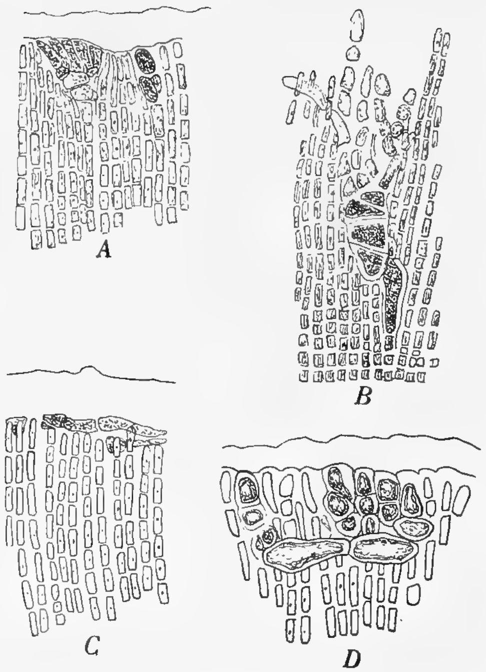


Fig. 554.
Ahnfeltia plicata. Vertical sections of nemathecia, October, showing groups of generative cells and horizontal or obliquely upward growing cell-rows springing from them. 625 : 1.

and poor in contents, while others have a rich plasmatic content (figs. 554, 555). Fig. 555 *A* shows the border of a nemathecium the outer portion of which is built up entirely of generative cells and their derivates. In fig. 554 *B* is shown a group of generative cells, situated at a low level in a nemathecium, from the upper cells of which new branched cell-rows growing obliquely upwards are produced. The lower part of this group is reminiscent of the "Senker" described by SCHMITZ.

In specimens collected in the middle of November the nemathecia had grown thicker and had also increased in circumference (fig. 556, Plate VIII, fig. 11). The generative cells which have arisen in October are found again in the lower portion of the cushion, partly immediately over the limit towards the cortex, partly at a somewhat higher level. They are easily recognisable by their greater size, their irregular shape, their dense cell-contents and their high staining power. A great number of upward growing cell-rows issue from them (figs. 557, 558). These cell-rows resemble the primary nemathecial filaments, but are, at any rate at first, somewhat thicker than the primary ones; they form new, secondary nemathecial filaments constituting the upper layer of the nemathecium. The irregular shape of the generative cells depends partly on the fact that fusions often take place between cells from different cell-rows (fig. 557). It is probably these fusions to which GREGORY refers (1930, p. 768), when he thinks it possible that they may represent a very much reduced sexuality. The nuclei of these cells were usually not very

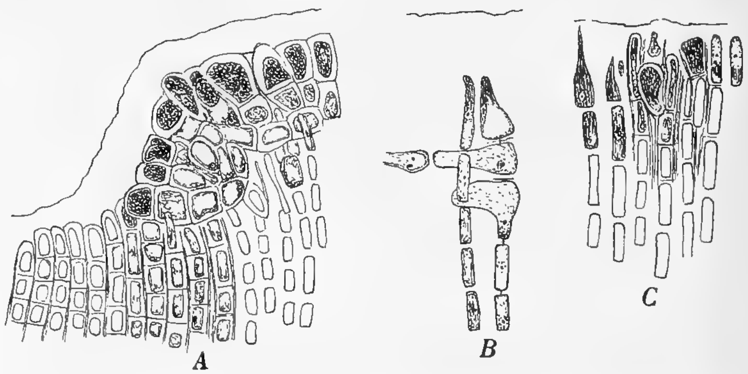


Fig. 555.
Ahnfeltia plicata. From a nemathecium, October. *A*, vertical section of the border. *B*, generative cells giving rise to horizontal cell-rows. *C*, generative cells and flask-shaped cells. *A* 960 : 1. *B* and *C* 1080 : 1.

distinct; at all events nothing has been found to support such an assumption, and it must be remembered that fusions occur between ordinary cortical cells too (comp. p. 558).

The development of the primary nemathecial filaments is to a great extent stopped by the formation of the flask-shaped cells and the generative cells; these filaments are replaced by new, secondary nemathecial filaments, and it seems probable that the development of the other primary nemathecial filaments, which have not produced any of the aforementioned particular cells, is also arrested after the formation of the generative cells and their derivates, so that the upper layer of the nemathecium is exclusively or for the most part built up of secondary nemathecial cell-rows.

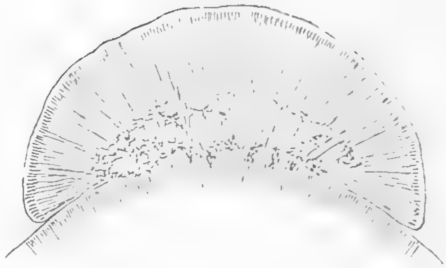


Fig. 556.
Ahnfeltia plicata. Vertical section of nemathecium, November. 160 : 1.

The marginal portion of the nemathecium is composed in the winter months of horizontal cell-rows which have probably taken their origin from generative cell-rows or their derivates like those shown in fig, 555 *A*, and must therefore be considered as secondary nemathecial filaments. The under side of the peripheral part of the nemathecium is appressed to the surface of the frond, but the undermost nemathecial cell-rows are not connected with the cells of the cortex (fig. 556).

The narrow cells of the secondary nemathecial filaments contain a small nucleus and one or more chromatophores. The apical cell has more plasmatic contents and a larger nucleus. It is at first scarcely thicker than the other cells but, when the cell-divisions are finished, it takes an oblong or obovate shape and develops into a monosporangium. This organ contains 2 to 4 or more very distinct chromatophores, most frequently rod-shaped or ribbon-shaped, and it is remarkable that these bodies not seldom were found lying in pairs close together (figs. 560, 561). My assumption is that they were on the point of fusing together

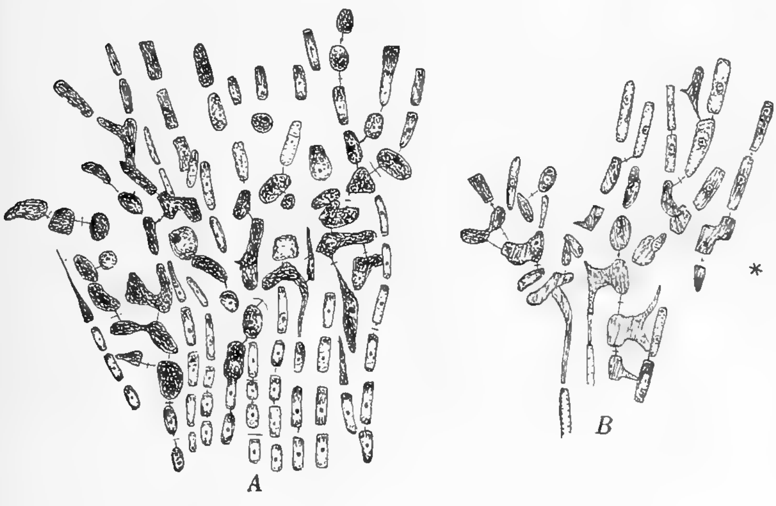


Fig. 557.
Ahnfeltia plicata. Vertical section of lowermost part of nemathecium, November. The irregular cells rich in plasmatic contents are situated at the level of the surface of the frond*. 1080 : 1.

along their longitudinal axis. It is in accordance with this interpretation that the ripe monospores seem to contain one single chromatophore (fig. 562 *G*).

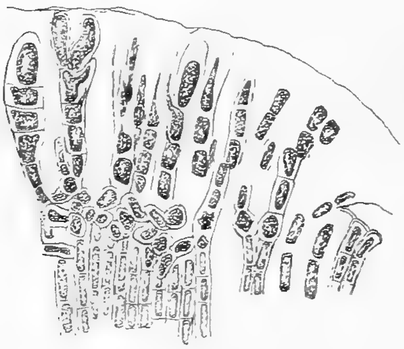


Fig. 558.
Ahnfeltia plicata. Vertical section of nemathecium near the border, December. 670 : 1.

The nucleus of the monosporangium is most frequently found in the resting stage, showing a large nucleolus or central body surrounded by a well marked hyaline halo but no chromosomes. In other cases the central body was differentiated into small grains staining intensely with hæmatoxylin. When they were most distinct, the number of the latter was seen to be four (fig. 561). In a dividing nucleus (fig. 561 *A*2) two groups of such 4 grains were to be seen. There can be no doubt that these grains were chromosomes. When Gregory (l. c. p. 768) states that "There is some evidence that there are eight chromosomes in the apical cells and in the monospores of *Sterrocolax decipiens*", it seems probable that this remark alludes to such dividing stages. The nuclear divisions observed were evidently all mitotic, and no indication of a synapsis stage or a heterotypic division was ever met with. It must be concluded from my investigations that the chromosome number of the (secondary) nemathecial filaments and the monospores is 4, and the nuclei of the frond seem to have the same number (comp. K. Rosenvinge 1931, p. 19).

The monospores ripen in winter and are still to be found in May. The ripe sporangia are ellipsoid or obovate. The number of chromatophores in the ripe sporangia is not easy to observe in fixed and stained material; there is a great amount of matter staining with hæmatoxylin surrounding the nucleus. A further fusion of chromatophores perhaps takes place here. After the evacuation of a

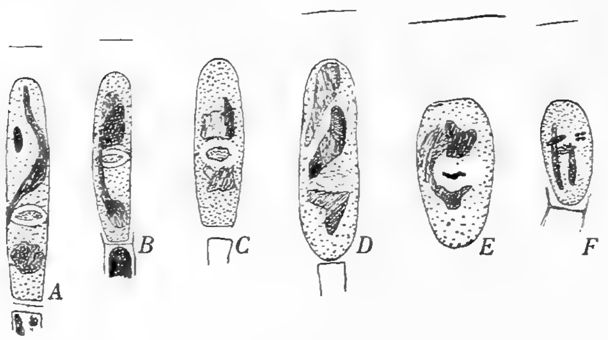


Fig. 559.
Ahnfeltia plicata, November (Flemming, Heidenhain). End-cells of (secondary) nemathecial filaments showing nucleus and chromatophores. In *F* the limitation of the nucleus is indistinct, a group of 4 chromosomes is situated to the right of the central body. 1800 : 1.

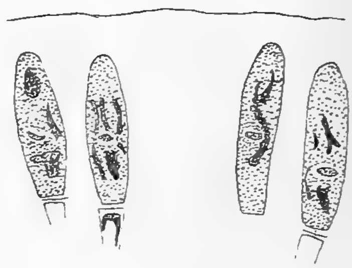


Fig. 560.
Same material as fig. 559. Four end-cells from the same section showing nucleus and chromatophores, the latter apparently partly fusing together. 1800 : 1.

monosporangium, a new sporangium can be developed from the cell beneath it (fig. 562 *D, E*). The ripe nemathecia are yellowish.

Germination of the monospores. Chemin (1930, p. 350) has observed the first stages of the germination of the spores and stated the interesting fact that the attachment disc does not arise directly by cell-divisions of the spore, but that the germinating spore first gives off a short germ tube which by segmentation forms a small orbicular disc. This may be contiguous to the spore cell or connected

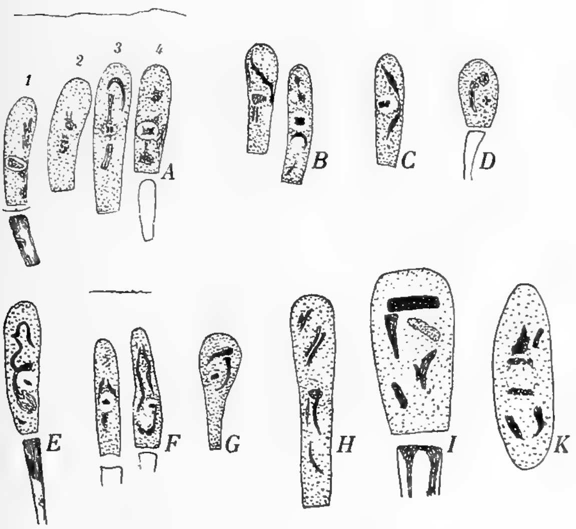


Fig. 561.
Ahnfeltia plicata. From a nemathecium from Frederikshavn, Henn. Petersen, May (Alcohol, Heidenhain). End-cells of nemathecial filaments showing very distinct chromatophores partly paired, and nucleus. In A^4 the nucleus is apparently in the first dividing stage, in A^2, the nucleus has lately divided and the two daughter nuclei show each four chromosomes but are still without nuclear membrane. 1800 : 1.

Fig. 562.
Ahnfeltia plicata. *A—F* from the same material as in fig. 561. Ripe monospores are present in *C*. The narrow, clavate intensely stained cells in *E* are perhaps end-cells of obliterate primary nemathecial filaments. *G*, living spore set free in May. *A—D* 670 : 1. *E—F* 1080 : 1. *G* 670 : 1.

with it by one or two cylindrical cells. This mode of germination agrees with that found in *Gloiosiphonia capillaris* (comp. the present work, part II, p. 277; comp. also *Dudresnaya* (Killian, Entw. Florid. 1914, p. 238). According to Chemin the protoplasm of the ripe spore is colourless and does not contain any trace of chromatophores or phycoërythrine. It was only in the two weeks old discs that "des chromatophores pariétaux s'organisent dans les cellules les plus âgées et chaque germination apparaît sous forme d'une petite tache rose". I did not find the spores just set free from the nemathecium colourless, but containing a yellow-brown chromatophore and numerous refractive bodies (starch). It is probable that the single chromatophore has arisen by repeated fusions of the originally multiple chromatophores, as described above. In the cultures established in May 1927 the first stages of the germination were unfortunately not observed. Only about three months after the sowing the young germlings were detected as small violet (not rosy) orbicular discs recalling those described and figured by CHEMIN. They were merely somewhat larger, the smallest ones consisting of about 30 cells, and no germ-tube was to be seen. In several cases the discs bore single hyaline hairs. Nor was I able to observe any germ tube on recently re-examining a slide containing numerous germlings from my culture in 1927, conserved in glycerin. As the germlings were nearly three months old, it is, however, quite possible that a germ-tube may have been present but decayed later without leaving any trace. It would be of interest to see whether the germination always takes place in the manner described by CHEMIN, or whether the germ disc may also arise by direct segmentation of the spore cell. In CHEMIN's cultures the discs multiplied after two months, new filaments growing out from some of the marginal cells and producing a new disc at their extremity. Such a multiplication was not observed in my cultures. Upright shoots were not given off in CHEMIN's cultures nor in mine. In my older cultures, the discs increased in diameter and became thicker, the cells dividing by horizontal walls, in particular in the middlemost part. An old disc measured 90 μ in diameter. These discs agreed exactly in colour and structure with the more expanded discs found in Nature from which the upright fronds of *Ahnfeltia* spring (comp. figs. 542 to 544). The discs met with in Nature often reach a considerable size before the formation of the first upright frond takes place.

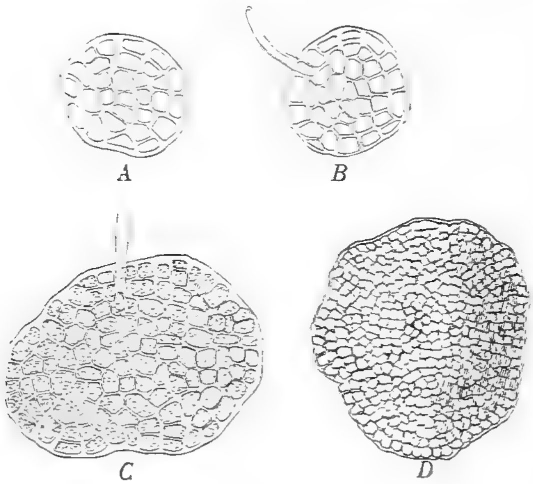
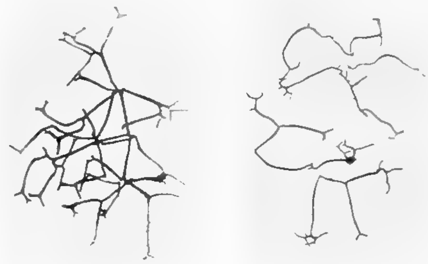


Fig. 563.
Ahnfeltia plicata. Germlings obtained by sowing monospores in May 1927. *A—C* about three months old, in *B* a young hair-cell, in *C* a long hair springs from the disc. *D* a two years old germling. *A—C* 625 : 1. *D* 350 : 1.

The principal conclusion from what has been set forth above is that SCHMITZ's view that the nemathecia are of a parasitic nature cannot be upheld. The nemathecia are outgrowths from the frond of *Ahnfeltia*, as maintained also by GREGORY and CHEMIN. They are the only organs of reproduction and finally produce monospores. Sex organs and tetrasporangia do not exist. As to the interpretation of the very peculiar mode of reproduction of *Ahnfeltia* reference may be made to the discussion in my previous paper (1931, conclusions, p. 21—25). Here I shall merely emphasize that the generative cells appearing in the young nemathecia are considered as reduced procarps. and that the cell-filaments growing out from them are considered as corresponding to the sporophytic phase of the typical diplobiontic Florideæ. The frond and the primary nemathecial filaments make the first generation, corresponding to the gametophytic generation of the diplobiontic Florideæ, though sex organs are not produced, whereas the cell-filaments springing from the generative cells, the secondary nemathecial filaments and the monosporangia, belong to the second, sporophytic generation arising from the first without any process of fertilization. As no fertilization takes place and no other nuclear fusion has been observed, it must be supposed that no diploid nuclei occur, and it is in good accordance herewith that the number of chromosomes seems to be the same (4) in the two generations, and that the formation of the monospores takes place without chromosome reduction. The monosporangia must most probably be considered as reduced tetrasporangia which have failed to be divided owing to the wanting reduction division of the nuclei, and the nemathecia of *Ahnfeltia* would then be comparable to the nemathecia of *Phyllophora Brodiæi.* In the discussion in my previous paper (1931, p. 24), yet another interpretation has been taken into consideration, namely that the secondary nemathecial filaments might be considered as gonimoblast cell-rows. The whole complex of secondary nemathecial filaments would then be a compound cystocarpium and the monospores must be regarded as carpospores. This interpretation seems, however, to be less probable than the first. Comp. Svedelius, Nuclear Phases and Alternation in the Rhodyphyceae. Beih. z. Botan. Centralbl. Bd. 48 (1931) Abt. I, p. 57.



A *B*

Fig 563 bis
Ahnfeltia plicata, f. *tenuior*. *A*, from NU, off Bovense, Store Belt. *B*, from aV, east of Samsø. 1.2 : 1.

The systematic position of the genus *Ahnfeltia* remains doubtful, as sex organs and cystocarps are wanting. The presence of nemathecia perhaps warrants its classification among the *Gigartinaceæ*.

Ahnfeltia plicata occurs in all the Danish waters except the Baltic Sea around Bornholm (**Bb**), from a little below low-water mark to 10 metres' depth, always growing on stones.

Localities. **Ns:** Thyborøn, on a groin. — **Sk:** Hanstholm, washed ashore; 13 miles SW by W1/2W of Rubjerg Knude light-house, 14 m, sand, a small specimen (C. A. J.); Hirtshals, the mole, stones west of the mole, Emstenen. — **Lf:** Common on stony ground from Kobberød, 2—4 m, to Hals mole (F. Børgesen). — **Kn:** Krageskovs Rev; Hirsholmene; Strandby; stony reefs around Frederikshavn; several localities north of Læsø; Nordre Rønner; TL. — **Ke:** Søborg Hoved Grund and Vesterlands Grund at Gilleleje; Gilleleje harbour. — **Km:** Vesterø harbour Læsø; XF South of Læsø; BO off Stensnæs; Gerrild Bay (Lyngbye); KG off Nordstrands Klint, Anholt. — **Ks:** Grenaa harbour; NB, Havknude Flak; Jessens Grund; EJ and HQ, Lysegrund; Hesselø (Lyngbye); Lynæs harbour; GG, Sjællands Rev — **Sa:** Common on stony ground. — **Lb:** Common from Bogense harbour to Brandsø, Linderum, at Sønderballe Hoved and dG, Hesteskoen. — **Sf:** CC, Hornenæs; CA near Faaborg; Ærø (Kjærbølling); Skaarupør (E. Rostrup). — **Sb:** Numerous localities along the coasts from 1 to 7 metres' depth, abundantly e. g off Stavreshoved near Kerteminde at 2—4 metres' depth. — **Sm:** Orehoved. — **Su:** Off Ellekilde and Hellebæk; Sletten harbour; Middelgrunds Fort. — **Bw:** Off Kobbel Skov, 1—2 m; dO, Bredegrund; fT south of Marstal, c. 10 m. — **Bm:** Præstebjergs Rev, 7 m.

Loose form: f. *tenuior* Lyngbye Tent. Hydr. 1819, p. 42.

In the inner Danish waters, in sheltered localities a loose form frequently occurs, in particular in the *Zostera*-formation, entangled among the rhizomes together with other loose Alga. It is well described by LYNGBYE under the above name, and authentic specimens collected at Hofmansgave by LYNGBYE are to be found in the herbarium of the Botanical Museum at Copenhagen. It is characterized by small dimensions (about 1—2 cm in diameter) and by the thin dichotomous frond with divaricate branches. It often forms irregular clumps with the branches pointing in all directions. It propagates by vegetative division, the frond by degrees dying away at the base during continued dichotomizing at the top (fig. 563 bis).

Localities. **Kn:** 6 miles SSW $^1/_2$ W of Læsø Trindel's light-ship, 8 m (C. A. Jørgensen); fE, east side of Krageskovs Rev, 7 m; Frydenstrand near Frederikshavn. — **Km:** XC, XE (Silderøn), KT and XF south of Læsø; 5 $^1/_2$ miles N by E $^3/_4$ E of Østre Flaks light-ship (C. A. J.); entrance to Mariager Fjord (Th. Mortensen). — **Sa:** PL, Wulffs Flak; AS, Mejlgrund; aV between Samsø and Endelave, 10 m, abundantly; aY at Fyns Hoved; MQ south of Paludans Flak, 11 m; Endelave bay (Thomsen); Hofmansgave (Lyngbye); cU and NZ north of Fyn; at the beacon east of Æbelø. — **Lb:** FY and AX, Bjørnsknude; FZ, Kasserodde; dA, at the beacon Fyrrenden N.

VI. Rhodymeniales.

Fam. 16. Rhodymeniaceæ.

1. **Rhodymenia palmata** (L.) Grev.

Greville, Algæ Brit. 1830, p. 93; Harvey, Phyc. Brit. II, pl. 217 (1849); J. Agardh, Sp. g. o. Vol. II pars II (1852) p. 376; Thuret, Rech. s. la fécond. des Fucacées etc. Seconde partie. Ann. sc. nat. 4e sér. tome 3, 1855, p. 43, pl. 3, figs. 8, 9. Wille, Morph. og phys. Stud. over Alger. Nyt Mag. f. Naturvid., Bd. 33, II, 1891, p. 99. Buffham 1893, p. 294, Pl. 13, figs. 13, 14; V. M. Grubb, Prelim. Note on the reprod. of Rhodym. palm. Annals of Botany, Vol. 37, No 145, 1923; E. M. Delf and V. M. Grubb, The spermatia of Rhodymenia palmata, Ag. Ann. of Botany, Vol. 38, No. 150, 1924; Ch. Killian, Le développement morphol. et anatom. du "Rhodym. palm". Annales d. sc. nat. 10e sér. t. 8, 1926; Printz, Algenveg. d. Trondhjemsfjordes 1926, p. 72; M. A. Westbrook, Contrib. to the cytology of tetrasp. plants of Rhod. palm. Ann. of Bot., Vol. 42, No. 165. 1928.

Fucus palmatus L. Spec. plant. II, p. 1162 (1753).

Fucus bullatus O. Fr. Müller, Flora Danica, tab. 770, 1778.

Fucus caprinus M. Vahl, Flora Danica, tab. 1128, 1794.

Fucus delicatulus M. Vahl, Flora Danica, tab. 1190, 1797.

Sphærococcus palmatus Kützing, Phyc. gener. 1843, p. 409. Taf. 63 I, Tab. phyc. 18, Tab. 89, 90.

The frond springs from an orbicular attachment disc, but a smaller or greater number of fronds, besides the primary one, may issue from the same disc, though usually of a smaller size. An attachment disc more than 1 cm in diameter showed in the centre the remains of the decayed primary shoot, near it three fronds produced later, and at the border a great number of small, feebly developed fronds. The frond of the first year has a short cylindrical stipe which is flattened upwards into the wedge-shaped base of the flat frond. This may be undivided or more or less cleft at the top, the first is very often the case in the Danish waters. Young plants are found in summer, e. g. on the stipes or the laminæ of *Laminaria digitata* and *L. hyperborea*, and are easily recognisable by their structure. They must have arisen by germination of tetraspores produced in winter. The development of the young plants has been described by KILLIAN (1926) on the basis of material from the above-named substratum. The growth of the frond stops at the end of summer. In specimens from greater depths and from the inner waters

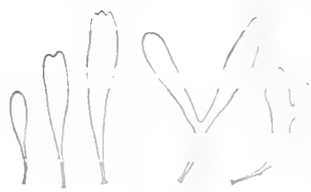


Fig. 564. *Rhodymenia palmata*. Young plants growing on the frond of *Laminaria digitata*. August. Nat size.

the frond of the first year is usually undivided or only feebly divided at the top, but adventitious shoots may be produced at the margins. Broad fronds more or

Fig. 565.
Rhodymenia palmata. Lille Belt. *A*, Fredericia harbour, June. *B*, Middelfart, July. *C*, Kongebro, August 1/2 nat. size.

less divided were principally found in harbours where they were protected against the waves and not strongly illuminated. The ramification of the primary frond, and of the secondary segments, takes place by dichotomy or polytomy or, more rarely, in a more irregular manner, the growing power of the upper marginal zone ceasing at one or more points. KILLIAN has shown (l. c. p. 204) that a cleaving of the frond may also take place by longitudinal slits arising under the mechanical influence of the waves either accidentally or in certain predestined places, much as in the *Laminariæ*. It seems, however, that this mode of division is rarely realized in the Danish waters where the species never occurs in places so much exposed to the influence of the waves as on the rocky shores of the Atlantic.

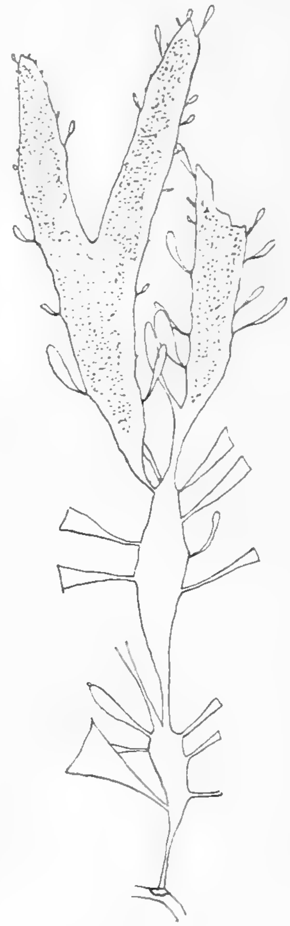


Fig. 566.
Rhodymenia palmata. Hellebæk, February (Børgesen). Four generations of shoots are to be seen. Nat. size.

Adventitious shoots arise at the margin of the frond in autumn and winter and grow out in the spring months to new assimilating frond segments. Their number is variable and their arrangement indeterminate. The segments are contracted at the base into a stipe, and this is usually so for the apical segments as well as for the lateral ones, and they have then all the character of adventitious shoots. Sometimes, however, though more rarely, there is only a slight or no constriction at the base of the apical segment or of the upper portion of the frond that has grown out after the last resting period, and the new portion then appears as a direct continuation of the old frond, produced by continued activity of the same marginal meristematic zone. Comp. fig. 566. Such cases were in particular observed among the broad fronds growing in harbours and further in repeatedly dichotomously divided narrow specimens from the Øresund. The difference between the new and the old frond is usually very distinct owing to the brighter colour of the first, and often too owing to the presence of organs of reproduction on the latter. It may happen that the upper portion of the frond dies or is eaten by animals in the course of the first year; adventitious shoots are then produced from the cicatrized border of the resting frond. The marginal fronds may produce new marginal adventitious fronds in the following winter, and the same process may be repeated once more. Three or four generations of shoots frequently occur, from which it can be concluded that the frond may reach an age of three or four years (fig. 566). The frond often attains a length of 20 cm, more rarely 24—27 cm (Lille Belt, Øresund). The frond segments of each year usually measure 10—13.5 cm.

As to the structure of the adult frond reference may be made to WILLE (1891). The marginal meristematic zone at the upper end of the frond does not show particular apical cells nor a marginal series of apical cells but consists of a great number of close cells without distinct arrangement. The frond is built up

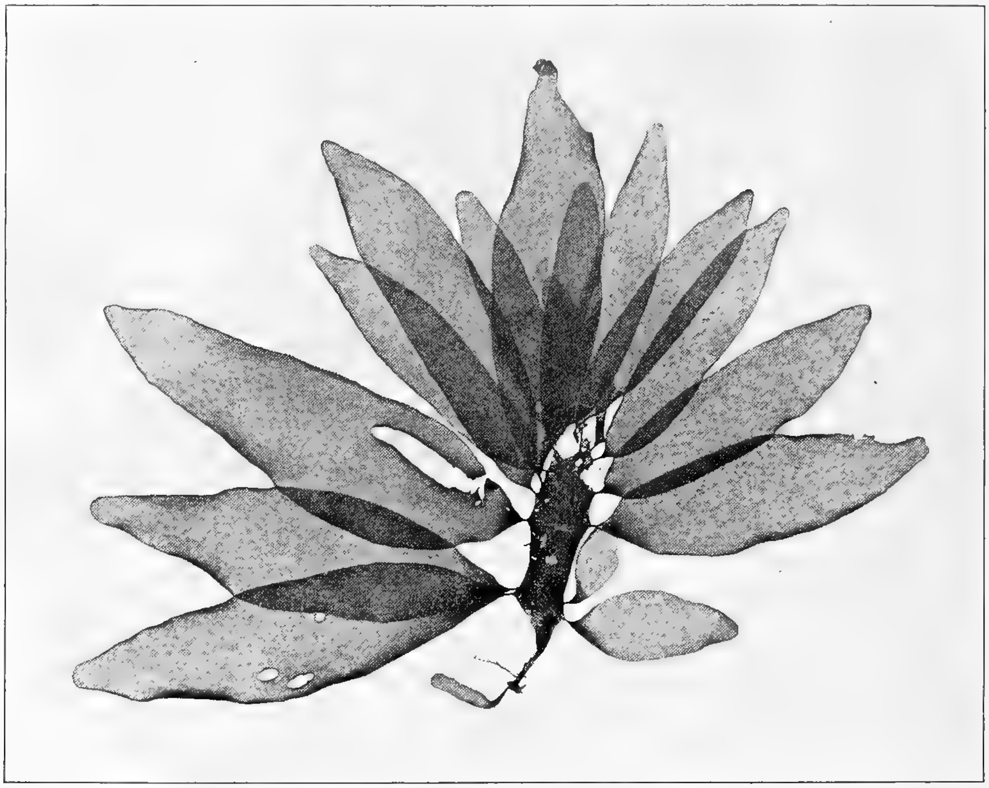


Fig. 567.
Rhodymenia palmata. From Eastern Kattegat, near Læsø Trindel, 19 m. May. Photo, $^2/_3$ nat. size.

of an inner tissue of one or two layers of large thick-walled cells, a medullary layer or mechanical tissue (Wille 1891, p. 104), and an outer assimilating tissue consisting of 1 to 2 layers of smaller cells containing numerous chromatophores (fig. 568). An intermediate layer, (secondary mechanical tissue Wille), is situated between the assimilating and the medullary layers.

Fig. 568.
Rhodymenia palmata. Superficial cells from young plant. 622 : 1.

The young fronds and frond-segments bear numerous hyaline hairs, developed from ordinary peripherical cortical cells from which they are separated by a basal wall situated at the level of the surface of the frond (fig. 569). The hairs appear on the young plants, but only when they have reached a length of about 8 mm. In the older fronds the hairs only occur in the young segments while they are still growing. The hairs are very numerous but are confined to distinct spots, where each superficial cell may bear a hair, while no hairs are found outside these spots (fig. 569, comp. L. K. R. 1911, p. 212). They are easily visible in the living plants, and the spots can be distinguished in dried specimens (fig. 567). The hairs were met with in the months of March to July; they are then shed, and the plants are hairless from August to the end of the winter. The hairs were first described by WILLE (1891, p. 103). V. M. GRUBB took them for trichogynes (1922, p. 151), a view which cannot be maintained, as true procarps have never been ascertained, and as the hairs occur on tetraspore-bearing and on male individuals, while female specimens are unknown; the hairs are purely vegetative organs agreeing with the hyaline hairs of such common occurrence among the Florideæ.

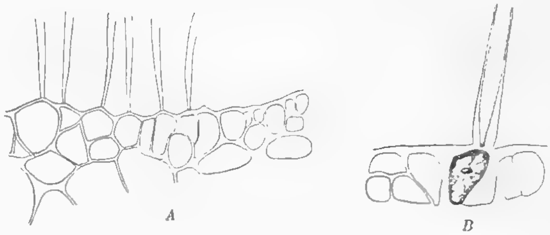


Fig. 569.
Rhodymenia palmata. *A*, transverse section through a part of a spot of hairs (400 : 1), *B*, base of a hair (630 : 1). (From K. Rosenvinge 1911, p. 212).

The large medullary cells do not contain starch as storage matter. On the other hand the frond contains a soluble carbohydrate which, according to KYLIN (Zeitschr. physiol. Chemie **101** 1918, p. 245), is trehalose and may amount to 14.8 p.c. of the dry weight.[1]

Fig. 570.
Rhodymenia palmata. Stipe of young plant. The large cells of the medullar tissue are to be seen in the upper part of the stipe. About 50 : 1.

KILLIAN has followed the development of the germinating spores, without doubt tetraspores, which he found on stipes of *Laminariæ*. The spore is divided by vertical and horizontal divisions, forming an hemispherical attachment organ, at the top of which a cell becomes larger than the others and takes the function of the initial cell of the young frond, which is at first fusiform, later flattened. The apical initial cell only functions in the quite young frond; it is early replaced by a multicellular meristeme, but its existence is of great interest, suggesting, as emphasized by KILLIAN, that *Rhodymenia palmata* may be derived from the type with a central axis ("Centralfadentypus").

The upper portion of the stipe contains a medullar tissue gradually tapering downwards. In a cross section it appears as an oblong or elliptical group of large cells sharply bounded towards the thick cortical tissue composed of radiating cell-rows. This cortex shows stratification in older fronds (comp. JÖNSSON 1891, p. 23, KILLIAN 1926, p. 207). In a specimen from Skagen, which was judged to be two or three years old, the presence of two or three layers in the cortex was ascertained.

[1] According to a recent note by H. COLIN and É. GUÉGUEN the sweet principle of this Alga is a monogalactose of glycerol. (Acad. d. sciences, Paris, July 21, 1930; cited from Nature, No. 3176, Vol. 126).

The attachment disc increases in diameter by marginal growth (comp. KILLIAN 1926, p. 206), but the thickness increases too by continued apical growth of the vertical cell-rows of which it is composed. The large disc mentioned above showed a horizontal zonation, evidencing the periodicity of the growth. The number of the layers was not always easy to ascertain, because the limits between the layers were often indistinct and sometimes confluent, much as in the cortex of *Ahnfeltia* (comp. p. 559); at least 4 or 5 layers could be distinguished.

The reproduction of *Rhodymenia palmata* is remarkable by the fact that tetrasporangia and antheridia have long been known while female sex organs and cystocarps have hitherto been searched for in vain.

The tetrasporangia are produced in irregular patches on both sides of the frond; they arise from superficial cells, being early cut off from a stalk-cell, which remains short, while the surrounding sterile cells divide by transverse walls, forming short cell-rows which make up the greater part of the sori (comp. KÜTZING, 1843, Taf. 46 I). The sporangia are cruciately divided. The development and the cytology have been carefully examined by Miss M. A. WESTBROOK (1928). Reference is made to this publication for details, the principal facts only will be related here. In the prophase of the first division of the tetrasporangium a double spireme stage and a synizesis were ascertained, and although this occurrence "is not absolute proof of meiosis, the constant association of the three in the sporangia of other Florideae suggests that in *Rhodymenia* too chromosome reduction is effected" (p. 164). The number of chromosomes could not, however, be determined with certainty, and the reduction division is therefore not quite settled. In the cortical cells, the number of chromosomes was judged to be greater than twenty.

The ripe tetraspores, according to WESTBROOK, contain numerous starch grains, small discoid plastids and an inconspicuous central nucleus.

The sori arise in the fronds or frond-segments which have been produced the winter before.

The development of the sori probably begins in autumn, for ripe tetrasporangia occur in winter (January to April). But the first stages of the sori were not observed by me. In the fertile specimens gathered in March and April, the sporangia were to a great extent exhausted. It seems that the tetraspore-bearing parts of the fronds normally die after the dissemination of the spores. Sori are therefore not to be found in summer and early autumn; in two cases only emptied sori were still met with in July (**Bw**) and September (**Ks**).

At more northern coasts the occurrence of the tetrasporangia is not limited to the winter, for at Iceland (JÓNSSON) and in Trondhjem Fjord (PRINTZ) they may be met with the whole year, and at the isles of Færöe they were met with in April, May, June and November (BØRGESEN), while at the coasts of England and France (Cherbourg) they only occur in winter.

The antheridia form patches on both sides of the frond similar to the tetrasporic sori but of a paler colour. They were first mentioned and figured by THYRET

(1855, p. 43, figs. 8—9), later by Buffham (1893, p. 294, pl. XIII, figs. 13—14), and more recently E. M. Delf and V. M. Grubb have given an account of their development (1924). According to the latter authors, the development of the male sori begins with a transverse division of the superficial cells. The lower cell thus formed is the basal cell, the upper one the antheridial mother-cell, which can produce in alternate succession at least four antheridia. Male specimens were met with in March and April.

Female sex organs and cystocarps are quite unknown; and as they have certainly been searched for repeatedly by many algologists in this wide-spread alga, it seems probable that they are really wanting. As mentioned above (p. 573), the interpretation of the hyaline hairs as trichogynes cannot be maintained. When the carpogonia are wanting, the question of the occurrence of a reduction division in the developing tetrasporangium will be of great interest. In case the reduction division can be definitely ascertained, a mixie might be supposed to take place at one or other moment of the life-history of the species. If a regular meiosis does not take place, there will be good accordance with the fact that a normal fertilization does not occur. In any case the spermatia are functionless though their structure is apparently quite normal. According to the facts known it must most likely be assumed that the reduction division in the tetrasporangia is initiated but not fulfilled owing to the wanting process of fertilization.

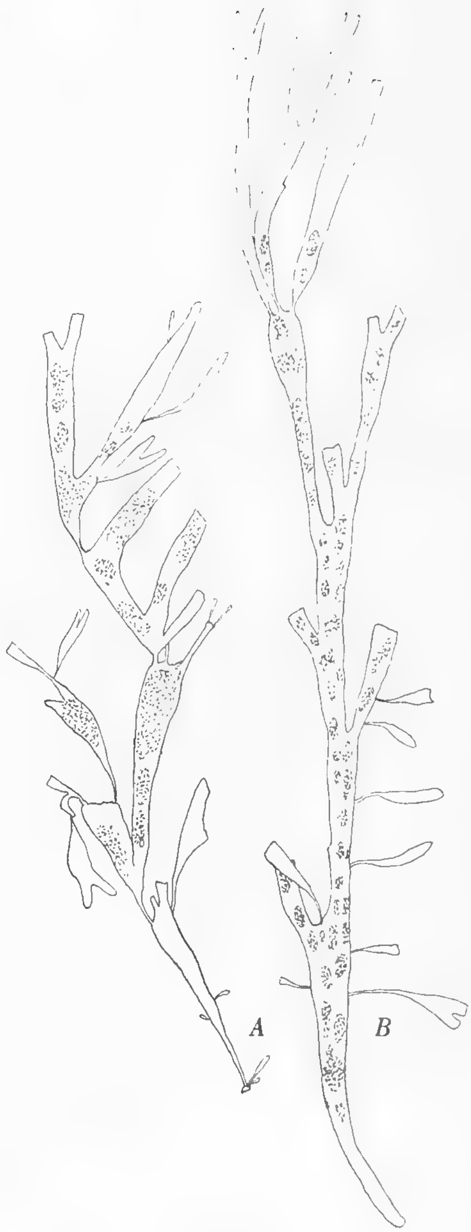


Fig. 571.
Rhodymenia palmata. From the Baltic, QZ off Moens Fyr, 7.5 m. July 1894. ²/₃ nat. size.

Rhodymenia palmata grows on stones and on various Algæ, most frequently on the stipes of *Laminaria digitata* and *hyperborea*, further on *Fucus serratus*, *Furcellaria fastigata*, *Chondrus crispus*, *Phyllophora membranifolia* and on roots of *Zostera*. It occurs most frequently at depths of (5), 7—20 m, more rarely down to 24 m. At slighter depths, 1 m, it has only been met with in harbours (Frederikshavn, Lille Belt). It grows in company with various other Algæ and usually constitutes only a slight part of the vegetation. It was found most abundantly in the Øresund, not only in deep water of high salinity south of Hveen but also at smaller depths in localities with a much lower mean salinity (around Taarbæk Rev).

In the Baltic Sea its occurrence seems rather dubious. It is true that it has been recorded at Darsserort by REINKE and in two localities in **Bm** in the neighbourhood of Møen; but in the two latter places it only occurred in a loose condition. In the one (SD) the small specimens were found in deep water on sandy bottom in company with several other loose Algæ; the specimens had an attachment disc, but most of them were attached to loose specimens of *Furcellaria*. In the other place (QZ), numerous long specimens were found at 7 or 8 metres' depth on stony bottom in company with *Fucus vesiculosus*, *Fuc. serratus* and other attached Algæ, but all the specimens of *Rhodymenia palmata* were certainly loose (fig. 571). Most of them had no basal portion; in some of them, to be sure, an attachment disc was present, but this seemed not to have been in function at the moment of collecting, or it was attached to a fragment of *Furcellaria* or a little stone only 5 mm in diameter. The specimens were long (up to 28 cm), mostly repeatedly dichotomous, linear, about 5 mm broad; although collected at the end of July they were beset in the greater part of their length with more or less confluent dark spots which turned out to be sporangial sori with checked sporangial mother-cells. These sori occupied a much longer portion of the frond than in the normal fronds and often occurred on two or three consecutive frond segments. Altogether the specimens remind of the specimens growing in the Øresund, and it seems highly probable that they have been introduced into the Baltic Sea by storms from the West, when the salt bottom water overflows the threshold at Saltholm and carries with it the Algæ torn off by the movements of the water. They have then been able to vegetate for some time in the loose condition in a locality where the salinity is only 8—10 p. m. Several other Algæ occurring here in loose forms have undoubtedly the same origin.

Localities. Not met with in **Ns**, **Sk** and **Lf**. — **Kn:** Harbour of Skagen; NV Rev, 7—9 m, Tyskerens Rev, Hvidstens Rev, NØ Rev at Hirsholmene; east of Græsholm, south of Hirsholm, 11 m; between Hirsholm and Kölpen, 7.5 m; at Deget; harbour of Frederikshavn; Tønneberg Banke 16—18 m; Læsø Trindel 11—15 m. — **Ke:** ZE[1], ZF, fH, Fladen, 17—22.5 m; Groves Flak 19 m (Børgesen); on the shore at Nakke (Lyngbye, April 1834). — **Km:** Gjerrild Bugt (Lyngbye, on the shore). — **Ks:** RL, near Ostindiefarer Grund, 15 m; on the shore at Tisvilde (Lyngbye) and Rørvig (E. Rostrup). — **Sa:** Vejrø Sund; PG west of Hatter Rev, 8 m; GD, north point of Sejerø, 11—14 m; PE off Revsnæs, 23.5 m. DK Bolsaxen 13—15 m; AH[1], Lille Grund at Fyns Hoved, 9.5 m. — **Lb:** Fredericia, harbour; Strib, harbour; Middelfart, harbour and 15—20 m (Rasch,!); Kongebro; off Snoghøj, 15—19 m; Fænø Sund; off Stenderup, 13—15 m. — **Sb:** GU, off Asnæs, 19 m; GP, at Halskov Rev, 10—11 m; UE, at Vresens Puller, 7 m. — **Su:** Hellebæk on the shore (Børgesen); Kronborg, on the shore (Nolte, C. Rosenberg, Steenberg, Ørsted); PZ, east of Hveen; TF[1], Staffans Flak, 12—13 m; bM, south of Hveen, 22.5 m; OH and bN, off Vedbæk, 10 m; east of Taarbæk Flak, 12.5 m, (S. Lund); Taarbæk Rev, 12—15 m, abundantly; OG[1], between Trekroner and Middelgrund. — **Bw:** Not observed by me; according to Reinke not met with in the western Baltic except at Darsserort at 20 metres' depth. — **Bm:** On the shore at Stevns (C. H. Ostenfeld); SD, N. E. of Møens Klint, 23.5 m, sand, loose, though several spec. with attachment disc; QZ off Møens Klint, 7.5 m, abundantly, loose, some with attachment disc. Similar specimens collected by Liebman at Møen, undoubtedly on the shore, are to be found in the herbarium of the Botan. Museum of Copenhagen.

Fam. 17. Champiaceæ.

Chylocladia Grev.

1. **Chylocladia kaliformis** (Good. et Woodw.) Hook.

Hooker, British Flora Vol. I, 1833, p. 297; Harvey, Phyc. Brit. II, 1849, pl. 145; Berthold, Pringsh. Jahrb. XIII, 1882; Debray, Bull. sc. du dép. du Nord 2e Sér., 9e an., 1886, p. 258; Debray, Bull. sc. de la France et Belg., t. 22, 1890, p. 405; Hauptfleisch, Fruchtentwickelung, Flora 1892, p. 360; Hassencamp. Bot. Zeit. 1902; Kylin, Studien 1923, p. 37—44.

Fucus kaliformis Good. et Woodw., Trans. Lin. Soc. Vol. III, 1797, p. 206, tab. 18.

Gastridium kaliforme Lyngb. 1819, p. 70.

Lomentaria kaliformis Gaillon, Résumé méth. des classifications des Thalassiophytes. Dict. des scienc. nat. Strasbourg 1828, p. 19; Kützing, Phyc. gen. 1843, p. 440, pl. 55; Nägeli, Neu. Alg. 1847, p. 246, tab. X, figs. 13—21. Flora Danica (Liebman) tab. 2578, 1852; J. Agardh, Sp. g. o. II, 3, 1863, p. 731; Kützing, Tab. phyc. 15 tab. 86, 1865; Wille 1887, p. 76—79, figs. 55—64.

As to the nomenclature of the species, reference may be made to the explanation by Hauptfleisch (1912, p. 308).

The structure of the frond has been treated by several authors (Nägeli, Berthold, Wille, Debray, Hauptfleisch, Hassenkamp, Kylin). The reader is referred principally to the papers of Hassenkamp and Kylin quoted above; here only the most important facts will be adduced. The frond is tubular, articulated with diaphragms at the constrictions. The wall of the frond is composed of one layer of large cortical cells, from the outer edges of which smaller cells are cut off by oblique walls. These small cells do not form a continuous layer but form a reticulate system of outer cortical cells. The large, primary cortical cells are at first angular, nearly isodiametrical, when seen from the face; later they increase considerably in the direction of the longitudinal axis of the frond. — There is not one apical cell at the tip of the frond, as indicated by Nägeli and Wille, but a number of cell-rows meet at the apex, each with an apical cell dividing by transverse walls. Within the cortex run a number of about 16 to 20 longitudinal, narrow cell-rows, and at regular intervals the cavity of the frond is traversed by septa composed of a single layer of cells. The

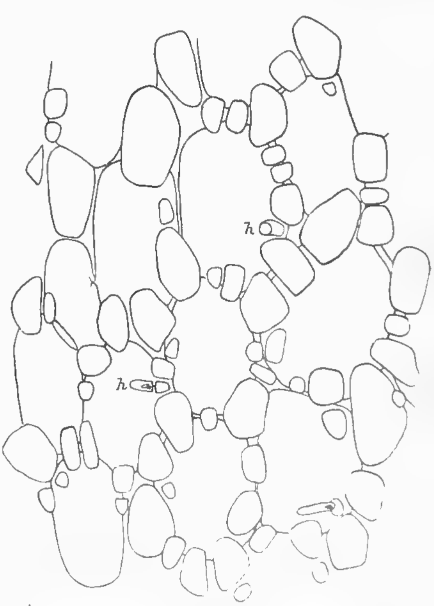


Fig. 572.
Chylocladia kaliformis. Surface view of frond *h*, hair-cells. 200 : 1

large cortical cells originally contain one nucleus, later a greater number (comp. Kylin 1923, p. 39), and numerous very small chromatophores, situated at the outer wall or at the anticlinal walls, or even at the inner wall of the cells; they are orbicular or shortly rod-shaped, often arranged in curved rows. The refractive bodies observed by Berthold (1882, p. 690) in the large cortical cells in specimens growing in sunny localities at Naples, were not met with in the Danish waters, but that is undoubtedly due to the fact that the species here is exposed to a much smaller intensity of light; it always occurs in rather deep water (7—18 m), the sea-water is much more troubled here than usually in the Mediterranean, and the sunlight does not penetrate so deeply, owing to the smaller height of the sun. The blue iridescent gloss of the plant described by Berthold I have never seen; nor does it seem to have been observed at the coasts of the British Islands. The colour of the living plants collected in July and August is bright pink, often yellowish or greenish. A greenish plant took a bright pink colour in drying.

Fig. 573.
Chylocladia kaliformis. Tip of frond with hairs. 195 : 1.

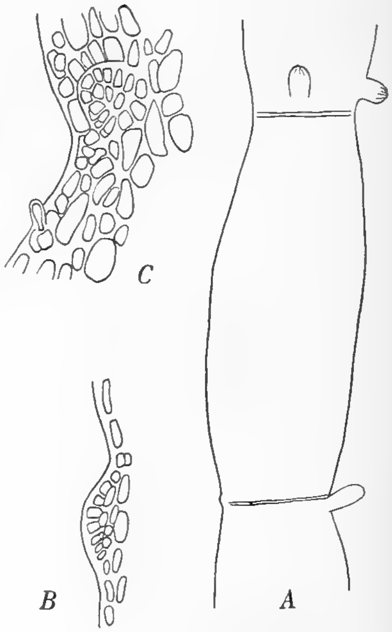


Fig. 574.
Chylocladia kaliformis. A. portion of frond with adventitious shoots at the constrictions, above two shoots above the constriction, below a shoot below the constriction and to the left a quite young shoot exactly in the constriction. 63 : 1. *B.* the last-named shoot 200 : 1. *C.* young shoot over the constriction 200 : 1.

The younger portions of the frond usually bear numerous vigorous hyaline hairs produced by some of the small cortical cells. They arise as outgrowths from these, cut off by a transverse wall (comp. Kylin 1923, p. 38, fig. 27 d); in a young stage they contain abundant protoplasm and a single nucleus. A number of these young hair-cells may remain in the juvenile stage, while others grow out early as long hairs of the usual structure (figs. 572, 573). The hairs are very thick, about 9—11 μ, and may reach a length of 1 mm or more. It probably depends on outer conditions whether the hair-cells grow out or remain rudimentary. Comp. Berthold (1882, p. 692), who found that their occurrence is largely determined by the intensity of the light. In the Danish waters the hairs were constantly met with in July and August and were also observed in September.

Ramification. The most common mode of ramification of the frond is lateral, the branches arising at some distance from the tip, in the young furrows, exactly at the level of the diaphragms or a little higher. One, two or three, or rarely more branches may arise in the same furrow, and the branches are therefore often verticillate, but the branches of the same furrow do not arise simultaneously. The development of these branches is altogether acropetalous, but some furrows remain branchless, especially in the branches. According to DEBRAY (1886, p. 15), the branches "proviennent des cellules du diaphragme adhérentes à la couche corticale. Si la paroi présente plusieurs assises de cellules, les petites cellules extérieures sont soulevées et séparées les unes des autres par le bourgeon se formant au-dessous d'elles". It is, however, not obvious from the description of DEBRAY, which is not illustrated by drawings, whether it refers to *Ch. Kaliformis* or to a related species. At any rate, my obervations, which are, however, not very thorough, do not agree with that of DEBRAY. True, the branches often arise exactly in the middle of the furrow, at the level of the diaphragm, but other branches are evidently placed at a little distance above this level, and an origin like that postulated by DEBRAY is consequently precluded. My observations seem to accord better with the assumption that the branches take rise from divisions of superficial cells (fig. 574).

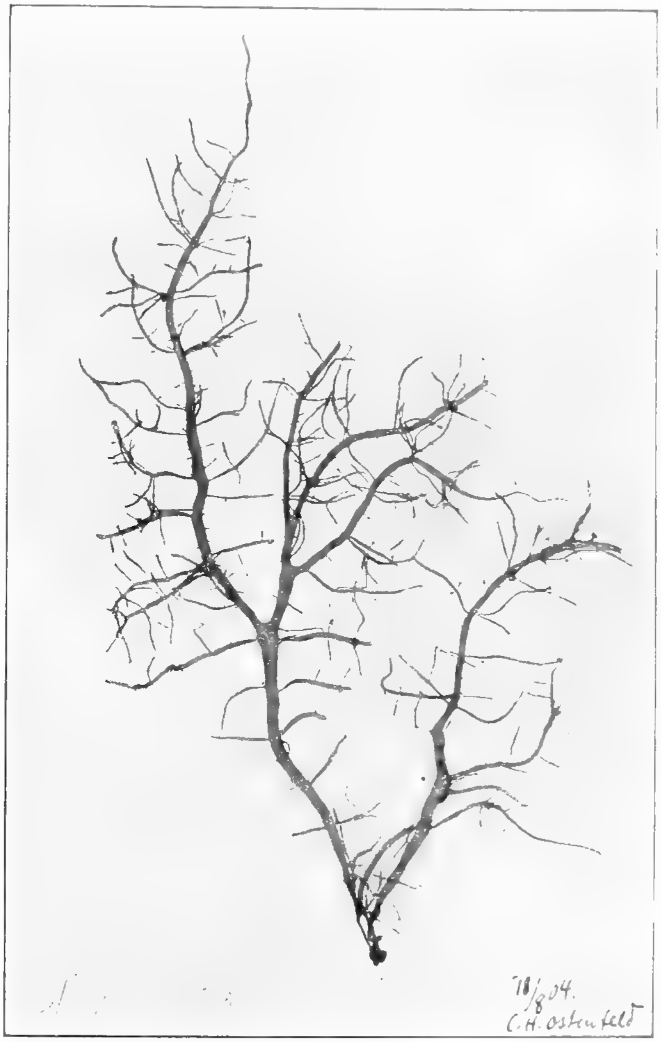


Fig. 575.
Chylocladia kaliformis. Dried specimen with cystocarps dredged by the late Professor C. H. Ostenfeld, North of Hirsholmene, August. Photo. $^2/_3$ nat. size.

In older portions of the frond adventitious branches arise in indeterminate places. They seem to arise, like the primary ones, by divisions of one or a number of superficial cells. The adventitious shoots may be rather numerous in older fronds; they are thinner than the primary ones.

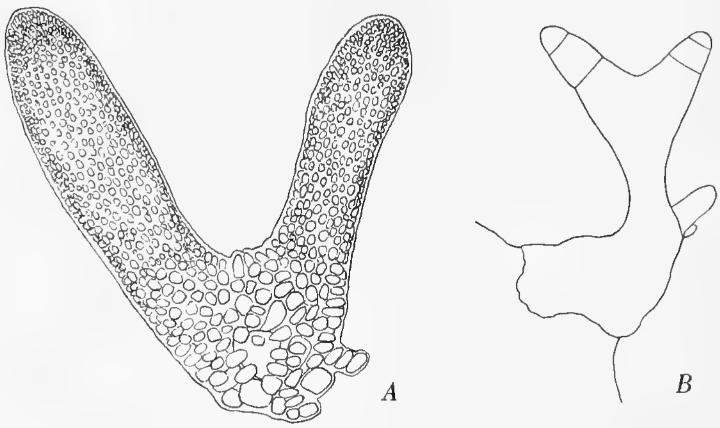


Fig. 576.
Chylocladia kaliformis. Young plants growing on a cystocarp-bearing specimen of *Chylocladia kaliformis.* August. *A*, with two fronds springing from the same attachment disc. 105 : 1. *B*, showing a dichotomy of the frond. 70 : 1.

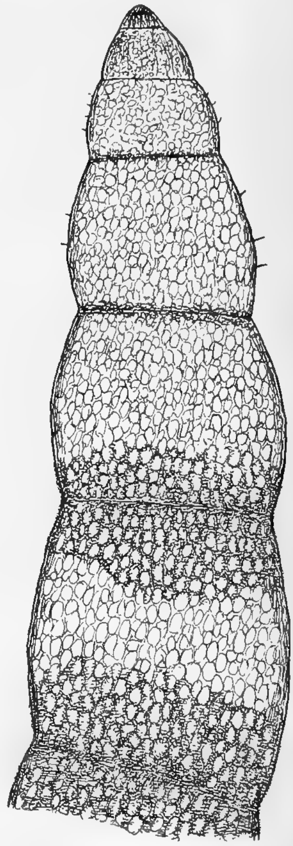


Fig. 577.
Chylocladia kaliformis. Upper end of frond of male plant with annular patches of antheridia-producing cell-rows. August. 30 : 1.

There exists yet a third mode of ramification, namely by dichotomy. Debray described such a ramification which he had particularly observed in *Chylocladia mediterranea* (1886, p. 13). I seems to be rare in *Ch. kaliformis*, for I have only observed a few instances of dichotomy, most obvious in a young plant (fig. 576), the growing-point of which had been bifurcated before the appearance of the first diapraghm; both branches show two diaphragms[1].

Reproduction. The antheridia were shortly described by Buffham (1891, p. 249, pl. 15, figs. 3—4) who found them forming pale patches as irregular rings around the frond, but otherwise they have not been mentioned; Kylin dit not observe them. I have examined a male specimen collected in August at Hirsholmene and preserved in alcohol by Mr. Boye Petersen. The ring-shaped patches detected by Buffham arise near the apex of the frond, in the transverse furrows at the level of the diaphragms. They are originally narrow, occupying only the furrow itself but increase early at their upper and lower margins and then form rather broad belts with irregular borders. In the young rings and at the borders of the older ones a great number of very small cells bud off from the edges of the cortical cells. These

[1] I have observed the same ramification in *Ch. kaliformis* var. *squarrosa* at Biarritz; some joints were found to be bifurcate.

cells divide actively and form close cell-rows growing inward from the edges of the cortical cells which are thus covered by a reticular layer the meshes of which diminish gradually in diameter by the growth of the creeping cell-rows, and the older parts of the fertile layer may finally be continuous, covering also the central parts of the cortical cells. From the upper side of the creeping cell-rows new small cells are early bud off, forming very short upright cell-rows the end-cells of which produce each a spermatium. The spermatia are shortly obovate, about 4 μ in diameter and contain a large nucleus (figs. 578 *C, D*). The spermatial layer is covered by a thick gelatinous layer (comp. BATTERS l. c.) which renders it very difficult to obtain good thin sections showing the development of the antheridia.

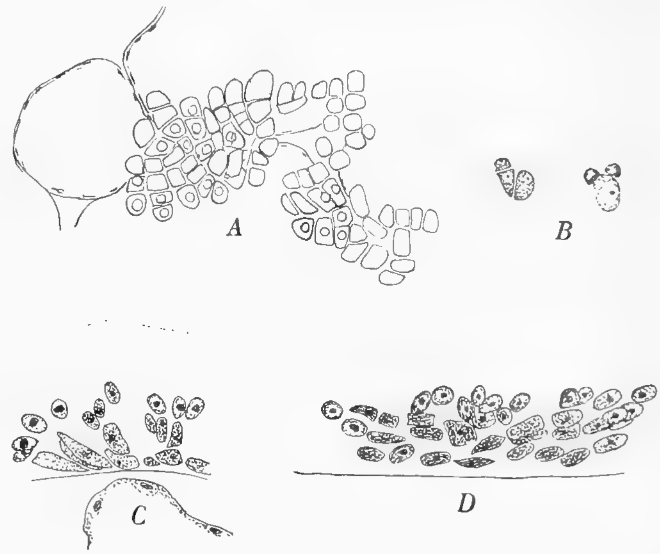


Fig. 578.
Chylocladia kaliformis. Antheridia-producing cell-rows. *A*, seen from the outside. *B*, isolated antheridia-bearing cells. *C* and *D*, transverse section of the antheridia-producing layer. 625 : 1.

The development of the carpogonial branch and of the cystocarp have been examined by several authors (JANCZEWSKI, SCHMITZ, HAUPTFLEISCH, HASSENKAMP and, latest and most exhaustively, by KYLIN (1923)). As I have nothing to add, I shall content myself by referring to the excellent paper of KYLIN, adducing only the principal facts. The curved 4-celled carpogonial branch is borne on one of the large cortical cells. This supporting cell has early cut off two lateral cells which become auxiliary mother-cells. These cells (or one of them) bud off an auxiliary cell, before the fertilization. The fertilized nucleus of the carpogonium divides in the carpogonium, which forms two protuberances fusing with the two auxiliary cells. The auxiliary cell buds off outwards a cell, the first gonimoblast cell which is divided by radial walls into a number of pyramid-shaped cells which divide by a cross wall into an inner, smaller, and a larger outer cell; the latter is the young carpospore, the inner cells fuse together with the auxiliary cells. By further fusions of the basal cells with the auxiliary cells and with cells of the inner fruit-wall a large fusion cell arises which bears the carpospores on the outer side. The large globular cystocarp is surrounded by a wall without apical pore, built up of 3 or 4 layers of cells.

The tetrasporangia are irregularly spread in the cortex. As shown by KYLIN (1923, p. 43), they arise from large cortical cells of the 3rd or 4th order which are not

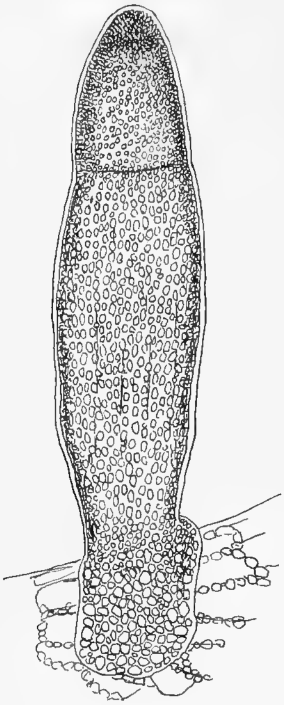


Fig. 579.
Chylocladia kaliformis. Young plant growing on a cystocarp-bearing specimen of the same species. August. 75 : 1.

terminal cells but segment cells, and are therefore connected with at least two neighbouring cells by primary pits. The ripe tetrasporangia project into the central cavity (comp. Kützing, Phyc. gen., tab. 55 IV).

The germination of the tetraspores begins, according to Kylin (1917, p. 5), by formation of vertical walls by which the spore is divided into four quadrant cells which are then further divided by horizontal walls. After 6 days the germlings had the appearance of multicellular globular bodies giving off at the base some 4 rhizoids, and showing at the top a group of smaller, meristematic cells, the initial cell-group of the upright frond. I have examined the germination of tetraspores and carpospores in cultures, but the cell-divisions were usually irregular, without doubt owing to the unfavourable conditions in the cultures, and only a small number of germlings resulted. The best developed of them showed after 17 days a thick, more or less orbicular attachment disc and an erect shoot issuing from it. Older germlings were found in Nature, the youngest growing on fructiferous specimens of *Chylocladia kaliformis,* both in tetrasporiferous and in cystocarp-bearing individuals. These germlings had usually a thick, hemispherical or nearly globular attachment body, and springing from it an upright frond. When this was about half a mm high, it was cylindrical without constrictions, and with an outer layer consisting of small, rather uniform cells. Not unfrequently two fronds were issuing from the same attachment disc (fig. 576). In the germling represented in fig. 579, which was about 1 mm high, the frond is inflated, hollow with at least one septum and with longitudinal cell-rows in the cavity. The identity with *Chyl. kaliformis* was thus indubitable. These germlings were met with in August and probably originated from spores of the fronds on which they were found growing. More developed young plants, met with in September and October, were only from a few mm to 2 cm high; they were provided with hairs, but only feebly developed or rudimentary.

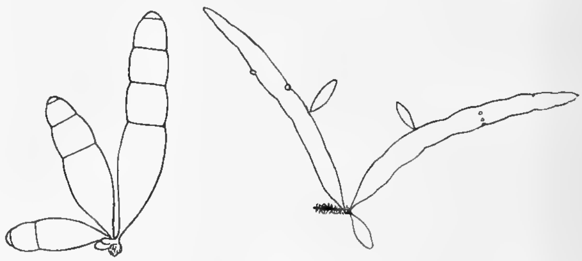


Fig. 580.
Chylocladia kaliformis. Young plants, growing on *Rhodomela* and *Brongniartella,* September. *A,* 3.5 : 1. *B,* 2 : 1.

The species has only been met with in the Northern and Eastern Kattegat. Its absence in the North Sea and Skagerak is certainly due to the want of protected localities. It has been met with at 8—19 metres' depth in water of comparatively high salinity (about 30 p. m.) on gravelly or stony bottom, but is very often attached to other Algæ (*Phyllophora membranifolia, Furcellaria fastigiata, Brongniartella byssoides, Corallina officinalis*) or to dead leaves of *Zostera*. It has only been observed in the months of July to October. Well developed fructiferous specimens, up to 26 cm high, were met with in July and August, but they seem to die away at the end of summer, for in September small specimens only were observed. Germlings were found in Nature already in August, and the small specimens found in September must be supposed to originate from spores produced in the foregoing summer. They were all sterile. It must further be supposed that the growth of the new plants is arrested during winter and spring and is only resumed in the following summer.

Localities: **Kn:** Tønneberg Banke, TP and PO, 16—18 m, stony ground, young specimens, September; TQ, near the light-ship at Læsø Trindel; FF, near Læsø Trindel, 15 m; Nord Øst Rev at Hirsholmene; east of Hirsholmene (Ostenfeld); Nordvestrev at Hirsholmene; TY south of Hirsholm, east of Kølpen (A. Otterstrøm); Trestensrev (Henn. Petersen); various places near Nordre Rønner; 7—11,5 m. — **Ke:** ZG, ZE[1], VY, Fladen, 17—19 m.

Lomentaria Lyngb.

1. **Lomentaria clavellosa** (Turn.) Gaillon.

Gaillon, Dictionnaire des sciences natur. Vol. 53. Extrait, Strasbourg 1828, p. 19; Le Jolis, Liste des Alg. mar. 1864, p. 132; F. Debray, Structure et développement des Chylocladia, Champia et Lomentaria. Bull. scient. de la France et de la Belgique, tome 22. Paris 1890, p. 399; Hauptfleisch, Flora 1892, pp. 325—350, figs. 58—77; Killian, Entw. Florid., Zeitschr. f. Bot. **6**, 1914, pp. 246—248; Kylin, Studien, 1923, pp. 44—49.

Fucus clavellosus Turner, Trans. Lin. Soc. VI, 1801, p. 133, pl. 9, Hist. Fucorum I, 1808. tab. 30.

Gastridium clavellosum Lyngbye 1819, p. 70, tab. 17.

Chondria clavellosa C. Agardh, Spec. alg. Vol. I, 2, 1832, p. 353; Hornemann, Flora Danica tab. 2200, 1834.

Chylocladia clavellosa Grev. in Harvey's Manual 1841, p. 71; J. Agardh, Sp. g. o. II, 2, 1852, p. 366.

Chrysymenia clavellosa J. Agardh, Alg. m. medit. 1842, p. 107; Harvey Phyc. Brit. I, 1846, pl. 114.

Chondrothamnion clavellosum Kützing, Tab. phyc. **XV**, tab. 81, 1865.

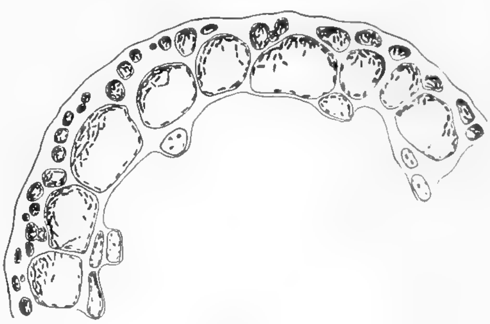


Fig. 581.
Lomentaria clavellosa. Cross section of frond. 420 : 1

As emphasized by earlier author's e. g. Kylin (1923, p. 44) there is much accordance between *Lomentaria clavellosa* and *Chylocladia kaliformis* as to the structure of the frond. The cortex forming the wall of the hollow frond consists, at least in older portions, of two layers of cells, the outer layer of smaller cortical cells being here continuous. The medullary longitudinal filaments (fig. 581) are more irregular and often connected with each other by lateral pits. Diaphragms are wanting.

The fronds spring singly or several from a flat or cushion-shaped attachment disc (fig. 582). The branches arise at some distance below the apex; they are sometimes opposite, more frequently alternate, biseriate and the fronds are therefore often flat, but the branches may also issue from all sides of the branches. When the branches are regularly opposite or alternating, distichous at regular intervals, it seems probable that the branches correspond to the verticils in *Chylocladia*, and the regions where they are inserted to the diaphragms. Adventitious branches with indefinite position may occur later; they are much smaller than the primary ones. Some shoots grow out and obtain a similar length and character to those of the main shoot, others remain short, but there are all transitions between the long and the short shoots. I have once met with a branchlet ending in an attachment disc (fig. 583); it occurred as a branch of the second order at some distance from the base in a specimen growing on the Bryozoan *Valkeria uva*.

Fig. 582.
Lomentaria clavellosa. *A*, small plant with cystocarps from Skagerak off Lønstrup, August. 3.3 : 1. *B*, lower portion of plant growing on *Desmarestia aculeata*, Hirsholm, October. 4.7 : 1.

The principal branches come near to the main frond in length and thickness; the latter attains a diameter of 1 to 1.5 mm. The branches of higher orders are much narrower, often very thin. Specimens referable or approaching to f. *sedifolia* have not been met with at the Danish coasts; the specimens growing here are always very slender.

The young portions of the frond still in development are usually beset with numerous hyaline hairs, like those in *Chylocladia kaliformis*, but much thinner and shorter; they are about 2.5 μ thick. They were observed at all the seasons, where the species was generally met with (May, July to October), though they were not met with in all the specimens observed.

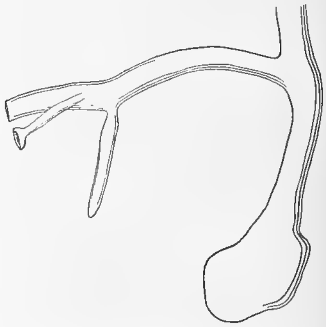


Fig. 583.
Lomentaria clavellosa. A branch ends in an attachment disc. 12:1.

The antheridial sori appear, as shown by Kylin (1923, p. 47), as patches on the branches of the last or penultimate order, probably always in particular male plants. The cells producing the antheridia (spermatangia) bud off from the small outer cortical cells as small colourless cells rich in protoplasm and containing one nucleus (mother cells of the spermatangia Kylin l. c., fig. 33). Specimens with antheridia were observed once in Skagerak, on the 1st of August, and once in Northern Kattegat, on the 13th of July.

The development and structure of the carpogonial branch and of the cystocarp have been treated by HAUPTFLEISCH (1892) and KYLIN (1923). Reference may be made to the description of KYLIN. The tri-cellular carpogonial branch arises as an outgrowth from a primary cortical cell (supporting cell) which becomes multinuclear. Two auxiliary cells are usually present the mother-cells of which bud off from the supporting cell, but one only is developed after fertilization. After the entering of a sporogenous nucleus in the auxiliary cell, a cell buds off from its upper side, and from this cell several gonimolobes are produced. The wall of the cystocarp has a well developed pore at the top. For more details see the papers quoted.

Fig. 584.
Lomentaria clavellosa. August. Tip of tetraspore-bearing frond. 30 : 1.

The tetrasporangia are embedded in the cortex, and form groups at the bottom of depressions in the cortex of the younger parts of the frond; the sporangia do not project inwards into the cavity of the frond (fig. 584). They are tetrahedrally divided.

The germination of the spores has been studied by KILLIAN (1914, p. 246), but owing to difficulties with the cultures he was not able to follow the first stages of the development of the germlings. The youngest stage figured by KILLIAN is an orbicular disc showing in the middle

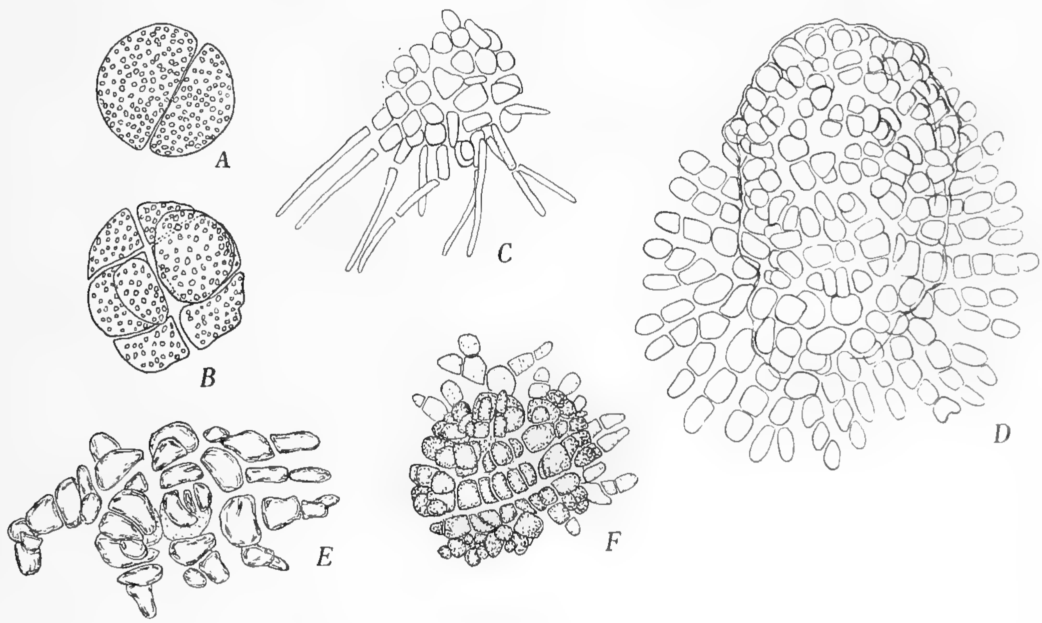


Fig. 585.
Lomentaria clavellosa. Germlings obtained in cultures. *A—C* and *E—F* 8 days old. *D* 15 days old. 560 : 1.

a group of four initial cells. The middlemost part of the disc projects and forms an upright frond which is first cylindrical, later vesicular, and the four apical cells become the first initial cells of the frond. In my cultures in the laboratory of marine biology at Frederikshavn in 1928 and 1929 the conditions were evidently also unfavourable to the germination, for most of the spores did not germinate, the divisions of the germinating spores were not regular, and the four initial cells could not be observed. After 7 or 8 days the germlings had the shape of discs or cushions with rhizoids issuing from the margin. The cell-divisions were more or less irregular, and sometimes portions of the original spore-cell did not take part in the divisions producing the germling. A group of initial cells could not be detected, but the cells often showed a very apparent arrangement in rows, an evident proof of the presence of a meristeme (fig. 585).

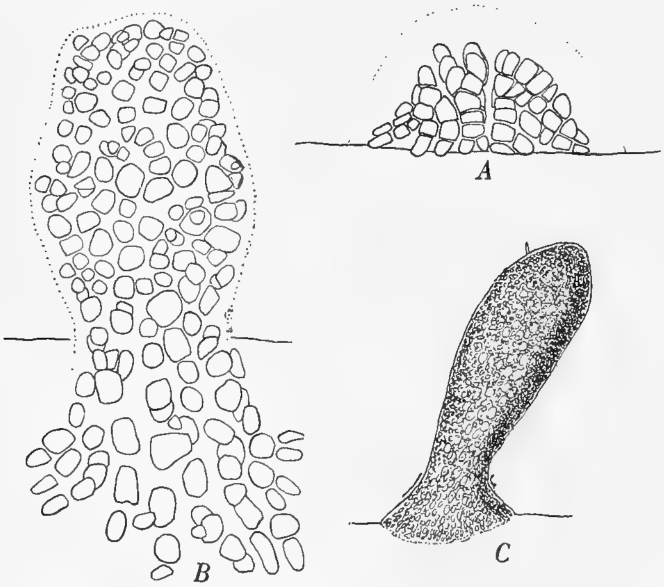


Fig. 586.
Lomentaria clavellosa. Germlings found in Nature, growing on Polysiphonia urceolata, Tønneberg Banke, northern Kattegat, July. *A*, *B* 560 : 1, *C*, 200 : 1.

After 17 days the germlings had grown much larger, having usually an orbicular disc composed of radiating cell-filaments about 100 μ in diameter and an upright frond of about the same length as the diameter of the disc. The upright fronds were nearly cylindrical, unbranched. The characteristic structure of the apex could not be observed. Hairs were wanting (August 4th) (fig. 585 *D*). Germlings from the same culture a month and a half older had only reached a length of 150 to 224 μ and did not show the normal structure, but their colour was normal. The fronds were often somewhat curved, sometimes showing incipient branching. Growing under better conditions, the germlings would probably have reached a larger size.

Germlings were repeatedly met with in Nature in the months of July to October, growing on various Algæ, as e. g. *Polysiphonia*, *Desmarestia aculeata*, leaves of *Zostera* or tests of Hydroids. They must have arisen from spores set free at the same season, and generally they agreed with the germlings obtained in the cultures. Those found in the middle of July reached a length of 0.2—0.3 mm (fig. 586), whereas germlings met with in August reached a length of 2 mm. The largest specimens of the young plants gathered in October reached in the various localities lengths of 2.5 mm, 7 mm and 2 cm, but smaller specimens, partly disc-shaped without any upright shoot, occurred with them. It must be concluded that the spores germinate in the middle and at the end of summer, and that the germlings or the majority of them remain small and feebly developed in autumn and grow out only in the following summer; but it seems quite probable that, under favourable external conditions, the earliest developed germlings may reach the stage of fructification in the same season in which they have arisen.

Lomentaria clavellosa only occurs in the northern Danish waters with high salinity (North Sea, Skagerak, northern and eastern Kattegat) and has only once been met with, many years ago, in the Great Belt at a great depth. On the other hand it has not been met with in the Limfjord, undoubtedly owing to the varying temperature in this area. It grows at depths of 9 to 31 metres, deepest in the North Sea (24.5—31 m) and the Eastern Kattegat (14—26.5 m), on gravelly or sandy bottom with small stones or on stony bottom, very often attached to various Algæ, e. g. *Halidrys*, *Corallina offic.*, *Polysiphonia* spp. etc., further on dead leaves of *Zostera*, on various Hydroids, *Flustra foliacea* and shells of molluscs. It has not been observed in winter and early spring and has probably a small size in this period. The specimens collected in May were only 2—3 cm high and sterile. The maximum of development is reached in July and August when the specimens may reach a length of up to 18 cm (Groves Flak) and are fructiferous, with ripe tetrasporangia and cystocarps at least after the middle of July.

Localities. **Ns:** ZQ, jydske Rev, 24.5 m; aF N.W. of Thyborøn, 31 m. — **Sk:** SY, north of Løkken, 13 m; ZK (0, 3, 7, 11) 8—19 m; various places N.W. of Hirtshals (YK, YL, XO etc.), 13—15 m, off Hirtshals (Børgesen). — **Kn:** Herthas Flak, 19—22.5 m; Tønneberg Banke, 16—19 m (Boye Petersen!); fG and dS near Læsø Trindel, 15—16 m; Nordøstrev and Norvestrev at Hirsholmene; south of Hirsholm, 11 m; Trestensrev (Henn. Petersen), N.E. of Deget 11.5—13 m (Stamm) and Borrebjergs and Laursrev, 7.5—11 m at Frederikshavn; VU, north of Læsø, 15 m; at Nordre Rønner, near the double broom, 11—14 m; TM, N.W. by N of Nordre Rønner, 15 m. — **Ke:** Fladens lightship in S by E, 1 mile, 23 metres; EX and EV, Groves Flak. 26.5 and 22.5 m; Groves Flak 19 m (Børgesen); EU, Lille Middelgrund, 14 m. — **Sb:** According to Magnus (Botan. Unters. der Pommerania Exped. Kiel 1873, p. 66 and 74) this species (*Chrysymenia clavellosa* J. Ag.) has been dredged in Store Belt W.S.W. of Romsø at 51 metres' (27 Faden) depth; it has not otherwise been met with in this water.

2. **Lomentaria rosea** (Harv.) Thur.

Thuret in Le Jolis, Liste des Alg. mar. de Cherbourg 1864, p. 131; Farlow, Mar. Alg. New England, 1881, p. 155.
Chrysymenia Orcadensis Harv., Manual Brit. Mar. Algæ. Sec. edition, London 1849, p. 100.
Chrysymenia rosea Harv. var *Orcadensis* Harv. Phyc. Brit. Vol. III, 1851, pl. 301.
Chrysymenia rosea Harv. Phyc. Brit. III, pl. 358 A.
Chylocladia rosea (Harv.) J. Agardh, Sp. g. o. Alg. III 1876, p. 298.

This rare and imperfectly described species has only been met with once, in July 1892 in the eastern Kattegat, at 22.5 metres' depth. The two dried specimens

Fig. 587.
Lomentaria rosea. Photo, $^{3}/_{2}$ nat. size.

represented in fig. 587 are the only ones collected in the Danish waters. As the structure and fructification of the species have been very little mentioned in the literature, only little can be adduced here on these matters. The specimens have a pink colour. The main shoots are lanceolate, the branches mostly opposite, comparatively narrow; the lowermost lanceolate, but most of them linear, 0.5—0.8 mm broad, sometimes a little broadened upwards. All the shoots are narrowed at the base.

The anatomical structure of the frond seems to be similar to that of *L. clavellosa.* The outer, small-celled cortical layer is subcontinuous, as in the above-named species, or interrupted, the small cells being only developed over the edges of the larger inner cells (fig. 588). The long medullary cell-rows running longitudinally within the cortical tissue were also distinguishable in the dried material. Hyaline hairs the tips of which were filled with protoplasm were met with abundantly in the young pinnæ.

Fig. 588.
Lomentaria rosea. Surface view of a broad frond. 350 : 1.

Both specimens are fructiferous, containing numerous sori of tetrasporangia in the pinnæ. The areas of the frond-wall containing the sori are concave, in accordance with the generic character. The tetrahedrically divided tetrasporangia were ripe in July.

Sex organs and cystocarps seem to be entirely unknown in this species. It has been met with at the coasts of the Northern Atlantic (United States, Iceland, Færöes, British Isles, Helgoland, Norway, Sweden), but from all localities only mentioned with tetrasporangia.

Locality. **Ke:** South end of Groves Flak, 22.5 m, July 12th 1892.

VII. Nemastomatales.

Fam. Rhodophyllidaceæ.

Cystoclonium Kützing.

1. Cystoclonium purpureum (Huds.) Batters.

Batters, Catalogue Brit. Mar. Alg., Journ. of Bot. 1902, p. 68.
Fucus purpureus Hudson Fl. Angl. 1762, p. 471 (not seen, teste Batters).
Fucus tuberculatus Lightfoot Fl. Scot. II, 1777, p. 926.
Fucus corallinus O. Fr. Müller Fl. Dan. tab. 709 (1777).
Fucus scorpioides O. Fr. Müller Fl. Dan. tab. 887[1] (1782).
Gigartina confervoides Lyngbye Hydr. 1819, p. 43 (quoad specim. Dan.).[2]
Gigartina purpurascens Lyngbye Hydr. 1819, p. 46 (exclus. var. γ *rostrata*).
Sphærococcus purpurascens Hornemann, Fl. Dan. tab. 1835 (1825). (Primary branches too numerous).
Cystoclonium purpurascens Kützing Phyc. gen. 1843, p. 404, Taf. 58 I; id. Tab. phyc. 18 pl. 15 (1868); J. Agardh, Sp. g. o. II.I, 1851, p. 307; Wille Bidrag, 1885, pp. 17, 30, 33, 76, pl. II figs. 20—22, IV figs. 46, 47, VI figs. 74—76; Schmitz u. Hauptfleisch 1896, p. 370, fig. 222 *C*; A. Henckel, Sur l'anat. etc. des Algues mar. Cystoclonium purpur. et Chordaria flagelliformis; Scripta bot. Petropol. fasc. 19, 1902; Kolderup Rosenvinge, Hyal. hairs, 1911, pp. 206—209, fig. 4; Kylin 1907, p. 131; id. 1917 p. 22; id. Entwick. Florid., 1923, pp. 22—30.
Hypnea purpurascens Harvey, Phyc. Brit. pl. 116, 1846.
Gracilaria purpurascens Nägeli, Die neu. Algensyst. 1847, p. 241.

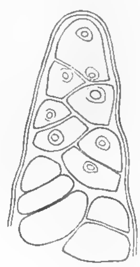


Fig. 589. *Cystoclonium purpureum.* Tip of frond showing the apical cell and its divisions. 560 : 1.

The structure and development of the frond of this common species has repeatedly been studied by Nägeli, Kützing, Wille, Henckel and Kylin. The apical cell of the frond is divided by oblique walls that are inclined alternately to the right and to the

[1] This figure is interpreted in J. Agardh's Sp. g. o. II.I p. 307 as representing *Cystoclonium purpurascens*; in the same work II.II p. 587, however, it is determined as *Gracilaria confervoides* "(fide spec. a Hoffm. datis)". The latter determination cannot be upheld; the figure represents a *Furcellaria* beset with two specimens of an Alga which is probably *Cystoclonium purpureum.* It should be noted, however, that the picture does not correctly represent the base of a *Cystoclonium* fixed to the *Furcellaria*, and the specimen to the left is not fixed to it at all. *Cystoclonium purpureum* is very often fixed to this substratum in Nature, whereas *Gracilaria confervoides* is always fixed to stones.

[2] In Lyngbye's herbarium one specimen only of *Gigartina confervoides* is to be found. It bears the following inscription: "Ex Hindsholm Fioniæ, Jan. 1816, ded. Hofman". It is an old denudated specimen of *Cystoclonium purpureum* easily recognizable by the base which is still preserved. On the wrapper Lyngbye has first written: *Fucus confervoides*; *Fucus* has then been changed into *Gigartina* and (probably later) *purpurascens* has been added to the name *Gigartina*. It is without doubt this specimen which is mentioned by Lyngbye l. c.

left, as shown by KYLIN (1923, p. 23), thus producing two rows of alternating segments (fig. 589). The central cell-row is only discernible in the upper end of the frond, later on it cannot be distinguished from the other longitudinal filaments filling up the central part of the frond. The outermost cell-layer has the function of assimilating tissue; it produces numerous long hyaline hairs (comp. K. ROSENVINGE 1911, KYLIN 1923), which arise in spring and early attain a considerable length, about 1 mm or more, with a diameter of about 10 μ (fig. 590). They form a hyaline clothing on the fronds still growing. When the growth ceases, the hairs are shed and are therefore not met with in autumn and winter.

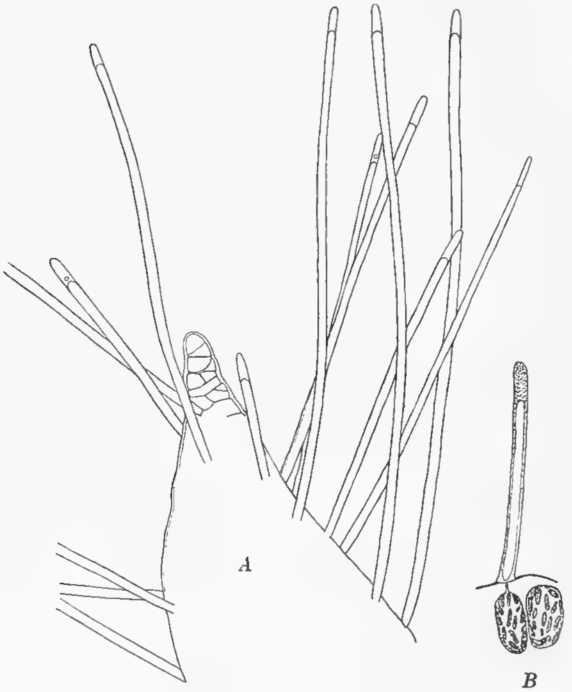


Fig. 590.
Cystoclonium purpureum. *A*, upper end of frond showing hyaline hairs. 200 : 1. *B*, two superficial cells, the one bearing a young hair. 325 : 1. After living plants.

The distinction between the assimilating and the storage tissues is not very sharp. WILLE and HENCKEL (1902, p. 6) count up to 5 layers of the assimilating tissue while KYLIN (1923, p. 23) has only one. Within this follows a storage tissue which has also a mechanical function, and the central part of the frond is filled up by the conducting tissue built up by longitudinal filaments, primary and secondary, composed of long cells the transverse walls of which, as shown by WILLE (1885, p. 76, pl. VI, figs. 74—76), are perforated by numerous fine threads of protoplasm.

The main stem is very distinct, in particular in the lower part of the frond where it is less branched than above. Near the base, however, a number of horizontal or downward bent branches arise which may reach a considerable thickness but only a length of a few, up to 5 cm (fig. 591). In contact with the substratum they form low hapters which afford a better fastening for the plant (fig. 592). When with increasing age the surface of the plant is very much increased, the primary attachment disc would not suffice to resist the pull caused by the movements of the water. The basal shoots taper gradually towards the top but are not much branched. Upright shoots are sometimes given off from them, and they may thus have the character of stolons but new fronds are usually only produced near the primary ones, and the horizontal shoots have therefore no significance for the propagation of the species.

The tendrils frequently occurring at the ends of the branches have been known for a long time. LYNGBYE described them (1819) as peculiar to a particular variety *β, cirrhosa*. They were later mentioned by J. AGARDH (Flor. Morph. 1879, p. 10) and in particular by WILLE (1885, p. 33) and HENCKEL (1902, p. 12) who studied their development and structure. They arise at the ends of branches which become long and thin whithout branchlets and are twisted, 5 or 6 worms of a screw often lying close together. The twisted part of the shoot bears a number of short, thick branchlets forming a small bush. The tendrils may remain free or catch fronds of other Algæ or of its own. When growing on *Halidrys siliquosa* the tendrils winding round branches of the host plant are particularly numerous, giving the *Cystoclonium* a very solid attachment. Specimens with tendrils are met with in all the Danish waters; their occurrence seems to depend on external conditions. WILLE found them in specimens from a locality with fairly agitated water, and HENCKEL thought that they might be caused by the contact with an algal frond. This can only be decided by experiments. The tendrils have been met with, from 1 to 20 metres' depth. In the North Sea and Skagerak, which are much agitated, specimens with tendrils frequently occur; but, on the other hand, specimens growing on the moles at Hirtshals and at Hanstholm where the sea is usually much agitated had no tendrils. At the greater depths the influence of the waves can only be feeble, but the water is here agitated by the currents.

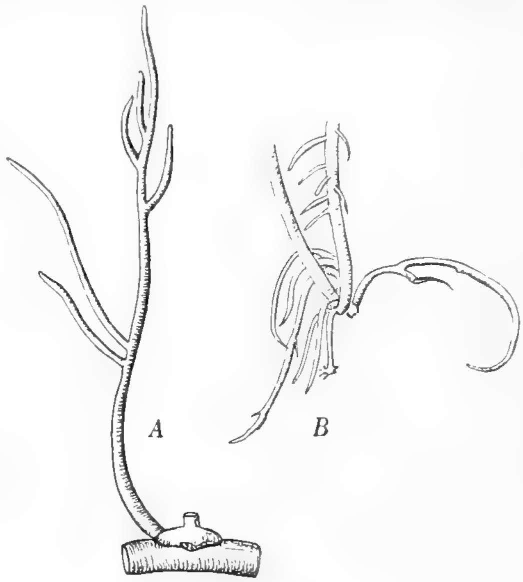


Fig. 591.
Cystoclonium purpureum. A, young plant growing on *Furcellaria*. February. 5 : 1. *B*, lower portion of frond. July. Nat. size.

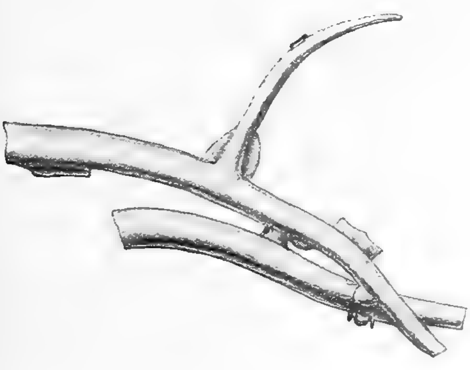


Fig. 592.
Cystoclonium purpureum. Creeping shoots with hapters. 20 : 1.

WILLE raises the question whether the cluster of small shoots issuing from the tendrils might give rise to a new individual, but he leaves that undecided (1885, p. 34). HENCKEL has never found tendrils having the character of stolons, nor have I myself ever found tendrils surviving during the winter and giving rise to new individuals next year.

As ripe spores are produced in summer (July to August) and are able to germinate immediately, young plants must occur already in summer. As shown in fig. 593, the germinating spores divide by orthogonal or more irregularly orientated walls forming a hemispherical body, scarcely larger than the spore. This is the attachment disc. After two weeks, in a culture at Frederikshavn in July, many of the cushions had produced a shoot, one of the superficial cells, not always at the summit of the cushion, taking the character of an apical cell (fig. 593 *F*). Sometimes two shoots arise simultaneously from the same cushion. From the under face, appressed to the substratum, short unicellular hapters spring (fig. 594).

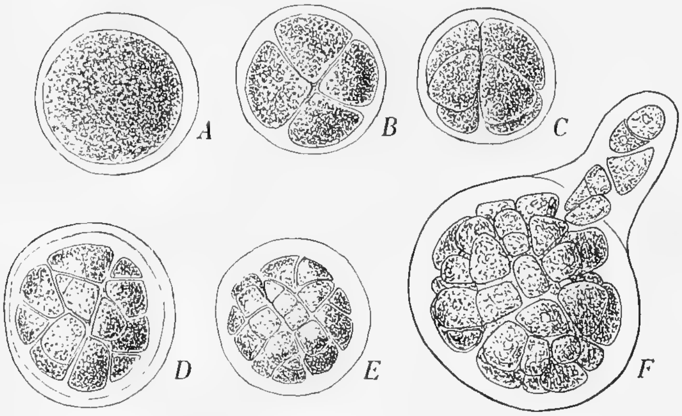


Fig. 593.
Cystoclonium purpureum. Germinating tetraspores, Frederikshavn, July. *F* 13 days old. *A—E* 350 : 1. *F* 560 : 1.

(Compare Kylin 1917, p. 7). A germling in a more advanced stage, agreeing well with those observed in cultures, was met with at the end of September at 16 metres' depth in the Northern Kattegat (fig. 595). The plants which arise from the spores germinating in summer probably reach a considerable degree of development before winter. In the Little Belt I found in February 2—4 cm long plants growing on *Furcellaria*. In some cases one frond only was given off from the basal cushion, in other cases two or a greater number, but some of them were then usually broken off (fig. 591 *A*). In March corresponding specimens were about 7 cm long. In the Northern Kattegat specimens which had apparently arisen from spores in summer, reaching only a few centimetres in length but having a great number of densely crowded shoots springing from the attachment disc, were frequently met with in autumn (September to November) (fig. 596); their growth is arrested during the winter and only begins again in early spring.

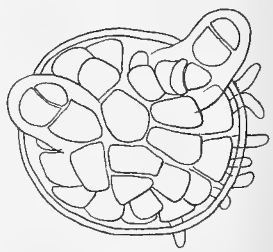


Fig. 594.
Cystoclonium purpureum. Germling 12 days old, seen from above. 560 : 1.

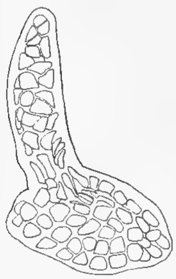


Fig. 595.
Cystoclonium purpureum. Germling found growing on Antithamnion Plumula, September. 75 : 1.

The development of the sex organs has been studied by Kylin (1923). The species is dioecious. The antheridia arise on the surface of younger shoots which may finally be entirely covered by them. They are, according to Kylin (l. c. p. 30), borne on „Spermatangien-Mutterzellen" which are cut off from the cells of the outermost, assimilating layer of cells. Some of the latter, however, remain unchanged (cf. Buffham 1893, p. 293). The spermatia, according to Kylin, contain about 20 chromosomes. The antheridia were met with in the Danish waters in June and July.

Fig. 596.
Cystoclonium purpureum. Lowermost part of young plant growing on *Furcellaria.* Numerous young basal shoots bud off from the attachment disc. September. 30 : 1.

The carpogonial branch was first described and figured by Schmitz and Hauptfleisch, (1896, p. 369, fig. 222 *C*). The development of the procarp and of the cystocarp has been carefully treated by Kylin (l. c. pp. 25—29) and will therefore only be very briefly mentioned here. The mother-cell of the carpogonial branch is early cut off on the inner side of a superficial cell, but when fully developed the carpogonial branch appears inserted on the inner side of the inner cortex (storage tissue). It is three-celled, and the lowermost cell produces a small lateral cell. The auxiliary cell, which is early developed, is situated near the carpogonium and issues from the same cell which bears the carpogonial branch. After the entrance of a diploid nucleus from the fertilized carpogonium into the auxiliary cell the first gonimoblast cell is formed from the inner side of the latter. The lowermost cell of the gonimoblast fuses with the auxiliary cell, and later similar fusing processes take place between the latter and other cells of the gonimoblast. For further details on the development compare Kylin (l. c.). The structure of the ripe cystocarp has been pictured by Kützing (1843, Taf. 58). Ripe cystocarps were met with in the Limfjord in June, otherwise everywhere in July and August. In September and October they were more or less empty.

The tetrasporangia arise in the cortex and are transversely divided. In a ripe state they were met with in June (Limfjord) and in July to September. The tetraspores germinate immediately after exhaustion, but it may happen that they are not set free and then germinate within the mother plant still surrounded by the sporangial membrane (fig. 597).

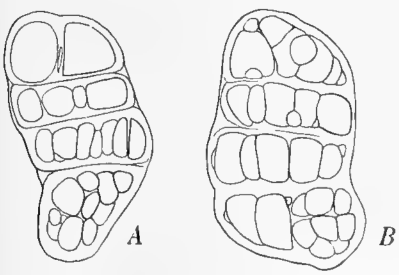


Fig. 597.
Cystoclonium purpureum. Tetraspores segmented within the sporangial wall. September. 200 : 1.

After frutification the fronds die entirely or with the exception of the lowermost portion. The cluster of horizontal shoots issuing from the base of the plant is able to survive through the winter, and new upright fronds then arise from them, or smaller shoots from the foregoing year not having reached the stage of fructification survive through the winter and develop next summer into large fructifying fronds. The species is then perennial, or may at least keep alive and fructify during two years; but many individuals never become perennial because the Algæ or the parts of the fronds to which they are attached die after having fructified.

Cystoclonium purpureum is common in all the Danish waters from the North Sea to the Western Baltic Sea, whereas it has not been recorded in the Baltic Sea proper. It grows in depths from a little under low-water mark to 20 metres' depth, rarely deeper (21.5 m in the eastern Kattegat, 24.5 and 35 m in the Little Belt), on stones and on various Algæ (*Furcellaria, Halidrys, Fucus serratus, Phyllophora Brodiæi, Ahnfeltia* and several others), further on oysters and other shells of bivalves. The largest specimens have been met with in the North Sea, Skagerak and the Northern Kattegat, where a length of 50 cm can be reached. In the inner waters the length does not usually exceed 20 cm, and the largest specimen collected in the Western Baltic was only 13 cm long.

The species is only little variable and no varieties or named forms can be distinguished. We shall merely mention that in exposed localities in the North Sea and Skagerak large specimens may be met with which are remarkable in having a number of long principal branches beset with numerous short branches of the second order in their whole length.

Localities. **Ns:** Not met with at Esbjerg-Fanø and on the groins at the entrance to the Limfjord. Vorupør, 3 m (S. Lund); XR, off Ørhage, 11—13 m; in the bay at Ørhage (Klitmøller), 2 m. — **Sk:** YT off Helshage, Hanstholm, 5.5—13 m, at Roshage, 2 m, mole immediately beneath low-water mark; YM, YN², Bragerne 2.5—10.5 m; SY off Løkken; ZK off Lønstrup; several places, XO, VJ etc. off Hirtshals, 5—15 m and abundantly on the mole. — **Lf:** Common from one to 7 metres' depth and from XV and LZ in Nissum Bredning to Hals mole; e. g. Oddesund, Thisted Bredning, Sallingsund, Livø Bredning and Løgstør Bredning. — **Kn:** Common everywhere on stony bottom from Skagen harbour, Herthas Flak, 20 m and Læsø Trindel, 16 m, southwards. — **Ke:** Several places in Fladen, Groves Flak, Lille Middelgrund from 10—22 m, further GJ, OO and Gilleleje harbour. — **Km:** Several places from Læsø Rende to XC off Fornæs, 4—11 m. — **Ks:** Several places from Grenaa harbour to Hastens Grund and D, grønne Revle. — **Sa:** Numerous localities from 0 to 15 metres' depth. — **Lb:** Several places, from 1 to 35 metres' depth, from Bogense harbour to dH east of Hesteskoen, 15 m. — **Sf:** Several places. — **Sb:** Several places, 1 to 19 m. — **Sm:** S.E. of Masnedø, c. 3 m. — **Su:** Hellebæk; Kronborg; PZ, east of Hveen, 13.5 m; Taarbæk Rev, 12 m; off Skovshoved, 11 m. — **Bw:** bY south of Als; cG off Kegnæs; cE, Middelgrund south of Als, 13 m; DX Vodrups Flak, 13 m; DV south of Marstal; LA, south of Lolland, 7.5 m; UL, Øjet 20 m; KY, Femerbelt 12 m.

Some specimens of *Cystoclonium purpureum* gathered in the neighbourhood of Frederikshavn and in the Limfjord were set with numerous tumours reaching a diameter of 2.5 mm or more. The smaller tumours are globular with even surface, the larger more irregular, somewhat resembling cauliflower. They are seated on both the thin and the bigger branches; in the first case they often cause a backward bending of the frond (fig. 598). Small shoots of *Cystoclonium* may issue from the surface of the tumours (fig. 598 *B*). The colour is bright, nearly white, yellow or rose to red-brown.

Such tumours have been shortly mentioned as early as 1808 by Turner (Fuci, p. 18, plate 9, figs. *f, g, h*) who described them as swellings "unconnected with the fruit" and depicted them as irregularly spherical bodies from which small adventitious shoots are given off.

SCHMITZ[1] gave a more detailed description of the tumours, especially their anatomical structure; he showed that the interior of the tumours is built up of a medullar tissue of interwoven cells whereas the cortex is somewhat similar to that of the normal plant. In the cortex rhizoids may appear, sometimes in great numbers. SCHMITZ further stated that almost the whole tissue of the tumours, in particular the cortex, is filled with small, nearly oval bacteria. The bacteria live intercellularly in the middlemost layer of the cell-walls. When they are very numerous, they penetrate towards the surface of the tumour, numerous rhizoids are then produced, the cells are partly disunited and the bacteria can escape into the surrounding water. SCHMITZ supposes that the tumours are galls occasioned by the bacteria.

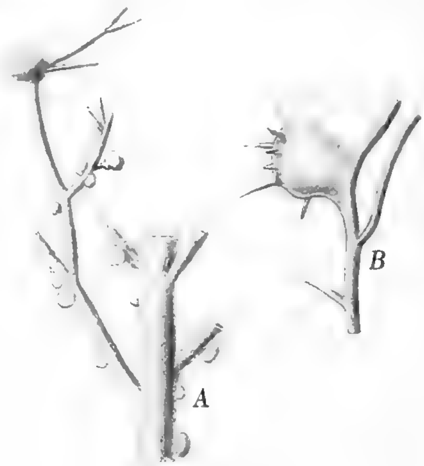


Fig. 598.
Cystoclonium purpureum. Parts of frond with tumours. A, 3 : 1.

The tumours have recently been examined by CHEMIN[2] who confirmed the observations of SCHMITZ. He states that the bacteria are "légèrement ovoides et leur grand axe atteint à peine 1 μ". He mentions an attempt at inoculating bacteria from a gall to another individual of *Cystoclonium*, without result however, but nevertheless he agrees with SCHMITZ in considering the tumours occasioned by the bacteria; in all the tumours examined he found bacteria.

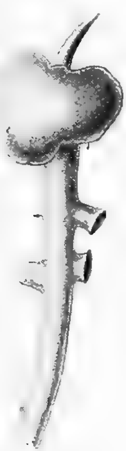


Fig. 599.
Cystoclonium purpureum. Upper end of shoot with hapters and a tumour. 23 : 1.

The tumours from the Danish waters examined by me agree with those described by the authors quoted, as to the outer appearance and anatomical structure; but there is the discrepancy that I have not been able to observe the intercellular masses of bacteria. In the swollen membranes of the tumours, only the homogeneous substance of the middlemost layer was to be seen, no bacteria, even after staining with gentiana-violet, and this was the case, too, in the large tumours with disunited cells. Only scattered rod-shaped bacteria much larger than those described by CHEMIN were sometimes observed. It seems doubtful, therefore, whether the tumours are really caused by bacteria; their etiology must be left for further research.

[1] FR. SCHMITZ, Knöllchenartige Auswüchse an den Sprossen einiger Florideen. Botanishe Zeitung 1892.

[2] E. CHEMIN, Action des Bactéries sur quelques Algues rouges. Bull. de la Soc. bot. de France 1927, p. 441.

In 1907 (Studien, p. 127) Kylin described a new parasitic Alga, *Choreocolax Cystoclonii*, growing on *Cystoclonium purpureum*. It forms irregular globular bodies, 1—4 mm in diameter, yellow-white, often with a tinge of pink; they have a cortex built up of radial cell-rows and an inner tissue of isodiametrical or irregular larger cells, and between them and springing from them long branched cell-rows which penetrate from the base of the parasite between the cells of the host. The parasite usually occurred abundantly on one and the same individual of *Cystoclonium*; it was always sterile. The supposed parasite bears so much resemblance to the tumours here treated, that the question arises if they might possibly be identical with them. Judging from Kylin's description, the outer appearance is the same, and there seems too to be much accordance as to the anatomical structure, though the hypha-like cell-rows show some disagreement; but the occurrence of these elements seems to be rather variable. I have not observed stages like that shown in Kylin's fig. 29 *a*, which is said to represent filaments of the parasite penetrating between the cells of the host. Altogether it must be said that the parasitic character of the bodies described by Kylin cannot be said to be proved. Considering further the fact that the supposed parasite was always sterile, it seems highly probable to me that they are identical with the tumours here described, and that like these, they are merely luxuriancies caused by some unknown agency. It should be stated that Kylin did not mention bacteria in the tissue of the tumours.

The tumours have been met with repeatedly in the environs of Frederikshavn, particularly east of Deget (Boye Petersen), off Feggeklit in the Limfjord, in Lille Middelgrund in the eastern Kattegat and near Ostindiefarergrund in the southern Kattegat.

Euthora J. Agardh.

1. **Euthora cristata** (L.) J. Agardh.

J. Agardh, Nya alger från Mexico. Öfvers. af K. (svenska) Vetensk. Ak. Förhandl. 1847; id., Sp. g. o. Vol. II, pars II, p. 385, 1851; N. Wille, Morph. og physiol. Studier over Alger. Nyt Mag. f. Naturvidensk. Bd. 32. II. 1891, p. 107 ff., Tavle II; Kylin, Entw. Flor. 1923, pp. 36—37.

Fucus gigartinus L.? Oeder, Flora Danica, Tab. 394. 1768.

Fucus cristatus L., Turner Fuci I. 1818, Tab. 23, p. 48.

Sphærococcus cristatus Agardh Synops. 1817, p. 29; Lyngbye, Tent., 1819, p. 13, Tab. 4 D.

Rhodomenia cristata Greville Alg. Brit. 1830, p. 89.

Rhodymenia cristata Harvey, Phyc. Brit. III, tab. 307, 1851.

Callophyllis cristata Kützing, Tab. phyc. 17, tab. 93, 1867.

This pretty little subarctic Alga has only been met with in a few places in the eastern Kattegat at 22—25 metres' depth. It will only be briefly mentioned here, as I have no new observations on the morphology and the development. The fronds are rather narrow, mostly alternately pinnate, more rarely secund or subdichotomous and flabelliform. The structure of the frond has been described by Wille and Kylin. As shown by these authors, the segments of the frond terminate in an apical cell dividing by oblique walls. The frond has an assimilating tissue consisting of about two layers of small cells while the inner tissue is composed of large thick-walled cells, by WILLE denoted as a mechanical tissue. There is also a feebly developed conducting tissue between the large inner cells.

Fig. 600.
Euthora cristata. From Groves Flak, Eastern Kattegat, 24.5 m. With cystocarps. Photo. nat. size.

The antheridia seem to be unknown; in the Danish waters they were not met with.

The procarps arise near the border of the young frond and consist, according to KYLIN (l. c.), of a three-celled carpogonial branch and an auxiliary cell borne on the same cell which bears the carpogonial branch. The development of the cystocarp has not been followed, but KYLIN has given a drawing of a nearly ripe cystocarp and shown that cell-rows grow out from the cystocarpial wall and divide the gonimoblast into smaller portions.

The tetrasporangia arise in groups in the last segments of the fronds and are cruciately divided; they have not been met with in the Danish waters.

The species has been dredged in the months of May and July, always on stony bottom at considerable depths, consequently in water of high salinity, growing on the hapters of *Laminaria hyperborea* and *L. saccharina* and on Hydroids, such as *Tubulina* and *Sertularia.* The fronds reach a length of 1—3.5 cm. Most of the specimens gathered in May had procarps or more or less developed cystocarps. Ripe cystocarps were met with in July.

Localities. **Ke:** ZF, 26.5 m, and JQ 21.5—30 m, Fladen; EV, 22.5 m and JT, 24.5 m, Groves Flak.

Rhodophyllis Kützing.

1. Rhodophyllis bifida (Good. et Woodw.) Kützing.

Kützing, Botan. Zeit. 1847, p. 23, Tab. phyc. **19**, pl. 50, 1869. J. Agardh, Sp. g. o. II, pars II, 1851, p. 388; Nägeli, Neu. Algensyst. 1847, p. 234; Reinke, Lehrbuch d. allg. Bot. 1880, p. 119; Wille, Entwickl. 1887, p. 71, figs. 38—39; Schmitz u. Hauptfleisch (Engl. u. Prantl) 1896, p. 376; Nienburg, Florideenkeiml., Hedwigia **51**, 1912, p. 303; Killian, Entw. Florid., Zeitschr. f. Bot. **6**, 1914, p. 248; Kylin, Entw., 1923, p. 31.

Fucus bifidus Good. et Woodw. Trans. Lin. Soc. Vol. III, 1795, p. 159, pl. 17 fig. 1.

Rhodymenia bifida Greville, Harvey, Phyc. Brit. I, pl. 32, 1846.

The structure and development of the frond have been described by NÄGELI, WILLE, KILLIAN and KYLIN. The tips of the dichotomous frond have a marginal row of apical cells, some of which, the principal ones, divide by alternate, oblique walls. The frond consists of three layers of cells, the middlemost of which is composed of hypha-like filaments forming a net-work with large meshes. Hyaline hairs were not observed.

According to KILLIAN the first stages of the germination of the carpospores and the tetraspores much resemble those of *Lomentaria clavellosa*. An attachment disc is produced by vertical divisions of the spore-cell. One of the cells of this disc, one of the original octant-cells, early becomes larger than the others and gives rise to the leafy frond.

According to KYLIN, the species is monoecious. The antheridia arise scattered on the surface of the frond, 3 to 5 small cells are cut off from a cortical cell, and each of these small cells produces 2 or 3 spermatangia. The development of the procarp and of the cystocarp has been carefully examined by KYLIN. The following facts only shall be mentioned here. The procarps arise near the border of the frond. The three-celled carpogonial branch is borne on a supporting cell which also supports

A *B*

Fig. 601.

Rhodophyllis bifida. From Groves Flak, 19 m, collected by dr. F. Børgesen. *A*, with cystocarps, *B*, with tetraspores. Photo, nat. size.

an auxiliary cell. From the outer side of the supporting cell and the auxiliary cell branched cell-rows are produced which form a cortical layer over the procarp. The auxiliary cell having received a dipoid nucleus from the fertilized carpogonium produces on its inner face the first gonimoblast cell from which a number of carpospore-producing bushes are given off. Fusions take place between the auxiliary cell and the inner gonimoblast cells. The ripe cystocarp has no particular ostiole.

The tetrasporangia are scattered over the surface of the outer segments of the frond. They arise by transformation of primary cortical cells and divide by transverse walls.

Rhodophyllis bifida has only been met with in Skagerak and the northern and eastern Kattegat at considerable depths, 14—27 m, where the salinity is high and the temperature slightly varying. It grows on stony or gravelly bottom, often attached to Hydroids or Algæ (*Halidrys*). The largest specimens, up to 3 cm long, were found in August and September whereas the specimens gathered in May were only 3 mm high. Cystocarps and ripe tetrasporangia were met with in August and September.

Localities. **Sk:** XO and YK N.W. of Hirtshals, 11—15 m. — **Kn:** Herthas Flak, 20—22.5 m (!, F. Børgs.); TO, Tønneberg Banke, 18 m. — **Ke:** Groves Flak, IT, EX, EV, 22.5—26.5 m, Groves Flak (F. Børgs.), 19 m.

Fam. 19. Plocamiaceæ.

Plocamium Harv.

1. **Plocamium coccineum** (Huds.) Lyngb.

Lyngbye, Tent. 1819, p. 39, tab. 9 B; Kützing, Phycol. gen. 1843, p. 449, Taf. 64; Harvey, Phyc. Brit. I, pl. 44, 1846; Nägeli, Neu. Algensysteme 1847, p. 228, Taf. X, figs. 22—37; J. Agardh, Sp. g. o. Alg. Vol. II.2, p. 395, 1852; Kützing, Tab. phycol. Bd. 16, Taf. 41; Schmitz, Untersuch. 1883, p. 26, Taf. V, figs. 37—38; Buffham 1884, p. 338, 1891 p. 249, Plate 16, figs. 8—9; Phillips, Developm. of the cystocarp in Rhodymeniales, Ann. of Bot. 11, 1897, p. 352; Oltmanns, Morph. u. Biol. 1904, pp. 597, 646, 661; Kylin 1923, pp. 49—53.

Fucus coccineus Hudson, Flora Anglica. Tom. II, 1778, p. 586, Goodenough and Woodward, Transact. Lin. Soc. 1797, III, p. 187.

The structure of this common Atlantic species has been described by Kützing (1843), Nägeli 1847, Oltmanns (1904) and Kylin (1923). The ramification and the cell-divisions at the tips of the frond were carefully explained by Nägeli who stated that in the vegetative pinnæ the apical cell is first divided by transverse walls, whereas they "beendigen ihr Wachsthum meist durch shiefe Wände"... "Die Sporenäste und Keimäste dagegen wachsen durch schiefe Wände in der Scheitelzelle" (l. c. p. 228). Kylin says (1923, p. 51) that he has not observed the oblique divisions of the apical cells, and it must be admitted that the apical cell of most of the vegetative pinnulæ are divided only by transverse walls. Nägeli's statement is, however, correct, at least for the feebler vegetative and for the male pinnulæ. In the lowermost, feeblest pinnula in a row, the last dividing walls of the apical cell are oblique, alternating (fig. 602), whereas the upper pinnulæ are divided by transverse walls to the very end of their growing activity, and in the tetrasporiferous pinnulæ the apical cells early begin to divide by oblique walls; the lateral ones are even divided only in this manner (fig. 603). In a female plant with young procarps, I found only transverse divisions in the apical cell of the pinnulæ.

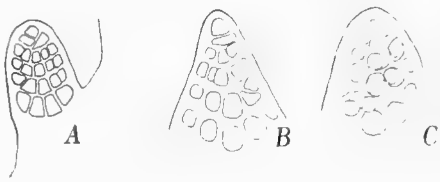


Fig. 602.
Plocamium coccineum. Lowermost sterile pinnulæ. 350 : 1.

As to the anatomical structure and its development reference may be made to the quoted paper of Kylin. We shall merely emphasize that the frond contains a central row of long cells rich in protoplasm, and is built up of an inner tissue of large parenchymatous cells which can be designated as a storage tissue, as it is rich in starch grains, and an outermost layer of small cells, which is essentially an assimilatory tissue; its cells contain numerous small chromatophores. Hyaline hairs are not produced.

Antheridia were not observed in the Danish specimens. According to Buffham (1891) and Kylin (1923, p. 53) they form a layer on the surface of the pinnulæ of the last and penultimate order.

The procarps arise in great numbers at the edges of the young branches of the flattened frond, at the inner as well as the outer edges. Their development has been described by SCHMITZ, PHILLIPS and KYLIN. Referring the reader to KYLIN's paper, I shall only mention that the carpogonial branch is 3-celled and that the supporting cell (Tragzelle) according to SCHMITZ and KYLIN develops directly into an auxiliary cell, while PHILLIPS thought that the auxiliary cell was cut off from the supporting cell after fertilization. The first gonimoblast cell is cut off from the outer side of the auxiliary cell; it gives rise to several lateral cells which produce each a gonimolobe. The wall of the globular cystocarp consists of 3—4 cell-layers.

The tetrasporangia are produced in particular pinnæ (stichidia) which are very different from the vegetative ones. They are flattened, simple and lanceolate or branched with nearly opposite or alternate, divaricate branches. The tetrasporangia are included, biseriate. OLTMANNS (1904, p. 661) compares them to the stichidia in *Tœnioma* and says that they are situated beside the central axis. The latter assertion, however, is not correct, for there is no axial cell-row in the fertile part of the stichidia, owing to the fact that the apical cell of this organ is divided by oblique segment walls, as pointed out by NÄGELI. The first segments of the fertile pinnæ are cut off by transverse walls, but after the formation of e. g. 4 segments by this mode of division, the apical cell divides for the rest of its active period by alternating oblique segment walls. The segments cut off from the wedge-shaped apical cell are first divided by a periclinal wall. The outer daughter cell divides by anticlinal cell-walls and gives rise to the marginal portion of the cortex or wall of the stichidium. The inner daughter cell divides by two periclinal cell-walls by which are cut off two peripheral cells which by anticlinal cell-divisions give rise to the cortex on the two faces of the stichidium, while the middlemost cell is a young tetrasporangium. The sporangia are therefore contiguous and form a continuous zigzag line along the longitudinal axis of the stichidium. The wall of the stichidium consists of only one layer of cells. When the stichidia are branched, the insertion of the branches is high, the breadth of the branches is greatest at the base and diminishes upwards. The branches are fructiferous from the very base. The uppermost cells continuing the zigzag row of sporangial mother-cells remain sterile.

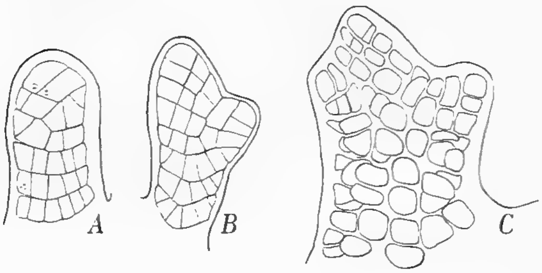


Fig. 603.
Plocamium coccineum. Young stichidia. *A*, 560 : 1, *B—C* 350 : 1.

As is well-known, the sporangia divide by three parallel walls. The primary nucleus is first divided into two, a transverse wall is produced in the middle of the cell, and the two daughter nuclei enter into the resting stage before the next divisions take place (fig. 604 *C*).

Buffham reports (1884, p. 338) that he has met with "a fine plant, divided near the base, bearing tetraspores on one half and coccidia on the other". If a similar case should be met with again, it would be of interest to ascertain whether the plant is really a single individual or if its origin might possibly be due to the fusing of two distinct individuals.

The germination I have not observed; but according to Kylin the germination of the carpospores begins with the formation of a disc-shaped body ("Keimscheibe") (1923, p. 53, fig. 34 e).

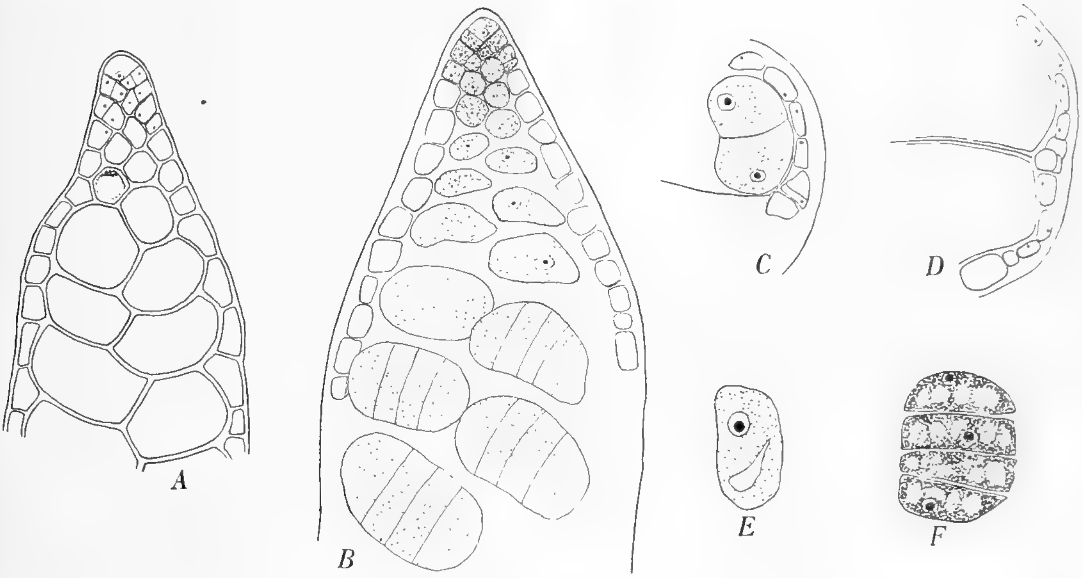


Fig. 604.
Plocamium coccineum. From Hirtshals, September (*A*) and from the Færöe Islands, May, collected by F. Børgesen. Stichidia. *A* and *B*, optical longitudinal sections. *C* and *D* cross sections. *E*, undivided sporangium. *F*, ripe sporangium. 350 : 1.

Plocamium coccineum has only been met with in the North Sea and Skagerak. It has only been collected in the months of June to October, but this is due to the fact that dredgings in these waters have not been made in winter and spring. It has been found at depths from 2 to 18 metres in Skagerak, and a small specimen was found in the North Sea at 27 metres' depth. It grows on stones and on various Algæ (*Laminaria hyperborea*, *Rhodomela*, *Phyllophora membranifolia*, *Furcellaria*).

The Danish specimens agree with the typical North European form. Though the species has not been collected in winter and spring, it is evident that it is perennial. In specimens gathered in June the new shoots had a brighter colour than the older ones, and the old portions of larger plants are often largely covered with *Membranipora pilosa*.

The fronds reach a length of up to 10 cm. Tetrasporangia and cystocarps frequently occur in August; they were also met with in September, but the stichidia were then partly emptied and thrown off. Young stichidia were observed in June.

Localities. **Ns:** Washed ashore at Römö (C. M. Poulsen); eR, 9 miles NW 1/2 N of Lodbjerg lighthouse, 27 m, a small incomplete specimen 7 mm long, October. — **Sk:** Bragerne, 2.5 m, on Rhodomela, 4 cm, sterile, July; Dana St. 2900, east of Bragerne, 9 m, 1.5 cm high, sterile, October; washed ashore at Løkken (Mrs. Witthøft), 4 cm in diameter with ripe cystocarps; ZK[7] abreast of Rubjerg Knude, 18 m, 4—6.5 cm high and two other places off Lønstrup, about 8.5 m, on Phyllophora membranifolia; repeatedly washed ashore at Lønstrup; off Hirtshals, 12 m, F. Børgesen, on *Laminaria hyperborea*, 7—8 cm in diam.; Bredegrund and Møllegrund off Hirtshals, 9—15 m, several specimens, up to 7.5 cm high, and washed ashore at Hirtshals.

The Botanical Museum of Copenhagen possesses two well developed specimens of *Plocamium coccineum* which according to the label were collected in Øresund by Ørsted but are named *Delesseria alata*. These specimens originate from the herbarium of C. M. Poulsen; they were not labelled by Ørsted and it cannot be imagined that this botanist should have confounded the two species in question. It must therefore be supposed that a confusion of the labels has taken place. *Pl. coccineum* has not otherwise been met with in the Danish waters within Skagen. At the western coast of Sweden it occurs at Bohuslän (Skagerak), but Kjellman records it with doubt from Skelderviken.

Fam. Gracilariaceæ.

Kylin, 1930, p. 54.

Gracilaria Grev.

1. Gracilaria confervoides (L.) Greville.

Greville, Alg. Brit. 1830, p. 123; Harvey, Phyc. Brit. I, 1846, pl. 65; J. Agardh, Sp. g. o. II pars II, 1852, p. 587; Thuret in Le Jolis, Liste d. Alg. de Cherb. 1863, p. 134; Thuret, Ét. phyc. 1878, p. 81, pl. 40; T. Johnson, The procarp and fruit in Gracilaria confervoides Grev., Ann. of Bot. I, 1888, p. 213, pl. 11; T. H. Buffham, Anther., 1893, p. 4, pl. 13, figs. 11, 12; Killian, Entwick. 1914, p. 254; Phillips, Origin of the cystocarp in the genus Gracilaria. Ann. of Bot. **39**, 1925, p. 787; Sjöstedt, Florid. Studies, Lunds Univ. Årsskr. **22** no. 4, 1926, pp. 51—64; Kylin, Entwick. 1930, p. 55.
Fucus confervoides L. Sp. plant. ed. 2, II, 1763, p. 1629.
Gigartina confervoides Lam. Thal. 1813, p. 48; Lyngbye Tent. 1819, p. 43.

The closely placed cylindrical fronds spring in a fairly great number from a fleshy flat disc. Harvey says that there is "a small disc accompanied by fibres" (Phyc. Brit. pl. 65, Manual, sec. edit. 1849, pl. 16), and his figure shows a "radix fibrosa". Other authors mention only a disc, and I have myself not seen any fibres in the Danish specimens. The disc has a parenchymatous structure, being composed of vertical or ascending cell-rows. The cells were in summer filled with numerous starch-grains. The disc increases in circumference by marginal growth and may reach a diameter of at least 0.5 cm; it becomes slowly thicker by continued growth of the vertical cell-rows of which it is composed. The periodicity in the growth may cause a stratification; the presence of one secondary layer could be ascertained in an older disc examined.

The upright cylindrical fronds reach a length of up to 32 cm, though most of the specimens collected scarcely exceeded 20 cm in length. The ramification is pronouncedly lateral, the branches arising at a long distance below the apex. All the shoots taper upwards.

As to the structure of the tip of the frond, the authors do not agree. Killian (1914) described the germination of the carpospores and found that the spore divides by vertical walls, forming an orbicular disc increasing by continued anticlinal and periclinal cell-divisions. The central part of the disc becomes vaulted, and one of the central cells develops more vigorously than the others; it becomes the initial cell of the primary upright frond issuing from the disc. The young frond has then a single triangular initial cell at the top (l. c. figs. 5—10); but Killian thought that this cell was later divided into a greater number of initial cells, and Sjöstedt (1926) is of the same opinion. Kylin has, however, recently shown (1930, p. 55) that the tips of the older fronds have the same structure as that described by Killian in the germling, and the species can thus be referred to the type with a central axis ("Centralfaden-Typus"), although an axial cell-row is not present.

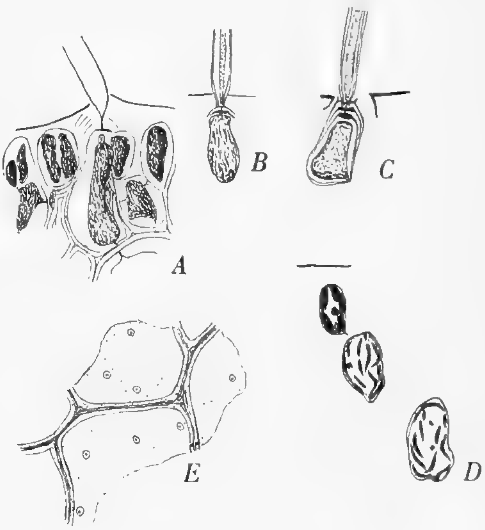


Fig. 605.
Gracilaria confervoides. *A*, Transverse section of frond with a hair. *B* and *C*, basal portions of hairs. *D*, cortical cells. *E*, medullar cells showing secondary pits seen from the face. *A*—D 560 : 1. *E* 420 : 1.

The structure of the frond has been finely illustrated by Thuret (1878) and described by Sjöstedt and Kylin (1930). The frond is early differentiated into a thin cortex composed of two or three layers of cells and a large medullary tissue built up of large, round, isodiametrical cells not lengthened in a longitudinal direction. These cells are connected by numerous pits, partly secondary, and are without any rhizoids (fig. 605 *E*). The young cortical cells contain one nucleus while the older and inner cells may contain a greater number. Each cortical cell contains several chromatophores which are long, linear, ribbon-shaped, bent and sometimes branched; they are most easily seen in the inner cortical and the outer medullar cells (fig. 605 *D*).

The young parts of the shoots bear numerous hairs (fig. 605). They were first briefly mentioned by me (1911, pp. 206, 208). Later Phillips observed the hair-producing cells but misinterpreted them as carpogonia (1925), whereafter Sjöstedt (1926) gave a description of the development and structure of the hairs (in *Gr. compressa*). They arise early (in *Gr. confervoides*) from primary cortical cells which remain undivided and therefore by continued growth become larger than the surrounding dividing cortical cells (fig. 605 *A*). The hair-bearing cell is connected with the hair by a narrow pit the transverse wall of which is situated a little lower than the surface of the frond. KYLIN thought that the hairs are rarely developed, albeit the hair-bearing cells frequently occur. I found numerous and very well developed hairs in July and August (fig. 606).

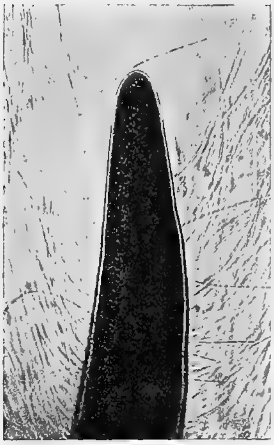


Fig. 606.
Gracilaria confervoides. From Hirtshals, August. Tip of frond with numerous hairs. Photo. 70 : 1.

The antheridia occur in particular individuals; they arise, as shown by THURET (1863, p. 134 and 1878, pl. 40, figs. 1—3) in globular crypts sunk whithin the surface of the frond, the antheridia-producing cells clothing the cavities, whereas in other species of the genus these cells form patches on the surface of the frond. The observations of THURET were confirmed by BUFFHAM (1893), and I have found the same in Danish specimens.

The development of the carpogonial branch, the gonimoblast and the cystocarp has been exhaustively treated by SJÖSTEDT (1926, pp. 54—63), and his observations have been confirmed by KYLIN (1930, pp. 55—59) who has given further drawings. According to these authors, the carpogonial branch is two-celled and developed from a primary cortical cell. The supporting cell of the carpogonial branch becomes very rich in protoplasm and multinucleate, and the same is the case with the basal cells of the vegetative branches issuing from the supporting cell. A connection takes place between the carpogonium and a vegetative cell in its environs, but not with one predesigned in structure and nuclear conditions, and the diploid nucleus remains in the carpogonium. According to SJÖSTEDT, a true auxiliary cell cannot therefore be pointed out in the genus *Gracilaria*. Further cell-connections take place with the result that a large ramified fusion-cell is produced, of which the carpogonium constitutes an essential part (fig. 607). Shortly after the formation of the fusion-cell, gonimoblast-cells are cut off from several points of its surface. The gonimoblast consists in an advanced stage of an inner parenchymatous layer, forming a placenta surrounding the fusion cell and an outer layer consisting of radiating cell-rows the outer cells of which are transformed into carpospores (fig. 608). At the periphery of the cystocarp particular long, radiating tubular cells are developed, springing from the parenchymatous tissue and penetrating with their apex into the pericarp which is separated from the gonimoblast by a split (fig. 608). As shown by SJÖSTEDT, they enter into connection with the cells of the pericarp and take up nutriment from them. The pericarp has

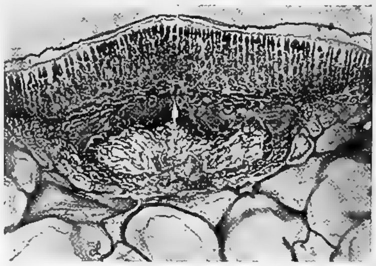


Fig. 607.
Gracilaria confervoides. Young cystocarp, showing the fusion cell, the parenchymatous placenta and the young carpospore layer. Photo. 100 : 1.

a well developed pore at the top. For further details of the structure and development of the cystocarp compare the quoted papers of Sjöstedt and Kylin.

The tetrasporangia are developed in particular individuals; they arise in the cortex by transformation of primary cortical cells. They are cruciately divided.

The species has been met with in several places at the coast of Skagerak from Hanstholm to Skagen, always growing near land at a depth of about one meter or at most two meters. It grows on stones but is often partly covered by sand. The species is perennial. It has not been observed in the winter months, because I have not visited the coast of Skagerak at that season, but large wintering specimens with emptied cystocarps were met with in April. The attachment disc winters, and the same is the case with a great part of the upright fronds or their lowermost part, and new shoots then arise from the disc or from the lowermost part of the wintering shoots. — Ripe tetrasporangia were met with in June, July and August, and as late as October tetraspore-bearing specimens were met with, but most of the sporangia were emptied. Antheridia were observed in July and August. Ripe cystocarps are common in July and August, and mostly emptied cystocarps were met with in October and as late as April.

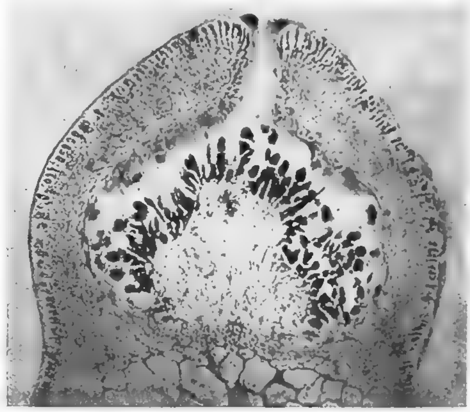


Fig. 608.
Gracilaria confervoides. Vertical section of ripe cystocarp, showing carpospores and among them absorbing tubular cells. Photo. 100 : 1.

Localities. **Ns:** Rømø, on the shore at Havneby (O. Jaap. Schrift. naturw. Ver. Schlesw.-Holstein, Bd. 12, 1902). Hjerting, 15. Aug. 1908 (collector unknown), some incomplete specimens, partly with cystocarps. — **Sk:** Hanstholm, west side of Roshage, near land, 2 metres; on the shore at Svinekløv (P. Petersen); Blokhus (E. Pingel); Løkken; Nørre Lyngby (Ove Paulsen); Lønstrup, 1 m, and numerous specimens on the shore; Hirtshals, on stones near land, 1—2 m, west side and east of the mole; north side of Skagens Gren, in a seine, common on the shore.

Loose forms. *Gracilaria confervoides* has only been met with attached to stones on the north coast of Jutland. Within Skagen it has only been found loose on the bottom in a few widely separated localities. Lyngbye records *Gigartina confervoides* from the coast of Hindsholm Fioniæ as found by Hofman Bang, and several specimens of this species from Hofmansgave are also contained in the herbarium of Lyngbye, and in that of the Botanical Museum of Copenhagen, all collected by Hofman Bang in the years 1824 to 1828, though it is said to be very rare. The species seems, therefore, to have lived here in a loose condition at least for some years, perhaps for a long time. On some of the specimens Lyngbye has written, that Hofman found them after the storm on the first of November 1827. It seems, therefore, that the species occurred only at a certain depth whence it was only washed ashore by violent storms. The specimens from these localities are only slightly different from the typical ones except that they are all without base and sterile, and it can be added that they are all devoid of hyaline hairs. They are about 12 cm long, and the branches are often somewhat bent. HOFMAN BANG referred them to *Fucus scorpioides* Fl. Dan. t. 887. LYNGBYE was much in doubt as to their determination. The anatomical structure agrees with that of *Gracilaria confervoides*, in particular the central tissue built up of large short cells, by which this species is easily distinguished from *Furcellaria fastigiata* and *Ahnfeltia plicata* with which the loose specimens have been compared.

Fig. 609. *Gracilaria confervoides* f. *tenuissima*. Ulfsund. Søren Lund. Nat. size.

Loose specimens were further met with in two localities in the Limfjord, where they occurred on clay-muddy bottom without vegetation. These specimens are only different from the normal ones by the want of base and by being sterile.

F. *tenuissima*. A more aberrant sterile, loose form has been gathered by Mr. SØREN LUND by dredging in Ulfsund on the north side of the island of Møen at 3 metres' depth, where it occurred in company with loose *Cladophora*. The specimens are only 2—3.5 cm long and very thin, 140—200 μ in diameter, while in the normal specimens the main axis often reaches a thickness approaching to one mm. At the first glance it did not seem easy to determine these thin specimens, but an examination of the anatomical structure showed that they must be referred to *Gracilaria confervoides*. The medullary tissue of the terete frond consists of large, almost isodiametrical cells without rhizoids, not lengthened in the longitudinal direction of the frond, and the tip of the frond agrees perfectly with that of the normal frond, being only somewhat thinner. The apical meristem was decidedly active in spring. The fronds have a brown-red colour; they have a firm consistency and are repeatedly branched; 7 generations of shoots were observed. The branches of the consecutive generations are essentially of the same thickness, the youngest branches only somewhat thinner. The branches are more divaricate than in the typical specimens. — It seems probable that these much reduced specimens derive from detached normal specimens accidentally introduced from the Skagerak in these waters in olden time, having been able to keep alive and vegetate in a sterile state by adaptation to the local external conditions, especially the low salinity which probably varies about 1 p. ct.

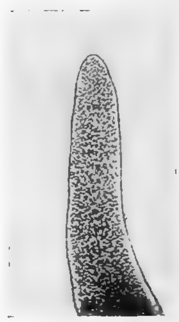


Fig. 610. *Gracilaria confervoides* f. *tenuissima*. Tip of frond. 70:1.

Locality. **Sm:** Ulfsund, off Nymarke Nakke, 600 m from land (S. Lund, April 1930).

General Remarks on the Danish Species of the Gigartinales Rhodymeniales and Nemastomatales.

Reproduction, Alternation of Generations.

Of the 18 species of these groups mentioned above, 11 only have the typical alternation of generations peculiar to the Florideæ. In one of these species the two generations do not occur simultaneously. As shown by STURCH, the sporophytic individuals of *Harveyella mirabilis* occur, at the British shores, in early spring, whereas the cystocarps are only met with in winter (December, January). In the Danish waters and at the west coast of Sweden the behaviour of this species is similar, for the cystocarps have only been observed in December and January, and the tetrasporangia most frequently occur in April to June, in individuals growing on branches and branchlets of *Rhodomela* produced in winter and thrown off in summer. The tetrasporangia are thus developed a little later in the Danish than in the British waters, and latest in the inner Danish waters. It must, therefore, be concluded, that two short-living generations, a sexual generation and a tetraspore-generation, succeeding each other, are produced in the course of one year. Aberrations from this scheme may, however, sometimes occur; e. g. individuals with the two kinds of sex organs and others with tetrasporangia were once found growing simultaneously on the same host plant in October, probably owing to special external conditions. On the other hand, the life-history of the species is different in the Arctic Sea, for it has only been found with sex organs and cystocarps in Scoresby Sound (East Greenland), whereas tetrasporangia were not met with at all, and it seems, therefore, that the sexual generation only is developed in the Arctic Sea.

The behaviour of *Harveyella mirabilis* at the shores of Northern Europe is a rare example of seasonal alternation of generations. SVEDELIUS has first used this term for the life history of *Ceramium corticatulum* in the Baltic.[1] This species has there an ephemeric gametophyte generation in late summer and a winter generation of tetrasporic plants, and SVEDELIUS points out that a similar seasonal alternation of generations has formerly been ascertained in *Chantransia efflorescens* and in *Harveyella mirabilis.* As to the former it must be admitted that no exact proof has been given of the assumption that *Rhodochorton chantransioides* is the sporophytic generation of *Chantransia efflorescens*, as maintained by KYLIN[2] and myself[3], and that the life-history of the species, therefore, needs further experimental and cytological investigation.

[1] N. SVEDELIUS, The seasonal alternation of generations of Ceramium corticatulum in the Baltic. N. A. reg. soc. sc. Upsal. Upsala 1927. — G. SJÖSTEDT, Revision of some dubious Swedish Ceramium types, their classification and ecology. Lunds Univ. Årsskrift, N. F. Avd. 2. Bd. 23, Nr. 12. 1928. — N. SVEDELIUS, The seasonal Alternation of Generations of Ceramium corticatulum. Svensk Botanisk Tidskrift, Bd. 23, 1929.

[2] H. KYLIN, Zur Kenntnis einiger schwedischen Chantransia-Arten. Botan. Studier tillägnade F. R Kjellman. Uppsala 1906, p. 113.

[3] L. KOLDERUP ROSENVINGE, Mar. Alg. Denm. Part. I, 1909, p. 137.

In *Lomentaria rosea* sex organs are thus far unknown, tetrasporangia only are known; but as the species is rather rare, great importance cannot be attached to this fact.

On the other hand, sex organs and cystocarps are the only known organs of reproduction in *Gigartina mamillosa*, whereas tetrasporangia are unknown. It should be ascertained whether the sporophyte generation is really wanting or whether tetrasporangial sori may perhaps have been confounded with cystocarps.

Rhodymenia palmata is very remarkable by having tetrasporangia and antheridia, whereas carpogonia and cystocarps are unknown. As this species is widely spread, it must be supposed that the last-named organs are really lacking, and the spermatia must then be without function. As a fertilization does not take place and no other mixie has been ascertained, it must be expected at the outset that nuclear division in the sporangium does not have the character of a meiosis. According to Miss Westbrook, a double spireme stage and a synizesis was ascertained by the first nuclear division, but the accomplishment of the reduction division has not been substantiated, and it may be supposed that this process is only initiated but not performed.

It is interesting to note that there are other Florideæ which agree with *Rhodymenia palmata* in having only tetrasporangia and antheridia whereas female sex organs and cystocarps are wanting, viz. *Antithamnion boreale* (Part III, p. 370), *Rhodochorton penicilliforme* (Part III, p. 389), *Rhododermis elegans*[1] and *Halosaccion ramentaceum*[2].

In *Ceratocolax Hartzii* well developed tetrasporangia occur, and the tetraspores are undoubtedly able to give rise to new plants infesting *Phyllophora Brodiæi*, though the first stages of the germination have not been observed. Sex organs too occur, at any rate procarps, which are, indeed, usually badly developed; apparently normal carpogonia with long trichogynes may, however, be met with. Antheridia, too, seem to be produced but they are scarcely quite normal. And the fact that fertilization and cystocarps have never been observed corroborates the supposition that the sex organs do not reach a normal development. The tetrasporangia develop in (winter and) spring, they are ripe in April and May, and after June tetrasporangia-bearing plants are not observed. The individuals as a rule bear either tetrasporangia or sex organs, but as, in one case at least, the presence of nemathecia and sex organs in one and the same specimen was ascertained, it is probable that this is a normal occurrence. It must then be supposed that an alternation of generations does not take place here, but that the individuals produce first tetrasporangia and later sex organs without normal function. As procarps may arise also in spring, it is possible, however, that some individuals produce only sex organs or that these organs can be produced independently of the nemathecia.

[1] Kolderup Rosenvinge, The Marine Algæ from North-East Greenland. Meddelelser om Grønland, Vol. **43**, 1910, p. 105.

[2] H. Jónsson, Mar. Algæ of Iceland, I. Bot. Tidsk. Bd. **24**, 1901, p. 139.

The reproduction of *Phyllophora Brodiæi* and *Ahnfeltia plicata* exhibits instances of a much reduced alternation of generations. In *Phyllophora Brodiæi* it has been shown that the globular bodies, formerly usually considered as a parasite of the genus *Actinococcus*, are much reduced tetrasporophytes of *Phyllophora Brodiæi*. The fronds of this species are all sexual plants usually bearing antheridia and procarps in the same individual. A fertilization process was not seen by the author, but observations of H. Claussen and Kylin suggest that a fertilization and a transfer of a sporogenous nucleus to the auxiliary cell really take place. The auxiliary cell gives off protuberances which do not become gonimoblast filaments but grow out as intercellular cell-filaments which finally give rise to the nemathecial bodies forming cushions outside the surface of the frond. The carposporophyte is abandoned, and in its place a tetrasporophyte is developed. The intramatrical cell-filaments growing out from the auxiliary cell represent the much reduced vegetative part of the tetrasporophyte.

Ahnfeltia plicata is a still more reduced type. Sex organs, fertilization process and cystocarps are wanting. The only organs of reproduction are the nemathecia, which produce monospores in the end-cells of the nemathecial filaments. In the young nemathecia small groups of generative cells appear which give rise to horizontal cell-rows and to secondary nemathecial cell-rows the end-cells of which develop into monosporangia. The groups of generative cells are considered as reduced procarps. These cells or some of them grow out into cell-rows partly in a horizontal, partly in a vertical direction, the latter forming secondary nemathecial filaments producing monospores in the end-cells. The whole complex of cell-filaments produced from the generative cells is considered as corresponding to the sporophytic phase of the typical diplobiontic Florideæ, although it arises without any fertilization process from the *Ahnfeltia* plant. The nemathecium of *Ahnfeltia* can be compared with that of *Phyllophora Brodiæi*, and the monosporangia of the former with the tetrasporangia of the latter. The monosporangia can be interpreted as reduced tetrasporangia which have failed to be divided, in good accordance with the absence of a reduction division.

Loose Forms of normally Attached Species.

The fronds of a comparatively great number of the species treated in the fourth part of this work are able to maintain life for a shorter or longer time after having been disengaged from their support. When living long in a loose condition, the fronds are always sterile. In stormy weather numerous fronds of Algæ are torn away from their substratum. Many of them are washed ashore but a great number are carried by the currents to localities often situated far away from the spot where they were growing and where the external conditions may be rather different from those in their original growing place. The annual species and others with a soft consistency of the frond die shortly after having been loosened; those with a more solid structure are able to keep alive for some length of time. In the Danish waters great quantities of loose Algæ are especially carried along the bottom by westerly storms, when the currents run from the northern areas with comparatively high salinity to the Belt Sea and the Baltic where the salinity of the water is lower, and they may then come to rest in localities where the water is less agitated and the external conditions altogether rather tranquil. In such localities the loose Algæ may find a tolerably permanent place of residence, whether they lie loose on the bottom or they are retained between the rhizomes of *Zostera*-plants or between attached Algæ. Loose forms of several species of Algæ are often found entangled with each other in such places. The power of keeping alive for a long time in a loose condition depends not only on the consistency of the frond but also on its ability to support the different external conditions in the new place (salinity, variation of temperature etc.), and on its power of increasing and branching after having been detached from the substratum. As will be seen in the following, the species here in question show great differences in their power of adaptation to the loose condition.

Phyllophora membranifolia does not seem very willing to vegetate in a loose condition. Detached fronds may be met with, but they are not different from the attached ones and seem unable to grow after having been detached. (Comp. p. 521).

Three loose forms of *Chondrus crispus* were mentioned above (pp. 506—507); they occur rather rarely and in small quantities, and it is doubtful whether they are able to vegetate and propagate in the loose condition. Specimens of f. *incurvata* showing a callus disc at the lower end of the frond cannot have lived long after the disengagement for the callus must be supposed to have been produced on the wound surface where the frond has been loosened, and the aberrant shape of the frond must, therefore, be supposed to have been accomplished by transformation of the frond, not by innovation.

Rhodymenia palmata occurs in a loose condition in the Baltic north of the Isle of Møen (**Bm**), where the species cannot live in the normal, attached state, owing to the low salinity of the water. These specimens have undoubtedly been carried into the Baltic from Øresund when the bottom current through Øresund overflows the threshold at Saltholm; they resemble those growing attached in Øresund. They undoubtedly keep alive for some time, but it is doubtful whether they can propagate for any long period. At any rate, as the species can continually be introduced in this part of the Baltic, it is understandable that it has often been met with in this area, like many other loose Algæ. The great length of the fronds gives evidence of a continued growth in the loose state.

Phyllophora Brodiæi which is very common in all the Danish waters often occurs in a loose condition of various shapes. The most common form is f. *concatenata* which is most frequently met with in the *Zostera* region; it is characterized by long fronds alternately filiform and flat, lanceolate, branched by dichotomy and by proliferations. Nearly related to it is f. *filiformis*, the frond of which is very narrow, almost entirely cylindrical. F. *stellata* has a quite different shape, the dichotomously branched frond bearing at the top of the branches bunches of radiating small, narrow shoots which must be considered as sterilized sexual shoots. These loose forms are probaby able to vegetate and propagate for a long time by continued growth and branching, a multiplication taking place by decay of the oldest parts of the frond.

Ahnfeltia plicata, which, like the foregoing species, is of common occurrence in the Danish waters, also appears in a loose form (f. *tenuior*, p. 568), which is easy to recognize as belonging to this species but, on the other hand, of a very aberrant shape. Its frond is lower and thinner and the branches divaricate. It is common in company with other loose Algæ, in particular between Zostera. It is undoubtedly able to vegetate and propagate by continued dichotomizing and dividing.

Gracilaria confervoides occurs, attached to stones, in the Danish waters only on the shores of the North Sea and Skagerak, but loose specimens have been met with in a few places in the inner Danish waters. A few specimens, not different from the normal ones except by being destitute of base were found in the Limfjord, where they may easily have been introduced by currents from the North Sea. It is more remarkable that loose specimens of the same species have been carried by the currents to two localities in the inner waters situated at great distances from those where the species is normally growing. At Hofmansgave, at the North coast of the island of Funen, loose specimens differing from the normal ones only by somewhat curved branches, but otherwise easily identified by their anatomical structure, were met with in the years 1824 to 1828. They must have originated from specimens introduced by currents from the Skagerak and have kept vegetating at least in that period. Later they have not been observed and have probably sooner or later decayed owing to the unfavourable external conditions. The specimens found at the north coast of Møen, where the salinity of the water is very low (about 8 ‰), are more aberrant in the inconsiderable size and small thickness of the fronds; the anatomical structure of the frond, however, showed with certainty that the fronds belonged to *Gracilaria confervoides*. The fact that the loose specimens were found in a considerable number in this locality suggests that this form f. *tenuissima* is able to vegetate and to propagate by dividing, and it can be concluded that it has been adapted to keep alive during a certain period. Whether it would be able to propagate for an indefinite period must be settled by later investigations.

The most remarkable example of loose Florideæ taking a shape very aberrant from that of the typical species is *Phyllophora epiphylla* f. *Bangii* (p. 540), characterized by its incised frond. It has so far been considered as an independent species, referred even by one author to another genus (*Rhizophyllis*). By examining a great number of specimens of *Phyllophora Bangii* I have been able to prove that it is a loose form of *Ph. epiphylla*, connected with it by rare transitional forms. The typical species only occurs in the North Sea, Skagerak and the Northern and Eastern Kattegat, whereas f. *Bangii* almost exclusively occurs out of this area in water of lower salinity in the inner Danish waters, including the Western Baltic. That it has not been met with in Øresund is probably due to the too low salinity of the surface water in this area. In some specimens (α), the frond is not incised in its whole length but has broader portions with more or less entire border, and in these specimens ramification by proliferations may occur just as in the typical species. Other specimens have not such dilatations of the frond and only branch by lateral ramification, never by proliferations (β, *tenuis* Lyngbye). This form has certainly arisen by branching of the broader form (α). It occurs partly together with the latter, partly alone, in the innermost waters (Great Belt and Western Baltic). It is interesting to note that in the southernmost part of the area of β a new form arises as branches from it, branching just like it by lateral ramification only, but entirely wanting the lacinulæ characteristic of β (fig. 528). — *Ph. Bangii* is able to vegetate and propagate by continued growth and ramification and decay by degrees of the lowermost part of the frond; it can therefore be maintained for a very long time even if renewal by transformation of the typical form only rarely occurs. In this respect it can be compared with the floating forms of *Sargassum* in the Sargasso Sea. The number of specimens of *Ph. Bangii* in the Danish waters is much larger than that of the typical *Ph. epiphylla.*

J. SCHILLER has designated the formations of loose Algæ as "Migrationsformationen"[1] or wandering formations; this designation would not, however, be particularly well-suited to the loose Algæ mentioned here, because they live in localities where the movements of the water are feeble and where the loose Algæ to a great extent are retained and entangled between *Zostera*-plants or attached Algæ; they are, therefore, practically resident on the same spot.

[1] J. SCHILLER, Über Algentransport und Migrationsformationen im Meere. Revue der ges. Hydrobiol. u. Hydrogr. Bd. II, H. 1 u. 2.

Addenda.

Fam. Bangiaceæ.

2. **Erythrotrichia reflexa** (Crouan) Thuret in herb.

Hauck, Meeresalg. Deutschl. u. Oesterr. 1884, p. 22; G. Hamel, Floridées de France. Bangiales. Revue Algologique, Vol. I, 1925, p. 288.
Bangia reflexa Crouan, Algues mar. du Finistère. III, N. 394, 1852.
Porphyra reflexa Crouan, Florule du Finistère 1867, p. 132, pl. 10, fig. 73.

In July 1923 I found in the harbour of Frederikshavn a small *Erythrotrichia* which agreed with *E. reflexa* (Crouan) by its short curved filaments attenuated at both ends. The same species was found again in the following years in several places in the Northern Kattegat.

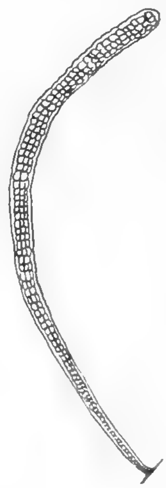


Fig. 611.
Erythrotrichia reflexa from Tonneberg Banke, Northern Kattegat, 19 m, July. The filament is by exception not attenuated at the top.

Only little has been added to our knowledge of *E. reflexa* since it was described in 1852 by the brothers Crouan upon specimens from Brest. Hauck recorded the species from the Adriatic Sea but, according to Hamel (l. c. p. 289), the plant which Hauck has communicated under this name is not *E. reflexa* but *E. obscura*. Hamel records the localities known on the coast of France, and gives some dimensions for the specimens of Crouan: thickness at base 10 μ, in the middle 35 μ and near the top 15 μ.

The Danish specimens, which I have examined in a living state and well preserved, show larger dimensions than those given by Hamel which are in accordance with my observations on examining the original specimens of Crouan and specimens from Bornet collected at Biarritz. The lower part of the frond consisting of a single row of cells showed a thickness of 17—35 μ, and the middlemost part a thickness of 32—63 μ, most often about 46 μ. The plants may reach a length of 5 mm but are usually shorter, about 2 mm

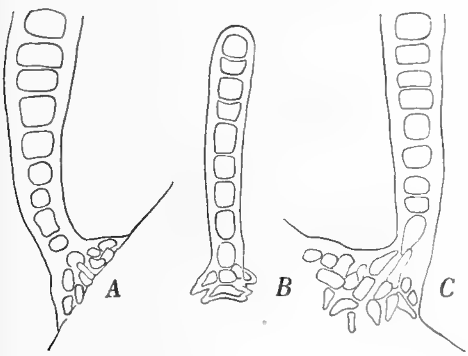


Fig. 612.
Erythrotrichia reflexa. *B*, young plant. *A* et *C*, basal parts of plants. 350 : 1.

or smaller. The thickness gradually increases towards over the middle, longitudinal divisions beginning at various distances from the base. The number of vertical septa in each joint of the middlemost part of the frond may be about 4. Near the top the filament is again tapering; longitudinal divisions are wanting.

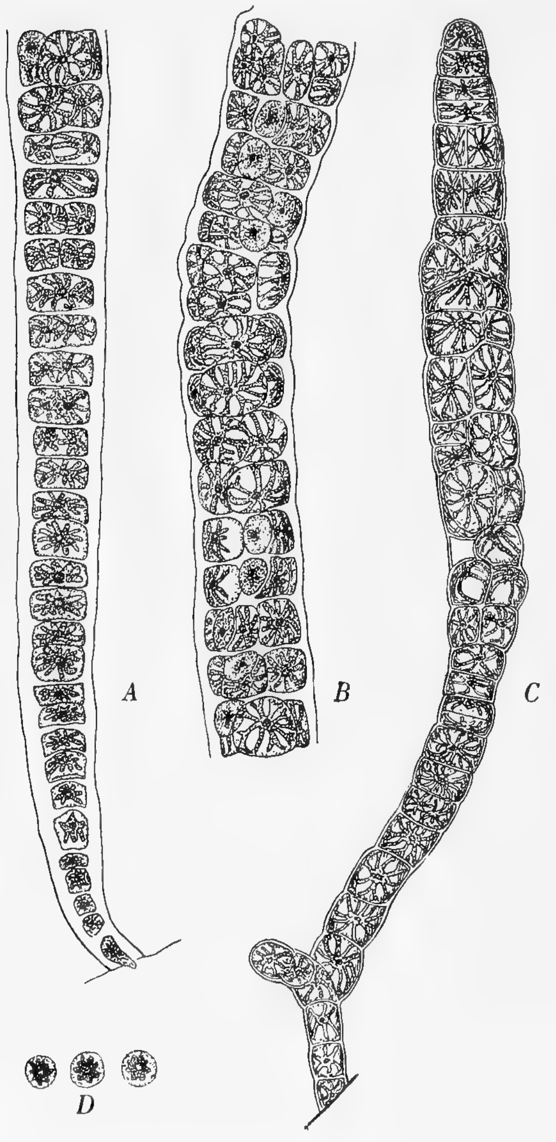


Fig. 613.
Erythrotrichia reflexa. After living plants. In *B* monosporangia are to be seen. In *C*, the basis of the plant was hidden. *D*, monospores. After living plants. 340 : 1.

As nearly all the observed specimens were unbranched, it appeared doubtful whether the Danish specimens ought to be referred to Crouan's species. One specimen only was found which showed a little branch issuing near the base (fig. 613 *C*). According to Crouan the fronds are branched or simple, with branches arising near the base, alternate or opposite.

The young plants are cylindrical, monosiphonous, fixed to the substratum (various Algæ) by rhizoids produced by the lowermost cells of the filaments (fig. 612 *B*) and forming a conical attachment organ composed of several closely united branched cell-filaments (fig. 612, *A*, *C*). Crouan described the "root" as colourless; I found it of the same dark purple colour as the upright filament. Each cell of the filaments contains a stellate chromatophore with a central pyrenoid and long, simple or dichotomously branched arms bent along the vaulted outside of the cell. In the polysiphonous portion of the frond the central part of the chromatophore is more or less approached to the outside of the cell.

The sporangia (gonidangia) are cut off by longitudinal or somewhat oblique walls from cells in the polysiphonous part of the frond (fig. 613). They are a little smaller than the vegetative cells, about 14—16 μ in greatest diameter, often broadly obovate, and are easily recognizable by their dense contents. The stellate chromatophore is not so distinct as in the vegetative cells, but the pyrenoids are easily observed. In the exhausted spores the chromatophore is very distinct (fig. 613 *D*); its arms are shorter than in the vegetative cells. In the living spores the chromatophore was red, while the pyrenoid appeared with a yellowish colour. In a certain position the chromatophore showed an incision on one side where the nucleus probably was situated. The living spores showed no amoeboid changes of shape, but were able to execute gliding movements on the slide.[1]

The Danish plants are here referred to *Erythrotrichia reflexa* although they are almost all unbranched and their dimensions larger than those of the French specimens, and though there seem also to be differences as to the attachment organ. Crouan attributed to his species a "Racine discoide incolore". I have not observed the attachment organ of the original specimens in Crouan's Exsiccate No. 394, but I have seen the attachment organs in specimens of the same species from Biarritz communicated by Bornet (herb. Thuret), and these agreed with those of the Danish specimens; I think, therefore, that Crouan's short description of the attachment disc is founded on some incomplete observation. Colourless attachment organs are otherwise not known in the genus *Erythrotrichia*. As to the nearly complete want of ramification in the Danish specimens, it is noteworthy that only one little branch has been met with, although the species has been observed repeatedly during recent years. On the other hand the greater part of the specimens examined from the collection of Crouan were unbranched, and all the filaments examined of the specimen from Biarritz were unbranched. The greater thickness of the filaments in the Danish specimens is perhaps due to the different external conditions. As long as *Er. reflexa* and its variation is not better examined in different localities, it is impossible to decide with certainty whether the Danish species is the same as that from the coast of France.

The species was found growing on various Algæ (*Polysiphonia urceolata, Cystoclonium purpureum, Sphacelaria saxatilis* and *Callithamnion Hookeri*) at 1 to 19 metres' depth; it was only observed in July and August.

Localities. **Kn:** N.W. end of Tønneberg Banke; Hirsholm harbour (Henn. Petersen); Frederikshavn harbour; Borrebjergs Rev, Marens Rev.

Fam. Naccariaceæ Kylin 1928.

Atractophora sp.

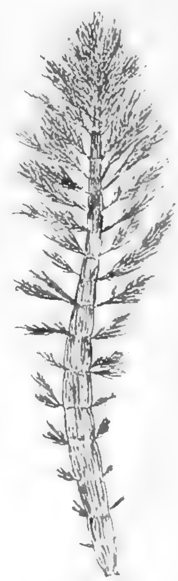


Fig. 614.
Atractophora sp.? 33 : 1

In July 1929 I found on a stone picked up from a depth of about 2 metres in the neighbourhood of Frederikshavn a small red Alga, only 2 mm high, issuing from a circular disc. As the

[1] Comp. L. Kolderup Rosenvinge, On Mobility in the reproductive Cells of the Rhodophyceæ. Botan. Tids. **40** p. 72.

species was unknown to me I tried to get other individuals in the same locality and in other similar places but without success. The only existing little specimen showing a very characteristic structure, I think it useful to give a short description of it and some figures in order to render an identification of the species possible.

The frond has a distinct axial cell-row which bears at each joint a whorl of branches, from the base of which downward growing cell-rows issue, which form a thick cortex surrounding the axial cell-row. The branches are mostly pinnate, with opposite branchlets and with limited growth; branchlets of the second order may occur. Many of the end-cells of the pinnæ and pinnulæ bear a hyaline hair. The lowermost branches are simple or feebly branched. Branches of the same kind as the primary axis, with enduring growth, occur. The colour of the plant is brownish-purple, somewhat resembling that of *Plumaria elegans*.

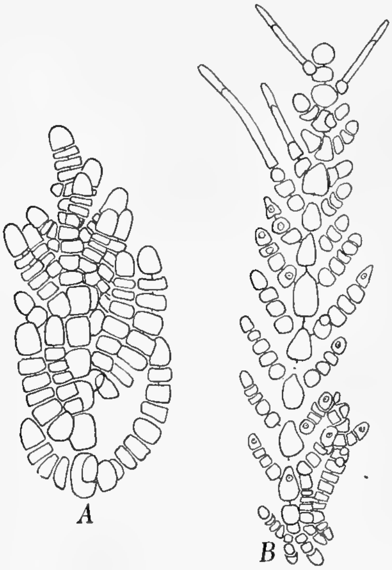


Fig. 615.
Atractophora sp.? *A*, tip of frond. 625 : 1. *B*, portion of branch. 440 : 1.

The plant recalls *Atractophora hypnoides* in the general structure[1]; but it differs so much that it cannot be identified with it. As I had no material for comparison, I applied to Mr. E. Chemin at Paris who has most kindly sent me some dried specimens of *Atr. hypnoides* from the north coast of France. An examination of these specimens, some of which were young, confirmed that the plant from Deget was decidedly different from *Atr. hypnoides*. The branches of the latter are similar to the primary axis, bearing shoots on all sides, and the cortex built up of

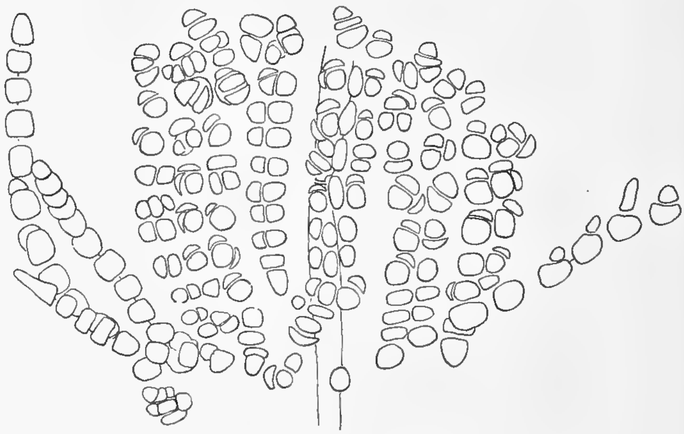


Fig. 616.
Atractophora sp.? Portion of the main axis. The cell-rows of the cortex are a little separated by pressure. The long cells of the axial cell-rows are to be seen in the middle. 625 : 1.

[1] Comp. Crouan, Ann. d. scienc. nat. III[e] sér. t. 11, 1848, p. 371, pl. 11 A; Nägeli, Morph. u. Syst. d. Ceram. 1861, p. 388; Zerlang, Flora 1889; Kylin, Entwick. Florid. Studien. 1928, p. 12; E. Chemin, Sur le développement des spores de Naccaria Wiggii Endl. et Atractophora hypnoides Crouan, Bull. soc. bot. France, t. 74, 1927, p. 274.

the downwards growing cell-rows budding off from the base of the branches has a quite different structure from that of the Danish specimen. In the French plant it remains filamentous, consisting of parallel cell-rows and it has a comparatively small thickness, while the cortical cell-rows in the Danish plant are early divided by numerous transverse and longitudinal walls, the latter being both radial and tangential, with the result that the cortex becomes thick and is built up of numerous short cells, whereas the axial cell-row is narrow (fig. 616), in contradistinction to *Atr. hypnoides* where it is very broad. Finally the cortical cell-rows of the latter bear numerous short simple or feebly branched filaments which do not occur in the Danish plant (comp. Crouan l. c. fig. 3—5). In spite of the differences quoted it seems probable that the Danish plant belongs to a species related to *Atractophora hypnoides*.

Locality. **Kn:** South coast of the isle of Deget near Frederikshavn.

Fam. Rhizophyllidaceæ.

Chondrococcus Hornemanni (Mertens) Schmitz.

This species was first described by Mertens in 1815 (Göttinger gel. Anzeiger 1815 No. 64) under the name of *Fucus Hornemanni*. It was mentioned and described 1819 by Lyngbye who writes (1819, p. 35) that it was found in Öresund "ubi ad oram Helsingoræ hanc speciem elegantem et quidem rarissimam cel. Forskaal olim legisse fertur". Lyngbye named it *Desmia Hornemanni* and gave a very good picture of it (l. c. Tab. 7 C). The original of this figure is to be found in The Botanical Museum at Copenhagen, labelled by Mertens: *F. Hornemanni*; on the back of the sheet Hornemann has written: "legit Forsk: ad oras Helsingoræ". The species was referred to *Sphærococcus coronopifolius* by C. Agardh in Synops. Alg. Scand. 1817, p. 30, and later united with *Sphærococcus Lambertii* (Suhr) by J. Agardh (Sp. g. o. II.ii. 1852, p. 641) under the name of *Desmia Hornemanni* (Mert.) Lyngb., which name is still kept in his Epicrisis, 1876, p. 357, while Kützing referred the species to the genus *Chondrococcus*. There can be no doubt that this Alga has not been found growing in the Öresund. Lyngbye had evidently his doubts as to the correctness of the locality cited, and J. Agardh wrote (1852, p. 642): "cum nave forsan transvecta?". Schmitz (Marine Florideen von Deutsch-Ostafrika, Engler's Bot. Jahrb. Bd. 21, 1895, p. 171) pointed out that *Chondrococcus Lambertii*, which is common at the Cape, is specifically quite different from the true *Ch. Hornemanni* which occurs in the Northern Indian Ocean. I can fully confirm this distinction. In *Ch. Hornemanni* the pinnæ are generally opposite while in *Ch. Lambertii* the branches are alternate and more distant, and the frond broader. It can be imagined that the specimen described and figured by Lyngbye has been collected by Forsskål in the Red Sea, but that a confusion of labels has occurred after Forsskål's death, during the last part of the journey or later.

Genera incertæ sedis.

Conchocelis Batters 1892.

1. Conchocelis rosea Batters.

E. A. Batters, On Conchocelis, a new genus of perforating Algæ, in G. Murray, Phycological Memoirs, Part I, London 1892, pp. 25—28, Pl. VIII. G. Nadson, Die perforierenden (kalkborenden) Algen. (Russian with abstract in German), Scripta Botanica Horti Univ. Petropolit. fasc. 18, 1900, pp. 14—19, 36—37. L. Kolderup Rosenvinge, On the Marine Algæ from N. E. Greenland. Meddelelser om Grønland, 43, 1910, p. 111. H. Printz, Algenveg. d. Trondhjemsfjordes. Skrifter utg. af D. Norske Vid.-Akad. Oslo. 1926, pp. 54, 257.

Batters described in 1892 a perforating red Alga living in the calcareous shells of Molluscs gathered near the coast of Scotland. The frond consists of a horizontal layer of thin, branched interlaced filaments giving off irregular inflations, which are simple or branched, and consist of from two to ten cells, each containing a star-shaped chromatophore. According to Batters the plant appears to be reproduced by means of spores formed in the cells of the inflations, one spore in each cell. He had "seen globular bodies which appear to be spores escape from the cells". In accordance with Bornet he referred the plant to the *Porphyraceæ (Bangiaceæ).*

The plant seems to be widespread for it has been met with repeatedly at the shores of northern Europe and in the Arctic Sea, but it is as yet imperfectly known. Nadson advanced (1900) the opinion that it was not a Rhodohycea but only a red variety of the green Alga *Ostreobium Queketti* Born. et Flah.; this opinion, however, has not been accepted by later authors (Kolderup Rosenvinge 1910, Printz (1926), and it can be taken for granted that *Conchocelis rosea* has been confounded by Nadson with a red variety of *Ostreobium Queketti.* Printz found such a red form of the last named Alga in the neighbourhood of Trondhjem, and I found a similar form in the Northern Kattegat, but they were both quite distinct from *Conchocelis rosea.* After having examined specimens of the latter gathered in East Greenland I maintained, though with doubt, that it could be referred to the *Bangiaceæ*, which classification was principally founded on the lack of pits in the transverse walls and the supposed presence of spores comparable to the monospores of the *Bangiaceæ.* On examining the Danish specimens of the species, I have, in order to gain a better determination of its systematic position, directed my attention in particular to the structure of the chromatophores, the presence or want of a pit in the transverse walls, and the reproduction.

The species is fairly widespread in the Danish waters where it grows in the shells of various molluscs; but it is most easily accessible when it occurs in the calcareous tubes of *Spirorbis* and *Pomatocerus triquetrus,* two Serpulids often attached to *Furcellaria* a. o. Algæ, and the shells of which are frequently pink owing to the abundant occurrence of *Conchocelis rosea.* For a study of the finer structure of this plant the shells of these Serpulids were treated with acetic acid, Carnoy's fluid, Nawashin's mixture or picric acetic acid. The latter treatment was particularly good for demonstrating the nuclei and the pit-connections between the cells.

The peripheral part of the frond is formed of long thin filaments, usually 3—4 μ thick, sometimes only 2 μ or still thinner. Where there is ample room the filaments may be long and straight and consist of very long cells; they may be simple or bear opposite or alternate branches rising rectangularly near the upper end of the cells. The branches are partly different from the long straight filaments by being composed of shorter more or less swollen, spindle-shaped or more irregular cells. (Comp. figs. 617—619). Later the filaments become very much branched and densely felted together, forming a more or less continuous layer within the surface of the shell. The cylindrical cells contain a small number of long ribbon-shaped or perhaps branched chromatophores and, in the middle of the cell, a nucleus which is often rather inconspicuous and feebly stained with hæmatoxylin. The transverse walls are very distinct but it is usually impossible to distinguish a central pit by application of dry lenses; but with high magnifying power a callus button deeply stained with hæmatoxylin on each side of the transverse wall could sometimes be observed (fig. 617 *A*, *E*), a sure sign of the presence of a pit. The structure of the inflated cells is similar to that of the cylindrical cells; the nucleus was in some cases very distinct (fig. 618 *B-F*), the chromatophores shorter. The transverse walls of the inflated cells have the same small diameter as those of the long cells. The contents of the inflated cells is at first not very rich, but later it often becomes dense and rich in granular matter, probably floridean starch, as it takes a red-brown colour with iodine, and the inflations may then resemble the chlamydospores of Fungi (fig. 618 *J*).

A new kind of cell-rows, different from those hitherto mentioned, spring, usually from the inflated cells, but sometimes perhaps directly from the long thin cells. The cells of these rows are different from the others by greater breadth and denser contents. Besides the cell organs they contain much floridean starch which gives the cell a granular, untransparent character. The cells are broader, not only in the middle but also at the transverse walls, which have a much larger diameter than the other cells. The cells of these filaments are cylindrical or a little inflated, almost of the same length as breadth, and they are uniform. These cell-rows are always branched but have a limited growth. The branches are usually more or less curved. As it must be supposed that they normally produce monospores, they will be called fertile cell-rows. In material from different shells they showed, however, certain differences; as I feel doubtful whether these variations are due to differences in the external conditions offered by the various tests in which the plants grow or if they may possibly be expressions of genotypical differences, specimens from various shells will be mentioned separately, and the drawings illustrating them are arranged so that each of the three groups of drawings (figs. 617—619) originates from plants growing in the same shell or, as to those growing in *Spirorbis*, at least from specimens of this Serpulid seated on the same host plant. They are all here provisionally regarded as belonging to the same species, *Conchocelis rosea.*

The specimens shown in fig. 617 grew in *Spirorbis* sp. attached to *Furcellaria fastigiata* gathered near Frederikshavn in July. The fertile filaments are here thick, about 14—16 μ in diameter, and the cells are usually more or less inflated or rounded, with convex outer-walls, of the same length as the breadth or shorter, rarely a little longer. Longitudinal or intercalary transverse or inclined divisions occur here

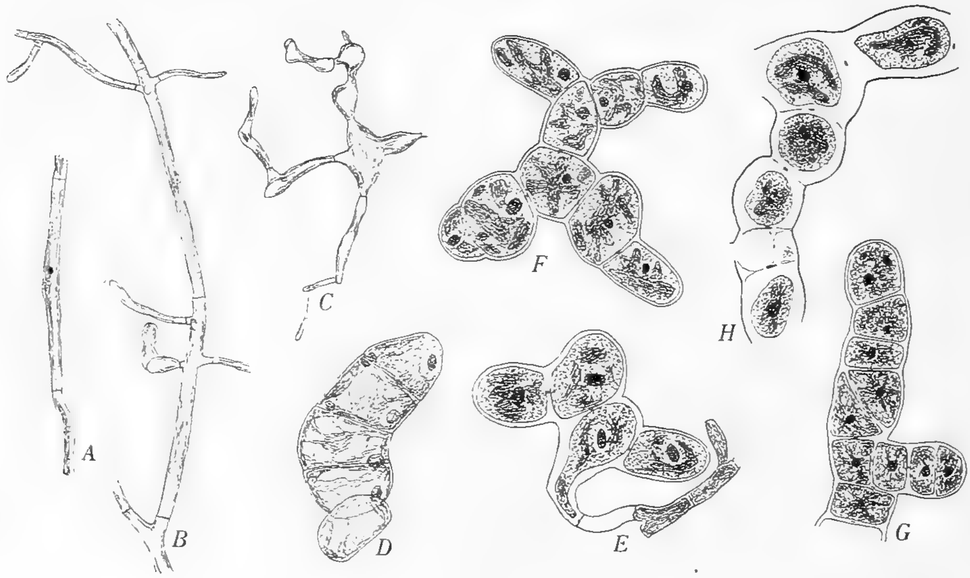


Fig. 617.

Conchocelis rosea, in test of *Spirorbis* sp. from Hjellen near Frederikshavn, treated with picric acetic acid. *A*, cell of long, thin filament, showing nucleus, chromatophores and pit-connections in the transverse walls. *B*, long filament with opposite branches, one with inflated cells. *C*, branched filament with partly inflated cells. *D*, row of broad cells with distinct flat chromatophores lining the wall. *E*, fertile cell-row springing from a thin filament, showing pit-connection in the transverse walls. *F*, branched fertile cell-row. *G*, fertile cell-row, with branch and an oblique intercalary wall. *H*, fertile cell-row the cells of which produce each a monospore. 630 : 1.

and there (fig. 617 *G*). The pit connections in the cross walls appeared distinctly in these specimens which had been treated with picric acetic acid, the callus button in the middle of the wall being intensely stained with hæmalum (figs. *E*—*H*). A young stage is shown in fig. *E*, where a 4-celled complex of fertile cells is seen in continuity with the thin filament from which it has originated. The larger bushes of fertile cell-rows may somewhat resemble a frond of *Stigonema*, but the outer wall is firm, not gelatinous. The cell-structure is often difficult to observe owing to its dense character. A central nucleus intensely stained with hæmatoxylin was always to be seen but its finer structure could not be observed. Many cells with dense contents suggested the presence of a stellate chromatophore as supposed by Batters and formerly by myself, and the nucleus then seemed situated in the middle of the chromatophore, suggesting a pyrenoid; but on observing well fixed cells with less dense contents, I succeeded in ascertaining that the intensely stained body was not a pyrenoid in a stellate chromatophore but a real nucleus situated in the cytoplasm and surrounded by chromatophores (fig. *E, F*). According to Batters (l. c. p. 26) the "inflations", by which term he denotes the fertile cell complexes, usually consist of from two to ten cells. The branched com-

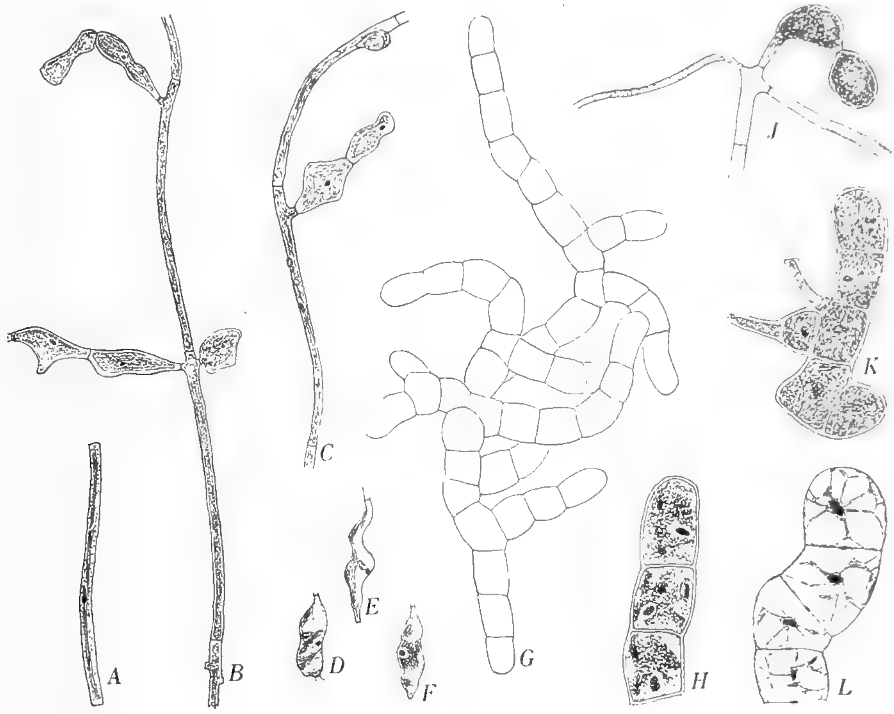


Fig. 618.
Conchocelis rosea. In shells of *Pomatacerus triqueter*. *A—H*, collected at Kobenhavner Rev near Frederikshavn, treated with picric acetic acid, stained with hæmalum. *J—L* from Marens Rev at Frederikshavn. *A*, long cell showing chromatophores and nucleus. *B* and *C*, long filament with branches consisting of inflated cells. *D, E, F*, inflated cells. *G*, branched complex of broad filaments. *H*, end of fertile cell-row. *J*, a couple of inflated cells with dense contents springing from a thin filament. *K*, a fertile cell-row in connection with thin filaments. *L*, four cells of a fertile cell-row from a section through a decalcified shell, showing the central nucleus and radiating plasma-strings, while the chromatophores are feebly stained. *A—F, H—K* 630 : 1. *L* 730 : 1.

plexes of fertile cells here described contain a much larger number of cells, about 50 or more. It is probably such complexes of which Batters treats when he writes (l. c. p. 27) that "the inflations often become detached from the horizontal filaments and are capable of an independent existence", and that he has found them of all sizes and shapes. The continuity of the larger complexes of fertile cells with the thin filaments was not indeed observed by me, and it is probable that their growth can be continued, if their connection with the thin filaments should be interrupted. I have also met with smaller groups of inflated cells consisting of 4 or 5 cells, resembling those figured by BATTERS but containing flat chromatophores lining the outer walls and one to three dense bodies, perhaps nuclei (fig. *D*). These cell-groups seemed not fully normal. — Fig. *H* shows a row of inflated cells the content of which is contracted and more or less globular, undoubtedly monospores; the callus buttons of the separating walls are very distinct.

Fig. 618, *A—H* show details from *Conchocelis* growing in a tube of *Pomatocerus triqueter* gathered in the same locality near Frederikshavn in July, while figs. *J—L* are from similar specimens gathered in a neighbouring locality three days later. The tube of *Pomatocerus* was coloured finely rose for a long way by the perforating Alga. The youngest part of the red shell contained principally very long straight filaments. A group of fertile cells in connection with thin filaments is shown in fig. *K*. Numerous large complexes of fertile cells were met with in the older part of the shell (fig. *G*). The cells of these cell-rows were cylindrical, scarcely swollen, usually a little longer than broad, and the diameter smaller than in the specimens from *Spirorbis*, viz. 9—11 μ. The structure of the fertile cells was not obvious, although the specimens had been treated with picric acetic acid or with Nawashin's mixture. An intensely stained nucleus could, however, be observed, but the shape and the number of the chromatophores were indistinct and a pit in the transverse walls was not usually discernible. In some cases dense bodies, intensely stained with hæmatoxylin, were observed in the chromatophores (fig. *H*); as these bodies were in some cases angular, they were perhaps crystalloids. In a transverse section of a shell treated with Nawashin's mixture and stained with hæmatoxylin after Heidenhain the fertile cell-rows were seen growing inwards in the shell from the vegetative layer. With high power of enlargement a central callus button proving the presence of a pit-connection was ascertained (fig. *L*). A number of strings recalling the arms of a stellate chromatophore were seen radiating from the central intensely stained nucleus; they seemed to be strings of protoplasm, whereas the presumed chromatophores were comparatively small and feebly stained.

The specimens drawn in fig. 619 grew in *Spirorbis* but agreed as to the fertile cell-rows with those just described from *Pomatocerus*. Fig. *C* shows a two-celled group of fertile cells given off from a spindle-shaped cell. The nuclei were intensely stained, whereas the chromatophores were very indistinct. The fertile cells were cylindric, which is also apparent in fig. *E*, where four globular monospores are to be seen.

The investigations here communicated have shown that there is a distinct difference between 1) a vegetative stage consisting of branched filaments composed of long, thin, cylindric cells and inflated, more or less spindle-shaped cells, both with narrow transverse walls, and 2) fertile branched cell-rows consisting of uniform, broad cells separated by broad cross-walls. The presence of a central pit in the cross-walls has been ascertained, and it has been shown that the cells contain a nucleus and probably always more than one chromatophore. The formation of a monospore in the fertile cells, as presumed by BATTERS, has been confirmed, and it seems that all the cells of the fertile cell-rows are capable of producing a monospore.

The formation of monospores is in good accordance with the reproduction of the *Bangiales*, but the presence of pit-connections between the cells shows that *Conchocelis* cannot be referred to this group, as such connections have never been observed within the *Bangiales*. The plant must therefore be referred to the *Florideæ*, but its relationship within this group is very doubtful. Monospores are known in several *Nemalionales*, but they are there always produced in particular monosporangia different from the other cells. Monospores have otherwise been found in female plants of *Nitophyllum punctatum*[1] where they arise in cells scarcely different from the vegetative cells, situated in groups near the procarps. This occurrence seems, however, to have no bearing on the consideration of the relationship of *Conchocelis*. Further researches are needed for the elucidation of this question.

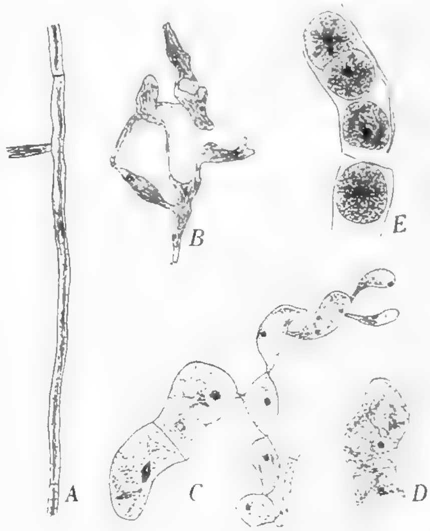


Fig. 619.
Conchocelis rosea. From shell of *Spirorbis* from Deget near Frederikshavn, treated with Carnoy's fluid, and stained with hæmatoxylin. *A*, long cell showing chromatophores. *B*, inflated cells. *C*, spindle-shaped cells; a fertile cell-row is given off from one of them. The nuclei are distinct, the chromatophores only feebly stained. *D*, end-cell of a broad cell-row, a pit-connection is seen in the transverse wall. *E*, Four globular monospores are formed in a fertile cell-row. *A*, *B*, *D* 630 : 1. *C* 510 : 1.

Conchocelis rosea has been met with in nearly all the Danish waters except the Baltic, growing in the calcareous shells of the Serpulids *Spirorbis* and *Pomatocerus triquetrus* and of various molluscs (*Buccinum undatum*, *Littorina littorea*, *Mytilus*, *Cyprina islandica*, *Astarte?* a. o.). According to Dr. JOHS. SCHMIDT it has also been met with in a calcareous stone. It has been gathered at depths from 1 to 32 metres. Fertile cell-rows have been met with in the months April to October (it has not been gathered in the winter months).

Localities. **Ns:** eP, off Lodbjerg light-house, 24 m, in Buccinum undatum. — **Lf:** Nykøbing, in Bucc. und. (Teilmann Friis). — **Kn:** fG, Tønneberg Banke, 15 m; off Aalbæk, 22 m, in Bucc. und.; at Hirsholmene and in numerous places near Frederikshavn, most frequently in Spirorbis and Pomatocerus. — **Ke:** Groves Flak. 23 m and 32 m, in Cyprina isl. (F. Børgesen,!); Søborg Hoved Grund, in Littorina lit., Gilleleje, in Spirorbis. — **Km:** East of Læso Rende, in Spir.; — **Sa:** $1^1/_2$ miles N.E. by N. of Sejerø, in Mytilus; Lille Grund, in Spir. — **Sb:** Hov Sand, in Spir.; Lohals, in Spir. Spodsbjerg Mole, in Spir.; off Holmegaard, in Spir. — **Su:** Skodsborg, in a calcareous stone (determ. Johs. Schmidt).

Halosaccion ramentaceum (L.) J. Agardh.

About 50 years ago Mr. O. SMITH sent me some Algæ cast ashore at Lerchenborg, Store Belt. Among these Algæ a specimen of *Halosaccion ramentaceum* is found.

[1] N. SVEDELIUS, Über Sporen an Geschlechtspflanzen von Nitophyllum punctatum. Ber. deut. bot. Ges. **32**, 1914, p. 106.

a very strange finding, as this species has never otherwise been met with in the Danish waters. Since the nearest known localities of this subarctic species are the Trondhjems-Fjord and the Færõe Islands, and as the specimen is quite normal and bears no sign of having been drifting for a long time in the Sea, I consider it most probable that the specimen in question, which has not been labelled by Mr. Smith, has been intermixed by an error among the Algæ found at the coast of Store Belt.

I am much indebted to Dr. Henning E. Petersen who has helped me in making microphotographs, to Lector J. Boye Petersen for having kindly photographed a number of dried specimens reproduced in the text, and to Mr. Søren Lund who has assisted me on several excursions. By the kindness of the authorities of the Fishery Department I have had the opportunity of making researches onboard in various boats belonging to the Fishery Control and Fishery Researches, for which permission I tender my best thanks. And finally I owe a debt of gratitude to the trustees of the Carlsberg Fund for a grant which has enabled me to defray various expenses in connection with the present part of my work.

INDEX

Synonyms are printed in *italics*.

CORRIGENDA

P. 30, l. 9 from top, to be added: 9.5 m.
P. 45, l. 12 from bottom, for E. by N. 1/3 N. read W. by S. 1/3 S.
P. 68, l. 5 from bottom, for Hveen read Hveen, 10,5—19 m.
P. 112, l. 14 from bottom, for **Sa** read **Lb**.
P. 277, l. 14 from bottom, for The fronds read The apical cells of the fronds.
P. 284, l. 6 from bottom, for f. *robusta* Kjellm. read f. *typica*.
P. 375, l. 19 from top, for 10 high read so high.
P. 402, l. 18 from bottom, for *Dasay* read *Dasya*.
P. 467, l. 7 from top, for *sinuosis* read *sinuosus*.
See further p. 150.

EXPLANATION OF PLATE VIII.

Microphotographs.

Figs. 1—3. *Phyllophora Brodiæi.* Sections of nemathecia (from K. Rosenvinge 1929). 1. Auxiliary cell with protuberances. 375 : 1. 2. Vertical section of nemathecium showing the central cell and a smaller nemathecium on the under face of the frond, evidently arisen by fusion of several small cushions. 64 : 1. 3. Transverse section of nemathecium showing the central cell. 77 : 1.

Figs. 4—10. *Ceratocolax Hartzii.*

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Fig. 11. *Ahnfeltia plicata.* Vertical section of nemathecium. 120 : 1.


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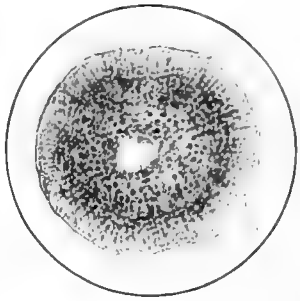
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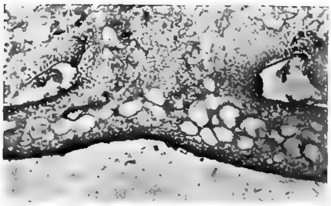
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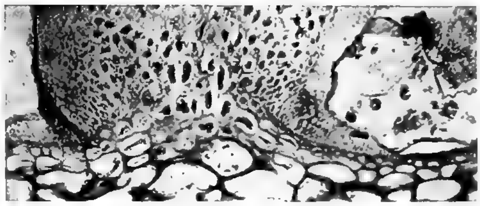
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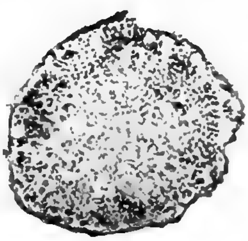
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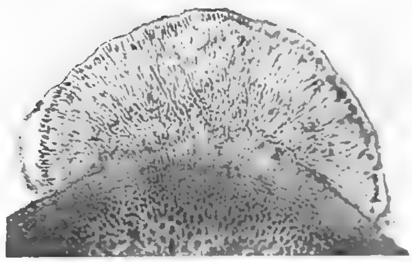
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Mémoires de l'Académie Royale des Sciences et des Lettres de Danemark, Copenhague,
7me série, Section des Sciences, t. VII, nº 1

THE MARINE ALGÆ OF DENMARK

CONTRIBUTIONS TO THEIR NATURAL HISTORY

PART I

INTRODUCTION. RHODOPHYCEÆ I.

(BANGIALES AND NEMALIONALES)

BY

L. KOLDERUP ROSENVINGE

WITH TWO CHARTS AND TWO PLATES

D. Kgl. Danske Vidensk. Selsk. Skrifter, 7. Række, naturvidensk. og mathem. Afd. VII. 1

KØBENHAVN

HOVEDKOMMISSIONÆR: ANDR. FRED. HØST & SØN, KGL. HOF-BOGHANDEL

BIANCO LUNOS BOGTRYKKERI

1909

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THE MARINE ALGÆ OF DENMARK

CONTRIBUTIONS TO THEIR NATURAL HISTORY

PART II

RHODOPHYCEÆ II.

(CRYPTONEMIALES)

BY

L. KOLDERUP ROSENVINGE

WITH TWO PLATES

D. Kgl. Danske Vidensk. Selsk. Skrifter, 7. Række, naturvidensk. og mathem. Afd., VII. 2

KØBENHAVN

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1917

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3.	**Warming, Eug.** Lagoa Santa. Et Bidrag til den biologiske Plantegeografi. Med en Fortegnelse over Lagoa Santas Hvirveldyr. Med 43 Illustrationer i Texten og 1 Tavle. Résumé en francais. 1892	10.	85.
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THE MARINE ALGÆ OF DENMARK

CONTRIBUTIONS TO THEIR NATURAL HISTORY

PART III

RHODOPHYCEÆ III.

(CERAMIALES)

BY

L. KOLDERUP ROSENVINGE

WITH THREE PLATES

D. Kgl. Danske Vidensk. Selsk. Skrifter, 7. Række, naturvidensk. og mathem. Afd., VII. 3.

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THE MARINE ALGÆ OF DENMARK

CONTRIBUTIONS TO THEIR NATURAL HISTORY

PART IV

RHODOPHYCEÆ IV.

(GIGARTINALES. RHODYMENIALES. NEMASTOMATALES)

BY

L. KOLDERUP ROSENVINGE

WITH ONE PLATE

D. Kgl. Danske Vidensk. Selsk. Skrifter, 7. Række, naturvidensk. og mathem. Afd., VII. 4.

KØBENHAVN
HOVEDKOMMISSIONÆR: ANDR. FRED. HØST & SØN, KGL. HOF-BOGHANDEL
BIANCO LUNOS BOGTRYKKERI A/S
1931

Pris: Kr. 9,75.

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