BOTANICA GOTHOBURGENSIA

I

STUDIES IN CLADOPHORA

by

JOHAN SÖDERSTRÖM

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Cladophora oblitterata SÖDERSTRÖM nov. nomen growing on a crust of Lithothamnion in a typical habitat, a spray pool, on the Norwegian south coast

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To the Memory of my Mother

PREFACE

In 1951 I was looking for a task in the field of marine biology, and thanks to Dr Mats Waern I became interested in algology, when during a week in June he introduced me to the algal flora of the Swedish west coast.

The original aim was that I should compare the algal flora of the enclosed firths or "sea lochs" north of the island of Orust in the province of Bohuslän, with the more well-known flora of the outer parts of the Bohuslän archipelago. Already during the preludes to this work my attention was aroused by the difficulties embodied in the determinations of Cladophora species, and so began a toil trying to the patience.

Through Dr Waern, who became my teacher in algology during the following years, I not only got a basic knowledge of algae, but also became one of the students at the Phytobiological Institute of the University of Uppsala. The head of this institute was at that time Prof. G. Einar Du Rietz and he always showed great interest in my work, helping me to obtain grants which enabled me to carry on the field research.

In 1958 I had to leave Uppsala and take up work as a teacher in Gothenburg. There I found a new home for my research work in the Marine Botanical Institute. The head of this institute, Dr T. Levring, encouraged me to go on with the work on Cladophora, and a university grant and the arrangements made by Dr S. Svenningsson, the sympathetic headmaster of the school where I have been employed, made it economically possible.

During my research I have had assistance from a great many persons. In particular I would like to mention the staffs of the Phytobiological Institute in Uppsala and the Marine Botanical Institute in Gothenburg. At the biological stations that I have visited during the field work I have always been well received and am therefore indebted to the staffs of Kristinebergs Zoologiska Station, Biologisk Stasjon, Espegrend, The Marine Laboratory, Plymouth and Laboratoire Maritime, Dinard, as well as the zoological department of the University College, Cork, who kindly let me use their premises at Lough Ine.

While studying in herbariums I have received help from the staffs of the botanical museums in Lund and Uppsala, the botanical departments of Riksmuseum, Stockholm, the British Museum, the Kew Herbarium and the Linnaean Herbarium, London, as well as the School of Botany, Trinity College, Dublin.

My field work has been made possible through grants from the Universities of Uppsala and Gothenburg, the Royal Swedish Academy of Science and the Royal Society of Arts and Sciences of Gothenburg.

During the last few years I have had the pleasure of working in the same building as Prof. Carl Skottsberg, who always showed a great interest in the intricate taxonomical problems I so often had to grapple with and it was of the greatest value for me to have his profound experience at hand.

In 1955 and 1960 Mr Anders Malmer was my assistant on many adventurous excursions by boat made along the Swedish west coast.

In the completion of the manuscript and the pictures I have had painstaking assistance of Mrs R. Törnström and Miss M. Haglund as well as Mr S. Carpenter who has made corrections in my English text.

My mother was my first teacher in botany and until her death never failed in her interest for my work. With great patience she saw her beautiful little summer house turned into a laboratory, with buckets of ill-smelling algae in the corners. She made it possible for me to keep a small auxiliary sailing yacht and often went along on the collecting trips, when she could often be seen to be the first one to enter the water and swim after green tufts. It is a source of great sorrow for me that she did not live to see the result of our efforts.

To be the wife of a person working on a dissertation cannot be an enviable lot. On my wife has fallen the duty of keeping the family going on the smallest possible means, with the husband mostly away and when at home often preoccupied and even short-tempered. Yet she has found time to assist me in various ways and to accompany me on collecting excursions whatever the weather. It is far from an exaggeration to say that this book would never have been written without her loyal support.

To all the persons, mentioned and unmentioned, who have helped me in some way or other in my work I wish to express my sincerest thanks.

Marine Botanical Institute, Gothenburg,

20.4.1963.

PART I

INTRODUCTION

Methods and definitions

The genus-name Cladophora is in this work used in a restricted meaning. When Kützing first described Cladophora, the genera Spongomorpha and Aegagropila, too, were set apart. Later on we got the genus Acrosiphonia through J. G. Agardh (1846). In "Species Algarum" (Kützing 1849 pp. 413 and 417) Aegagropila and Spongomorpha appear as a sort of subgenera in Cladophora, and certainly all these plants are near related. Farlow (1881 p. 51) used the name Eucladophora to denote the part of Cladophora that consists of "tufted plants, or, at times stratose, not united into spongy masses by rhizoidal branches or recurved branches". Rhizoids can be found, at least at the base of the tufts, also on plants belonging to Farlow's Eucladophora and the group is more of a conventional division than of a well defined taxonomic unit. For practical purpose, however, it is a convenient division as most algologists associate the name Cladophora with just such plants that Farlow united to Eucladophora, and therefore I have chosen to use the name Cladophora in this conventional and restricted sense in this work.

Taxonomy in our times works with the aid of many biological branches and Cladophora too has been the subject of painstaking embryological and cytological studies, the two names especially worthy of mention being Bliding and Schussnig. However, the result of their work has been of only limited value to the field botanist who still finds himself in a taxonomical jungle as soon as he tries to classify his finds of Cladophora. This is perhaps the fault of the genus, or of ambiguous descriptions, or even a combination of both. At first the different species met with on the seashore seem to change gradually into each other and as they also respond quickly to the surrounding milieu with variations one is easily led to the conclusion that a delimitation of the species on an anatomical and morphological basis is more or less impossible. However, such a delimitation must be our first aim and our second is to put the thus found units on a working nomenclatural basis. This is also expressed by Camp (1951) in a definition of biosystematy where he writes that the first thing to do is to "delimit the natural biotic units". Waern (1952 p. 48) has also discussed a similar question and in conclusion writes: "It is only when we begin to feel our feet and start to ponder on Species problems that it is any good resorting to culture experiments".

The methods by which our units should be given their names are stated in the

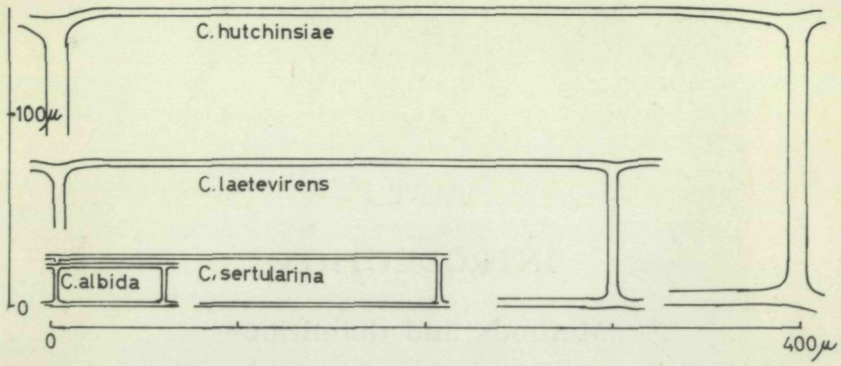


Fig. 1. Between some species there is a great difference in the size of the cells. This picture shows medium sized cells from four species. C. Agardh's name C. sertularina is used here, it is a synonym to Cl. oblitterata, a new name introduced in this work.

international code of botanical nomenclature. Many an algologist is apt to find faults in this code which apparently applies more to phanerogam systematy than to phycological. As it stands there is not much else to do than to follow it. There is otherwise always the risk that someone with a knowledge of the code, but not the genus, sets out to revise the names with the inevitable result that it will be still more difficult to understand them.

A following of the nomenclatural code means that the oldest descriptions get a key position. The biotic units found by the field botanist must therefore be sorted out by methods that make it possible to compare them with descriptions and specimens perhaps 200 years old. And we cannot count the chromosomes in the cells of specimens in an old herbarium, but we can study their mode of growth, the size of the cells and perhaps get some knowledge of their ecology out of the description of the locality where they were collected. With this in view I have set out to find the units of the genus Cladophora, using as far as possible the same means that were available to eighteenth- and nineteenth-century botanists.

The size of the cells have been a centre of interest in the study of Cladophora, since Kützing in 1849 gave measures to each of his species. The measures have usually appeared as the average for a species in round numbers; in many cases one must also suspect that the figures are derived without control from other works. In this way we still know only a little more about the cell sizes of Cladophora than can be derived out of Kützing's works. Several authors have, however, expressed the opinion that species can be delimited with the aid of measurements. In 1916 Hylmö wrote about Cladophora (p. 32): "Ein zukünftiger Monograph muss ohne Zweifel versuchen in den Zellenteilen oder in den Zahlenverhältnissen feste Charaktere zu finden, die eine scharfe Arteinteilung ermöglichen". In order to show both the actual size and the relative length, I have tried to express the results of my measurements in diagrams besides the usual method, that is to give the ex-

Fig. 2. Microphotographs of the three specimens which are used to demonstrate the different types of diagrams. From the left: Cl. oblitterata, Cl. flexuosa, Cl. glaucescens. ×30.

treme values in different parts of the tufts. As sizes of cells to some degree vary with age, the youngest branchlets have been specially examined, but in some cases, for instance in the delimitation of Cl. albida (Huds.) Kütz., also the main branches and the basal filaments are of great interest. The values given in the diagrams are the results of 100 cells being measured for each investigated specimen. They are not chance values in the usual statistical meaning, as the measuring has been made in several parts of the tufts selected in order to make the resulting diagram as representative as possible.

The diagrams show the length and the breadth of each cell. Oblique lines divide the diagram in six groups with different ratios between length and breadth. These groups are used in the tables that follow the descriptions of the species. The reader is asked to observe that the scale of length is half that of breadth. Not only the actual size and the relative length of the cells can be studied on the diagrams, but also information about the celldivisions can be obtained from them. Roughly the diagrams may be divided into three types and the following three illustrate these.

The first diagram shows the size of the cells in a specimen of Cl. oblitterata Söderström with the form typical of the sheltered parts of the Bohuslän archipelago. Here celldivision mostly occurs in the apical cells, the cells further

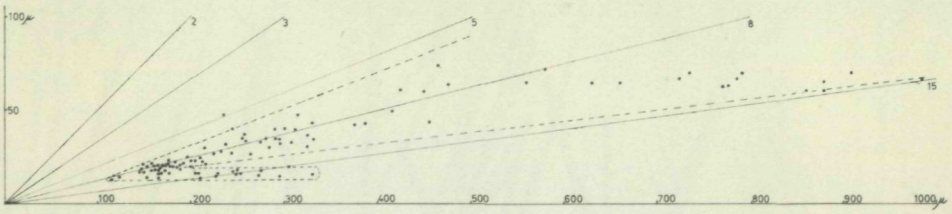


Fig. 3. Sizes of cells from a specimen of Cl. oblitterata. Kungsbackafjorden, July 1955.

down in the branches grow uniformly and keep their ratio between length and breadth unchanged in the proximity of the values 8—15 times as long as broad.

Diagram number two shows the size of the cells in a typical specimen of Cl. flexuosa (Müll.) Kütz. from a somewhat sheltered shore in the outer parts of the Bohuslän archipelago. I call this the trapezium form. The level underside of the swarm of dots shows that the apical growth follows the same pattern as in Cl. oblitterata above. However, the upper side is also level and this is explained by intercalary divisions being more or less regular. It can be seen from the diagram that the intercalary divisions occur at a specific relative length, in this case between 5 and 8, and this results in the trapezium form.

The third diagram illustrates the size of the cells in a typical specimen of Cl. glaucescens Harvey. This diagram has to the left a rectangular form and the explanation for this is that the cells undergo secondary divisions at a specific actual length, in this case about 175 μ. Further down in the tuft divisions occur less regularly and as a result some basal cells reach a considerable relative length.

The mode of branching is another often used character. There is no doubt that some species differ in a significant way in this matter, but at the same time it is subject to great variations, for instance, as a result of wave action, and often only a vague tendency can be seen. It is difficult to express such a tendency in fixed terms, and though terms as dichotomus, fastigiate, secund and so on, may be found in the description, it is the figures, I hope, that will show where the different ways of branching tends to be more or less uniform in a species.

The measuring of the cells has been made with an ocularmicrometer, calibrated by a micrometerscale, and, except in the case of very big cells, were made at an

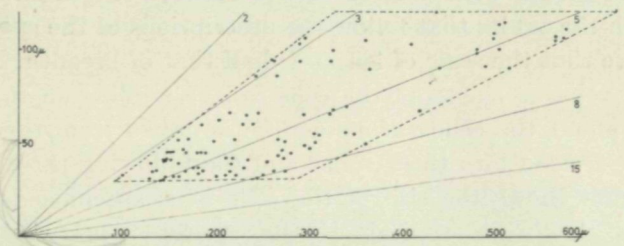


Fig. 4. Sizes of cells from a specimen of Cl. flexuosa. Koster, September 1962.

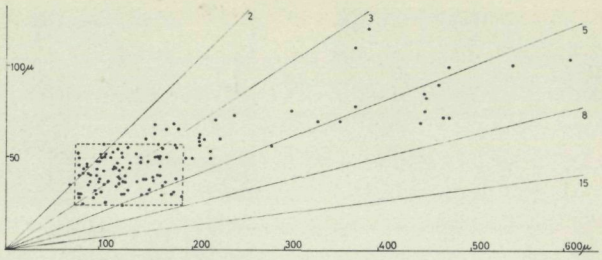


Fig. 5. Sizes of cells from a specimen of Cl. glaucescens. Koster, June 1960.

enlargement of 250, when the units of the scale represent 5 microns, and it was fully possible to estimate closely the values at 1 micron. The drawings were all made with the aid of a projecting mirror mounted on the microscope. The same apparatus has been used throughout the work to ensure uniformity and to make the drawings really comparable. The drawings and measurements have usually been made from plants preserved in alcohol, in which medium the cells retain their size and shape very well.

My knowledge of the European shores has been achieved as the result of a field work that has been going on since 1951. The greater part of the material has been collected on the Swedish west coast. In 1957 I visited several places along the Irish west coast, in 1960 places in South Norway from the mouth of the Oslo fjord

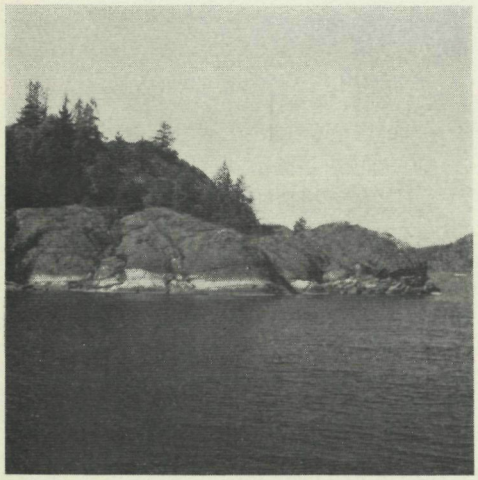


Fig. 6.

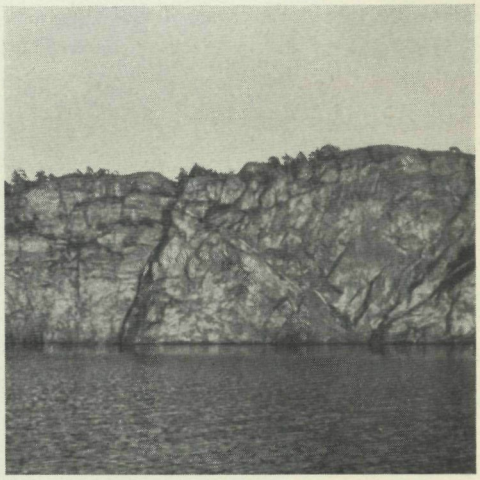


Fig. 7.

Fig. 6. A part of the shores in the sea-loch Borgilafjorden near Henån in the province of Bohuslän (see map). The tide here has an amplitude of around 2 dm, and the hydrolitoral is dominated by Fucus vesiculosus with Cl. oblitterata as a common epiphyte.

Fig. 7. A fault-line scarp facing north in Borgilafjorden. Habitat of Cl. albida and Cl. glaucescens which otherwise are rare in this sea-loch.

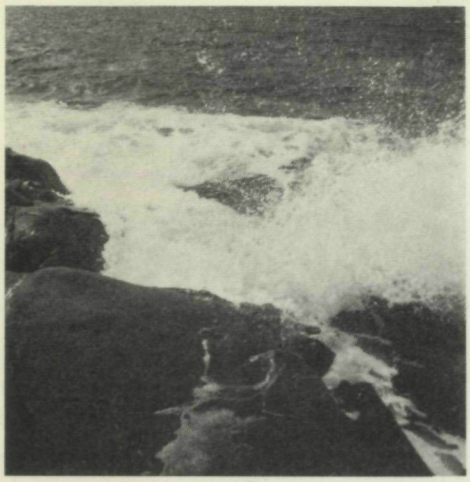


Fig. 8.

Fig. 9.

Fig. 8. The west side of the skerry Bonden, the outermost skerry in the Kristineberg area. Wind velocity at this moment 7 mps. The find-spot of Cl. hamosa.

Fig. 9. Splash pools on Byxeskär, Kristineberg. A typical habitat of Cl. albida. Observe that, because of the small amplitude of the tide in Sweden, pools of this type never get quite dry.

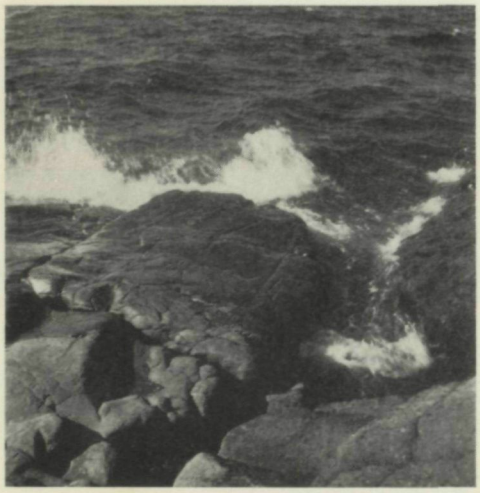


Fig. 10.

Fig. 11.

Fig. 10. Small crevice at Torekov (see map). The water is brackish and Cl. glomerata grows abundantly, in this crevice together with Cl. albida.

Fig. 11. In the estuary of the river Nordre Älv Cl. glomerata is often quite dominating on the rocky shores, but in this picture it grows together with Fucus vesiculosus sheltered from the direct fresh water stream.

to Bergen, and in 1962 the tidal shores at Dinard and Plymouth were studied during a couple of weeks. (The visited places are shown on a map at the end of the book.) The number of plants examined during this work I estimate to about 5 000.

As one of the principal ideas with this study of Cladophora has been that the specimens as far as possible should be investigated in living state and their localities studied, the original idea of making a monograph covering all the North Atlantic coasts has been abandoned. There are, however, so many resemblances between the flora of especially the New England coasts and the European coasts that it is possible to compare species of Cladophora from different sides of the Atlantic, even if one side must be judged by printed floras and a few dried specimens, but it must at the same time be remembered that this is always a little dangerous in the case of Cladophora and my comments on the American species may in some cases well be erroneous. But I firmly believe that mistakes of a more complicated type would be the result of an investigation dealing with European plants only and ignoring the American part of the genus.

To denote the region which this work is applicable to, I have used the term temperate parts of the North Atlantic. In 1905 an attempt to divide the atlantic marine algae in different flora regions was made by Børgesen and Jónsson (1905 p. XV). This resulted in five groups viz. A. The Arctic group, B. the subarctic group, C. the boreal-arctic group, D. the cold-boreal group and E. the warm-boreal group. Børgesen's and Jónsson's system has the disadvantage that it is at the same time a division of the algae and of the Atlantic. If a geographical delimitation is desired their system cannot therefore be applicable without alterations. In the case of Cladophora the south border of the "arctic group" can be used, as it seems clear that most species never occur north of this line, the only exceptions being Cl. rupestris and flexuosa. This border roughly coincides with the isoterm for 0° C surface temperature in January and the isohaline for 35 $^{0}/_{00}$. In the boreal groups Børgesen and Jónsson placed algae with a distribution as far south as to the coasts of North Africa. In those parts, however, several subtropical species are already common (cf. Schmidt 1931, Gayral 1958) and among them also some species of Cladophora. Consequently I find it better to describe the region concerned in this work with the expression "temperate parts", which I understand as stretching from northernmost Norway to Portugal on the European side and from New Foundland to Cape Hatteras on the American side. A more detailed discussion of this question appears in part III.

I would like to conclude this chapter with a short discussion of the word "species". The species concept is something most botanists seems to disagree about and I must admit that I have used the word in a very general meaning. As my leading star I have used the following words of J. Huxley (1940 p. 11): "— species and other taxonomic categories may be of very different type and significance in different groups; — there is no single criterion of species. — Failure to interbreed or to produce fertile offspring is the nearest approach to a positive criterion. It is however, meaningless in apogamous forms, and as a negative criterion it is not appli-

cable, many obviously distinct species, especially of plants, yielding fertile offspring, often with free Mendelian recombination on crossing. A combination of criteria is needed, together with some sort of flair." If the word species is to be understood in this way I do not think we are very far from Camp's "biotic units". In many cases when dealing with old works on Cladophora it has been also more convenient to use the word species in the same meaning as of those earlier authors, where some other term perhaps ought to be used instead. I am not in favour of the application of modern terms to old texts, they easily brings with them a stifflegged exactness that was not in the original work. As long as we all are aware that the species concept is an elastic one, and use our own "flair", I do not think there need be any misunderstandings.

The appearances of the different biotic units of Cladophora in older works

As mentioned in the previous chapter, it is impossible to bring order to the genus Cladophora without bestowing careful consideration upon the oldest botanical works. The genus itself was not created until 1843, when Kützing united species of Conferva with uniform branches and named them Cladophora, but his list already contained 69 names of supposed species and at the same time some other botanists, e.g. Harvey in Great Britain and Areschoug in Sweden, were working with the genus. The result was that in the middle of the 19th century more than one hundred names of Cladophora were published and so the confusion began. However, many of the new descriptions are based on, or can be traced back to, older descriptions of Conferva-species and thus J. J. Dillenius' Historia Muscorum, 1741, seems to be the natural starting point. It is true that Dillenius' descriptions are not valid according to nomenclatural rules of to-day, but specimens in his herbarium together with his drawings were the basis for descriptions given by Linnaeus and Hudson. References to Dillenius are also found in Florae Danicae Iconum, as well as in the Works of Roth, Dillwyn and C. Agardh. Though not actually having quoted Dillenius, Lyngbye should be mentioned here in order to complete the list of more important older works dealing with the Cladophora part of Conferva.

J. J. Dillenius, Historia Muscorum. 1741 (2nd ed. 1763)

Ten of the descriptions in Historia Muscorum are of interest in connection with Cladophora. It is reasonable to assume that they represent some of the more common plants and in that case, and judging by text and pictures, the following list can be put together.

1. Tab. 3 fig. 11. "Palustris bombycina, Pitch Cotton, Rotherithe and Deptford ditches, Spring and Summer on the sides of cisterns in all seasons." Pictured is a

plant with some affinity to what nowaday is called Cl. fracta. It is most probably a fresh water plant. Linnaeus called it C. bullosa and it is also the basis for C. crispata Roth which also has been associated with C. fracta (cf. Waern 1952 pp. 76—77).

2. Tab. 3 fig. 12. "Marina tomentosa, tenerior & albicans. White Sea Flock. Selsey Ditches and Ponds Sussex, Summer." As they are connected here with the word marina, "ditches and ponds" may be assumed to be the same as tide pools. Hudson called this plant C. albida, a name which has the same meaning today.

3. Tab. 5 fig. 27. "Ramosa, geniculis longioribus cateniformibus. Jointed Link, Bahama Isles." A subtropical species and therefore not commented upon here. Linnaeus called it Cl. catenata.

4. Tab. 5 fig. 28. "Fluviatilis trichodes, extremitatibus ramosis. River Beard." The figures 28, 29, 30, 31 and 33 make an interesting series. Three species, C. glomerata sensu Linnaeus, C. rupestris sensu Linnaeus and C. laetevirens sensu Dillwyn appear in the series. The "River beard" is placed together with C. rupestris by Hudson, but yet we must assume that it is some form of C. glomerata. The picture shows a plant very like C. rupestris, but glomerata can have this look in running water.

5. Tab. 5 fig. 29. "Marina trichodes ramosior. Sea Beard." Called C. rupestris by Linnaeus; there is very little doubt concerning the identity of this plant.

6. Tab. 5 fig. 30. "Marina trichodes, ramosissima, sparsa. Spreading Sea Beard. On small stones, Shepey and Anglesey." The picture shows a plant with some likeness to the "Cluster" fig. 31 which, according to Waern (1952 p. 76), is the original of Linnaeus' C. glomerata. A marine plant with a likeness to C. glomerata is just how Harvey describes C. laetevirens.

7. Tab. 5 fig. 31. "Fontalis ramosissima, glomeratim congesta. Cluster." The original of Linnaeus' C. glomerata, as mentioned above.

8. Tab. 5 fig. 32. "Marina trichodes, lanae instar expansa. Sea-Wool, Selsey-Marshes, Sussex, Salt-Ditches, Gravesend." Here we are approaching the problems concerning the detached forms of Cladophora. Quite a lot of such forms are described from both fresh and salt water, C. vagabunda, fracta, expansa and vadorum are examples of names belonging here. Therefore, nothing more can be said about Dillenius' "Sea-Wool" than that it is a marine plant growing like fracta. Linnaeus refers to tab. 5 fig. 32 when describing C. vagabunda.

9. Tab. 5 fig. 33. "Trichodes virgata, sericea. Beasom-like Silk, Small Stones, Shepey, New River near London, Mill-Timber Hounslow-Heath, Norbury-River near Bishop's-Castle Shropshire." This is the basis for Hudson's C. sericea, a name later on used in extremely diversified meanings. However Dillwyn considered it to be a mixture of C. glomerata and his own C. laetevirens (Dillwyn 1809 p. 34).

10. Tab. 6 fig. 34. "Fluviatilis, sericea, tenuis. Fine River Silk, Munnow-River near Kenchurch, Hertfordsh." This is the picture quoted by Linnaeus in his description of C. glomerata. Waern (1952 p. 76) is of the opinion that figs. 31 and 34 show one and the same alga.

C. Linnaeus, Species Plantarum, 1753

Six of the above listed plants of Dillenius appear in Species Plantarum (p. 1164—68) and in connection with Cladophora one new species is founded viz. Conferva aegagropila. This species is not discussed here because though closely related to Cladophora, it is sometimes also placed in a genus of its own, the Aegagropila of Kützing. Furthermore it is also a genuine freshwater species, in the Baltic it is only found in those parts with low salinity (cf. Waern 1952 p. 83).

Of the names given by Linnaeus to plants belonging to Cladophora in the restricted sense, three are used to-day, C. rupestris (Dill. 5:29), C. glomerata (Dill. 5:31 and 6:34) and C. catenata (Dill 5:27), while two, C. bullosa (Dill. 3:11) and C. vagabunda (Dill. 5:32) are forgotten and have not been used since the beginning of the 19th century. Probably bullosa is the same as Cl. fracta (Vahl) Kütz. and vagabunda identical with Cl. flexuosa (Müll.) Kütz., but we can not be quite sure, as Linnaeus had not written any names under the specimens in the Linnaean herbarium, and besides there is a possibility that bullosa was some form of glomerata and vagabunda some form of fracta. In fact only one specimen in Linnaeus' herbarium can be linked with a description in Species Plantarum and that is a plant on which he has written "21", which is the number the description of C. aegagropila has in Species Plantarum. However, the names rupestris and glomerata are at least so well established that no difficulties need arise out of our using them.

G. Hudson, Flora Anglica, 1762, second ed. 1778

Conferva bullosa, glomerata, rupestris and *vagabunda* appear in Flora Anglica in the same way as in Species Plantarum. To this is added a description of Dillenius' "Beasom-like Silk", which here is given the name C. sericea, as well as a description of a new species, C. pellucida. The latter plant is described in a way that leaves no doubt as to it being one and the same plant that to-day is called Cl. pellucida. As an example I might mention the peculiar colour "viridi-purpurea", which is characteristic of C. pellucida which has often a reddish tint in the basal parts caused by a parasitic redalga (Hamel 1930 p. 3). In the second edition of Flora Anglica, the name C. albida is given to the "White Sea Flock" (Dill. 3:12) and from the investigation by Dillwyn (1809 p. 32, cf. also Söderström 1955 p. 276) it is clear that the name means the same to-day.

Florae Danicae Iconum (O. F. Müller and M. Vahl) 1775—1787

In the years 1775 to 1787 some interesting descriptions and pictures were printed in "Florae Danicae Iconum". Beside C. sericea, glomerata and rupestris four new names appeared, viz. C. flexuosa, pennatula, fracta and hirta. We must now bear in mind that the coasts of Denmark have quite another character than the English, and also that the eastern shores are washed by brackish water with a salinity not more than 20 ‰ and in many parts less. Significant is that C. laetevirens Dillwyn was included in C. glomerata by Lyngbye (1819 p. 153). This shows that the

word marine had another meaning for Lyngbye than for Dillwyn. This must be kept in mind when comparing descriptions made by algologists in the western parts of Europe with descriptions emanating from parts where the Baltic is involved. As 18th century botanists were for the most part interested in plants growing on land, the true marine plants were probably also under represented in their works. Of the four new species in Fl. Dan. only one has got a description that includes its habitat. This species is C. flexuosa (1783 tab. 882), which is said to be "in litore haud raro". A plant resembling the one shown on tab. 882, is not uncommon in the inner parts of the archipelago of the Swedish westcoast and is identical with Cl. gracilis in the works of Kylin (1907 p. 30, 1949 p. 55). As pointed out by Lyngbye (1819 p. 153), C. hirta must be a fresh water alga and it does not seem possible to keep it apart from C. fracta, the next preceding species in Fl. Dan. Both hirta and fracta are anatomically of the type that Linnaeus and Hudson called C. bullosa. The remaining new name, C. pennatula (tab. 945) cannot be referred to any of the older descriptions with certainty, but the picture resembles very much some forms of Cl. glomerata that I have found in an estuary in the province of Bohuslän, Sweden.

A. G. Roth, Catalecta Botanica, 1797—1806

A. G. Roth described many new species, but not so few have been withdrawn in fasc. III of the "Catalecta". Thus Conferva glauca (fasc. II p. 208) and virgata (fasc. I p. 195) are embodied in C. rupestris (fasc. III p. 243); Conferva divaricata (fasc. I p. 179) in C. fracta (fasc. III p. 230); C. fasciculata (fasc. I p. 184) in C. prolifera (fasc. III p. 246); C. pura (fasc. II p. 221) in C. crystallina (fasc. III p. 239). C. cristata (fasc. I p. 193) was founded on Hudson's and Dillenius' sericea and in fasc. III (p. 235), two forms of cristata appear together with C. glomerata. For a picture of C. flavescens (fasc. II p. 224) Roth refers to Fl. Dan. tab. 945 (C. pennatula). Of the remaining species C. diffusa (fasc. II p. 207 and Tab. VII) is, judging from the picture and a fragment of an authentic specimen in Herbarium Algarum Agardhiorum, a variety of C. flexuosa in Fl. Dan.; C. crystallina (fasc. I p. 196), also judging by a fragment of an autentic specimen in Herb. Alg. Ag., is only a form of C. glomerata; C. crispata (fasc. I p. 178) is declared by Roth to be the same as Dillenius' "Pitch Cotton" (fasc. III p. 276) and has later on been connected both with glomerata and fracta (Brand 1906 p. 245, Waern 1952 p. 77); C. nigricans (fasc. III p. 277), pictured by Dillwyn after a specimen named nigricans by Roth, is a more difficult case, but being a fresh water alga with dark main branches, it is probably some form of C. fracta; C. refracta is also a name entailed with difficulties, since C. hirta, tab. 947, in Fl. Dan., is given as a figure whereas Roth's specimens were collected on a seashore. Finally there is Conferva prolifera (fasc. I p. 182 and tab. III fig. 2). This alga was originally described as being from Corsica. In some aspects it is very like C. pellucida Hudson and specimens of this species sent to Roth from Turner, who made the description of C. pellucida in Dillwyn's "British Confervae" (Dillwyn 1809 p. 35),

were placed by Roth as a variety of C. prolifera (Fasc. III p. 247). Turner, however, thought this a mistake, and it seems probable that C. prolifera is not only a new name but a really new species. This is supported by Roth's picture, in which something can be seen that could be such rhizoids as Hamel (1930 p. 7) has drawn Cl. prolifera with. The conculsion must however be that, with the exception of C. prolifera, very few, if any at all, of Roth's names can be stated to constitute names of new species. However, many of the names are used in modern times and it is therefore impossible to omit a discussion of them (cf. Hamel 1928, C. prolifera, crystallina; Newton 1931, prolifera, refracta; Kylin 1949 diffusa; Taylor 1957, flavescens, crystallina and refracta).

L. W. Dillwyn, British Confervae, 1809

The step from Roth to L. W. Dillwyn is longer than their publishing dates indicate. The earlier parts of "British Confervae" were published at the same time as Roth worked on the fasc. III of "Catalecta Botanica" but, nevertheless, when we read Dillwyn we are anticipating a new age in the studying of algae. This is, inter alia, noticeable through the great care Dillwyn took in trying to make most of his descriptions and pictures from living plants. He was himself aware of the advantage of this and in the comments to plate 21 he criticises Roth with the following words: ". . . almost all the plates of Conferva in the Catalecta Botanica are copied from plants, either in a dry state, or which have been dried. They are not therefore in general applicable to the species examined while recent. Many of the descriptions labor under a similar disadvantage, from the learned author's residing at so great a distance from the sea." As far as Cladophora is concerned very few new descriptions are added by Dillwyn. This is certainly in great part due to the close study he bestowed Hudson's work and the Dillenian herbarium. As a result of this study he described C. laete-virens in which the marine part of Hudson's sericea was included. Entirely new is C. Hutchinsiae. The description of this plant is one of the few he made from dried specimens, but the figure is drawn by the discoverer, miss Hutchins. C. Hutchinsiae is described as having clustered branches, short cells and unusually thick filaments which, furthermore, are of about the same thickness at base and end. It seems clear that something like this had not been described before Dillwyn presented it. I must also mention here C. Brownii, but as it is a very special plant growing in caves in the spray zone, and perhaps not a true marine plant, and, furthermore, usually referred to the aegagropila group of Cladophora, it cannot be discussed here. One more fact should be mentioned before leaving Dillwyn. He has adopted the name flavescens from Roth, but he seems to have overlooked that C. pennatula in Fl. Dan. was originally included in C. flavescens. He therefore used both the names, and flavescens was placed in close relation to C. fracta, a species not mentioned by Roth in this connection. A new conception of C. flavescens was thus brought forth and in this the name has been used later on, for instance by Harvey (1851 pl. 298).

H. C. Lyngbye, Tentamen Hydrophytologiae Danicae, 1819

Lyngbye does not add any new names that may be mentioned here. This does not necessarily mean that the plants that were in his mind were the same as those met with in the works of his predecessors. C. glomerata, sericea and crystallina are of particular interest. From Roth the name C. crystallina β virescens has been adopted and used on a plant reported from a locality near Arendal in the south of Norway. C. glomerata and C. sericea were both given a variety called marina. Thus we get three taxa starting in fresh or slightly brackish water, but with varieties in a more marine milieu. It is most probable that Lyngbye's marine varieties represent something that neither Linnaeus (describing glomerata), nor Hudson (describing sericea) or even Roth (describing crystallina) had seen. It has already been mentioned that Lyngbye found that C. hirta in Fl. Dan. must have been a fresh water alga and that he considered it to be a variety of C. fracta. It is a pity the name hirta was not permitted to stay where Lyngbye put it.

C. A. Agardh, Systema Algarum, 1824 and "Aufzählung — — —", 1827

C. A. Agardh described some 40 species belonging here and among them not a few new ones. His large herbarium in Lund (from now on referred to as Herb. Alg. Ag.) makes it possible to obtain a knowledge of his species that the mere text does not render possible. A study of Conferva-Cladophora in this herbarium is, however, also a caution against a too formal application of the international code of nomenclature. Many of the plants in the herbarium are, judging by to-day's knowledge, wrongly determined and there are signs indicating that Agardh not always remembered the species he himself had described. In many cases Agardh made out species on the basis of characters which are not accepted or even thought of today. A search for Agardh-names on Cladophora in the most used modern floras e.g. Hamel 1930, Newton 1931, Kylin 1949, Taylor 1957, shows that only two are still in use, viz. C. rudolphiana and C. neesiorum. C. rudolphiana was described by Agardh in 1827 from the Adriatic sea. As a biotic unit it seems to be something new, thinner, slender and more long-celled than any of the earlier described units, but the specimens in Herb. Alg. Ag. clearly show that it is the same as C. sertularina, described from the Swedish west coast by Agardh in 1824, and in this work given the new name Cl. oblitterata. C. neesiorum is in Herb. Alg. Ag. nothing else than C. albida sensu Hudson, Dillwyn and others. The only one of C. Agardh's conferva-species to be retained is thus C. sertularina, the rest, with exception of some tropical ones, can be assigned to older taxa.

F. T. Kützing, Phycologia generalis, 1843 and Species algarum, 1849

In 1843 the genus Cladophora was set apart from Conferva by Kützing. At the same time he gave a list containing 69 species. In 1849 the division of the genus was carried still further so that besides Aegagropila and Spongomorpha, it contained 160 species. Very few of his names are used to-day; a lot of them were put

together as synonyms by Hauck (1885), while others have been forgotten or are out of use owing to the difficulty of separating them from more well-known taxa. A detailed revision of Kützing's species would be of little value compared with the required work and it is obvious that very few new biotic units can be found behind the flood of new names. It is only necessary to mention here, therefore, the group consisting of Cl. corymbifera, hamosa, refracta, spinulifera, curvula and lepidula. This group contains algae of a type that has been connected with C. refracta Roth, viz. tufts like C. albida Hudson, but coarser. As mentioned before, Roth's name cannot be used without further notice, since his refracta has the fresh water C. hirta in Fl. Dan. as a synonym. Probably we have here an unsolvable question and the best procedure seems to be the one chosen by Hamel (1930 p. 47), i.e., to use the name hamosa and try to forget that a refracta was described by Roth.

W. H. Harvey, Phycologia Brittanica, 1846—1851

W. H. Harvey had a more realistic grip on Cladophora than Kützing and described only a score of species from Great Britain and Ireland. Among these are some new ones and at least Cl. glaucescens and Cl. rectangularis are distinct species, representing something hitherto undescribed, although Cl. glaucescens had been collected earlier, by e.g. C. Agardh, but at that time supposed to belong to some of the known species.

Many more authors could be mentioned in this survey, but with the above the aim of the survey is reached; to show which of the taxa, described already in the middle of the 19th century, can be used to-day, and also that nearly all the species found in floras of to-day were described already at this time. To be added are only Cladophora pygmaea Reinke 1888 and perhaps Cladophora boodleoides Børgesen 1925.

As a summary of the various discussions in the preceding pages and as a basis for the next part the following list of Cladophora on the shores of the temperate parts of Europe can be proposed.

In fresh or brackish water

Cladophora fracta (Vahl) Kützing. *Cladophora glomerata* (L.) Kützing.

In salt or brackish water

Cladophora oblitterata Söderström. *Cladophora albida* (Huds.) Kützing. *Cladophora hamosa* Kützing. *Cladophora glaucescens* Harvey. *Cladophora flexuosa* (Müll.) Kützing. *Cladophora rupestris* (L.) Kützing. *Cladophora pygmaea* Reinke.

In salt water

Cladophora laetevirens (Dillw.) Kützing. *Cladophora Hutchinsiae* (Dillw.) Kützing. *Cladophora pellucida* (Huds.) Kützing. *Cladophora prolifera* (Roth) Kützing. *Cladophora rectangularis* Harvey. *Cladophora boodleoides* Børgesen.

PART II

SPECIES ON THE ATLANTIC SHORES OF EUROPE

Cladophora fracta (Vahl) Kützing

Conferva fracta Vahl 1787, Florae Danicae Iconum tab. 946.
Cladophora fracta Kützing 1843 p. 236.

References and synonyms

Conferva fracta in Roth 1806 p. 230. — Dillwyn 1809 p. 65 and Tab. 14. — Lyngbye 1819 p. 152 and Tab. 52. — C. Agardh 1824 p. 109.

Conferva hirta Vahl 1787, Fl. Dan. Tab. 947 (Non C. Hirta Kützing, Hauck, Kylin, Hamel and others, the C. hirta in their works belongs to C. flexuosa (Müll.) Kütz.).

Conferva divaricata Roth 1797 p. 179.

Conferva crispata Roth 1797 p. 178. — Lyngbye 1819 p. 152. — C. Agardh 1824 p. 109, partim (the variety β subsimplex).

Conferva nigricans Roth 1806 p. 297. — Dillwyn 1809 p. 63 and sup. Plate E. (Non C. nigricans Lyngbye 1819 p. 158 and Tab. 54).

Conferva flavescens in Dillwyn 1809 p. 64 and sup. Plate E. — Lyngbye 1819 p. 157. — C. Agardh 1824 p. 112.

Conferva patens C. Agardh 1824 p. 110 (Non Cl. patens Kütz. 1845 p. 216 and 1849 p. 394 which is a synonym to C. expansa C. Agardh 1824 p. 114).

Conferva globosa C. Agardh 1824 p. 113.

Cladophora fracta in Harvey 1851 Pl. 294. — Farlow 1881 p. 56. — Hylmö 1916 p. 38. — Hamel 1930 p. 38. — Levring 1940 p. 15. — Kylin 1949 p. 59, partim (the description is copied from C. fracta F. marina Hauck, but excludes Hauck's thin variety which best resembles the true fracta of Vahl; in Kylin's herb. most of the specimens called fracta belong to C. flexuosa (Müll.) Kütz. but two specimens are identical with C. fracta (Vahl) Kütz.). — Waern 1952 p. 75.

Cladophora fracta F. *marina* Hauck 1885 p. 461, partim (the variety with 25—100 μ cell-diameter).

Cladophora fracta var. *flavescens* in Newton 1931 p. 87.

Cladophora flavescens Kützing 1843 p. 267. — Harvey 1851 Pl. 298.

Cladophora marina in Hylmö 1916 p. 36. — Levring 1940 p. 14.

Doubtful synonyms

Conferva bullosa Linneaus 1753 p. 1164. Founded on Dillenius Conferva palustris bombycina, which Roth also thought was the same as C. crispata (Roth 1806 p. 276), this name can be treated as a synonym to C. fracta Vahl. However, the three specimens connected with bullosa in the Linn. Herb. are not named by Linnaeus himself and, furthermore, one is a form of C. glomerata (L.) Kütz. and one is probably a Chaetomorpha.

Conferva vagabunda LINNAEUS 1753 p. 1167. Founded on Dillenius' Conferva marina trichoides, lanae instar expansa. C. Agardh (1824 p. 110) considered this to be the same as C. fracta, but the specimen in the Linn. Herb. (not named by Linnaeus) could as well be a form of C. flexuosa Müller.

Conferva refracta ROTH 1800 p. 193. Originally C. refracta was described as a synonym to C. hirta Müller. Lyngbye (1819 p. 152) has put refracta with a question mark to C. fracta δ marina. C. Agardh was also of the opinion that C. fracta δ marina Lyngbye and C. refracta Roth belonged together, but the specimens called refracta by Agardh in Herb. Alg. Ag. are identical with C. albida Hudson.

Investigated herbarium specimens

"bullosa? (m. Sm.) * (m. L.) (Dill:) Conferva i Ups. ån" Linn. Herb. nr 1277.27. — "Conf. flavescens Sp. orig. Dillwynii Yarmoth 30.4.1802", Herb. Alg. Ag. nr 9025 and 9026. — "Conferva fracta var. nigrescens ad interim in submarinis ad Hofmansgave Novbr 1821" (C. Agardh's handwriting), Herb. Alg. Ag. nr 9090 and 9091. — "Conferva crispa Dillw." (C. Agardh's handwriting; C. crispa Dillw. is a synonym to C. crispata β subsimplex C. Agardh 1824 p. 109), Herb. Alg. Ag. nr 7501 and 7502. — "Conferva globosa, Gråen" (C. Agardh's handwriting), Herb. Alg. Ag. nr 8923. — "Conferva patens" Leg. C. Agardh, Trieste 1827, Herb. Alg. Ag. nr 9051 (The nrs 9025—9070 were by C. Agardh placed in a cover titled "Conferva flavescens Dillw." and nrs 9080—9187 in the same way titled "Conf. fracta Dillw.") — "Cl. crystallina var. tenerrima (Kütz.) Wittr. Prope Fiskebäckskil fluitans 30/6 1877", Wittrock & Nordstedt nr 122, spec. in Brit. Mus. — "Cl. fracta (Fl. Dan.) Kg ad juncos in stagno aquae vix salsae" Leg. W. G. Farlow, Falmouth, Mass. 1881, Kew. Herb. (I am not quoting Farlow's perhaps more well-known specimen nr 208 in Alg. Exsicc. Am. Bor., collected at the same locality, because the specimen in Lund, Herb. Alg. Ag. nr 7542, belongs to Cl. flexuosa and corresponds in every detail to Farlow's own description of Cl. expansa. A confusion seems to have been made in the distribution of the exsiccat, the specimen of nr 210 in Lund, Herb. Alg. Ag. nr 7549, which should be Farlow's Cl. expansa is a Cl. fracta, while the specimen in Kew is a Cl. flexuosa.). — "Cl. fracta (Fl. Dan.) Kütz. f. marina Hauck. Blåbergsholmen 14.8.1905". Leg. & det. H. Kylin, Bot. Mus. Lund.

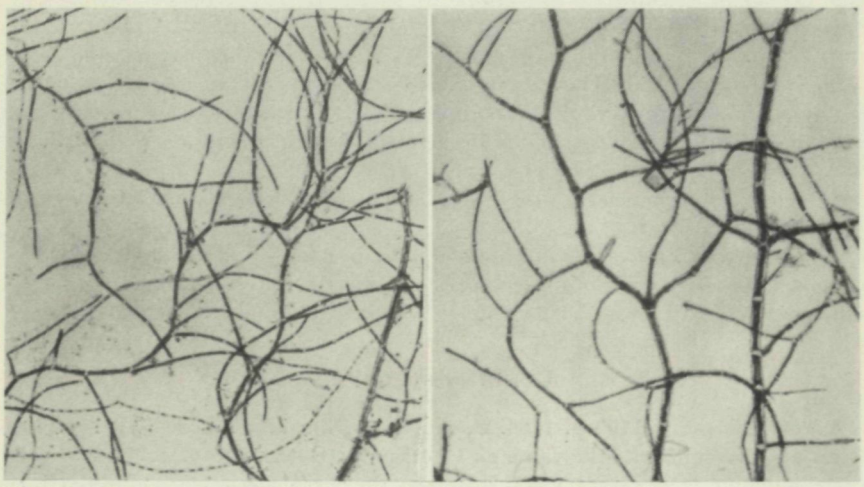


Fig. 12. To the left Cl. fracta from the inner parts of the Öregrund archipelago in the Baltic, 27.9.1952; to the right Cl. fracta from Henån, the locality is described in the text, 20.8.1954. ×30.

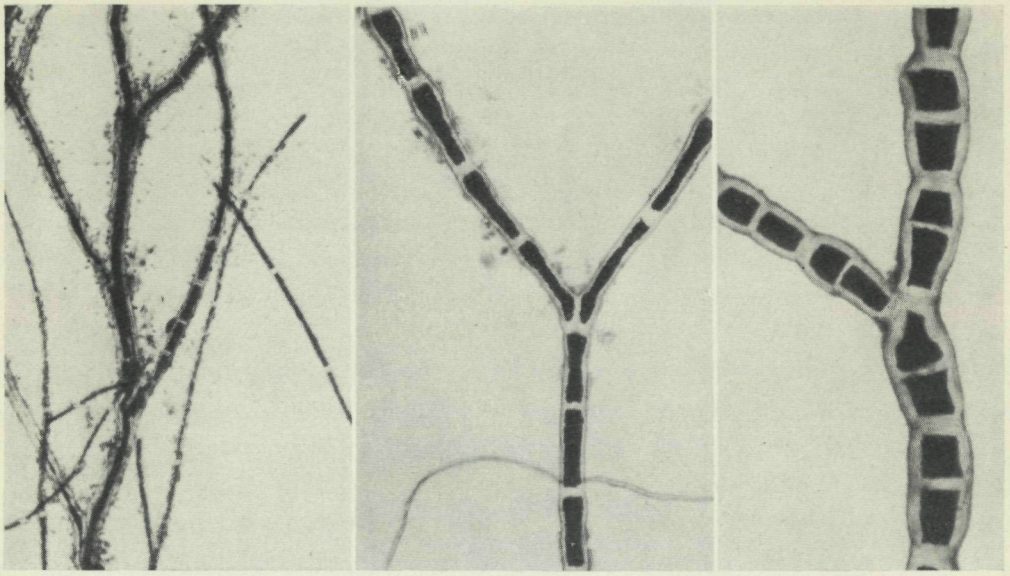


Fig. 13. Different types of cells from the Öregrund specimen mentioned in the text to fig. 12. The fig. to the left ×30 the other two ×80.

Taxonomical remarks

When Kützing transferred Conferva fracta to Cladophora he got the name from Dillwyn. However, since Dillwyn referred to Florae Danicae, and evidently used the name in the original meaning, the combination Vahl-Kützing does not lead to any difficulties. Conferva fracta is sometimes referred to Müller, who (cf. Lyngbye 1819 p. 153) seems to have made the picture which after Müller's death was used by Vahl, who, however, was the editor of the fascicle of Florae Danicae where C. fracta appeared.

Other references and synonyms here listed, are explained by the herbarium specimens.

Description

Cells of varying shape and size according to the age of the plant. Young plants with sparsely branched outer parts, branchlets slender and consisting of many cells which have a diameter mostly less than 20 μ often only 10—15 μ. The relative

Fig. 14. Starch grains in a winter cell from Cl. fracta. ×250.

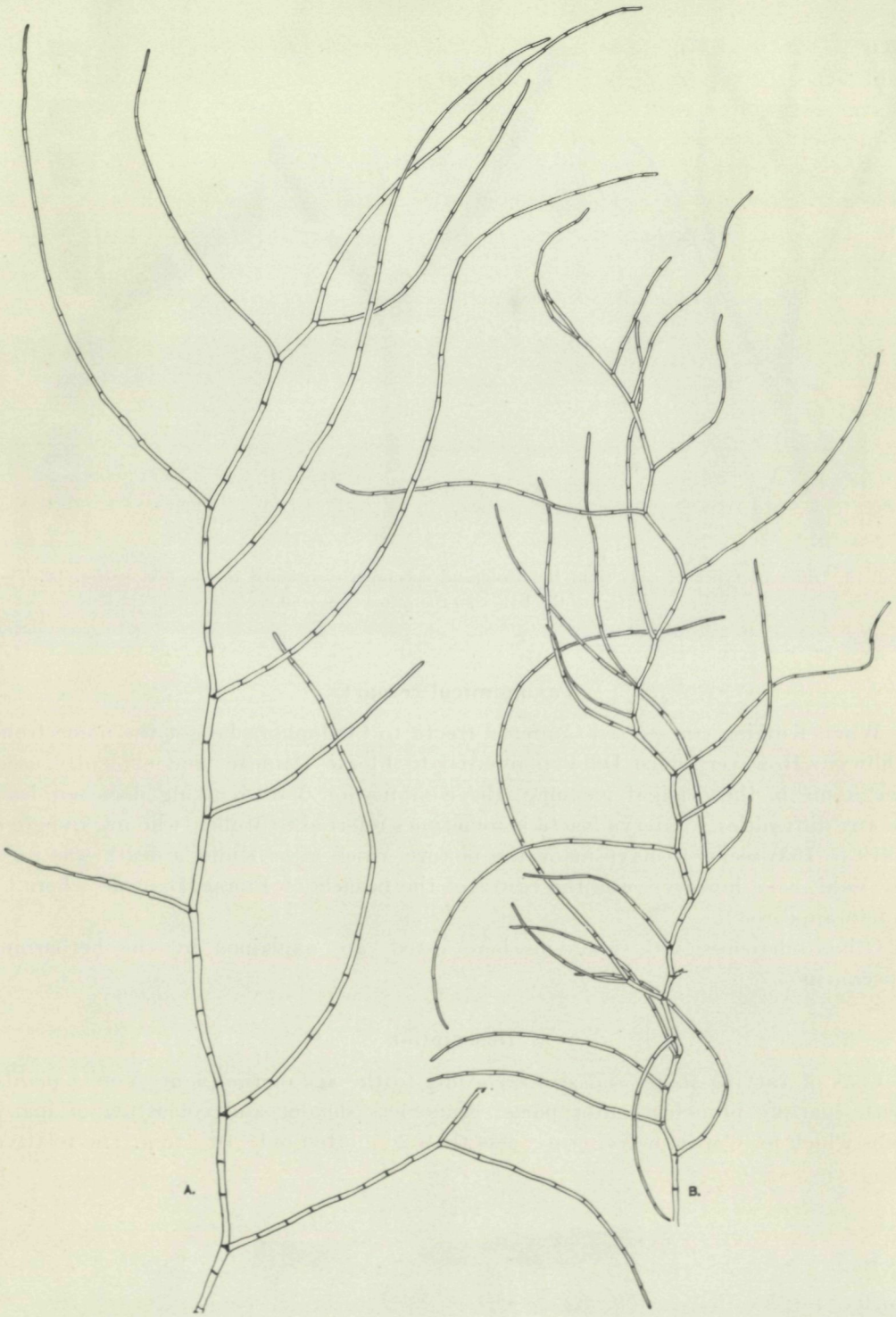


Fig. 15. Still growing branches from Cl. fracta, A. from Henån, B. from Öregrund. ×20.

length of the cells in those branchlets is in the neighbourhood of 10 (at least 70% of the cells between 5 and 15). Main branches have a diameter between 30 and 100 μ. In the autumn the cells divide and at the same time thicken. Their size then approaches the values reported by Hamel (1930 p. 38): branches (40—) 50—75 (—90) μ, main filaments (75—) 100 (—200) μ, relative length 2—5. Mostly found detached, sometimes in great masses in quiet, fresh or slightly salt water, upper limit of salinity probably around 10—15‰.

Differs from detached Cl. glomerata through the size of the cells, which are thinner and have less relative length (see diagrams fig. 22,27), and from detached Cl. flexuosa through having cells in the main branches as short as, or even shorter than, in the branchlets (rectangular form in the diagram of Cl. fracta, trapezium form in the diagram of Cl. flexuosa see fig. 22,24).

The name Conferva fracta or Cladophora fracta has in the past been used both in a too wide and a too restricted sense. In the first case it has simply been used as a name for all sorts of floating Cladophora while in the second case the shape of the cells has been given too much importance. Thus Hylmö (1916 pp. 36—38) distinguished between Cladophora marina and Cladophora fracta; in doing which he described marina with long and narrow cells and fracta with short and dark cells. It is very typical for Cl. fracta that short, dark cells develop at the end of the summer season (fig. 13). This is the result of an accumulation of starch in the main branches (fig. 14) together with secondary celldivisions. In this state it has a highly characteristical look and it is no wonder this state has been considered a species of its own, to be kept separated from plants with ordinary cylindrical cells. However, the description in Fl. Dan. talks of "articulis cylindricis" and already Kützing (1843 p. 263) carried out investigations that showed how long-celled specimens changed into short-celled during autumn and how new cells grew out from the winter cells in the spring. In September 1952 I collected in the Öregrund archipelago in the Baltic, specimens of Cl. fracta that posessed all the transitional stages (fig. 13). The younger branches of these specimens agree very well with the floating Cladophora that can be found in shallow and brackish bays on the swedish west coast. The mode of branching shows good likeness (figs. 12 and 15) and the diagrams over the size of their cells also show a remarkable resemblance.

Besides Cl. fracta the two species Cl. glomerata and Cl. flexuosa are occasionally found detached in sheltered bays on the Swedish coasts. Figs. 17 A and 18—21 show such forms. The mode of branching (note especially the disturbed polarity) is often difficult to distinguish from what is seen in Cl. fracta and should probably be regarded as a modification due to the floating life. However, the diagrams of the cell sizes show characteristic differences. The detached Cl. glomerata has the biggest cells and furthermore the cells have a remarkable length relative to the diameter, in the most extreme cases the relative length reached a value of 30—40 diameters. Very few cells were shorter than 8 diameters. (A similar modification of Cl. glomerata can be found in Waern 1952 fig. 31 E). In the case of Cl. flexuosa the reverse has been found, very few cells exceed a relative length of 8 diameters; the majority

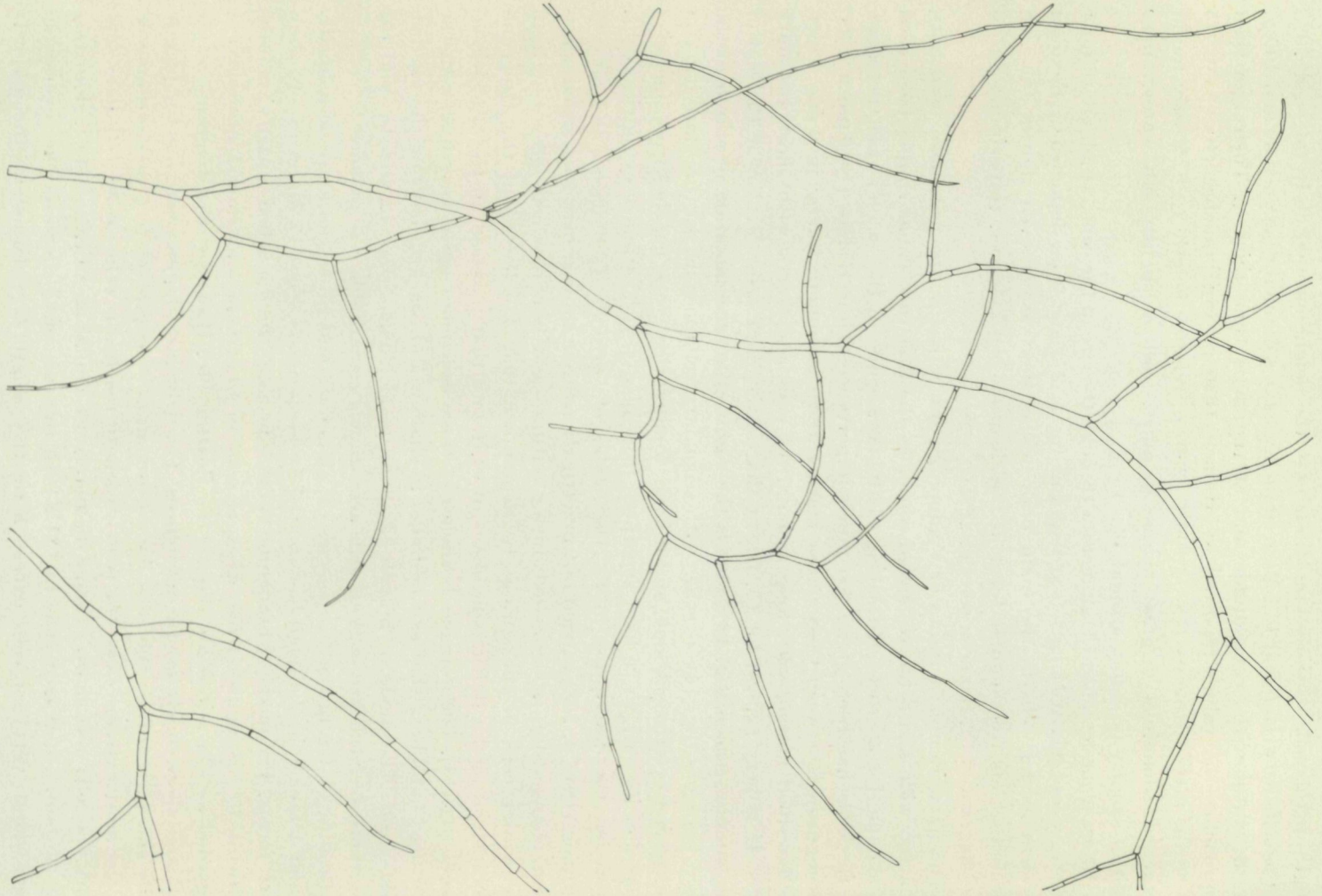


Fig. 16. Part of the main branches in a specimen of Cl. fracta from Henån. Note the short cells. ×20.

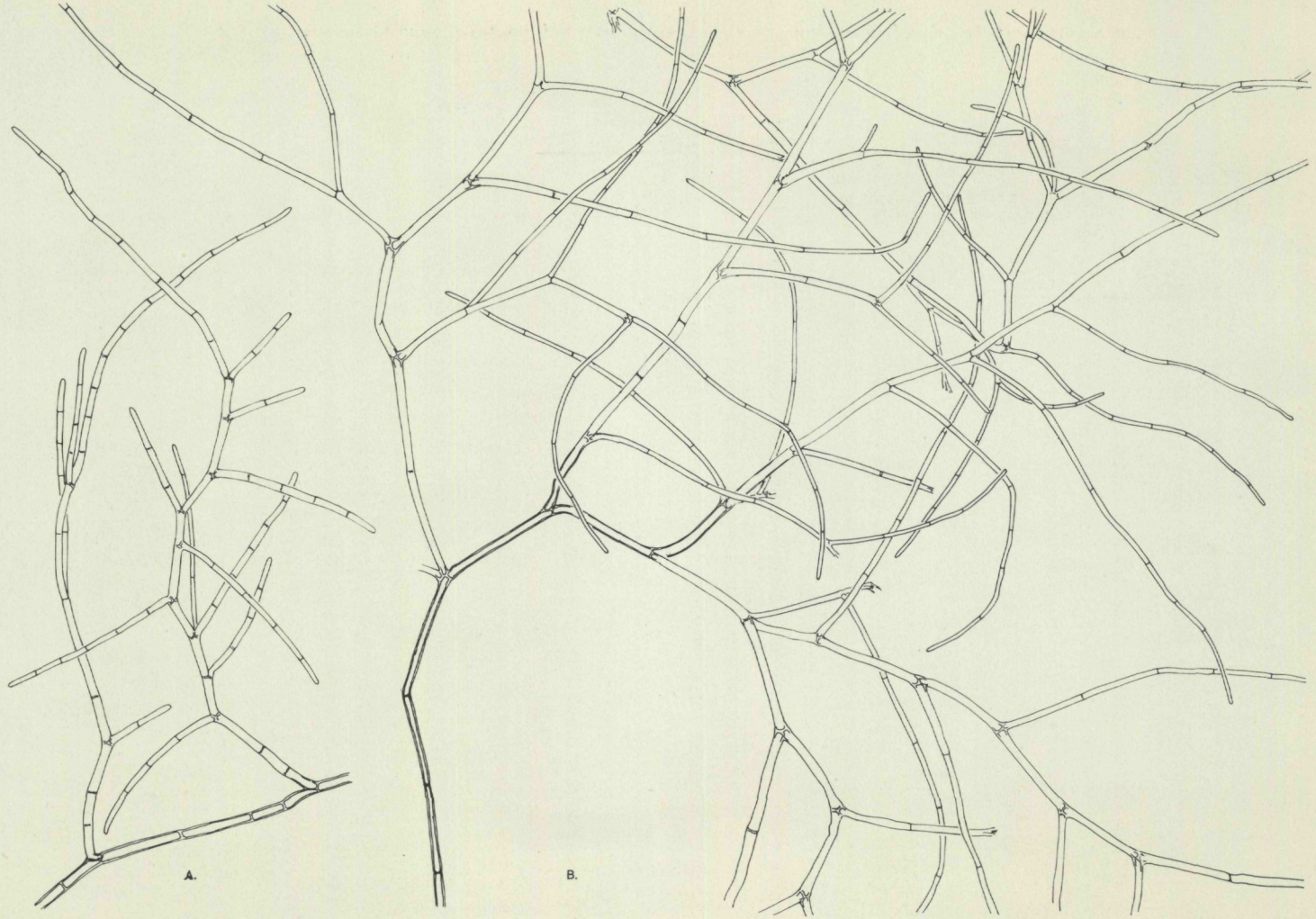


Fig. 17. To be compared with fig. 16 and 18. A. shows branches from a detached specimen of Cl. flexuosa, Kungsbackafjorden, 1.8.1955, B. branches from a specimen of Cl. fracta, Öregrund, 27.9.1952. ×20.

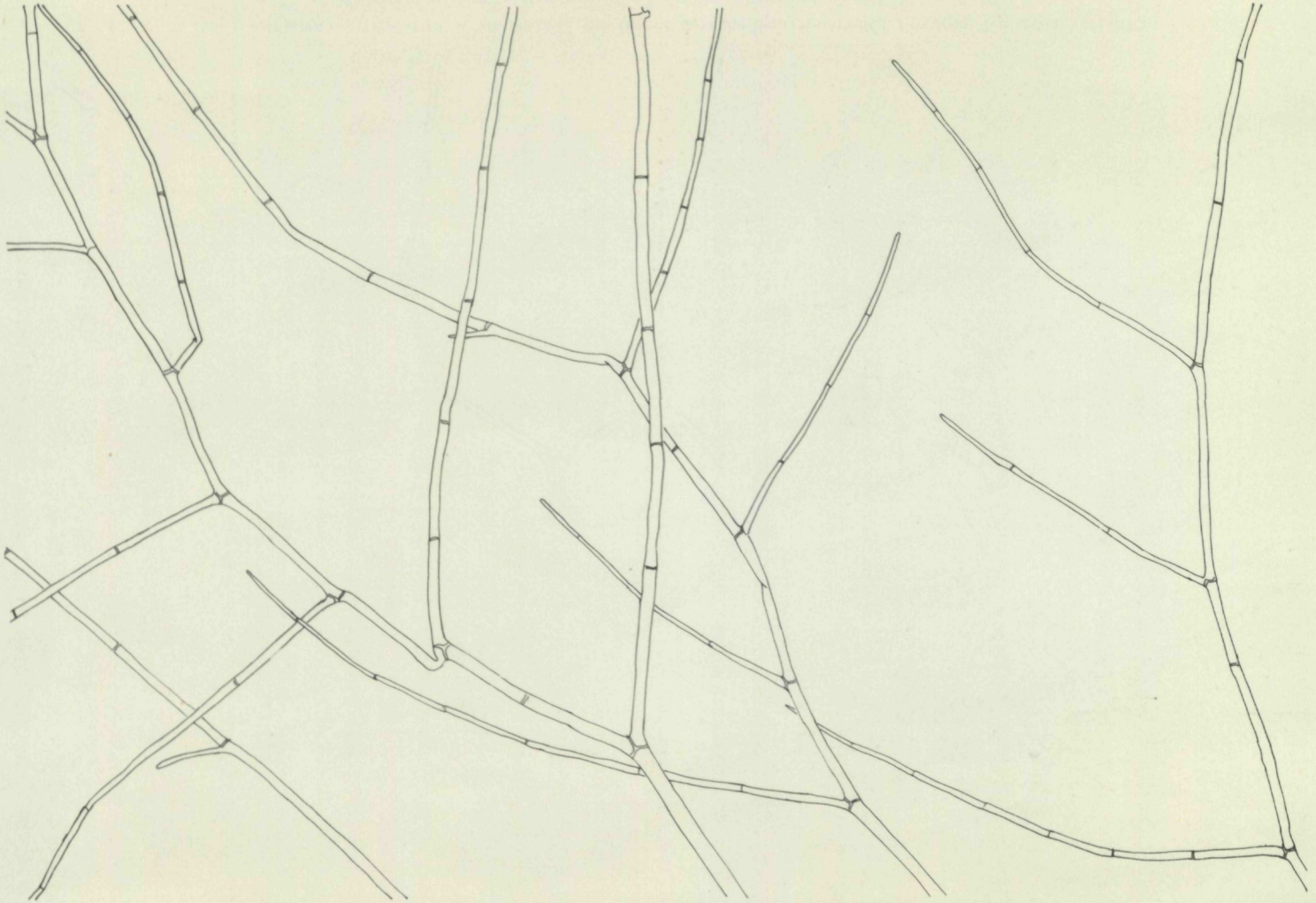


Fig. 18. Branches from a detached specimen of Cl. glomerata, Kungsbackafjorden, 31.7.1955. ×20.

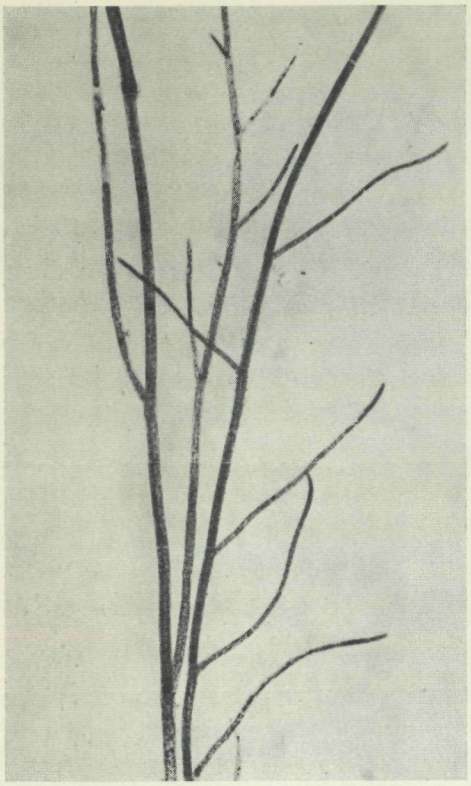


Fig. 19.

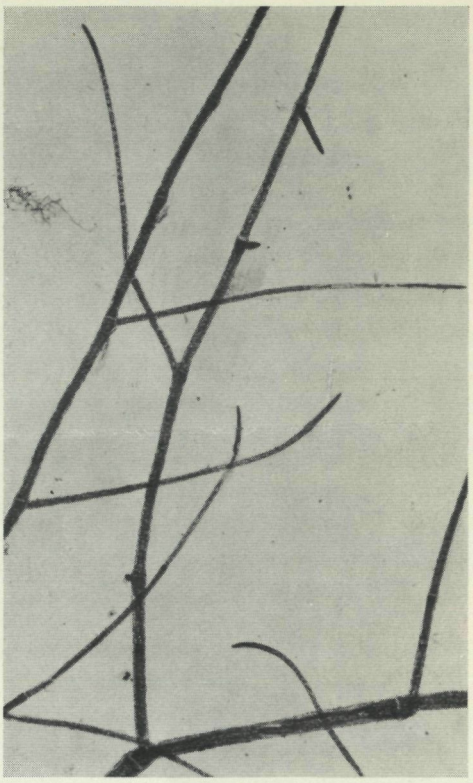


Fig. 20.

Fig. 19. Branches from a semi-detached specimen of Cl. glomerata, artificial pond, Uppsala, 13.7.1955. × 15.

Fig. 20. Branches from a detached Cl. glomerata, Kungsbackafjorden, 31.7.1955. Note in the upper part of the picture the new branch with reversed polarity. × 15.

fall between 5 and 8. Compared with those two, Cl. fracta may be considered intermediate as far as the relative length is concerned, but differs through the thinness of the outer (younger) cells that often have a diameter less than 20 μ. When present, cells with a short relative length were always found in the main branches of Cl. fracta, a result of the secondary divisions that precede the formation of the winter cells. I have too little material of Cl. fracta to be able to make a more definite statement, but from what I have seen in the herbariums it seems that the tendency expressed in the above figures may be a useful character.

Waern (1952 p. 76) reports Cl. fracta from "rockpools with a faintly brackish, almost fresh water". Typical is also Farlows description of a locality where he collected Cl. fracta: "Ad juncos in stagno aquae vix salsae." On the Swedish west coast Cl. fracta is a much rarer plant than it appears in works of Swedish algologists and nearly all the herbariums specimens collected from the Swedish west coast and called Cl. fracta I have found to be forms of Cl. flexuosa.

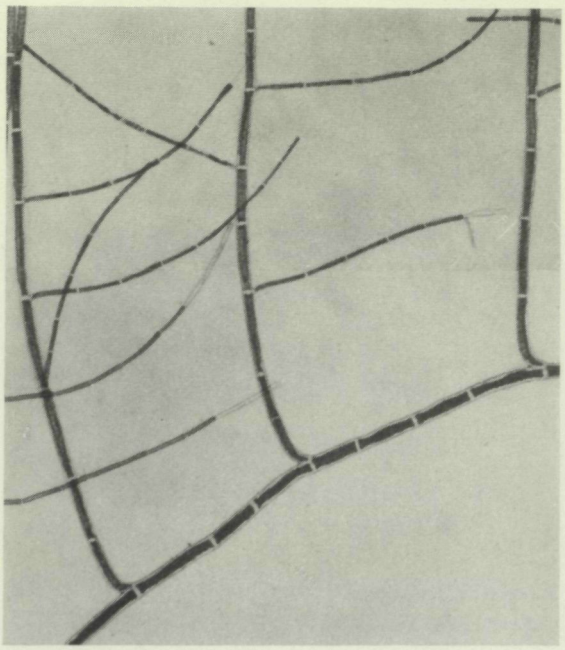


Fig. 21. Branches of a semi-detached Cl. flexuosa, from a small sheltered bay outside Kristineberg, 6.8.1962. This specimen looks similar to Cl. fracta, but compare the size of the cells; the diagram fig. 86 emanates from this plant, fig. 22 and 23 show the size of the cells in specimens of Cl. fracta. ×15.

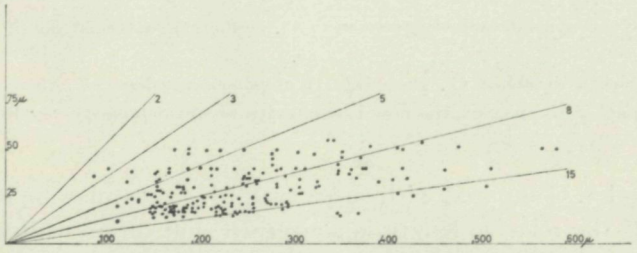


Fig. 22. Sizes of cells from two specimens of Cl. fracta from Öregrund.

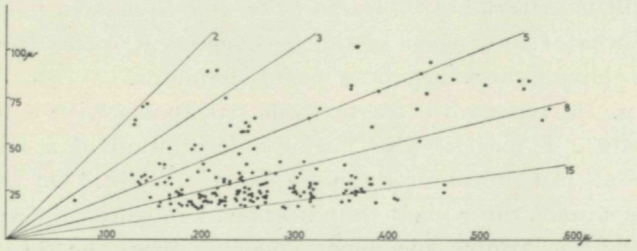


Fig. 23. Sizes of cells from two specimens of Cl. fracta from Henån.

In Bohuslän I have found Cl. fracta to be restricted to the innermost parts of shallow bays where at least some small stream discharges its water. As a typical locality I regard the small harbour of Henån in the middle of Bohuslän; the specimens shown in fig. 12—16 were collected there. In the latter half of July and in August Cl. fracta is to be seen every year floating in great masses in this locality. The floating strata have been found to emanate from a muddy shore between the mouth of two rivulets. The dominating plant on the mud is Ruppia spiralis. The plants continue their growth even in the floating state and I have several times observed sporelings growing as epiphytes on older branches.

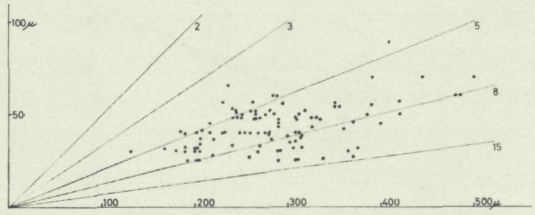


Fig. 24. Sizes of cells from a detached specimen of Cl. flexuosa, leg. T. Levring, Varberg, 6.8.1932.

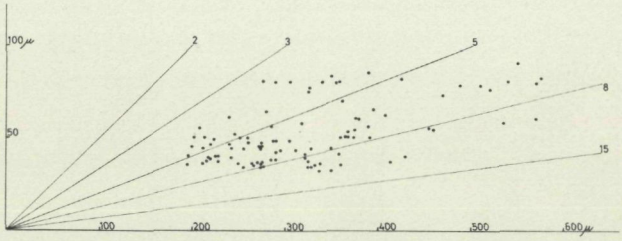


Fig. 25. Sizes of cells from a detached specimen of Cl. flexuosa, Kungsbackafjorden, 1.8.1955. The same specimen in fig. 17 A.

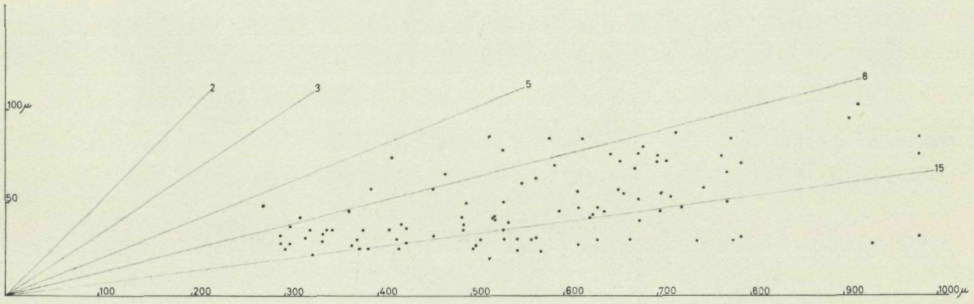


Fig. 26. Sizes of cells from the specimen of Cl. glomerata shown in fig. 19.

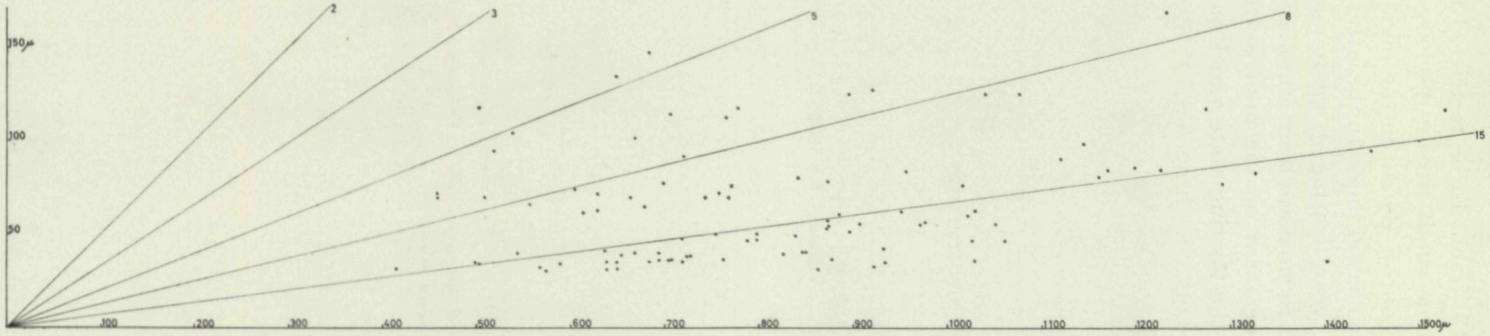


Fig. 27. Sizes of cells from the specimen of Cl. glomerata shown in fig. 20.

Cladophora glomerata (L.) Kützing

Conferva glomerata Linnaeus 1753 p. 1167.
Cladophora glomerata Kützing 1843 p. 266.

References and synonyms

Conferva glomerata in Müller Fl. Dan. Tab. 651:2. — Roth 1806 p. 235. — Dillwyn 1809 Tab. 13. — Lyngbye 1819 p. 154 and tab. 53. — C. Agardh 1824 p. 107 partim (the variety roseola is in Herb. Alg. Ag. a mixture of Cl. albida (Huds.) Kütz. and Cl. oblitterata Söderström).

Conferva sericea Hudson 1762 p. 485 partim (sec. Dillwyn who considered some of Hudson's specimens to belong to C. laetevirens Dillwyn). — Müller Fl. Dan. Tab. 651:1. — Lyngbye 1819 p. 153 and Tab. 53. — C. Agardh 1824 p. 113. — Areschoug 1850 p. 194 partim (section b).

Conferva cristata Roth 1797 p. 193 (included in C. glomerata Roth 1806 p. 235).

Conferva crystallina Roth 1797 p. 196. — Lyngbye 1819 p. 155 (the variety virescens is doubtful). — C. Agardh 1824 p. 112 partim (perhaps Agardh's crystallina ought not to be mentioned here at all since he concluded his description with the words "An C. sericea?" and in Herb. Alg. Ag. C. crystallina appears as a mixture of at least four species).

Conferva nigricans in Lyngbye 1819 p. 158 and Tab. 54 (C. nigricans Dillwyn 1809 p. 63 and Tab. E is most probably a form of C. fracta. As Dillwyn's description and picture were made from specimens named by Roth, C. nigricans Roth too ought to belong to fracta. C. Agardh, however, placed both Roth's and Dillwyn's nigricans together with C. aspera Ag. a plant that without doubt is a form of glomerata).

Conferva elongata C. Agardh 1824 p. 109 (non Conferva elongata Hudson 1778 p. 599, which is the nomenclatural basis for Polysiphonia elongata).

Conferva aspera C. Agardh 1824 p. 115.

Conferva strepens C. Agardh 1827 p. 636.

Conferva cannabina Areschoug 1850 p. 207 partim (The specimens from Warholmen).

Cladophora glomerata in Kylin 1907 p. 31. — Hylmö 1916 p. 34. — Sjöstedt 1927 p. 10. — Bliding 1936 p. 533. — Levring 1940 p. 13. — Kylin 1949 p. 59. — Waern 1952 p. 76.

Cladophora Suhriana Kützing 1843 p. 266.

Cladophora sericea in Reinbold 1890 p. 135.

Cladophora cristata in Kylin 1907 p. 32. — Sjöstedt 1927 p. 10.

Cladophora refracta in Söderström 1955 partim (The plant represented by fig. 12).

Investigated herbarium specimens

"Conferva crystallina Roth, dedit Roth ipse.", Herb. Alg. Ag. nr 7812. — "Conferva sericea Lyngbye. Donatione ipsius. Habitat in Lacu Fuursö, Saellandiae", Herb. Alg. Ag. nr 9027. — "Conferva glomerata γ simplicior Höje å Sthlm", Herb. Alg. Ag. nr 8067—70. — "Conferva glomerata δ ochrochloa Gothemsån", Herb. Alg. Ag. nr 7822—43. — "Conferva elongata. In rivulo prope Helsingborg — ad Ramlösa — Gåsebäck", Herb. Alg. Ag. nr 7410—37. — "Conferva aspera", Herb. Alg. Ag. nr 9188—89. — "Conferva strepens", Herb. Alg. Ag. nr 9105—08 and 9155—72 (all those specimens have names in Agardhs handwriting). — "Conferva sericea" (from Lake Mälaren) Areschoug Alg. Scand. Exsicc. ser II nr 272, Riksmuseum, Stockholm. — "Conferva laetevirens" (from a brackish locality in Bohuslän) Areschoug Alg. Scand. Exsicc. ser II nr 227. Riksmuseum, Stockholm. — "Conferva cannabina" Areschoug Alg. Scand. Exsicc. ser I nr 14, ser II nr 135, Bot. Museum, Uppsala. — "Cladophora crystal-

lina (Roth) Kütz. forma typica, Malören prope Haparanda, T.O.B.N. Krok "Wittrock & Nordstedt exsicc. nr 120 a, Bot. Museum, Uppsala and Brit. Museum. — "Cladophora crystallina var. abbreviata, Malören prope Haparanda" ibid. nr 121, Bot. Museum, Uppsala and Brit. Museum. — "Cladophora glomerata, Gottskär 8.7.1902". — "Ibid. Varberg 24.7.1902" leg. et det. H. Kylin, Bot. Museum, Lund. — "Cladophora cristata, Halmstad 12.6.1904, leg. H. Kylin.", Bot. Museum, Lund. — "Cladophora glomerata, Skåne, Lomma 10.8.1930 — ibid. Blekinge, Karön 14.7.1936 — ibid. Småland, Bergkvara 9.7.1937, leg. T. Levring.", Marine Bot. Inst., Göteborg.

Taxonomical remarks

Conferva sericea was described by Hudson (1762 p. 485) with the words "Conferva filamentis geniculatis ramosis fasciculatis confertis viridibus" a description which could apply to more than one of the species in the genus. However, his description was based on Dillenius' tab. 5 fig. 33 the "beasom-like silk". Dillwyn (1809 p. 34) used Dillenius' herbarium in order to understand what Hudson had meant with sericea. He found two specimens called sericea of which one, according to Dillwyn, was "a trifling variety of Conferva glomerata", the other was a marine alga, from the island of Sheppey, the same as Dillwyn called Conferva laete-virens. Dillwyn's conclusion was that he doubted "whether C. sericea can be regarded as a single species". As long as C. laetevirens Dillwyn is accepted, the name sericea should therefore not be used. However both names are found in Kützing's Phycologia generalis, but Kützing's Cladophora sericea (1843 p. 264) was not founded on Hudson's sericea but on Lyngbye's (1819 p. 153).

The question then arises whether C. sericea Lyngbye and C. sericea Hudson have the same meaning, i.e., if two species are also involved in Lyngbye's C. sericea. Lyngbye described C. sericea together with a variety marina and this could naturally be suspected of being the same as the marine part of Hudson's C. sericea. We must then remember that Lyngbye was a Danish botanist and that the greater part of the Danish waters are brackish. C. sericea γ marina is reported by Lyngbye as growing "ad littus Torbaek Sellandiae" — the salinity here is less than $15^0/_{00}$. I myself have not been able to find in those parts a plant resembling the marine part of Hudson's C. sericea (sensu Dillwyn), either on the shores or in the herbariums. It seems clear to me that C. sericea Lyngbye consisted entirely of forms of Cl. glomerata. In 1849 (p. 401) Kützing still described Cl. sericea with a reference only to Lyngbye. The Cl. sericea we now meet with is a very thin alga. The diameters of the cells are only 1/120—1/40 lines — about 19—55 μ. It was an alga of this type Hauck (1885 p. 459) reckoned with in his description of Cl. crystallina and which then appeared under the name Cl. sericea in Kylin's list of Cladophora from the Swedish west coast (1907 p. 31). This had, in a way, already been summed up by Areschoug (1850 p. 194). A close study of the specimens in his exsiccat work and his specimens in Riksmuseum, Stockholm, shows that section a of his C. sericea corresponds to C. flexuosa Müller, section b to C. glomerata sensu latissime and section d to C. sertularina C. Agardh. As section c another alga appears which will be dealt with in connection with Cl. hamosa Kützing.

Fig. 28. Optimum specimen of Cl. glomerata from the estuary of the river Nordre Älv, 13.8.1955. The locality is shown on fig. 11. In the neighbourhood Areschoug collected the plants that he called C. laetevirens, compare fig. 33. $\times 15$.

Fig. 29. To the left Cl. glomerata from the river Fyrisån, near Uppsala, leg. M. Waern 20.10.1956, in the middle Cl. glomerata from a shore in the Bothnian sea, leg. G. E. Du Rietz 1949, to the right Cl. glomerata from a similar shore at Torekov, 25.7.1955. ×20.

A. Cl. sericea of some interest is the one described by Reinbold (1890 p. 135). Bliding (1935 p. 57) refers to Reinbold in his paper on culture experiments with some species of Cladophora. One of the cultured plants is described as belonging to "dem Formenkreis sericea — wie diese Art von Reinbold und Lakowitz aufgefasst wird". What did Reinbold then mean with Cl. sericea? It is described as well branched, sometimes penicillate and with long cells. The diameter is given as 75—100 μ, but we do not know if this refers to the main filaments or to branchlets.

Reinbold refers to three numbers in exsicc. Areschoug and two in exsicc. Wittrock & Nordstedt. Of these Areschoug nr 272 (cf Waern 1952 p. 76), and Areschoug nr 227 are Cl. glomerata (a picture of a branch of the latter is shown in fig. 33 and may be compared with my own Cl. glomerata from Nordre Älv, fig. 30 B, not far from where Areschoug collected his specimens), while Areschoug nr 127 (two specimens were examined) seem to be old specimens of Cl. flexuosa. Wittrock & Nordstedt nr 120 is divided into a and b. A is clearly a Cl. glomerata, while b belongs to Cl. flexuosa. Lastly, Wittrock & Nordstedt nr 121, is a Cl. glomerata. All this makes it almost a certainty that Reinbold's Cl. sericea consisted of forms of Cl. glomerata and it is no wonder Reinbold found it difficult to separate sericea and glomerata and preferred to unite them. Since Bliding has kindly shown me specimens of the alga he cultured under the name Cl. sericea (fig. 46 A is from a plant given to me by Bliding) it is possible for me to say that it does not belong to Cl. sericea Reinbold, but to Cl. oblitterata Söderström. Blidings (1936 p. 535) conclusion about Reinbolds Cl. sericea is therefore wrong and I find all this a strong argument when vindicating that we still know too little about the taxonomy of Cladophora to make culture experiments really profitable.

As already mentioned, the stated marine part of C. sericea Hudson was assumed by Dillwyn to be the same as his C. laetevirens. When this name was adopted by Kützing (1843 p. 267) it was also given a variety in the Baltic. If what Kützing really meant was the original laetevirens, I do not know, but Hauck has at least declared that Harvey's Cl. laetevirens is not the same as Kützing's (Hauck 1885 p. 455). Hauck gives to Cl. laetevirens Kützing the measurement 25—80 μ (1885 p. 458), which is far too small for the British laetevirens. Cl. laetevirens Harvey is placed by Hauck in Cl. utriculosa Kützing, to which species he gives the measurements 70—250 μ, a size that well agrees with what I have found in the British specimens. Consequently Cl. utriculosa is a name that ought to be rejected. Hamel (1930 p. 27 (3)[1])) seems to have overlooked the fact that C. laetevirens originated from Dillwyn, 1809, and therefore proposed the rejection of this name and the retention instead of Cl. utriculosa Kützing. In Cl. utriculosa, Hamel included a specimen of Wyatt exsicc. nr 143 "Conferva glomerata", the number supposed to be the basis for Cl. laetevirens Harvey, but another specimen with the same number

[1]) In the foreword to "Chlorophycees des côtes Françaises" Hamel points to an error in the pagination of the part on Cladophora, page one should be page 25. The corresponding page in Revue Algologique Tome IV Nos 1—4 nov. 1929 is p. 43. In the continuation the corrected pagination will be used.

Fig. 30. Rivermouth-glomerata, A. from the mouth of the stream Gothemsån, island of Gotland in the Baltic, leg. R. Ivarsson, B. from the mouth of Nordre Älv, see fig. 11, C. and D. shows the gradual change into nearly unbranched forms, as the plants in the estuary of Nordre Älv grow more and more exposed to the stream. ×20.

Fig. 31. A comparison between Cl. glomerata from the river Fyrisån (to the left) and an extremely thin form from Torekov. In Sweden the latter form has often been called Cl. cristata or Cl. crystallina. ×15.

he found to be thinner and this he called Cl. sericea. The name sericea was adopted by Hamel from Kützing and Reinbold, but if Hamel's pictures of Cl. utriculosa and Cl. sericea are put in the same magnifying scale it is easy to see that no significant difference exists between the pictures (fig. 107). As conceived by Hamel Cl. utriculosa Kützing must be the same as Cl. laetevirens Harvey, which in turn is the same as Dillwyn's and consequently the marine part of C. sericea Hudson.

According to Hauck's apprehension of Kützing's Cl. laetevirens the name is illegitimate for this plant. However, the name has also been used in Kützing's and Hauck's meaning, for instance, by Kylin (1907 p. 29). Later on Kylin (1949 p. 54) placed his laetevirens together with a plant cultured by Bliding under the name Cl. albida var. refracta and made for these plants the new name Cl. Blidingiana. There is no doubt that Bliding's determination was correct and that no connection exits between Cl. laetevirens Kylin and the original C. laetevirens Dillwyn (cf. Söderström 1955 p. 278 and fig. 7).

Conferva crystallina was originally described by Roth (1797 p. 196) on material from the neighbourhood of Wismar in the Baltic. Already the locality points to Cl. glomerata and the description which talks of sometimes unilateral branches and fasciculated tufts does not contradict this. Roth's original material is lost but in Herb. Alg. Ag. I have found a small specimen (fig. 34) on which C. Agardh had written "Conferva crystallina Roth, dedit Roth ipse". It seems to me quite clear that this is ordinary C. glomerata. The name crystallina has also mostly been used on forms of C. glomerata, especially the thinner ones. Hamel (1930 p. 36) used the name on an alga which must be a form of Cl. oblitterata Söderström, the same applies also, at least partly, to the use of crystallina in the works of Hylmö (1916 p. 35), Sjöstedt (1927 p. 11) and Levring (1937 p. 33). The Cl. crystallina of Hauck (1885 p. 459) is more difficult to explain but judging from the description it seems to have been a mixture of several species. Thin forms of Cl. glomerata were certainly involved, likewhise thin forms of Cl. flexuosa can not be excluded and Kylin (1949 p. 53) has used Hauck's description as a basis for his own Cl. sericea and thus Cl. oblitterata is also involved (cf. p. 53).

Cladophora Suhriana Kützing is put here as an example of the many Kützing-plants that must be forms of Cl. glomerata.

Description

One of the most variable plants in the genus. Dillenius "cluster" on which the original description was founded, represents a well branched and relatively short-celled form. This form is also found in Swedish rivers and lakes as well as in brackish localities, for instance the Öregrund archipelago and on rocky shore in the mouth of Nordre Älv near Gothenburg (fig. 28, c.f. also Waern 1952 fig. 31). This form has to the greater part cells with a relative length between 3 and 8 and a

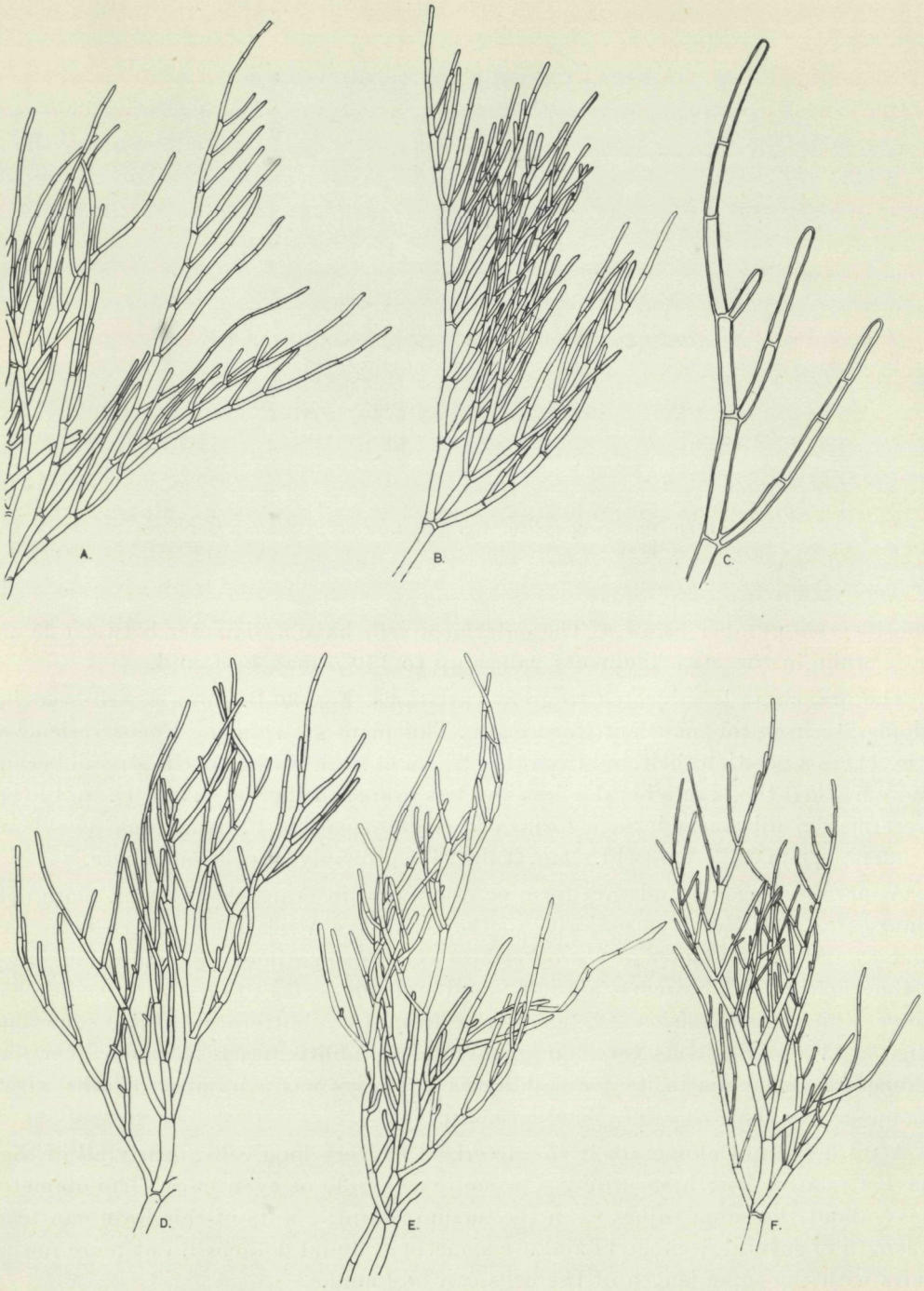


Fig. 32. Different types of ramification in Cl. glomerata. A, B and D show specimens from Torekov, E a specimen from the Bothnian sea, leg. G. E. Du Rietz, F is a Cl. oblitterata from Hallands Väderö just outside Torekov. The ultimate branchlets in Cl. oblitterata are thinner and straighter, sometimes bending in the opposite direction compared with what can be seen in Cl. glomerata; fig. C. shows a typical end branch from Cl. glomerata. Fig. C. $\times 55$, the other $\times 20$.

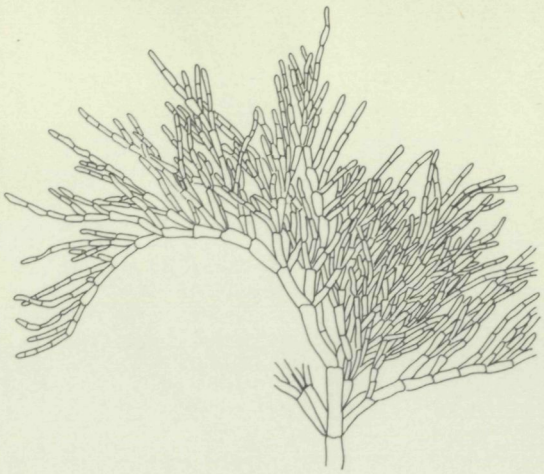


Fig. 33. A branch from Areschoug exsicc. Alg. Scand. nr 227, Conferva laetevirens. ×20.

considerable number below 5. The outermost cells have a diameter between 25 and 50 μ while in the main filaments values up to 150 μ may be found.

The branching is subjected to great variations. Fig. 30 B.shows a well-branched glomerata from the mouth of Nordre Älv. This plant grew among Fucus vesiculosus (fig. 11) in a position sheltered from the stream of fresh water. As the stream became more marked the plants became less and less branched (fig. 30 C. and D.)until they were nearly unbranched. Such forms constitute a part of C. cannabina Areschoug. Conferva pennatula Vahl (Fl. Dan. Tab. 945) probably also belongs here.

A more long-celled and thin form can be found in brackish water on more open shores (fig. 31). Here the majority of the cells have a relatively length between 5 and 15 and the diameter in the outermost cells is sometimes as small as 20—22 μ. Values below 20 μ, however, are not found and this seems to be a very useful character which distinguishes Cl. glomerata from Cl. oblitterata, which sometimes (fig. 32 E. and F.) looks very like glomerata. Cl. oblitterata is so much finer than glomerata that even in its coarsest forms it always has a number of cells with a diameter less than 20 μ (cf. Waern 1952 p. 78).

A third form of glomerata is characterized by very long cells, nearly all of them have a relative length exceeding 8, some reaching 30 or even more. The diameters have about the same values as in the medium form. Plants of this form can reach a length of several decimeters and are sometimes found detached, but more normal tufts with the same length of the cells can be found.

At the tip of the branches Cl. glomerata often has a characteristic bend (fig. 32 C.). Even in the long-celled detached forms I have seen a tendency to this bend. Much stress must not be laid on such a character, but in some cases it is a good help for the determination.

Fig. 34. A branch from the authentic specimen of C. crystallina Roth in Herb. Alg. Ag. ×20.

Cladophora glomerata is usually apomictic (Bliding 1936 p. 533) though Schussnig (1951 p. 597) reports gametes. Schussnig (1954 p. 320) gives the number of chromosomes as 96. As 12 is the usual haploid number in Cladophora Cl. glomerata is thus octoploid.

The ecology of Cl. glomerata is carefully dealt with by Waern (1952 p. 78—80). I have only to add some notes concerning glomerata on the Swedish west coast. All my finds there have been specimens growing near the surface and mostly in the hydrolitoral, though some have also been found in the upper sublitoral (the term hydrolitoral is here used in the same meaning as the hydroamphibiontic belt in Du Rietz 1940 p. 106 and the litoral in Levring 1940 p. 121). With exception of the detached specimens they have been growing on the rock and not found epifytic. In the southernmost parts of the west coast I found in 1955 Cl. glomerata to be a dominating plant on shores washed by the waves. It grew here together with Cl. albida. In spray pools it was less common but not rare. In these pools it was sometimes found mixed with Cl. oblitterata and was at first difficult to distinguish from this species. Along the coast of the province of Halland Cl. glomerata becomes less common and in the province of Bohuslän it is only known from the brackish water at the mouths of Göta Älv and Nordre Älv. In 1951 I found a

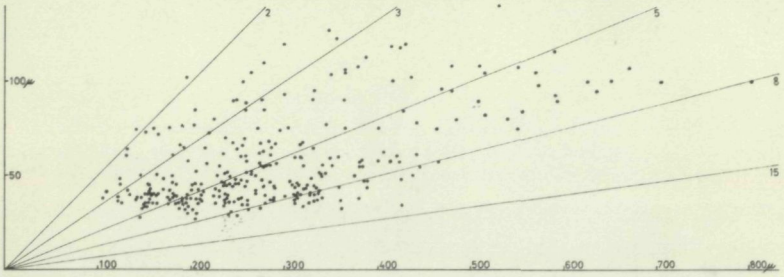


Fig. 35. Sizes of cells from three specimens of Cl. glomerata with comparatively short cells. (The same specimens as in table 1.)

small population of an alga that I then ascribed to Cl. refracta Areschoug, but later on, after having seen glomerata in other places, I was convinced that it must be a form of Cl. glomerata. This population grew in a pool in a sheltered bay north of the island of Orust. The salinity is here during the summer around 23 $^0/_{00}$. Though I have visited this bay several times every summer since 1951 I have never come across Cl. glomerata again and it seems probable that the deepening some years earlier of the inlet to the system of firths to which the said bay belongs, has caused an increase in salinity, with the result that Cl. glomerata cannot grow there any more. As an upper limit for glomerata 20 $^0/_{00}$ salinity therefore seems reasonable.

As my material from fresh and brackish waters is restricted, and furthermore Cl. glomerata is known as an extremely variable species, as well as being apomictic, I have refrained from describing any varieties or forms. However, I wish to point out that in the material that has been measured two abrupt changings in relative length can be seen, thus the material can be sorted out in three groups. Measurements from three plants of each of these groups are shown here. The first and most shortcelled group consists of plants that perhaps could be called typical Cl. glomerata. In the second group cells with a relative length shorter than 5 become scarce. This group corresponds to what Sjöstedt (1927 p. 10) called Cl. cristata.

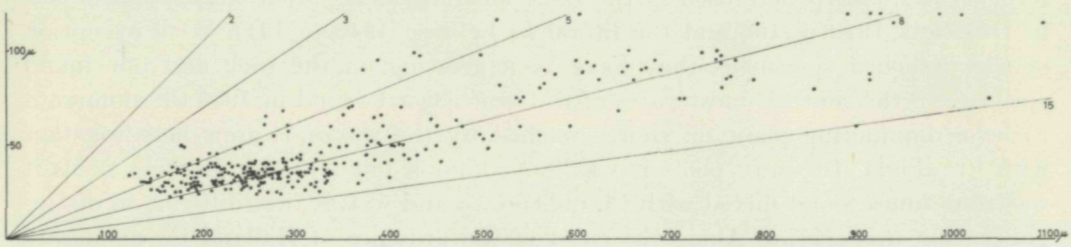


Fig. 36. Sizes of cells from three specimens of Cl. glomerata with medium relative length of the cells. (The same specimens as in table 1.)

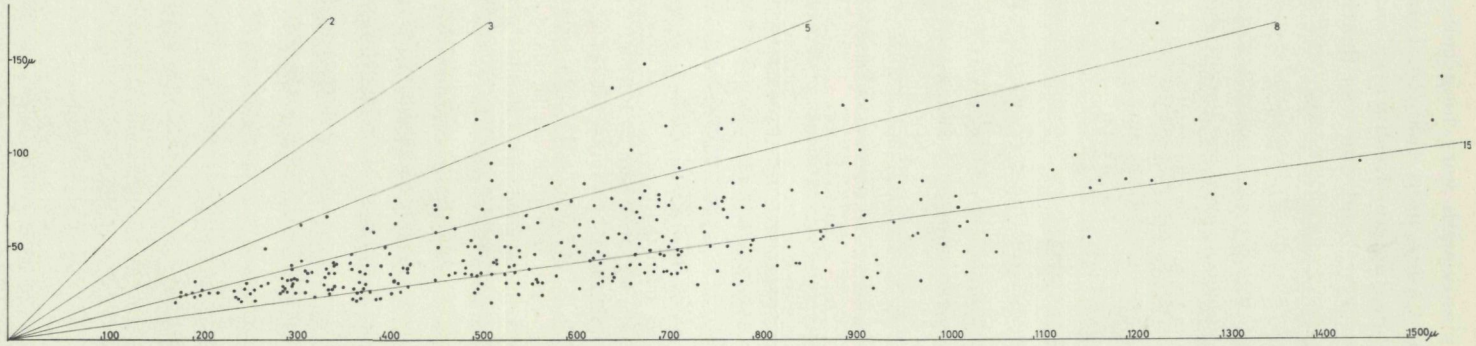


Fig. 37. Sizes of cells from three specimens of Cl. glomerata with extremely long cells. (The same specimensas in table 1.)

The third group consists of plants with very long cells, the majority have more than 8 in relative length and not a few more than 15. The three plants in this group differ ecologically, as one is from stagnant fresh water, one from an exposed locality where the salinity is about 6—7 ‰, and one was floating in quiet water with a salinity in the region of 15 ‰.

TABLE 1. *Relative length of cells from Cl. glomerata.*

To the left the percentage of cells in each of the classes of relative length shown with oblique lines in the diagrams, in the middle the designations of the finds, to the right the percentage of cells in some other classes of relative length.

— 2	— 3	— 5	— 8	— 15	—		>8	<5	3—8
0	13	63	23	1	0	EC13c/55	1	76	86
1	5	23	61	10	0	EC13e/55	10	29	84
1	11	21	49	18	0	Ulva kvarn	18	33	70
0	0	9	56	35	0	EC2b/55	35	9	65
0	0	8	51	41	0	EC2a/55	41	8	59
0	0	8	49	42	1	Sörmjöle	43	8	57
0	0	3	12	35	50	EC7/55	85	3	15
0	0	0	10	75	15	Jungfrun	90	0	10
0	0	0	9	64	27	Uppsala	91	0	9

Description of the localities.

EC13c/55 and EC13e/55 (fig. 30) are from the mouth of the river Nordre Älv, 13.8.1955. — Ulva kvarn, in the river Fyrisån near Uppsala, leg. M. Waern 20.10.1956. — EC2a/55 and EC2b/55 (figs. 31, 32), wave exposed shore, Torekov, 25.7.1955. — Sörmjöle, slooping rock near Umeå in the gulf of Bothnia, leg. L. Hartin september 1959. — EC7/55, (fig. 18) detached in the bay of Kungsbackafjorden 31.7.1955. — Jungfrun, shady crevice together with Pylaiella, island of Jungfrun in the Baltic, Leg. G. E. Du Rietz 22.6.1929. — Uppsala, artificial pond with waterlilies in the town of Uppsala, 13.7.1955.

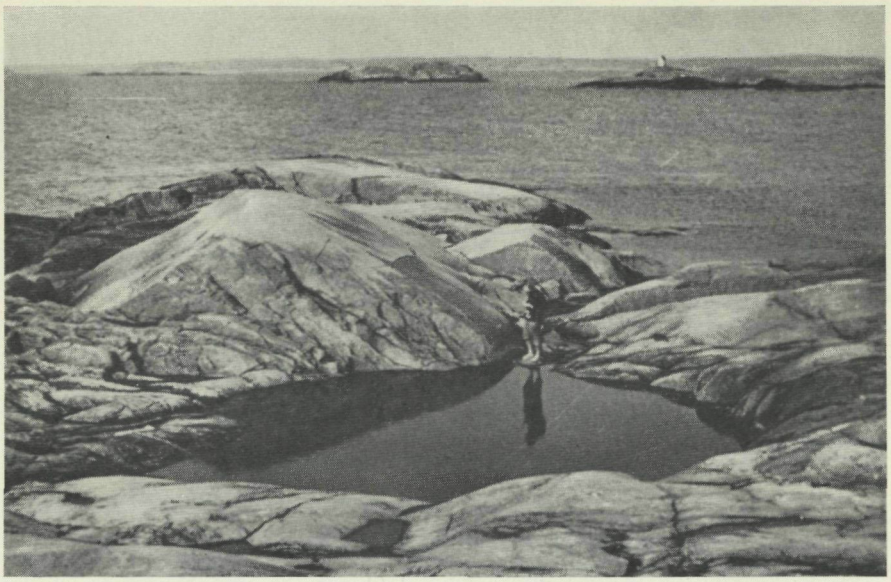


Fig. 38. In the outer part of the archipelago outside Kristineberg, the characteristic habitat of Cl. oblitterata is in bigger spray pools like the one shown in this picture.

Cladophora oblitterata Söderström nov. nomen

References and synonyms

Conferva sertularina C. AGARDH 1824 p. 117 (non Conferva sertularina Montagne 1840 p. 200 nec Cladophora sertularina Kützing 1849 p. 396).

Conferva Rudolphiana C. AGARDH 1827 p. 636, partim.

Cladophora Rudolphiana KÜTZING 1843 p. 268. — HAMEL 1930 p. 36. — TAYLOR 1957 p. 84. — (Non Cl. Rudolphiana in Harvey 1846 pl. 86. — Kützing 1849 p. 404. — Cotton 1912 p. 111).

Cladophora crystallina in HYLMÖ 1916 p. 35, partim. — HAMEL 1930 p. 36. — LEVRING 1940 p. 14, partim.

Cladophora glaucescens in HYLMÖ 1916 p. 36, partim. — FARLOW 1881 p. 52, partim.

Conferva sericea in ARESCHOUG 1850 p. 194, partim.

Cladophora sericea in KYLIN 1907 p. 31. — VICKERS 1908 p. 18, pl. 14. — BLIDING 1935 p. 57, 1936 p. 533.

Investigated herbarium specimens

"Conferva sertularina" (C. Agardh's handwriting), Herb. Alg. Ag. nr 8129—8131. — "Conferva Rudolphiana, Trieste" (C. Agardh's handwriting), Herb. Alg. Ag. nr 7863—7897. "Cladophora crystallina (Roth) Kütz. Utklippan 26.6.1936. Leg. T. Levring", Marine Bot. Inst., Göteborg. — "Cladophora glaucescens (Griff.) Harvey prope Barsebäckshamn in Profunditate m. Leg. D. Hylmö 31.7.1916", Herb. G.E. Du Rietz, Uppsala. — "Conferva sericea Huds. d.

Phyc. Scand. Warholmen 1859" ("Warholmen" is a small island outside Göteborg), Herb. Areschoug, Riksmuseum, Stockholm. — "Cladophora sericea (Huds.) Kütz. Gottskär 21.6. 1904. Leg. H. Kylin". — Ibid. Nordkoster 3.7.1905. — Ibid. Kristineberg 17.6.1935.", Bot. museum, Lund. — "Cladophora albida (Huds.) Kütz. Grassy Island, Woods Hole, Mass. W. R. Taylor 16.8.1928.", Marine Bot. Inst., Göteborg. — "Cladophora flexuosa f. N. L. Gardner 4147, January 1918. In warm salt water Oakland California", Kew Herb.

Exsiccata: Wittrock & Nordstedt nr 1031 "Cladophora crystallina (Roth) Kütz. Sueciae in regione litorale suprema maris Bahusiensis prope Lysekil, in sinu tranquillo lapillis affixa 9.7.1891. F. R. Kjellman", Brit. Museum and Bot. Museum, Uppsala. — Ibid. nr 930 "Cladophora crystallina, Lindesnäs", Kew Herb. — Ibid. nr 118 "Cladophora sericea in scrobiculis saxorum maris Bahusiensis in Flatholmen prope Lysekil. 9.8.1877. Leg. F. Kjellman.", Brit. Museum. — Alg. Exsicc. Am. Bor. nr 205 "Cladophora glaucescens (Griff.) Harvey, Wood's Holl, Mass. Aug. 1881. Leg. W. G. Farlow.", Herb. Alg. Ag. nr 7544 and Brit. Museum. — Vickers, Algues de la Barbade nr 23 "Cladophora sericea Kg.", Brit. Museum. — Phyc. Bor. Am. nr 267 "Cladophora Rudolphiana (Ag.) Harvey "Fresh Pond" (brackish), Stratford Conn. May 1891.", Brit. Museum.

Diagnosis

Cladophora oblitterata: Filis tenuissimis, inferne duriusculis subcontinuis simplicibus tum di- vel trichotomis flexuosis, articulis cylindricis diametro 3—20plo longioribus; ramis primariis 50—155 μ crassis; ramulis terminalibus 10—30 μ; alternatio gametophytorum et sporophytorum regularis; $n=12$.

Typus: Herbarium Algarum Agardhiorum nr 8129 "Conferva sertularina".

Fig. 39. Conferva sertularina C. Agardh, type specimen in Herb. Alg. Ag. Lund. ×30.

Taxonomical remarks

In 1824 (p. 117) C. Agardh described with the help of material collected in the province of Bohuslän in Sweden, a species which he called Conferva sertularina. Later on in 1827 (p. 636) he used material from the Adriatic sea to describe a similar plant which he called Conferva Rudolphiana. The two species differ chiefly through the occasional swellings which Agardh observed in C. Rudolphiana and regarded as so important that he made a drawing of them in his herbarium (fig. 41). I have also observed swellings of this type in specimens of Cl. oblitterata from Sweden (fig. 42), but they occur in other species, too. They can be catalogued under such monstrosities as article 67 of the international code of botanical nomenclature mentions. Furthermore, Agardh seems to have distributed several species under the name C. Rudolphiana (cf. Harvey 1846 pl. 86); in his herbarium some of the specimens belong to Cl. albida (Huds.) Kützing, and British authors have used the name Rudolphiana on thin forms of Cl. flexuosa (Müll.) Kützing. The specific epithet Rudolphiana, therefore, must be rejected according to both article 65 and 67 of the code.

In 1849 a species called Cladophora sertularina appeared in Kützings work "Species Algarum" (p. 396). The basis for this taxon however, was not Conferva sertularina C. Agardh, but quite a different plant collected in Cayenne by Leprieur and listed by Montagne in "Cryptogamae Guianenses" 1840. As Kützing himself has expressed doubts as to this species being the same as Agardh's, his description must be regarded as valid for a new species, which furthermore is legitimate and validly published. Cladophora sertularina Kützing is clearly a species other than Conferva sertularina C. Agardh; the latter has never been transferred to the genus Cladophora, and when this transfer is made Agardh's plant must be given a new name, cf. article 55 (1) in the code.

It may at first look as if this is a case that applies to the last part of article 55 in the code. However, Kützing not only erroneously applied the epithet sertularina to a different species, but he did not even intend to transfer C. sertularina C. Agardh to Cladophora. Even if it were possible to retain the combination as Cladophora sertularina (C. Ag.) Kützing, under the provisions of this article, this would not be advisable, as it implies that we get a name of a taxon that is used with different meanings.

As the plant that C. Agardh described as C. sertularina is one of the more common of the Cladophora species both on the European and the American shores, and in reality was without a name after Kützings mistake, it has been the source of many misunderstandings. The thinnest forms of Cl. glomerata are habitually like Cl. oblitterata and names originally used on plants belonging to the formseries of Cl. glomerata — for instance Cl. crystallina and Cl. sericea, — have often been used, especially in Sweden. Other species which may easily be confused with Cl. oblitterata are Cl. glaucescens Harvey and Cl. albida (Huds.) Kütz. Many specimens of Cl. oblitterata can be found in the herbariums also under those names.

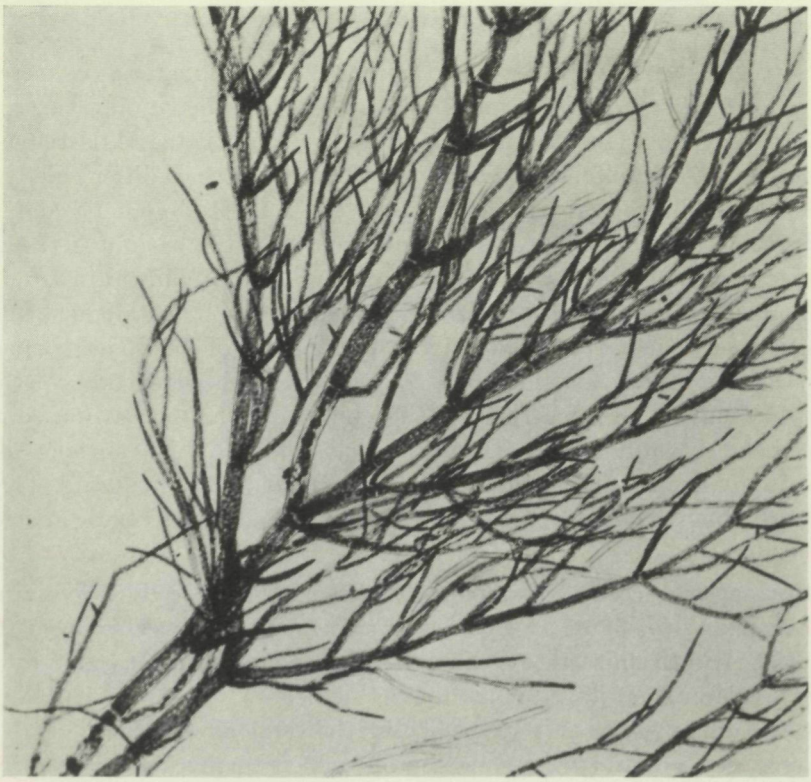


Fig. 40. The big difference between the ultimate branchlets and the main branches is one of the characteristics of Cl. oblitterata; compare fig. 39. Epiphytic on Ascophyllum nodosum, Borgilafjorden, Henån (see fig. 6), 28.6.1953. ×30.

Harvey (1846 pl. 86) described Cl. Rudolphiana growing in 2—6 fathom water in Roundstone Bay (West Ireland, see map). The picture shows an alga with the swellings mentioned by Agardh, but with the ramification typical of floating specimens of Cl. flexuosa (Müll.) Kütz. This is the same plant that Cotton (1912 p. 111) too called Cl. Rudolphiana and judging by herbarium specimens it represents thin forms of Cl. flexuosa. Cl. Rudolphiana in the sense of a synonym to Cl. oblitterata, is badly represented in British herbariums and none of the species listed by British algologists can with certainty be referred to Cl. oblitterata. However, the species is probably not uncommon in Great Britain, though it grows not on 2—6 fathom water but in pools in the upper part of the Pelvetia belt, or even higher, a type of habitat that seems to be somewhat neglected by British algologists (cf. fig. on back of title-page). I found Cl. sertularina in such pools both in Roundstone in August 1957 and in Plymouth in July 1962.

In the work of Hamel (1930 p. 36) Cl. oblitterata is found under the names Cl. Rudolphiana and Cl. crystallina. I found Cl. oblitterata a not uncommon plant on

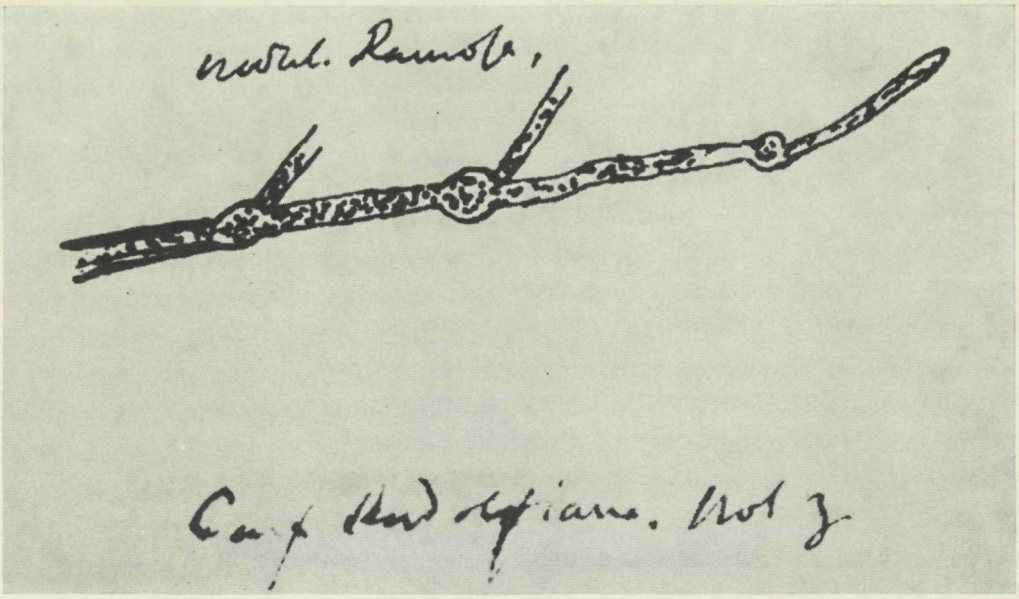


Fig. 41. C. Agardh's drawing of the swellings in Conferva Rudolphiana.

the shores at Dinard in June 1962 and from the description and picture delivered by Hamel, it is evident that Cl. Rudolphiana sensu Hamel is identical with Cl. oblitterata. Cl. crystallina sensu Hamel only represents a pectinated form which cannot be kept apart.

One also meets with a Cl. Rudolphiana in the works of Farlow (1881 p. 54), Taylor (1957 p. 84) and some other American algologists. Taylor's description together with his pictures, show a plant that must be identical with Cl. oblitterata. The size of the cells in the branchlets as given in the text does not indeed coincide very well with what I have found in Cl. oblitterata from European waters, but the drawings (Taylor 1957 pl. 5 figs. 3—4 and pl. 6 fig. 2) show just the very thin end cells and the ramification that are characteristic of Cl. oblitterata. The habitat as described by Taylor — upper sublitoral, particularly in warm shallow bays — does not exclude forms of Cl. flexuosa, but is especially typical for Cl. oblitterata in temperate waters. However, Taylor and Farlow seem to have conceived the species in a too restricted sense because some specimens of Cl. oblitterata also appear under the names Cl. glaucescens and Cl. albida. Thus the two specimens of nr 205 in Alg. Exsicc. Am. Bor. which were called Cl. glaucescens by Farlow, and are cited to this species by Taylor (1957 p. 84), are good examples of Cl. oblitterata. A specimen in the herbarium of the marine botanical institute of Gothenburgh collected by Taylor in 1928 and by him called Cl. albida, is likewise a Cl. oblitterata.

In Sweden where Cl. oblitterata is especially common the names Cl. sericea and Cl. crystallina have been most often used to denote this species. As mentioned

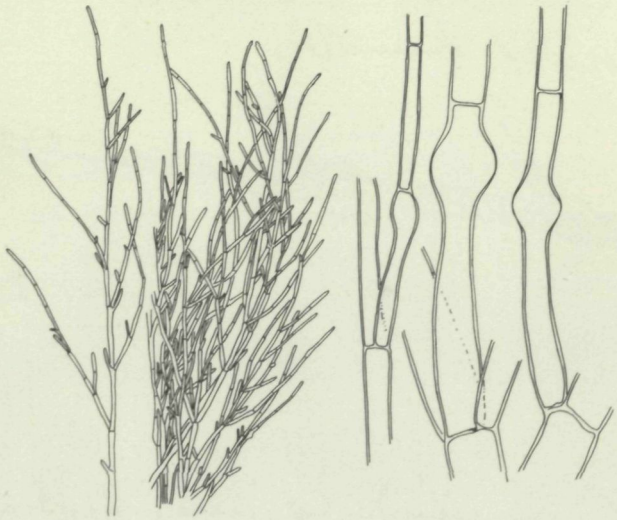


Fig. 42. Cl. oblitterata, specimen with Rudolphiana-swellings, Torekov 25.7.1955. ×20, the details ×135.

Fig. 43. A. and D. show end branches and basal part from two specimens of Cl. oblitterata, A. collected at Henån, D. at Torekov, B. and C. similar parts from one of Agardh's own specimens of C. Rudolphiana from Trieste. ×20.

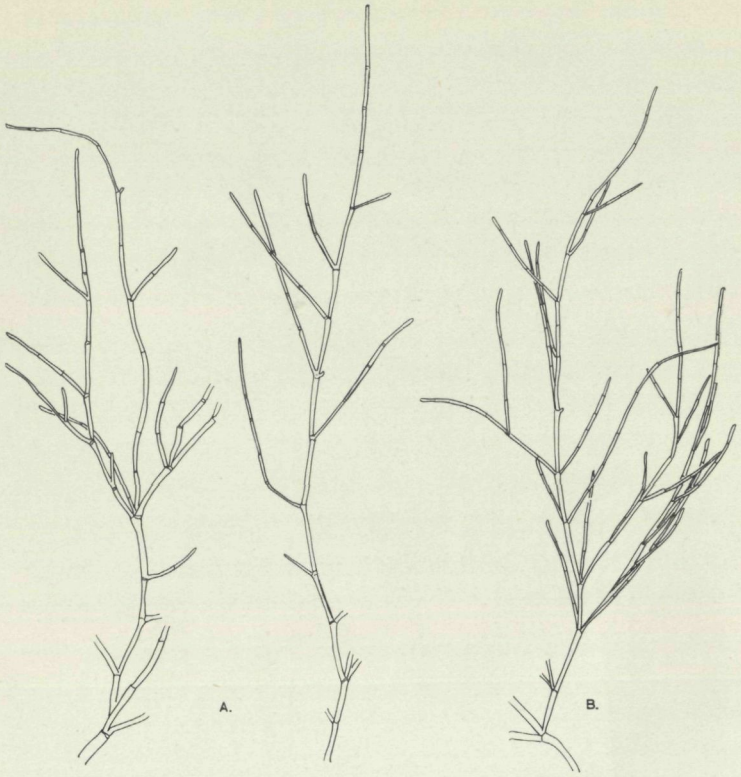


Fig. 44. Though Cl. oblitterata may vary in habit, the ultimate branches often show good similarity. A. is branches from a tide pool specimen from Roundstone, B. branch of a specimen from a small lagoon on a skerry outside Kungsbackafjorden. × 20.

before Bliding (1935 p. 57) used the name sericea on the plants he cultured and there are no doubts that Kylin (1949 p. 53) meant the same plant when he listed a Cl. sericea from the Swedish west coast. It is therefore natural to assume, as for instance Waern (1952 p. 77) has done, that Kylin's description should apply to Bliding's plants. This is however not the case. Kylin's description is only a true transcript of Hauck's (1885 p. 459) description of Cl. crystallina and therefore not applicable to the Swedish plants. Hauck's Cl. crystallina must be regarded as a mixture of several species and especially Cl. glomerata — judging by the text — and Cl. flexuosa — judging by a specimen in Kew Herb. — are involved.

Description

Cl. oblitterata usually forms light green richly branched tufts 5—10 cm high. In quiet warm water the tufts may reach a size of 20 or even 30 cm. The branches in well-developed specimens are arranged in whorls (fig. 48) and given off at fairly wide angles (45—60°). The outermost unbranched branchlets consist of only few

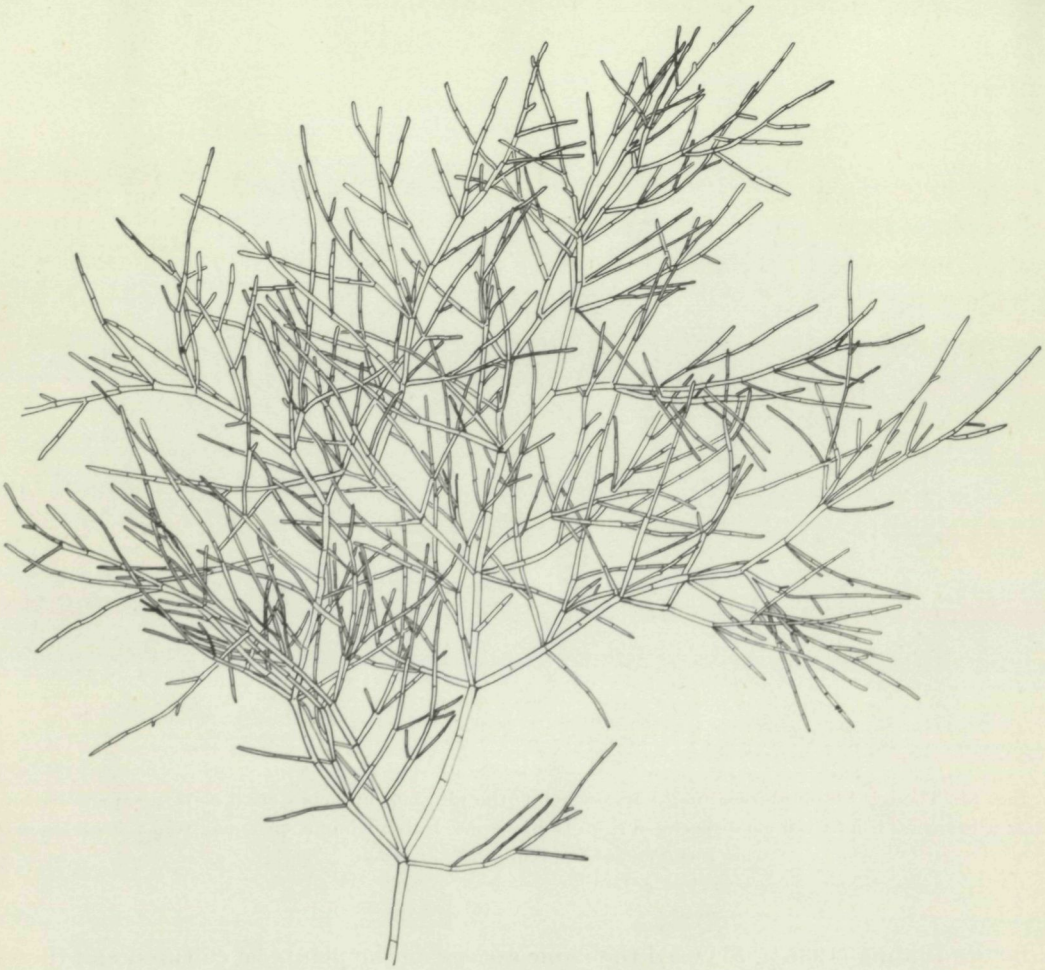


Fig. 45. Cl. oblitterata, epiphytic on Fucus serratus in a small bay on the sheltered side of a skerry outside Kristineberg, 3.7.1954. ×20.

cells, usually 3—6, and the cells have here a relative length varying between 5 and 15, but mostly in the neighbourhood of 8. The diameter of the cells in these branchlets does not increase much as the cells grow. The cells in the branches on the contrary thicken rapidly (fig. 40) and intercalary cell divisions occur, though they are by no means common and regular in this species. The cells in the branchlets measure 10—30×80—600 μ, in the main filaments the biggest cells I have found measured 80×1200 and 155×650 μ. Investigations of several hundred specimens from different parts of Europe have convinced me that end cells with a diameter below 20 μ are always present. As shown by the diagram (fig. 53) the cells vary comparatively little in size in the branchlets. The variation in relative length is

Fig. 46. Cl. oblitterata. A, Leg. C. Bliding, Kristineberg 5.7.1954, B, "Conferva sericea d. Phyc. Scand." Herb. Areschoug, Riksmuseum, Stockholm, C—G, specimens from Borgilafjorden, Henån, 28.6.1953 and 13.7.1953. C and G epiphytic, D—F from one and the same population growing on the rock at l.w.l. ×20.

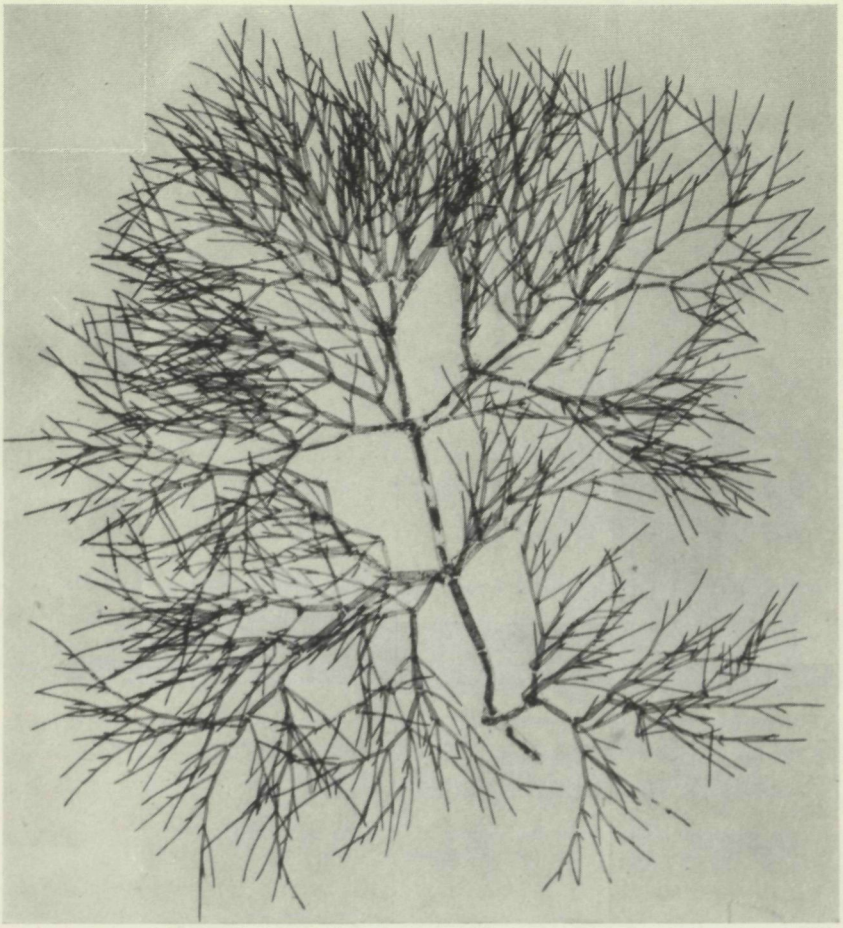


Fig. 47. Cl. oblitterata, coarse form from a pool in the Balanus belt, Koster 22.6.1960. × 15.

shown in table 2. The variations are chiefly depending on whether the cells are more, or less, than 8 diameters long. The percentage of cells with a relative length between 5 and 15 is therefore comparatively constant in different specimens. The type of ramification is more variable but this seems to be dependent on ecological conditions. In the outer part of the Bohuslän archipelago, on moderately exposed shores, a form with recurved and pectinated branches can be found (fig. 47) corresponding to Cl. crystallina sensu Hamel. This form is also a little coarser and less long-celled than the forms found in more sheltered positions (fig. 48, and 49). In quiet pools an extension of the main filaments (figs. 51 and 54) and a decrease in the number of branchlets have been observed.

The species with which Cl. oblitterata can be confused are Cl. glomerata, glaucescens, flexuosa and albida. From Cl. glomerata Cl. oblitterata differs especially in

Fig. 48. Cl. oblitterata, thin form epiphytic on Fucus vesiculosus, sheltered position at the mouth of Kungsbackafjorden, 2.8.1955. ×15.

Fig. 49.

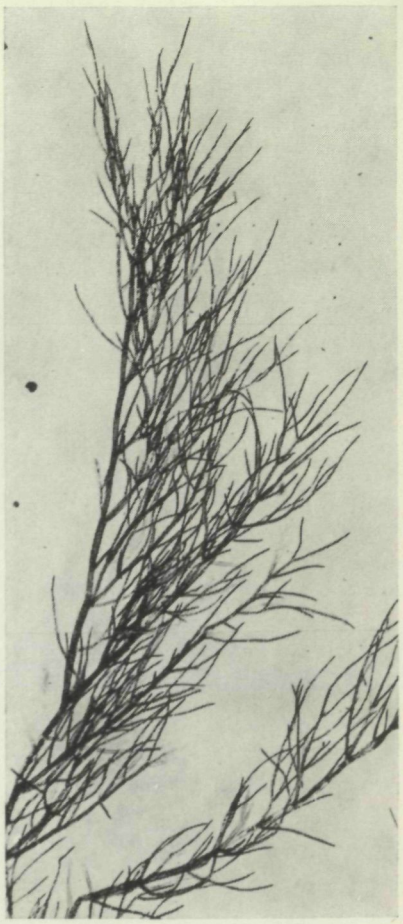


Fig. 50.

Fig. 49. Cl. oblitterata, epiphytic on Ascophyllum nodosum, Borgilafjorden, 28.6.1953. ×15.

Fig. 50. Cl. oblitterata, specimen from the same population as in fig. 45. ×15.

the diameter of the end cells. As mentioned above Cl. oblitterata has always been found to possess end cells with a diameter below 20 μ. Such small measurements have not been found in Cl. glomerata. Waern (1952 p. 78) used the 20 μ line as a sign that the Cl. crystallina reported by Levring from Blekinge not was present in the Öregrund archipelago. Even in the narrowest hunger forms Waern did not find cells with a breadth below 20 μ. In order to study this diameter limit I made in 1955 the experiment of following Cl. oblitterata from the parts of Bohuslän where, because of the high salinity, Cl. glomerata does not grow, southwards to Torekov and Hallands Väderö (see map) where Cl. glomerata, through the works

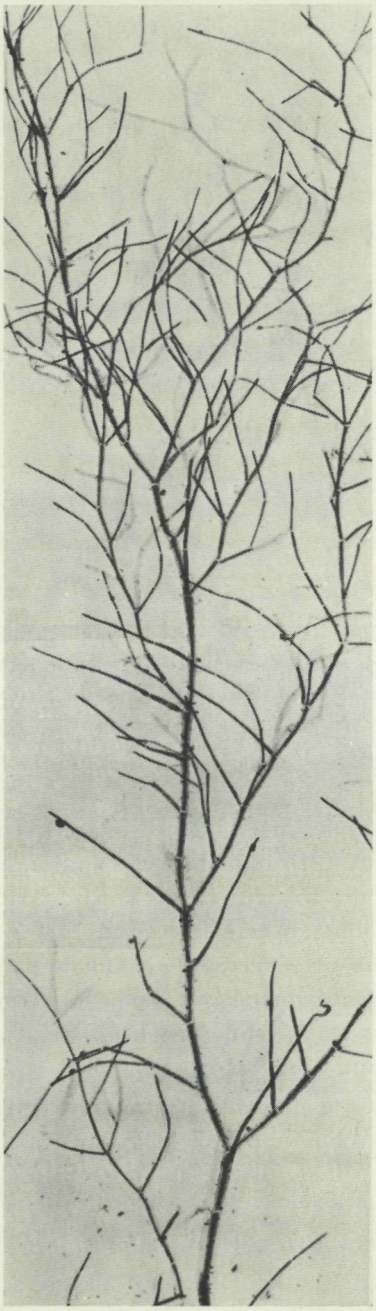


Fig. 51. Cl. oblitterata, in a pool a little above h.w.l., Plymouth, 19.7.1962. ×15.

Fig. 52. A. Cl. oblitterata from a big pool (see fig. 38), and a branchlet from the same specimen. B. Cl. glaucescens, among Fucus vesiculosus on a smooth rock, and two branchlets from the same specimen. Note the intercalary cell divisions in the latter. Kristineberg 2.7.1954. ×20, the details ×55.

of Hylmö and Sjöstedt, was known to be abundant. In this way it was possible for me to learn to recognize Cl. oblitterata without making measurements, using characters which are difficult to express in words. When Cl. glomerata began to appear together with Cl. oblitterata I immediately knew it from the latter. The material thus obtained was preserved in alcohol and later on measured, and it was proved that all the plants sorted out as Cl. oblitterata in the field possessed cells with a diameter below 20 μ, while in Cl. glomerata only some few cells with 21 μ diameter were found and none below 20.

The curved end branches mentioned in the description of Cl. glomerata may also sometimes be useful. While such branches are not constant in Cl. glomerata they have not been observed at all in Cl. oblitterata. Cl. oblitterata usually has very straight branchlets and when not straight they bend in the opposite direction, as compared with Cl. glomerata (fig. 47 cf. fig. 32).

From Cl. glaucescens and Cl. flexuosa, two species that sometimes are as thin as Cl. oblitterata, this species differs through having relatively longer cells, fewer cells in the unbranched branchlets and few intercalary divisions, especially in the branchlets (fig. 52 and the diagrams figs. 3 — 5).

Sometimes Cl. oblitterata has been confused even with Cl. albida. It, however, differs considerably from Cl. albida through its long cells. At least 50% of the cells in a specimen of Cl. albida should have a relative length below 5 (table 3) while even in the most short-celled of the specimens of Cl. oblitterata I have only found around 20% cells shorter than 5 diameters. Cells with a relative length exceeding 8 are very unusual in Cl. albida while at least 20% of the cells in a short-celled specimen of Cl. oblitterata have this length.

TABLE 2. *Relative length of cells from Cl. oblitterata.*

(For explanation see table 1 p. 46)

– 2	– 3	– 5	– 8	– 15	–		>8	<5	5–15
0	0	0	1	70	29	H14d/53	99	0	71
0	0	0	4	74	22	Eir70/57	96	0	78
0	0	0	9	76	15	N36/60	91	0	85
0	0	1	11	82	7	H8a/53	89	1	93
0	1	3	10	76	10	Ec1a/55	86	4	86
0	0	0	18	79	3	1/60	82	0	97
0	0	5	16	59	20	H1a/52	79	5	75
0	2	4	17	55	22	P20/62	77	6	72
0	0	0	23	70	7	EC10e/55	77	0	93
0	4	8	13	64	11	F20/54	75	12	80
0	0	2	31	59	8	2/60	67	2	90
0	0	7	26	59	8	16/60	67	7	85
0	0	3	42	43	12	H4/56	55	3	85
0	1	5	40	46	8	Din1/62	54	6	86
0	0	7	42	49	1	4/60	50	8	91
0	0	5	51	43	1	2/60b	44	5	94
0	0	13	45	42	0	F25/54	42	13	87
0	3	7	52	36	2	16/60b	38	10	88
0	0	10	55	32	3	Din23/62	35	10	87
0	0	6	63	27	4	Din20/62	31	6	90
0	2	19	49	29	1	12/60	30	21	78
0	0	14	60	26	0	F12/54	26	14	86
0	0	5	70	25	0	Din2/62	25	5	95
0	3	12	68	19	1	3/60	20	15	87
0	3	14	63	20	0	15/60	20	17	83

Description of the localities.

H14d/53, sheltered bay inside Orust, epiphytic on Fucus serratus, 21.7.1953. — Eir70/57, tide pool in the upper part of the Pelvetia belt, Roundstone, 12.8.1957. — N36/60, large spray pool (see fig. on front fly-leaf) on an exposed skerry, Justöen, 3.7.1960 (zoospores $9 \times 20\ \mu$). — H8a/53, epiphytic on Fucus serratus among stones in a sheltered bay, Henån, 28.6.1953. — EC1a/55, shallow lagoon on the sheltered side of a small exposed skerry outside Kungsbackafjorden, 22.7.1955. — 1/60, on stones in a shallow sandy bay, Strömstad, 17.6.1960. — H1a/52, smooth, slooping rock facing south east, epiphytic on Fucus vesiculosus, Henån, 24.6.1952. — P20/62, tide pool at h.w.l., Plymouth, 19.7.1962. — EC10e/55, epiphytic on Fucus vesiculosus in somewhat sheltered position, Kungsbackafjorden, 3.8.1955. — F20/54,

large spray pool on small exposed skerry (fig. 38) outside Kristineberg, 3.7.1954. — 2/60, detached specimen from a sheltered bay, Strömstad, 17.6.1960. — 16/60, epiphytic on Fucus vesiculosus in sheltered position, Koster, 22.6.1960. — H4/56, stony shore, epiphytic on Fucus vesiculosus in shelter of a thick growth of Chorda filum, Kristineberg, 5.7.1956. — Din1/62, artificial tidepool beneath the marine laboratory, Dinard, 19.6.1962. — 4/60, on level rock at a depth of 2 dm in somewhat sheltered position, Strömstad, 17.6.1960. — 2/60b, another detached specimen from the same bay as 2/60 above, 17.6.1960. — F25/54, small shallow lagoon on the sheltered side of an exposed skerry, Kristineberg, 3.7.1954. — 16/60b, another specimen from the locality mentioned above as 16/60, 22.6.1960. — Din23/62, tide pool, reached by the water only at spring tide, Dinard, 22.6.1962. — Din20/62, ordinary tide pool, Dinard, 22.6.1962. — 12/60, level rock at a depth of 2 dm, sheltered position, Strömstad, 21.6.1960. — F12/54, crevice washed by the waves, exposed position, Kristineberg, 28.6.1954. — Din2/62, Small tide pools in the Pelvetia belt, Dinard, 20.6.1962. — 3/60, epiphytic on Fucus vesiculosus, slightly exposed position, Strömstad, 17.6.1960. — 15/60, pool in the upper part of the Balanus belt, slightly exposed position, Koster 22.6.1960. Note: Indications of depth from the Swedish localities set out from an estimated mean water level. A plant at a depth of 2 dm will not be laid bare during the summer.

The reproduction of Cl. oblitterata has been studied by Bliding (1935 p. 57 and 1936 p. 535). As mentioned before (p. 53) Bliding used the name sericea. Bliding has kindly shown me specimens of his plant and also determined some of mine (figs. 45 and 46). According to Bliding Cl. oblitterata has a regular change between two generations, one consisting of plants delivering either +gametes or −gametes and one delivering zoospores. In this respect Cl. oblitterata differs from both Cl. glaucescens and Cl. glomerata, which in Sweden are known only with zoospores.

The number of chromosomes is reported to be n=12 (A. Wik in manus).

Cl. oblitterata is best developed when the temperature in the water reaches about 18° or more. At the Swedish west coast it is especially a plant of sheltered bays or sea lochs, as well as pools or basins above high water level in the outer part of the archipelago (figs. 6 and 38). In the sheltered firth of Borgila near Henån (see map) Cl. oblitterata has been observed in great masses growing on Fucus vesiculosus, Fucus serratus and Ascophyllum nodosum, but not every summer. Thus in 1952 comparatively few specimens were found, while in 1953 the species was abundant in the firth and in 1954 again less common. The average surface temperature as measured at the hydrographical station in the firth of Gullmar near by was during those years: June 1952 14.02° C, July 1952 17.78° C, June 1953 17.17°, July 1953 18.96° C, June 1954 16.23° C, July 1954 16.72° C (Fishery Board of Sweden, Series Hydrography, Report 3, 4 and 6). The surface temperature in the firth of Borgila is usually somewhat higher owing to less vertical movements in the water but else comparable. In accordance with these observations Cl. oblitterata has on the Norwegian, British, and French shores been found only in pools in the upper part of the Pelvetia-belt where the water is warmed by the sun.

Cl. oblitterata has been found along all the Swedish west coast, but in the southernmost parts where the salinity goes down to 8—10‰ it seems to be rare. A few specimens have been found in Blekinge by Levring but otherwise I have not been able to find it in collections from the Baltic.

Cl. oblitterata is in Sweden often observed as epiphyte on Fucus and Ascophyllum, but especially in the pools it often grows on stone or on crusts of, e.g., Lithothamnion (fig. on back of title-page) and on the whole the substratum seems to be of little importance.

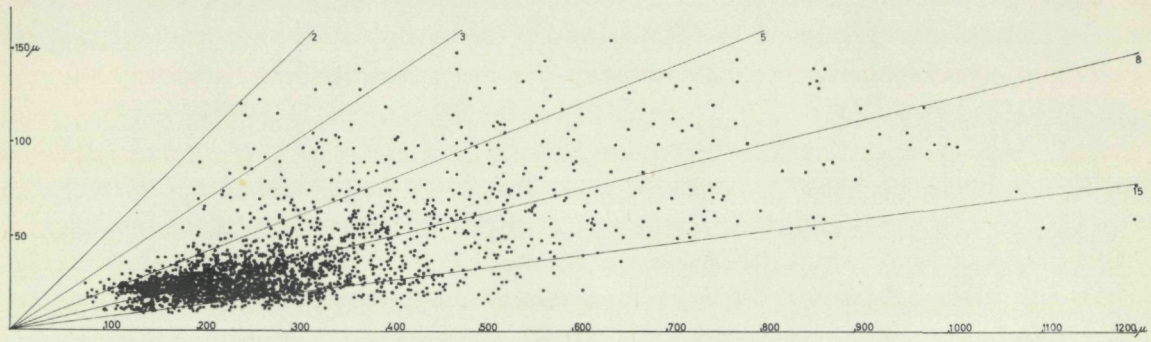


Fig. 53. Sizes of cells from 25 specimens of Cl. oblitterata.
(The same specimens as in table 2.)

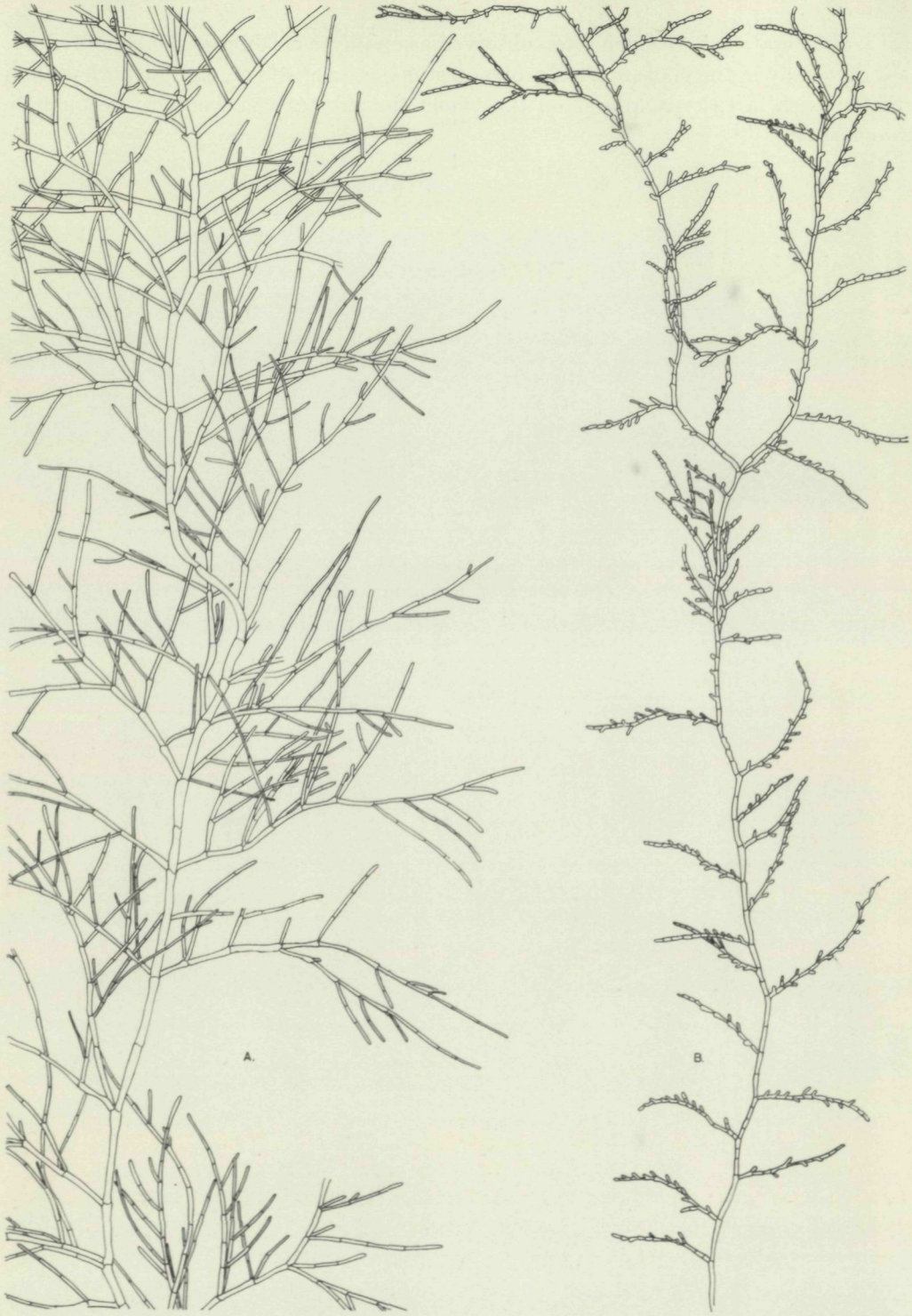


Fig. 54. Modification in the same direction made this two plants externally similar. A. Cl. oblitterata from a warm pool on a skerry outsideKristineberg, 3.7.1954. B. Cl. albida from a crevice on the skerry Bonden (see fig. 8), 28.6.1954. ×20.

Cladophora albida (Huds.) Kützing

Conferva albida Hudson 1778 p. 595.
Cladophora albida Kützing 1843 p. 267.

References and synonyms

Conferva albida in Dillwyn 1809 p. 32 and 66 (inclusive the variety protensa).

Conferva glomerata β roseola C. Agardh 1824 p. 108 (partim, some of Agardh's specimens belong to Cl. oblitterata.)

Conferva refracta in C. Agardh 1824 p. 114 (Probably non C. refracta Roth 1800 p. 193).

Conferva Neesiorum C. Agardh 1827 p. 636 (Non Cladophora Neesiorum in Kützing 1845 p. 208 and 1849 p. 396).

Cladophora albida in Kützing 1849 p. 400 and Tab. Phyc. IV tab. 15:II (Near related judging by the pictures and the size of the cells are in Kützing's works also Cl. reticulata, ramellosa, gracillima and perhaps also Cl. pumila though the picture of the last one could as well represent a thin form of Cl. glaucescens Harvey). — Harvey 1851 pl. 275. — Farlow 1881 p. 51. — Hauck 1885 p. 458. — Hamel 1930 p. 48. — Newton 1931 p. 86. — Söderström 1955 p. 275. — Taylor 1957 p. 83.

Cladophora albida var. *refracta* Thuret in Le Jolis 1863 p. 60. — Bliding 1936 p. 531.

Cladophora refracta in Kylin 1907 p. 28.

Cladophora Blidingiana Kylin 1949 p. 54 (sec Bliding; Kylin's description applies partly to Cl. laetevirens in Hauck 1885 p. 458).

Investigated herbarium specimens

"Conferva albida β protensa Dillw. Miss Hutchins 1809.", Ex. Herb. Dillwyn, Kew Herb. — "No 96. Conferva albida. Hook Br. Fl. p. 352. On rocks and larger algae, not common." — "Roundstone July 1848" and 9 other specimens collected between 1831 and 1848, ex. Herb Harvey, Trinity College, Dublin. — "C. refracta Griff. 1843", ex Herb. Le Jolis, Herb. Alg. Ag. nr 7918. — "Conferva Neesiorum Trieste juni 1827" (C. Agardh's handwriting, this should be the type, van den Hoek has in the herbarium marked nr 7920 as type, but that specimen is determined by J. G. Agardh), Herb. Alg. Ag. nr 7949. — "Conferva Rudolphiana" (C. Agardh's handwriting) Herb. Alg. Ag. nr 7898—7905 (cf. Harvey 1846 pl. 86 where he writes about Cl. Rudolphiana "— Agardh has distributed several different species under this name"). — "Cladophora refracta (Roth) Kütz. Morup 21/7 03" leg. & det. H. Kylin, Bot. Museum, Lund. — "Cladophora sericea (Huds.) Kütz. Varberg 25/7 03" leg. & det. H. Kylin, Bot. Museum, Lund. — "Cladophora glaucescens (Griff.) Harvey, Kristineberg 3/8 26" leg. & det. H. Kylin, Bot. Museum, Lund. Exsicc:. Wyatt, Alg. Danmon. nr 96, Riksmuseum, Stockholm.

Taxonomical remarks

Hudson's original description, made after Dillenius "White Sea Flock", is naturally of little value for the understanding of this species. Dillwyn, however, also made a description with a picture on the basis of the Dillenian specimen and since then it has been a comparatively uniform interpretation of C. albida. The references to Kützing. Harvey, Farlow, Hauck, Hamel, Newton and Taylor therefore hardly need any commentaries and its also of minor importance that one specimen, called C.

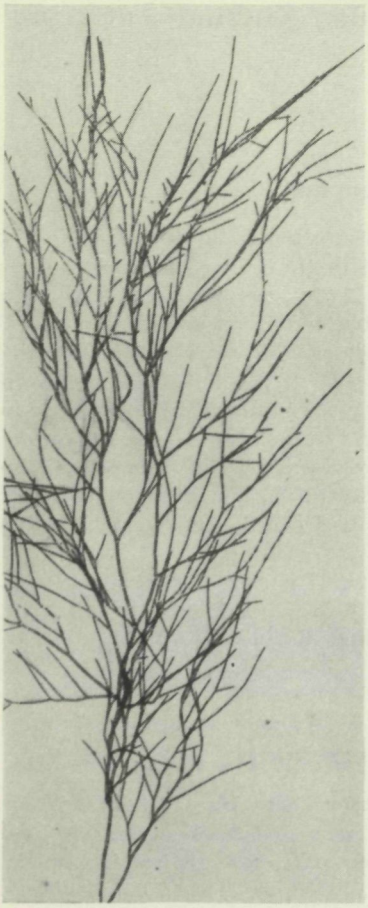


Fig. 55.

Fig. 56.

Fig. 55. Cl. albida, in the middle of the hydrolitoral in bore holes on quay-stairs, Ballydonegan 4.8.1957. See also fig. 58 E, and fig. 60 which show the same specimen. ×15.

Fig. 56. Cl. albida, on the rock among Fucus vesiculosus on an exposed skerry outside Kristineberg, see fig. 9 which shows the locality. 3.7.1954. (Compare this fig. with fig. 63, Cl. hamosa.) ×15.

albida by Hudson, was found by Dillwyn (1809 pl. 106) to be what he described as Conferva Hookeri — the basis for Callithamnion Hookeri (Dillw.) Agardh.

In Sweden Cl. albida was first collected by C. Agardh but by him called C. refracta Roth. As mentioned in a previous chapter (p. 22) C. refracta Roth is a dubious taxon. Roth's reference to C. hirta Vahl (Fl. Dan. tab. 947) however makes it possible that C. refracta Roth and C. refracta C. Agardh not are one and the same species. Areschoug (1850 p. 196 and Exsicc. Alg. Scand. nr 338) seems also to have hade a somewhat different idea of C. refracta Roth. In his work of 1850 none of the species listed can be referred to Cl. albida, nor is there any certainty that it was included

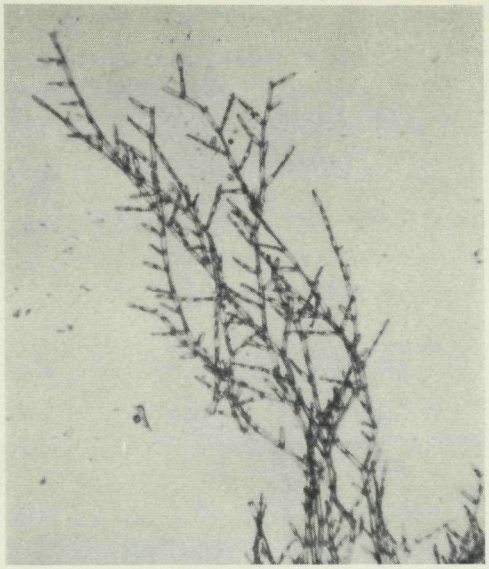


Fig. 57. Conferva Neesiorum C. Agardh. Type specimen in Herb. Alg. Ag. ×30.

in any of them. In lectures during 1865—66 he however reckoned with a Cl. albida which he said was less coarse than refracta (Notes by Theorin at Växtbiologiska institutionen, Uppsala University). This seems not to have been common knowledge among Swedish algologists and Kylin used the name C. refracta in the same meaning as C. Agardh. Kylin also reckoned with a Cl. laetevirens, conceived after Kützing and Hauck, of which no specimens are left in his herbarium, but which probably also was Cl. albida since it is included in his Cl. Blidingiana. Cl. Blidingiana is Kylin's new name on the plant that Bliding correctly called Cl. albida (Huds.) Kütz. var. refracta Thuret (cf. Söderström 1955 p. 276).

There exists a refracted form of Cl. albida and it must have been this form that was described as the variety refracta by Thuret. In herb. Le Jolis it was originally called C. refracta, with a reference to Griffiths which in turn leads us to Cl. refracta in Harvey (1846 pl. 24). Harvey's refracta is also sometimes regarded as a variety of albida, for instance by Hamel (1930 p. 49) but I have not listed it among the references above as Harvey has stated that his refracta precisely agreed with Areschoug's — and Areschoug's refracta was coarser than albida and is by Hamel included in Cl. hamosa Kützing.

Description

Cl. albida is often described as forming "dense tufts of a pale colour and almost spongy consistency" (Farlow 1881 p. 52). This has certainly caused many wrong determinations, more slender and pure green specimens being referred to other

Fig. 58. Different types of ramification in Cl. albida. A. Crevice at Torekov, 25.7.1955. B. Moderately exposed shore, Kristineberg, 2.7.1954. C. Tide pool in the middle of the hydrolitoral, Dinard 19.7.1962 D. Spray pool on exposed skerry outside Risör, 30.6.1960. E. Bore hole in quay stairs, Ballydonegan, 4.8.1957. ×20.

TABLE 3. *Relative length of cells from Cl. albida.*

(For explanation see table 1 p. 46)

— 2	— 3	— 5	— 8	— 15	—		>8	<5	3—8
1	34	58	7	0	0	Eir74/57	0	93	65
0	15	71	14	0	0	EC2a/55	0	86	85
0	11	58	28	3	0	N19/60	3	69	86
0	13	50	33	4	0	B4/55	4	63	83
0	7	55	32	6	0	Din21/62	6	62	87
0	2	60	36	2	0	18/60	2	62	96
0	15	44	39	2	0	Din8/62	2	59	83
0	5	48	45	2	0	Eir46/57	2	53	93
2	8	42	45	3	0	N9/60	3	52	87
0	1	49	48	2	0	Din11/62	2	50	97

Description of the localities.

Eir74/57, tidepool in the lower hydrolitoral on exposed shore, Dogs Bay, Roundstone 12.8.1957. — EC2a/55, crevice washed by waves, mixed with Cl. glomerata, (fig. 10) Torekov 25.7.1955. — N19/60, pool, reached by moderate waves, exposed shore, Risör 30.6.1960. — B4/55, steep rocky shore in sheltered position at the highly exposed skerry "Bonden" outside Kristineberg, 22.8.1955. — Din21/62, moderately exposed rock in the lowest hydrolitoral, Dinard 22.6.1962. — 18/60, moderately exposed crevice washed by waves (cf. fig. 9 which shows a similar locality) Koster 22.6.1960. — Din8/62, the same as Din21/62, 19.6.1962. — Eir46/57, bore-hole in quay stairs in the middle hydrolitoral Ballydonegan 4.8.1957. — N9/60, sheltered lagoon about 10 meters from N19/60, Risör 30/6.1960. — Din11/62, sheltered tidepool in the upper hydrolitoral, Dinard 19.6.1962.

species, as for example Cl. glaucescens. The number of branches and the colour seem, however, to be entirely dependent on ecological conditions. If exposed to the waves Cl. albida tends to be more dense and develops recurved branches; in a quiet pool, on the contrary, it is slender and often superficially reminding of Cl. oblitterata (fig. 60). In the microscope Cl. albida is, however, always easy to recognize because of its small cells, which furthermore seem to vary very little. The diagram here shown (fig. 59) is the result of measurements from ten specimens selected to represent different ecological types. The same measurements are used in the table of relative length. In the branchlets the cells were found to have sizes ranging from around $12 \times 40\ \mu$ to $30 \times 150\ \mu$. Intercalary cell divisions occur when the cells have reached a length of $100—140\ \mu$ and the individual diagrams show a tendency to rectangular form. In the main filaments the cells are more irregular and especially near the base cells with a length of $400—500\ \mu$ have been observed. Those long cells often seem to be the result of such disintegrations of the cell walls as Kolderup Rosenvinge (1892 p. 49) has described. Even in the main filaments cells with a diameter exceding $50\ \mu$ are very rare and I have used this fact to distinguish Cl. albida from the plants usually called Cl. refracta (in sensu Areschoug) or Cl. hamosa

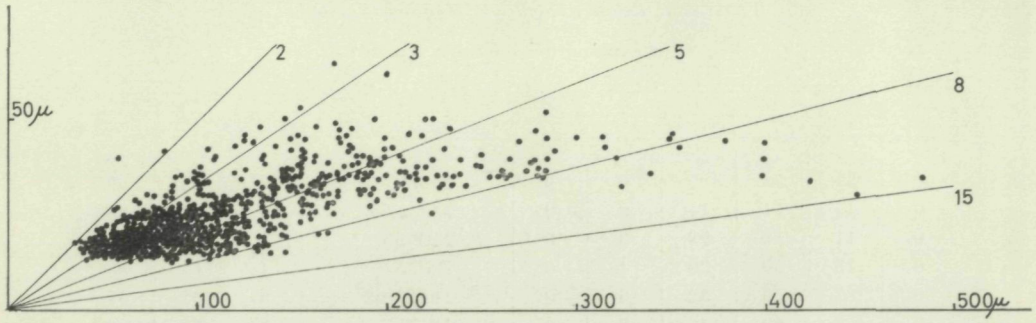


Fig. 59. Sizes of cells from 10 specimens of Cl. albida. (The same specimens as in table 3.)

Kützing. As the latter species is conceived by a lot of algologists (Harvey, Areschoug, Farlow, Hauck, Hamel) as being coarser than Cl. albida this seems reasonable. But I would herewith like to state that I am not quite convinced that Cl. hamosa is a distinct species.

The reproduction of Cl. albida has been studied by Bliding (1936 p. 531). He found a regular change between two generations. The zoospores were found to be considerably smaller than in Cl. sertularina. ($6.4 \times 13.8\ \mu$ resp. $7.7-9.0 \times 16.0-22.5\ \mu$) A. Wik (in manus) reports n=12 as the chromosome number.

Cl. albida seems to be one of the most common and wide-spread of the European species of Cladophora. I have found it on nearly all the localities I have visited, from the brackish waters in the south part of the Swedish west coast to the oceanic coast of Ireland. The only exception is the shores of enclosed firths in the province of Bohuslän, especially those situated inside the island of Orust (see map and figs. 6 and 7). Though these parts have been investigated with great care nearly every summer since my work with Cladophora began only three finds of Cl. albida have been made. They were all made on shores where either because of tidal streams or because of waves, the movements of the water were stronger than is usual in these sheltered waters. My impression of Cl. albida is therefore that it is a species that grows well, both in water of a salinity as low as around $15^0/_{00}$ and in normal oceanic water, but needs moving water to be well-developed, or at least new water at regular intervals. It has never been found in the spray pools mentioned as typical habitats for Cl. oblitterata. It should not because of this be considered a cold water species, Cl. Neesiorum C. Agardh, which is a synonym, was from the Adriatic sea and I have examined a specimen from Guadeloupe and found it to be identical with the European Cl. albida.

Fig. 60. Whole plant of Cl. albida, from bore hole in quay stairs, Ballydonegan, 4.8.1957. This is probably what Dillwyn meant with var. protensa. ×5.

Fig. 61. Cl. hamosa, highly exposed shore (see fig. 8), sublitoral among Laminaria at a depth of one m. 22.8.1955. ×8.

Cladophora hamosa Kützing

Cladophora hamosa Kützing 1843 p. 267. (The genus name Conferva is used, but that is obviously a misprint).

References and synonyms

Cladophora refracta Harvey 1846 pl. 24. — Farlow 1881 p. 52. — Sjöstedt 1927 p. 12. — Taylor 1957 p. 87. (Non Conferva refracta Roth 1800 p. 193).

Cladophora hamosa in Kützing 1849 p. 397 and Tab. Phyc. IV tab. 8:II. — Hauck 1885 p. 456. — Hamel 1930 p. 47. — Kolderup Rosenvinge 1892 p. 35 and fig. 6.

Conferva sericea c. *Conferva refracta Roth* in Areschoug 1850 p. 196.

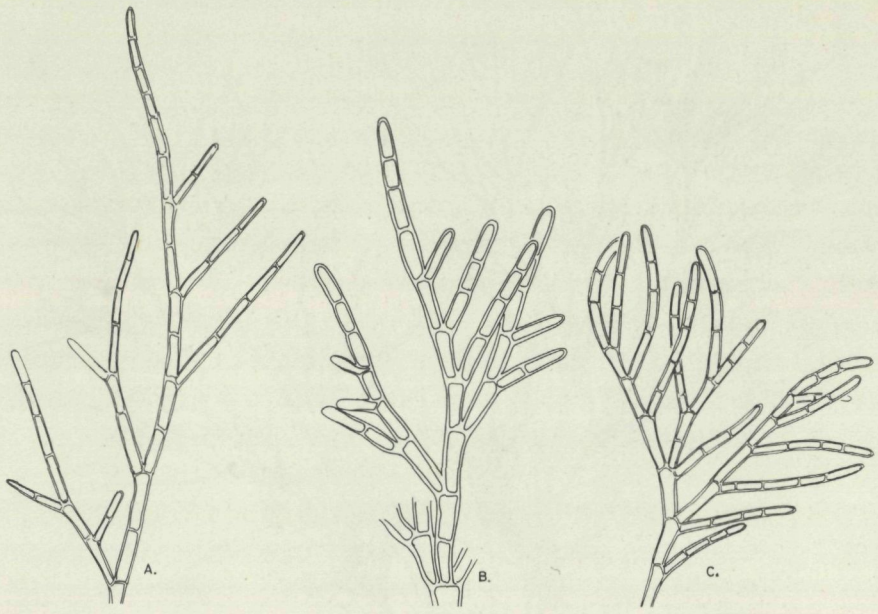


Fig. 62. End branches of A. Cl. albida, B. and C. Cl. hamosa. × 55.
A and B. Exposed shore, "Bonden" outside Kristineberg, 20.8.1955, C. Woods Hole, leg. T. Levring.

Investigated herbarium specimens

Areschoug Alg. Scand. Exsicc. nr 338, Cladophora refracta. Specimen in Riksmuseum, Stockholm and Brit. Museum (the latter less typical). — Alg. Exsicc. Am. Bor. nr 207 "Cladophora refracta Areschoug. Cl. refracta in Aresch. Alg. Scand. Exs. 338. Cl. refr. Farlow Mar. Alg. N. Engl. 52. Non Cl. refracta Auct. Brit. nec Auct. Gall. An Conferva refracta Roth? Cl. hamosa Kg var. refracta Hauck Meeresalgen 457. Nobis forma refracta Cl. flexuosa sensu Auct. Am. videtur. Wood's Holl, Mass., Aug. 1881 Leg. W. G. Farlow". Specimen in Herb. Alg. Ag. (nr 7543) and Brit. Museum. — Cl. refracta Woods Hole 6.8.1959 Leg. T. Levring Det. W. R. Taylor.

Taxonomical remarks

As previously mentioned it is with doubts that Cl. hamosa is retained here. Usually algologists have had nr 338 in Areschoug, Alg. Scand. Exsicc. ser 2 as a basis for this species, either the name C. refracta Roth or Cl. hamosa Kützing has been used. When Roth (1800 p. 193) described Conferva refracta he put as a synonym to this species C. hirta, pictured in Fl. Dan. Tab. 947. No doubt C. hirta originally was a name on a form of C. fracta (cf. Lyngbye 1819 p. 153, where he points out

Fig. 63. Cl. hamosa, the same population as in fig. 61. ×15.

that some leaves of Lemna trisulca can be seen in the picture of C. hirta) but that is of minor importance since it is what Roth thought C. hirta to be which is of interest for the interpretation of C. refracta Roth. I find it very difficult to imagine that if Roth had in his mind a plant identical with what is known as Areschoug's C. refracta he then should have referred to the picture in Fl. Dan. According to Hauck and Hamel nr 338 in Alg. Scand. Exsicc. belongs to Cl. hamosa Kützing, in which species Hamel included several other of Kützing's species, viz. Cl. refracta, Bertolonii, corymbifera, curvula and Cl. lepidula Montagne in sensu Kützing. At least Cl. curvula and, though in a lesser degree, Cl. lepidula were described by Kützing with cells of sizes that do not coincide with what Hamel has

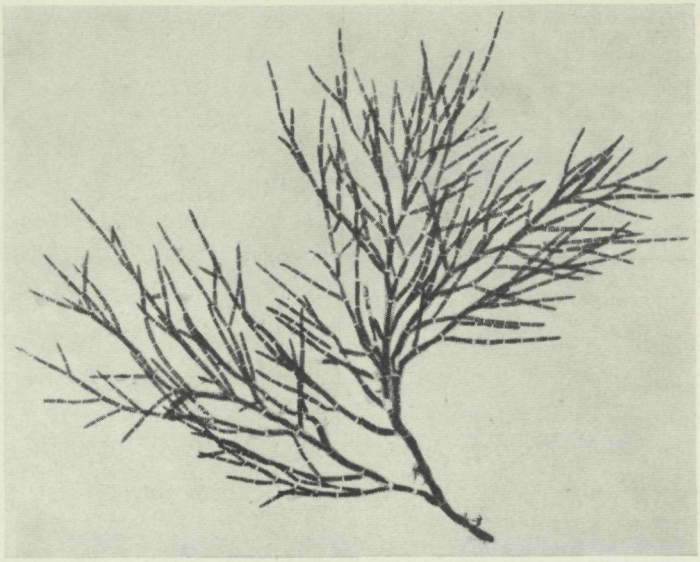


Fig. 64. Cl. hamosa? Together with Cl. albida on under water stone outside Espegrend, 13.7.1960. This specimen has some characters in common with Cl. glaucescens, particularly the size of the cells, see fig. 68 and compare fig. 79, but except that it is not refracted the ramification is similar to the typical Cl. hamosa. ×15.

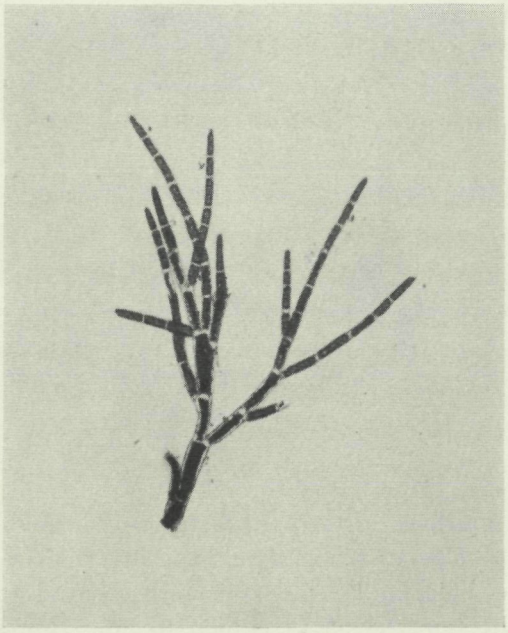


Fig. 65. End branch from the same specimen as in fig. 64, compare with fig. 62. ×30.

Fig. 66. The relation between Cl. hamosa and Cl. glaucescens. A. Areschoug, Exsicc. Alg. Scand. nr 338, "C. refracta". B. Cl. hamosa, another branch of the specimen in fig. 63. C. Intermediary plant from an exposed shore at Roscoff, France, leg. M. Waern. D. Another branch of the specimen in fig. 64. E. Cl. refracta, det. W. R. Taylor, leg. T. Levring, Woods Hole, Mass. . F. Cl. glaucescens, Varberg, 29.5.1958, leg. Å. Lindkvist. × 20.

stated about Cl. hamosa. More probably these two plants belong to Cl. albida. I should like to mention here instead Cl. laetevirens sensu Kützing (1849 p. 400 and Tab. Phyc. IV tab. 15:1) as this plant has both the size of the cells and the ramification which are typical of the plants usually called Cl. refracta or Cl. hamosa.

As mentioned in the remarks on Cl. albida (p. 67), Harvey considered his Cl. refracta to be the same as Areschoug's. This relation was denied by Farlow (1881

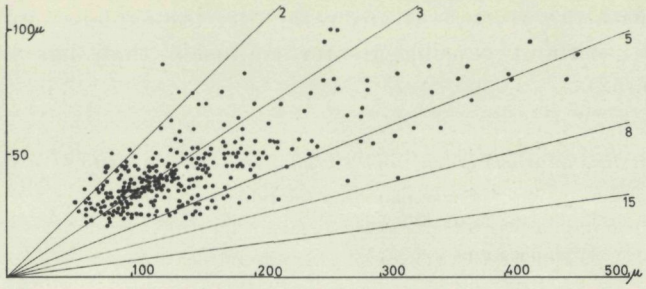


Fig. 67. Sizes of cells from the specimens B, C and D in fig. 66.

p. 52) and Hamel (1930 p. 49); these two authors have both referred Cl. refracta sensu Harvey to Cl. albida and consider it to be the same as Cl. albida var. refracta Thuret. I have examined one of Farlow's specimens called Cl. refracta and found it to be somewhat thinner than Areschoug's and very difficult to distinguish from old specimens of Cl. albida. The specimen in Lund needs, however, not necessarily be typical for what Farlow meant with Cl. refracta. I will here remind of a specimen listed in the account of Cl. oblitterata, viz. a specimen collected by Farlow at Woods Hole and by him called Cl. glaucescens (Griff.) Harvey. If Farlow mistook forms of Cl. oblitterata to be Cl. glaucescens it is extremely probable that forms of the real Cl. glaucescens by him were referred to Cl. refracta. Cl. hamosa in Kolderup Rosenvinge 1892 is probably also some form of Cl. glaucescens.

Fig. 66 shows some plants which can be said to constitute intermediary forms between the typical Cl. hamosa sensu Hamel and Cl. glaucescens. On one hand reported finds of Cl. hamosa or Cl. refracta thus can be suspected of being old specimens of Cl. albida in the refracted form, while on the other they may be forms of Cl. glaucescens. If, however, I hesitate to reject Cl. hamosa, it is because of the picture and description given by Hamel and because of the beautiful specimen shown in fig. 61. This specimen was found only a meter from quite typical specimens of Cl. albida and furthermore the find was made on August 20, which, in Sweden, is considered very late for Cl. glaucescens. My conclusion must be the same as Far-

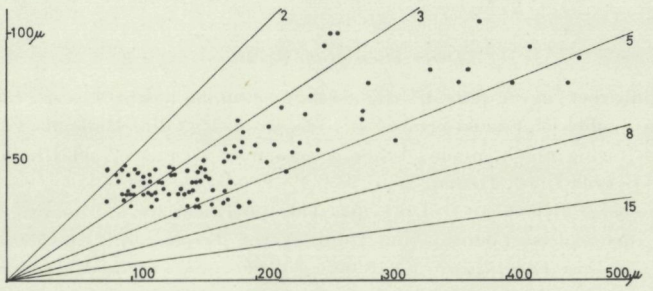


Fig. 68. Sizes of cells from the specimen D in fig. 66. Compare fig. 79.

low expressed with the words: "At any rate, after the explanation given, the name can be retained without causing greater confusion than has hitherto existed" (Farlow 1881 p. 52).

TABLE 4. *Relative length of cells from Cl. glaucescens Harvey and Cl. hamosa Kützing.*
(For explanation see table 1 p. 46)

Cl. glaucescens								
– 2	– 3	– 5	– 8	– 15	–	Specimen nr:	>8	<5
1	1	29	45	24	0	8/60	24	31
0	4	38	52	6	0	EC3a/55	6	42
0	6	42	42	10	0	H3c/53	10	48
0	9	42	42	7	0	F10/54	7	51
0	2	46	50	2	0	Din17/62	2	48
0	12	40	42	6	0	13/60	6	52
0	3	47	50	0	0	N18/60	0	50
1	14	52	32	1	0	N10/60	1	67
0	7	75	17	1	0	Din22/62	1	82
1	31	49	19	0	0	N19/60	0	81
0	19	66	15	0	0	Din21/62	0	85
5	26	60	9	0	0	P17/62	0	91
8	26	60	6	0	0	N1/60	0	94
8	34	45	13	0	0	18/60	0	87
5	35	53	7	0	0	N21/60	0	93
6	41	50	3	0	0	N48/60	0	97
8	45	41	6	0	0	N42/60	0	94
19	38	37	6	0	0	N39/60	0	94
43	33	18	4	2	0	P7/62	2	94
68	19	13	0	0	0	P27/62	0	100
Cl. hamosa								
– 2	– 3	– 5	– 8	– 15	–	Specimen nr:	>8	<5
1	26	59	14	0	0	N79/60	0	86
5	36	49	10	0	0	B20/55	0	90
1	38	56	6	0	0	B20/55	0	94

Description of the localities.

8/60, smooth sloping rock, never quite dry (fig. 00 shows a similar locality) Rossö, Strömstad, 17.6.1960. — EC3a/55, in the shadow of Fucus serratus at a depth of 2—3 dm, Hallands Väderö, 26.7.1955. — H3c/53, Steep rock facing north, among other species may be mentioned Rhodocorton Rothii and Bryopsis plumosa, Borgila fjord, Henån, 26.5.1953. — F10/54, smooth sloping rock, never quite dry, L:a Harpö, Kristineberg, 21.6.1954. — Din17/62, Tide pool near l.w.l., Dinard, 20.6.1962. — 13/60, level rock in small sheltered bay, depth about 2 dm, Tjärnö, Strömstad, 21.6.1960 (this plant was just releasing spores of the size $13 \times 17\ \mu$). — N18/60, pool at h.w.l., exposed position, Risör, 30.6.1960. — N10/60, small lagoon, together with Cl. albida, Risör, 30.6.1960. — Din22/62, wave-exposed rocky shore, tidepool about one m above l.w.l., Dinard, 22.6.1962. — N19/60, spray pool on wave-exposed

shore, Risör, 30.6.1960. — Din21/62, on the sheltered side of a reef, near l.w.l., Dinard, 22.6.1962 (spores of the size 10×15 μ). — P17/62, somewhat sheltered midlitoral tide pool, Salcombe, 18.7.1962. — N1/60 In the Balanus belt on sheltered smooth rock, Risör, 29.6.1960. — 18/60, crevice washed by waves, exposed position, Koster, 22.6.1960. — N21/60, steep rock facing north, a few dm below l.w.l., Justöen, 2.7.1960 (spores of the size 10×18 μ). — N48/60, in the Fucus vesiculosus belt in a sheltered bay, Egersund, 6.7.1960. — N42/60, pool, washed by waves, on small exposed skerry, Egersund, 6.7.1960. — N39/60, the same locality as N42/60, specimen beginning to develop spores, Egersund, 6.7.1960. — P7/62, midlitoral tide pool, beneath the marine laboratory, together with, among other species Bryopsis plumosa, Plymouth, 16.7.1962. — P27/62, tidal stream in the Fucus serratus belt, W. Looe, 18.7.1962 (spores of the size 10×15 μ).

N79/60, sunk rock in the middle of a firth, 2 dm below l.w.l., together with Cl. albida, Espegrend, 13.7.1960. — B20/55, on steep rock in a big crevice on the west side of exposed skerry "Bonden", depth about 1,5 m (fig. 8), Kristineberg, 20.8.1962.

Description

I base the description chiefly on some few specimen from the wave-exposed western side of the skerry Bonden outside Kristineberg. The locality is shown in fig. 8. The specimens were collected among Laminaria at a depth of a little more than a meter.

The size of the cells in the outer branches and in the branchlets of the investigated specimens were $20-50 \times 60-165$ μ. Towards the base of the plants the cells were $40-80 \times 85-375$ μ. These values do not distinguish the plant from Cl. glaucescens, nor is there any difference in relative length (table 4). Cl. albida on the other hand has smaller cells, especially in the main branches.

Intercalary cell-divisions occur to the same extent as in Cl. glaucescens and Cl. albida. Cl. hamosa is therefore most easily recognized by the type of ramification. Side branches develop some few cells beneath the top of an end branch and grow rapidly so that the four or five outermost side branches reach about the same height (fig. 62 B). The tufts are more rigid and compact than the tufts of Cl. albida.

Like Hamel (1930 p. 47) the author assumes Cl. hamosa to be a plant belonging to wave-exposed rocky shores.

Cladophora glaucescens (Griff. ex Harvey) Harvey

Conferva glaucescens Griffiths ex Harvey 1841 p. 139.
Cladophora glaucescens Harvey 1849 pl. 196.

References and synonyms

Cladophora glaucescens in Kützing 1849 p. 403 and Tab. Phyc. IV tab. 24:I. — Harvey 1858 p. 77. — Farlow 1881 p. 52 (partim, includes forms of Cl. oblitterata). — Hauck 1885 p. 460. — Kylin 1907 p. 32. — Hylmö 1916 p. 36 (partim, includes forms of Cl. oblitterata). — Hamel 1930 p. 46. — Newton 1931 p. 85. — Bliding 1936 p. 529. — Levring 1937 p. 33. — Kylin 1949 p. 52. — Taylor 1957 p. 84.

Cladophora Balliana Harvey 1851 pl. 356.

Investigated herbarium specimens

"Conferva cristata marina in saxis ad littora Norwegiae — 1800" (This plant was later on called C. glomerata γ simplicior by C. Agardh in which, however, some specimens belonging to Cl. glomerata (L.) Kütz. were also included.) Herb. Alg. Ag. nr 8071. — "Conferva glaucescens", specimens sent to Harvey from Mrs Griffiths. Herb Harvey, Trinity College, Dublin. — "Cladophora Balliana, Harvey Phyc. Brit! t. 356! Clontarf May 16/43." Herb. Harvey, Trinity College, Dublin. — "Cladophora glaucescens, Halifax, W. H. H." Herb. Alg. Ag. nr 7457. — "Cl. glaucescens (Griff.) Harvey, Båstad 7/6 03" Leg. & det. H. Kylin. Bot. Mus. Lund. — "Cl. glaucescens (Griff.) Harvey, Kristineberg 22/6 1935 leg. T. Levring det. C. Bliding". Marine Bot. Inst. Göteborg. Exsicc.: Wyatt, Alg. Danmon. nr 195. Brit. Museum.

Taxonomical remarks

As Cl. glaucescens is usually an easily recognized species it has not caused any difficult taxonomical problems. In his description (1849 pl. 196) Harvey points out an affinity to Cl. albida and Cl. refracta, and in the description of Cl. Balliana (1851 pl. 356), Cl. Rudolphiana is mentioned in a similar way. Cl. Rudolphiana in sensu Harvey has been found (p. 50) to represent thin forms of Cl. flexuosa, but Cl. oblitterata has also been confused with Cl. glaucescens, e.g. by Farlow and Hylmö. Those mistakes, however, do not appear in the various descriptions; there is a good uniformity in the conception of Cl. glaucescens in the literature on Cladophora. What difficulties there are have arisen in connection with more or less atypical specimens, and Cl. Balliana Harvey should certainly be regarded as an example of this. The type specimen of Cl. Balliana was collected in May; it looks just like Cl. glaucescens, as this plant appears on the Swedish shores in the beginning of the summer. The cells in young specimens have a greater relative length and the plant is in this state not easy to distinguish from slender specimens of Cl. flexuosa or oblitterata.

The find from Norway in C. Agardhs herbarium is listed here to show that before the taxon Cl. glaucescens appeared, the plant was collected and included in other species. In the case of Cladophora it was often not a question of discovering new species but of discerning them among a mass of already known plants. Several of the older taxa must have included more than one species, as for instance C. sericea Hudson and C. Rudolphiana C. Agardh did, and a rigid insistence on the nomenclatural rules lead to consequences that nobody desires, and which would in fact be contrary to the principles of the code.

Description

Harvey (1841 p. 139) described C. glaucescens with the following words: "tufts dense, glaucous green, sub-fastigiate; filaments very slender, excessively branched; branches, straight and erect, the lesser one furnished with close, very erect, straight, elongated ramuli; joints very short." This is a very good description of a well deve-

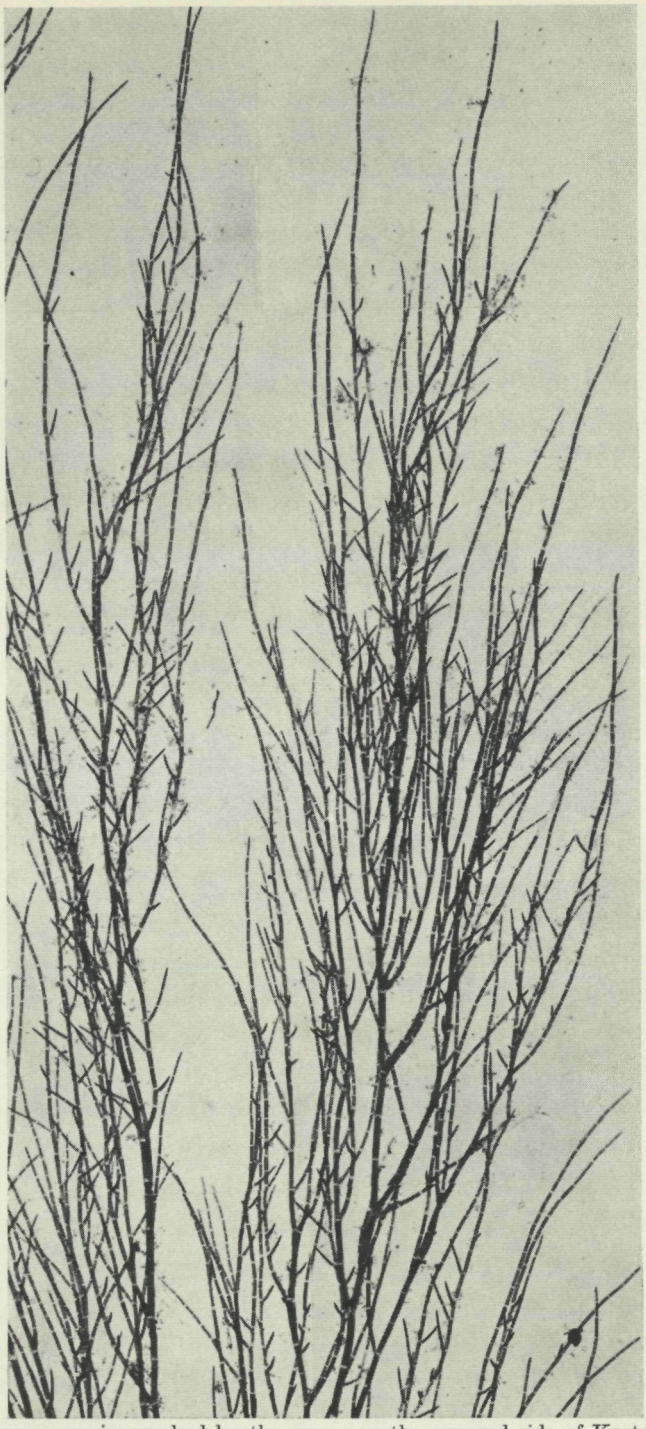


Fig. 69. Cl. glaucescens, crevice washed by the waves on the exposed side of Koster, 22.6.1960. ×15.
(The size of the cells can be seen in fig. 5.)

Fig. 70. Cl. glaucescens, on the rock among Fucus vesiculosus, sheltered locality, Risör, 29.6.1960. ×15.

loped specimen of Cl. glaucescens immediately before the beginning of sporeformation. Fig. 73 B shows some branches of such a specimen that agrees well with Harvey's description and picture. However, all the four plants on fig. 73 belong to Cl. glaucescens and only represent variations with age and ecology. Fig. 73 A is made from a plant that I take to be an example of Cl. glaucescens, as it looks when it is fully developed (some branches had already released spores) and has had good access to light and nourishment. It grew in a tide pool beneath the marine laboratory in Plymouth and was collected on 16.7.1962. The plant from which

Fig. 71. Cl. glaucescens, tide pool in the middle of the hydrolitoral, Plymouth, 16.7.1962. ×15. (The size of the cells in fig. 80.)

fig. 73 C is made was collected in a somewhat sheltered tide pool near Dinard 22.6.1962 and was certainly in a young state. Fig. 73 D shows a similar plant, though it was collected late in July. It was collected on 26.7.1955 in a sheltered bay on the island of Hallands Väderö, and grew in the shadow of big specimens of Fucus vesiculosus. I can only surmise that the lack of light detains the development of Cl. glaucescens. Still another form of Cl. glaucescens is shown by fig. 74 B.

Fig. 72. Cl. glaucescens, on the top of a stone in a pool in the Porphyra belt, exposed skerry, Egersund, 5.7.1960. ×15.

Fig. 73. Different forms of Cl. glaucescens, A. Hydrolitoral tide pool, Plymouth 16.7.1962. B. Splash pool, exposed skerry, Kristineberg, 21.6.1954. C. Hydrolitoral tide pool, Dinard, 22.6.1962. D. At a depth of 2 dm in the shadow of Fucus serratus, sheltered locality, Hallands Väderö, 26.7.1955. $\times 20$.

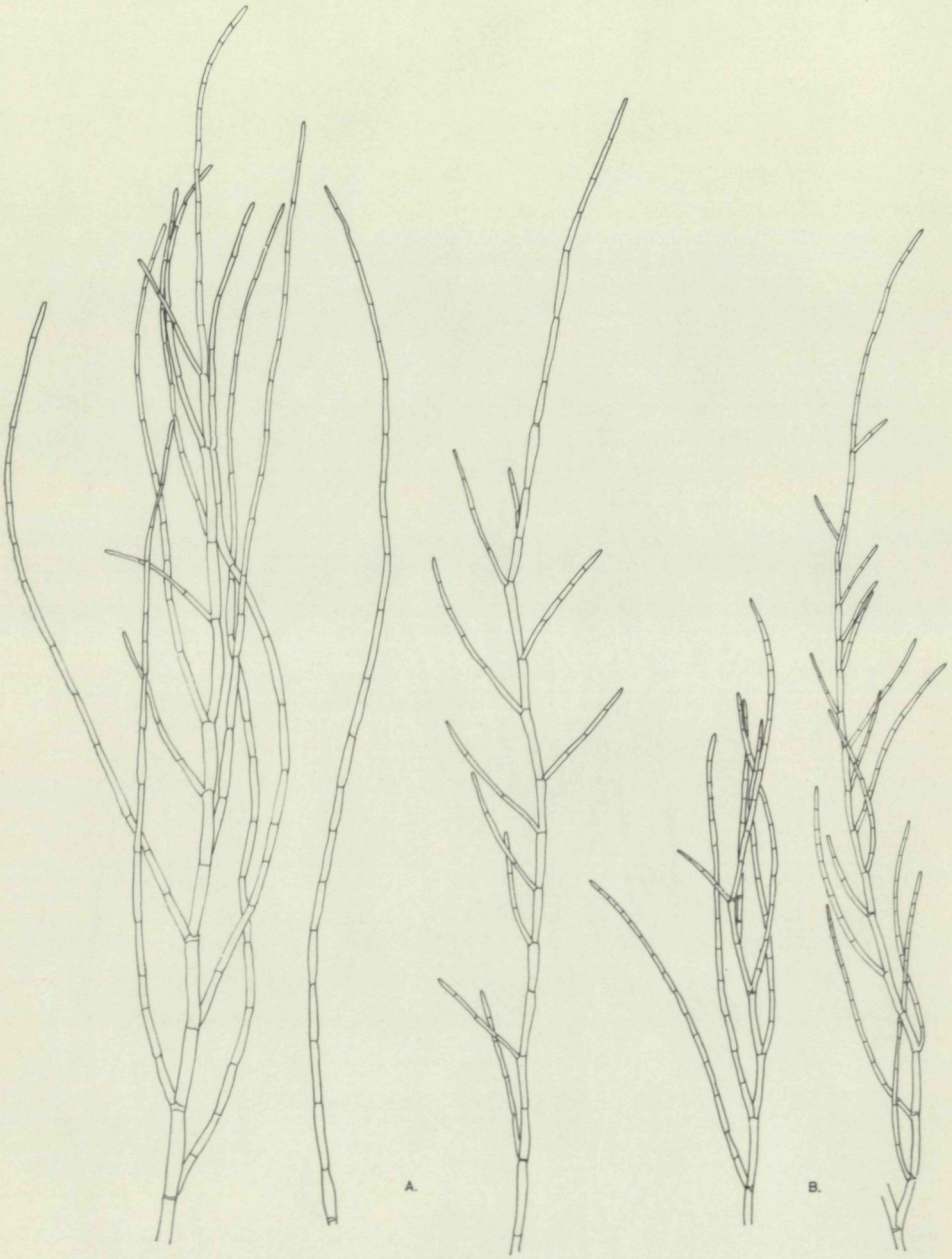


Fig. 74. A. Cl. flexuosa, sublitoral in a small bay outside Kristineberg, 23.8.1955. B. Cl. glaucescens, splash pool outside Kristineberg, 21.6.1954. Note the similar ramification and compare the diagrams fig. 75 and 76. $\times 20$.

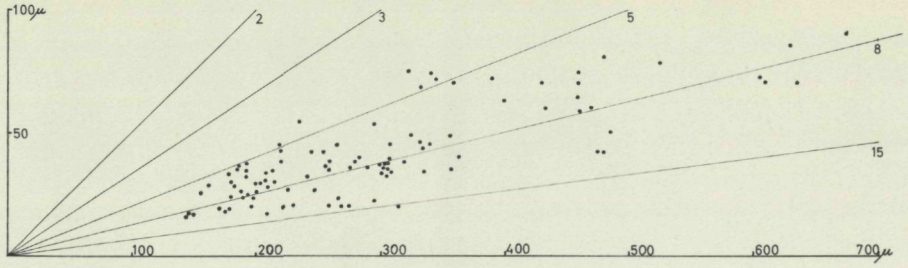


Fig. 75. Sizes of cells from the specimen fig. 74 A.

The specimen from which the drawing was made was collected in a wave-washed pool outside Kristineberg on 21.6.1954. It may be taken as an example of Cl. glaucescens in a young state and wave-exposed habitat, but in this case the extreme affinity to Cl. flexuosa (A in the same fig.) is of more interest.

Fritsch (1956 p. 234) writes about Cladophoraceae: "In most genera of Cladophoraceae all the cells are capable of division, but in Spongomorpha, Cladophora and Pitophora growth is partly carried out by the apical cells which, when they have reached a certain length, undergo division into two, the lower cell in many cases undergoing no further appreciable elongation." In all the species of Cladophora that I have studied I have found intercalary cell-divisions, though they sometimes occur only in the main branches and therefore may easily be overlooked. Cl. oblitterata is an example of a plant where secondary cell-divisions are not found in the ultimate branches, which distinguishes this species from Cl. glaucescens where a second division sometimes can be seen already in the third cell beneath the top (fig. 52). Secondary divisions occur regularly also in the ultimate branches of Cl. flexuosa and those two species at first sight sometimes look alike. Hamel has also united Cl. glaucescens and Cl. flexuosa in a group that he calls flexuosae (Hamel 1931 p. 43). The culture experiments carried out by Bliding (1936 p. 529 and p. 532) show, however, that they are distinct species, Cl. flexuosa having an isomorphic alternation between sexual and asexual individuals, while Cl. glaucescens reproduces

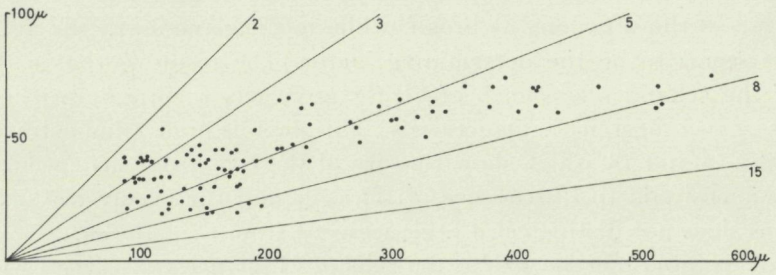


Fig. 76. Sizes of cells from the specimen fig. 74 B.

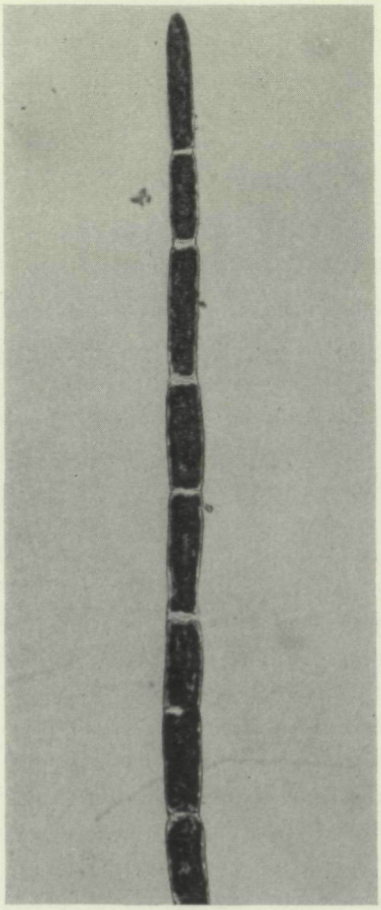


Fig. 77. End branch of a sublitoral specimen of Cl. glaucescens, Justöen, locality similar to the one in fig. 7. Note that the sixth cell from the top is newly divided and the halves have the same length as cell nr 2 from the top. ×110.

only with the aid of zoospores. I have therefore tried to distinguish the two species through a difference in the occurrence of the secondary divisions. In Cl. flexuosa those divisions occur when the cells have reached a certain relative length, usually when they are 8 times as long as broad, while in Cl. glaucescens the actual length of the cells seems to be the determining factor. The result is that a diagram of the size of the cells in a specimen of Cl. flexuosa gets a trapezium form, while it approaches a rectangel in Cl. glaucescens. This fact is well demonstrated by the diagrams figs. 75 and 76, which show the size of the cells from the specimens in fig. 74. As previously said (p.79) the size of the cells and the occurrence of secondary cell-divisions does not distinguish Cl. glaucescens from Cl. hamosa.

As already pointed out the size of the cells of Cl. glaucescens varies with the age of the plant and probably also with environmental conditions. It is therefore diffi-

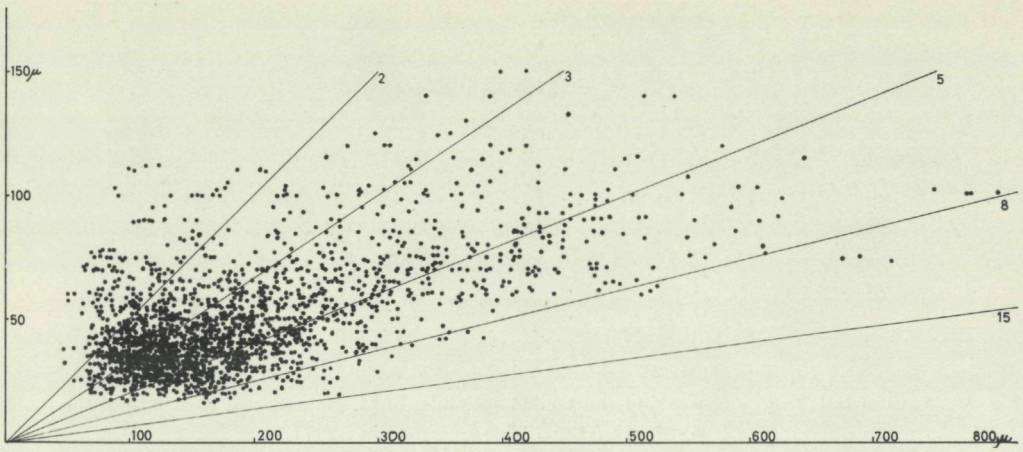


Fig. 78. Sizes of cells from 20 specimens of Cl. glaucescens. (The same specimens as in table 4.)

cult to give precise measurements. In the investigated material the thinnest specimens (all collected during May and June) have been found to have the following size of cells; in outer branches and branchlets $18-45 \times 80-260$ μ, in the basal parts $40-110 \times 200-650$ μ. The coarsest plants (collected in July, usually in wave-exposed positions) had instead in outer branches and branchlets $30-80 \times 50-240$ μ, in the basal parts $50-150 \times 100-685$ μ. Cells with a diameter exceding 100 μ were few.

The relative length of the cells also varies with age, the youngest having the longest cells (table 4). Usually the majority of the cells are less than 5 times as long as broad.

Cl. glaucescens has been found to thrive best in well-lighted habitats which, furthermore, are gently washed by the waves. Its ecology is similar to that of Cl. albida. Like the latter it has also been found in the brackish water in the southernmost parts of the Swedish west coast and, also like Cl. albida, it is a more rare

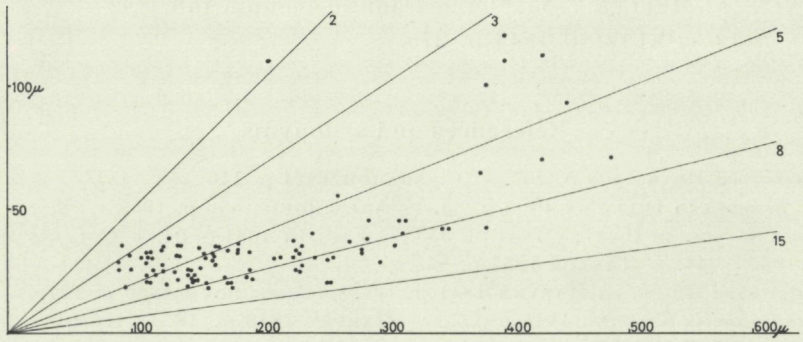


Fig. 79. Sizes of cells from a thin specimen of Cl. glaucescens, sheltered locality, Strömstad 17.6.1960.

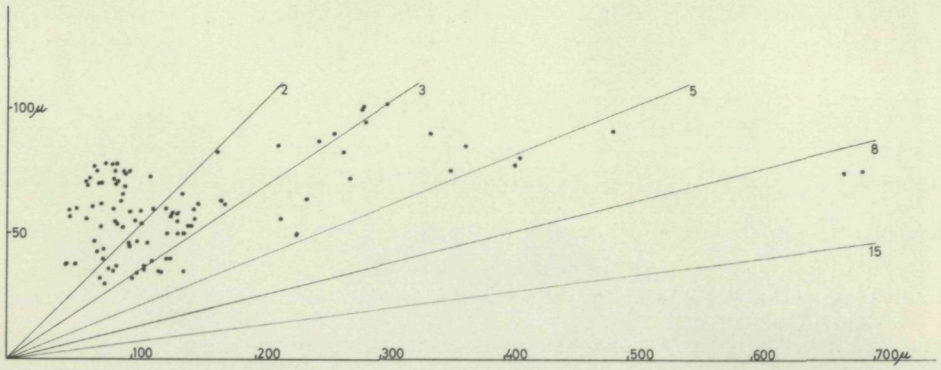


Fig. 80. Sizes of cells from a coarse and shortcelled specimen of Cl. glaucescens, hydrolitoral tide pool, Plymouth, 16.7.1962. (The specimen in fig. 71.)

plant in the innermost and sheltered parts of the archipelago of the province of Bohuslän. The biggest specimens I have found grew in small tidal streams on the shore at W. Looe in July 1962. Those specimens which could reach a length of up to three dm also had a more brownish green colour and not the usually mentioned silky glaucous green. The colour of the plant must not be used in the determinations.

As said before the reproduction of Cl. glaucescens has been studied by Bliding. He found that Cl. glaucescens only delivered biciliate zoospores. Miss A. Wik, who is at work with the cytology of Cladophora using some of my material, has as a preliminary result reported $2n=22$ as the number of chromosomes in two specimens of Cl. glaucescens, one from the Swedish west coast and one from Plymouth.

Cladophora flexuosa (Müll.) Kützing

Conferva flexuosa Müller 1783 Florae Danicae Iconum tab. 882.
Cladophora flexuosa Kützing 1843 p. 270.

References and synonyms

Conferva diffusa Roth 1800 p. 207. — C. Agardh 1824 p. 116.
Conferva flexuosa in Dillwyn 1809 p. 65. — Areschoug 1850 p. 195.
Cladophora flexuosa in Harvey 1851 pl. 353. — Farlow 1881 p. 54. — Collins 1902 p. 121. — Hamel 1930 p. 44. — Taylor 1957 p. 85.
Conferva gracilis Griff. ex Harvey 1841 p. 137. — Areschoug 1850 p. 197.
Cladophora gracilis Kützing 1845 p. 215. — Harvey 1846 pl. 18. — Kützing 1849 p. 403 and Tab. Phyc. IV:23:II. — Farlow 1881 p. 55. — Hauck 1885 p. 457. — Kylin 1907 p. 30. — Hamel 1930 p. 45 — Bliding 1936 p. 532. — Kylin 1949 p. 55. — Taylor 1957 p. 86.

Cladophora hirta KÜTZING 1845 p. 208, 1849 p. 395 and Tab. Phyc. IV:1:II. — HAUCK 1885 p. 456. — KYLIN 1907 p. 28. — HAMEL 1930 p. 43. — KYLIN 1949 p. 57. (Non Conferva hirta Vahl 1787 tab. 947.)

Conferva expansa MERTENS ex C. AGARDH 1824 p. 114.

Cladophora expansa (MERTENS) KÜTZING 1843 p. 265 and Tab. Phyc. III:99:I. — FARLOW 1881 p. 55. — HAUCK 1885 p. 462. — HAMEL 1930 p. 40. — TAYLOR 1957 p. 85.

Cladophora Rudolphiana in HARVEY 1846 pl. 86. — KÜTZING 1849 p. 404 (partim). — COTTON 1912 p. 111.

Conferva Bruzelii C. AGARDH 1824 p. 116.

Conferva heteronema C. AGARDH 1824 p. 114.

Conferva vadorum ARESCHOUG 1843 p. 269 (not seen).

Cladophora crystallina HAUCK 1885 p. 459 (partim).

Investigated herbarium specimens

"Conferva flexuosa, Sp. orig. mis Dillwyn", Herb. Alg. Ag. nr 9206. — "Conferva fracta *β* prolifera Ag. 55, C. flexuosa, Yarmouth.", Herb. Hookerianum, Kew Herb. — "Conferva flexuosa, Griffiths Aug. 1839.", Trinity College, Dublin. — "Cladophora flexuosa (Griff.) Harvey. Wood's Holl Mass. W. G. Farlow.", Brit. Museum. — "Cladophora flexuosa Harv. Barbade. A. Vickers.", Brit. Museum. — "Cladophora flexuosa (Griff.) Harvey, near low-water mark, Montego Bay, Jamaica, January 19, 1907. Leg. M. A. Howe, Det. F. S. Collins.", Kew Herb. — "Cladophora flexuosa, leg. et det. G. Hamel.", Biol. station, Dinard. — "Conferva gracilis Tor Abbey, October 1833. This is sometimes 20 inches long." (Griffiths' handwriting), Trinity College, Dublin. — "No 97 Conferva gracilis. New species on Zostera, Tor Abbey." (Harvey's handwriting), Trinity College, Dublin. — "Cladophora gracilis, Cherbourg septembre Le Jolis.", Brit. Museum. — "Cladophora gracilis, Wood's Holl July 1889. W. G. Farlow." (two specimens), Brit. Museum. — "Cladophora gracilis (Griff.) Kütz. Väderöarne 22.6.1905. Leg. H. Kylin.", Bot. Museum, Lund. — "Cladophora gracilis (Griff.) Kütz. Varberg 4.9.1917, D. E. Hylmö.", Bot. Museum, Lund. — "Cladophora gracilis (Griff.) Kütz. Nobska Pt., Woods Hole ,Mass. 15.8.1929. Leg. W. R. Taylor.", Marine Bot. Inst., Göteborg. — "Cladophora gracilis, Black Rock, New Bedford Hbr., Mass. W. R. Taylor 28.7.1931.", Brit. Museum. — "Conferva diffusa R. dedit Roth.", Herb. Alg. Ag. nr 9215. — "Conferva heteronema.", Herb. Alg. Ag. nr 8109, 8159. — "Conferva Bruzelii.", Herb. Alg. Ag. nr 8122—23, 8243. — "Conferva Rudolphiana, Roundstone aug. 1845." (Harvey's handwriting), Trinity College, Dublin. — "Cladophora Rudolphiana, Achill Sound July 1910 attached. Clare Island Survey A.D.C. 1909—11.", Brit. Museum. — "Cladophora fracta. f. marina Hauck, Koster 21.7.1905. — Ibid. Varberg 11.7.1902. — Ibid. Gottskär 8.7.1904. Leg. H.Kylin.", Bot. Museum, Lund. — "Cladophora expansa, leg. et det. G. Hamel.", Biol. Station, Dinard. — "Cladophora glaucescens, Kiel, leg. Reinbold.", Kew Herb. — "Cladophora hirta, På Laminaria, Drøbak 13.4. 1912. D. E. Hylmö.", Bot. Museum, Lund.

Exsiccata: Wyatt, Alg. Danmon. nr 97 "Conferva gracilis.", Riksmuseum, Stockholm. — Alg. Exsicc. Am. Bor. nr 209 "Cladophora gracilis (Griff.) Kg, Falmouth, Mass. 1881. W. G. Farlow.", Herb. Alg. Ag. nr 7553. — Ibid. nr 210 "Cladophora expansa, in fossis subsalsis. Leg. Farlow.", Kew Herb. — Wittrock & Nordstedt nr 940 "Cladophora expansa, Akeröen, (Hvalöernel in fundo 2—4 orgyas alto, M. Foslie 24.8.1884.", Brit. Museum. — Ibid. nr 1041 "Cladophora hirta Kütz. Suceiae in mari Bahusiensi ad Kristineberg in regione litorali scopulis et lapidibus affixa. 4.4.1890. F. R. Kjellman.", Brit. Museum and Kew Herb. — Ibid. nr 120 b "Cladophora crystallina, Fiskebäckskil.", Brit. Museum. — Hauck & Richter nr 377 "Cladophora crystallina (Roth) Kütz. Leg. F. Hauck.", Kew Herb. — Areschoug Alg. Scand. Exsicc. Ed. 2 nr 127 "Cladophora sericea". — Ibid. nr 128 "Cladophora gracilis." — Ibid. nr 180 "Cladophora vadorum.", Riksmuseum, Stockholm.

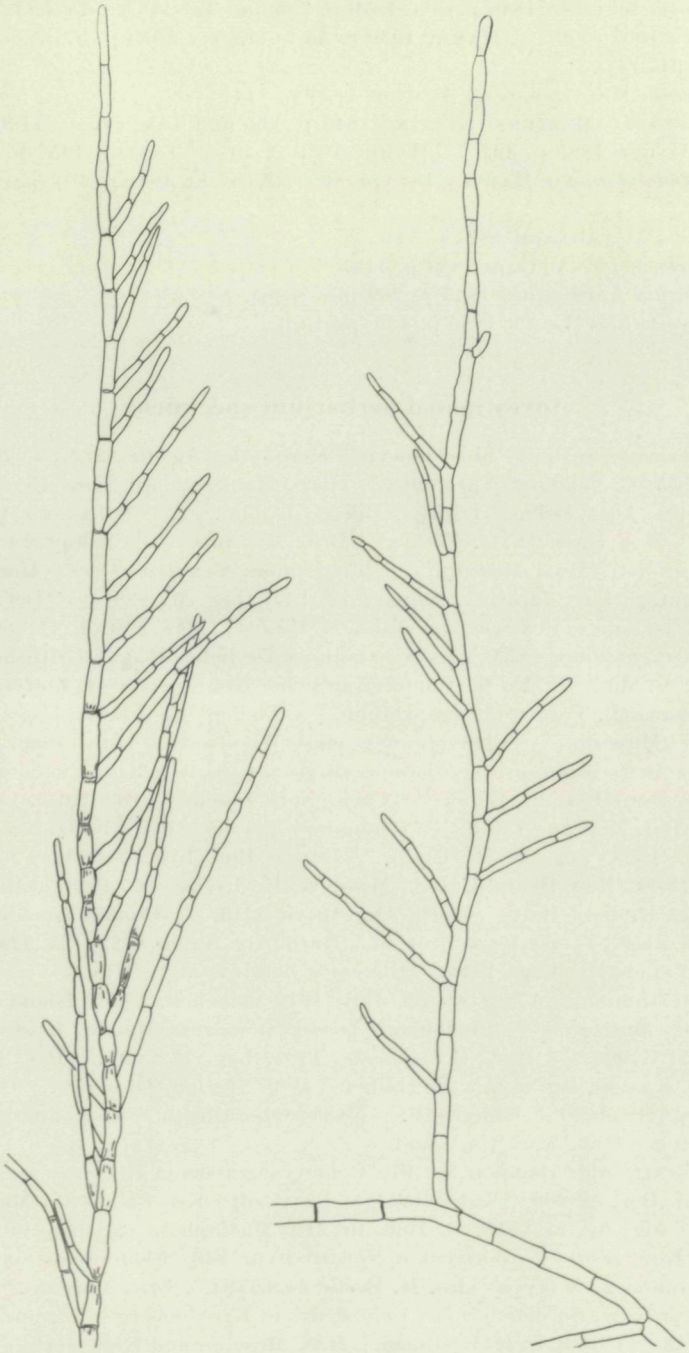


Fig. 81. Exsicc. Wyatt, Alg. Danmon. nr 97, C. gracilis. The branch to the left is of the type that should be characteristic of Cl. gracilis, the one to the right is more flexuosa-like, both are from the same specimen. ×20.

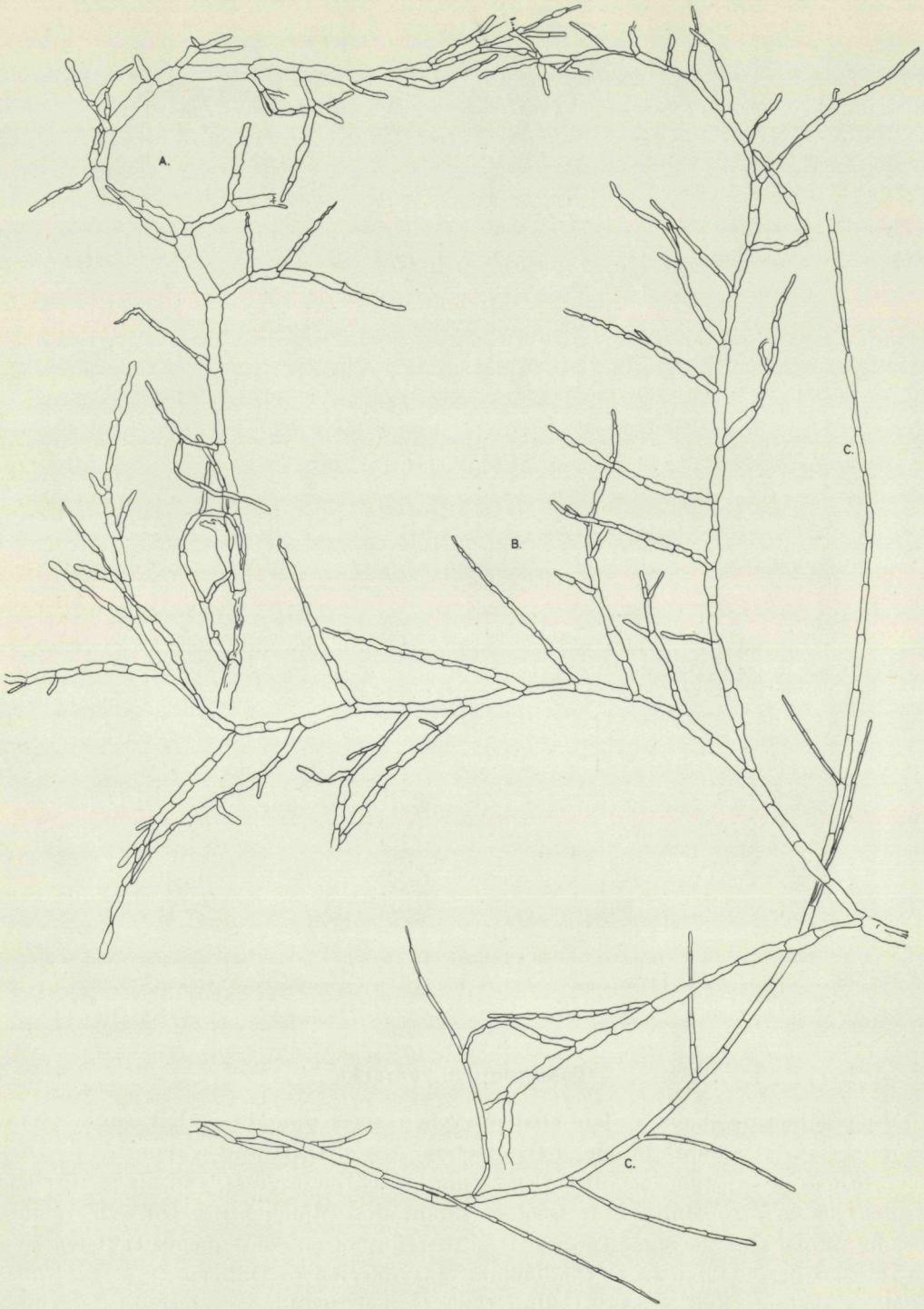


Fig. 82. A. Areschoug, Alg. Scand. Exsicc. nr 127, C. sericea, B. Ibid. nr 180, C. vadorum, C. Ibid nr 128, C. gracilis. ×20.

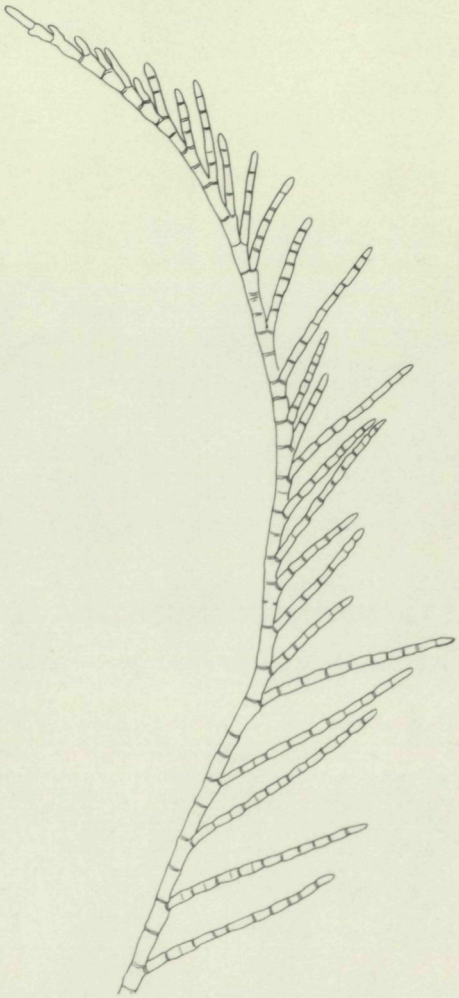


Fig. 83. Cl. flexuosa, the form often called Cl. hirta. In the place where this specimen was collected only ordinary specimens of Cl. flexuosa could be found a few months later. Henån, 18.2.1957. ×20.

Taxonomical remarks

Müller's picture shows a plant that in every respect resembles what can be found in quiet bays at a depth of one or two meters. A similar habitat is reported by Dillwyn, whose description has often been regarded as the original, and his picture has a great likeness to Müller's. It is of no doubt that Müller's and Dillwyn's plants belong to one and the same species. It is therefore of no consequence that Kützing in transferring C. flexuosa to Cladophora only referred to Dillwyn.

Many authors (Farlow 1881, Collins 1909, Hamel 1930) have referred Cl. flexuosa to (Griff.) Harvey. Harvey himself mentioned Dillwyn's C. flexuosa but thought it

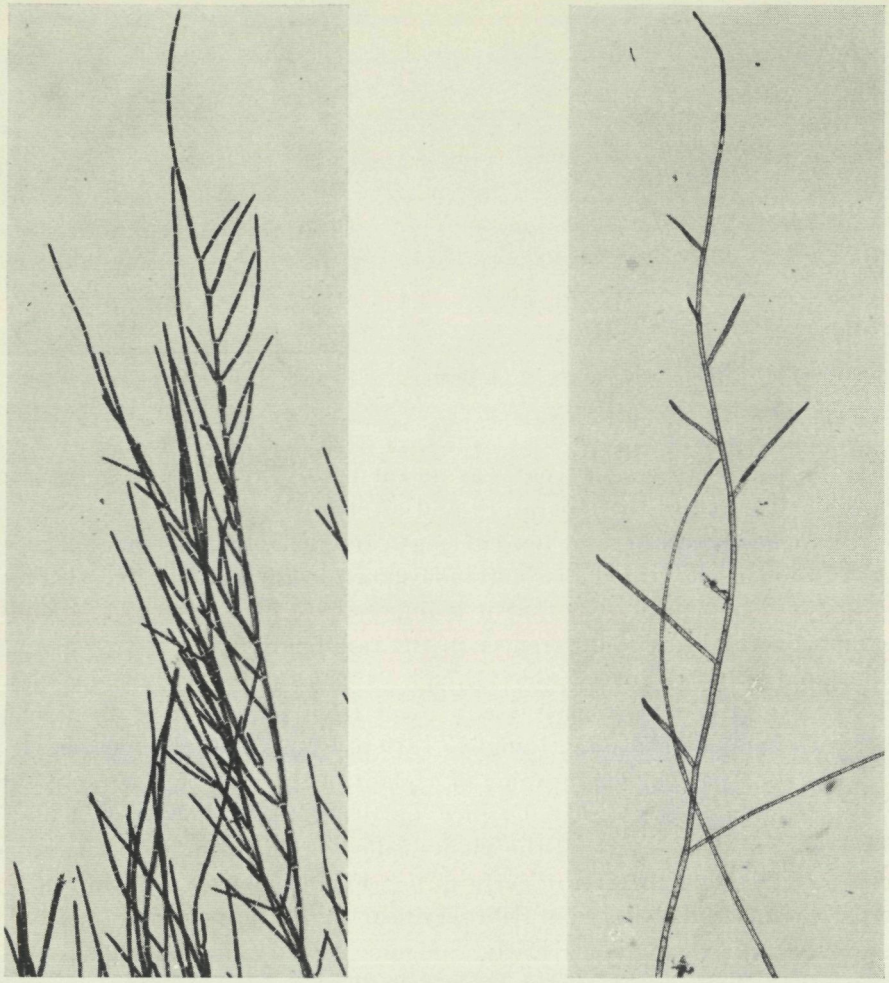


Fig. 84. Cl. flexuosa. To the left a specimen collected on 14.9.1962 at Koster, to the right the sporophyte that in five months grew out from a zygote from the Koster plants. Sizes of cells in fig. 4 and fig. 85.

"best to abstain quoting any synonyms or habitat which I have not recently verified". Cl. flexuosa sensu Harvey is a more branched plant than Dillwyn figured, but not at all difficult to find a place for in the form series of Cl. flexousa (Müll.) Kützing.

The name Cl. gracilis has been very much used. Typus of this taxon is a plant in Harvey's herbarium, Trinity College, Dublin, and Griffiths' specimens in Wyatt, Alg. Danmon. nr 97, might be called isotype material. The most used character is the pectinated ultimate branchlets. In the type specimen, as well as in a specimen of Wyatt 97, that I have examined, both the gracilis-type and the Flexuosa-type of ramification can be seen (fig. 81). Fig. 84 shows a specimen of Cl. flexuosa of a type

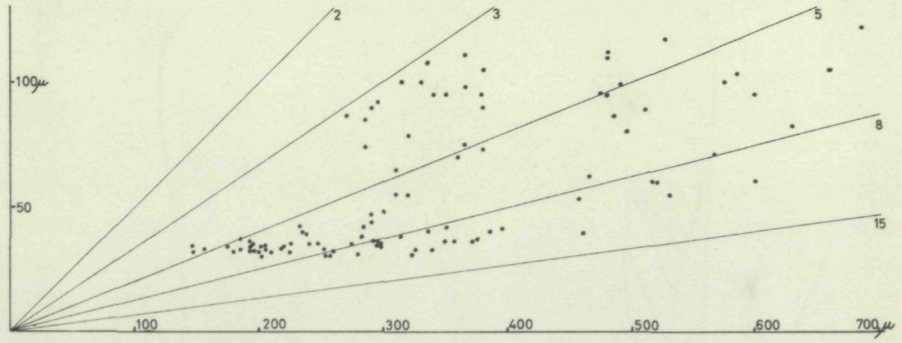


Fig. 85. Sizes of cells from a sporophyte of Cl. flexuosa cultivated in the laboratory, compare fig. 86.

that may be said to represent what was meant with Cl. gracilis. Zygotes from this plant were cultivated in the laboratory and after 5 months they had grown out to sparsely branched plants of some few cm length and delivered four-ciliated zoospores. A branch from the cultivated sporophyte is shown to the right in fig. 84. From this experiment it seems quite clear that it is impossible to separate a Cl. gracilis from Cl. flexuosa on the basis of differences in the ramification.

The original Conferva hirta Vahl (1787 pl. 947) has probably nothing to do with the Cl. hirta in later works, as it was a plant from pure fresh water which grew together with Lemna trisulca (cf. Lyngbye 1819 p. 153). Later on, however, the name Cl. hirta has been used in the meaning of a plant of the type that is represented by Wittrock & Nordstedt's often cited exsicc. nr 1041; "Cladophora hirta Kütz.". It is interesting to see that nearly all the plants called Cl. hirta in the herbariums have been collected in the late winter or early spring. Fig. 83 shows a branch from a plant, about one cm high and collected in February near Henån in the province of Bohuslän. Some months later I examined closely the same locality and found only ordinary specimens of Cl. flexuosa. That the short cells in the "hirta" not are found at the

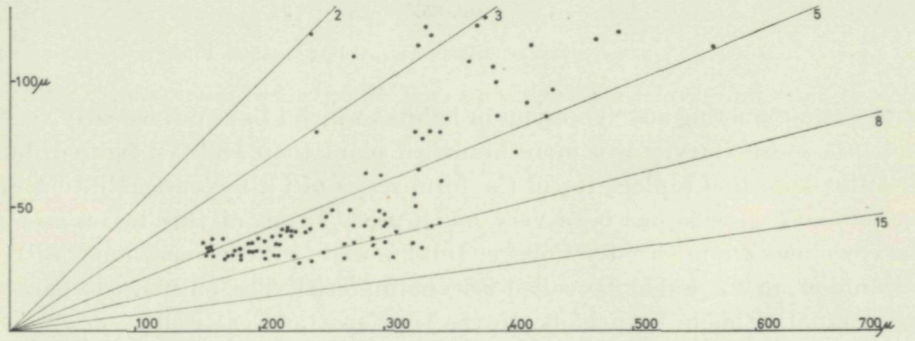


Fig. 86. Sizes of cells from a semi-detached specimen of Cl. flexuosa from a sheltered bay outside Kristineberg, 6.8.1962.

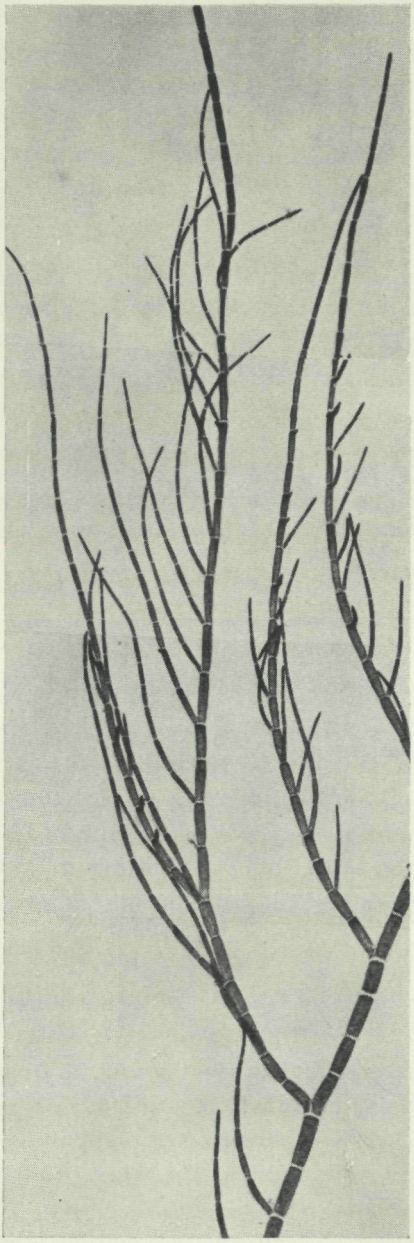


Fig. 87. Cl. flexuosa, typical branching in a semi-detached specimen; among Chorda filum and Laminaria saccharina in a small sheltered bay outside Kristineberg, 6.8.1962. (Sizes of cells in fig. 86) $\times 15$.

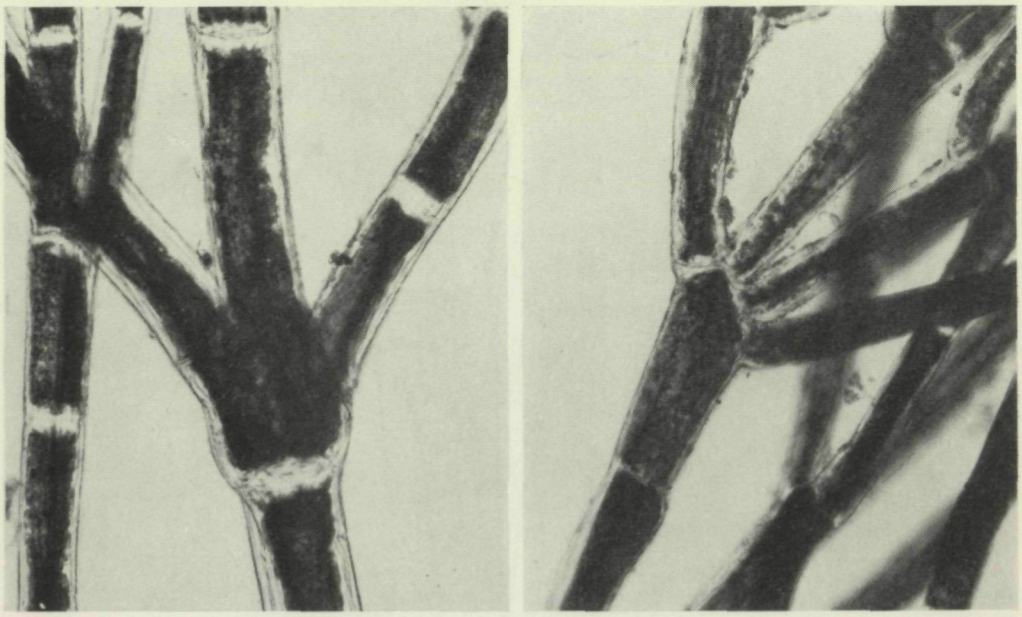


Fig. 88. Cl. flexuosa (to the left) and Cl. laetevirens. The picture shows the difference at the points of branching. ×110.

base of the full grown Cl. flexuosa may be explained by such disintegrations of the cell walls that Kolderup Rosenvinge has demonstrated (1892 p. 22).

The authentic specimen of C. diffusa Roth in Herb. Alg. Ag. is of a similar type. Dillwyn describes C. diffusa as being much coarser than flexuosa (C. flexousa: "finer than the hair of the human head"; C. diffusa: "equal to horse hair") and no doubt C. diffusa in Dillwyn is the same thing as in Harvey (1849 pl. 130). I have found Cl. diffusa Harvey to be forms of Cl. Hutchinsiae (Dillw.) Kützing. Roth's picture, on the other hand, shows the ramification characteristic of some forms of Cl. flexuosa.

I have more doubts concerning Cl. expansa. It is a taxon with a peculiar history. Kützing published Cl. expansa in 1843 (p. 265) as a transference of Conferva expansa Mertens to Cladophora. Mertens C. expansa was a plant in an exsiccat, Jürgens "Algae Aquaticae. —" 1816—1822 (not seen by me). C. Agardh referred to this plant when describing Conferva expansa in 1824 and I have therefore written C. expansa Mertens ex Agardh. Kützing never described Cl. expansa; we know it only from his picture Tab. Phyc. III:99:I, and in Herb. Alg. Ag. I could not find a single specimen old enough to be an authentic specimen of C. expansa Agardh. Kützing placed C. Agardh's expansa together with his own Cl. patens (1849 p. 394) a plant, which, according to the measurements and the picture Tab. Phyc. III:98, well may be said to belong to Cl. flexuosa. If it then was Kützing's meaning that Cl. patens should succeed Cl. expansa he ought to have pictured both. He also ought to have known that Conferva patens was already described by C. Agardh (1824 p. 110) as a fresh

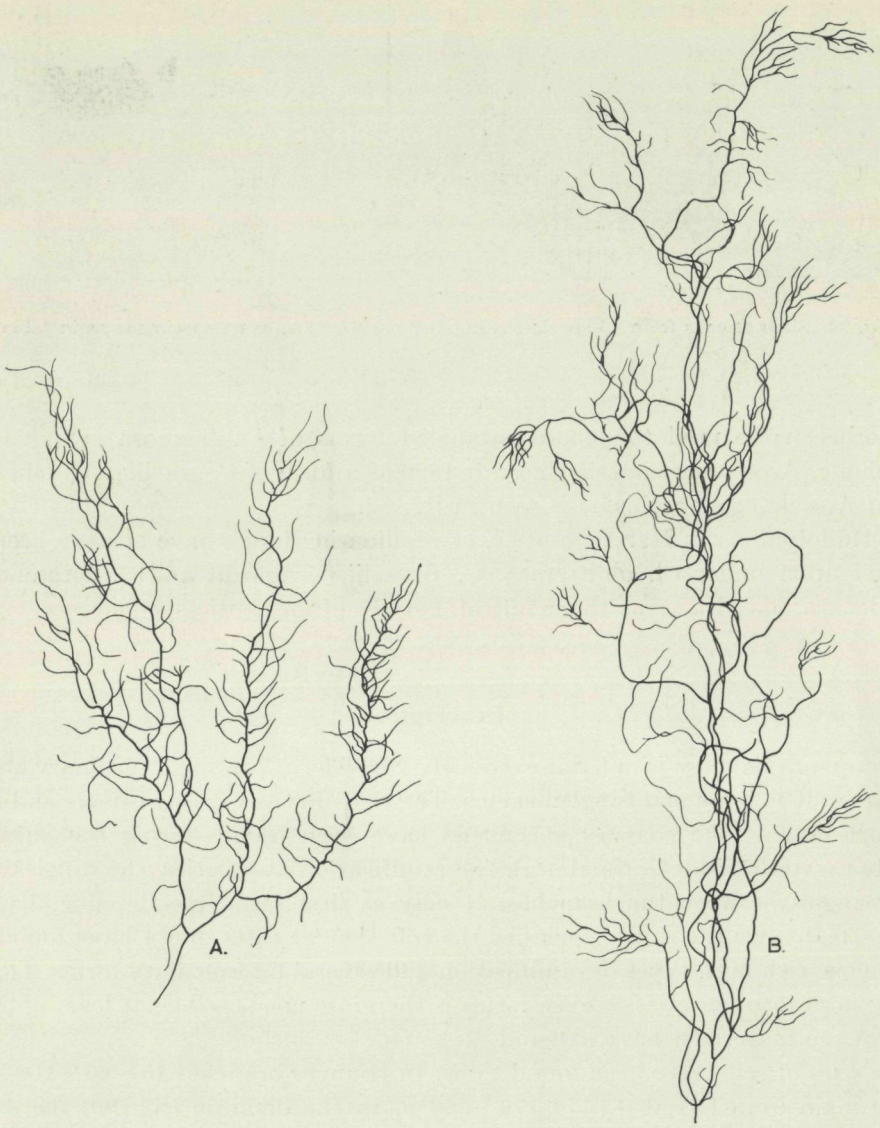


Fig. 89. Cl. flexuosa, ramification in specimens from the inner part of the Bohuslän archipelago, A. Steep rock facing north, Borgilafjorden, Henån, 8.7.1953, B. similar locality inside the island of Orust, 7.8.1953. Half the natural size.

water plant, including a part of C. divaricata Roth. Divaricata is a name used by Kützing for a plant from the North Sea, and this taxon has got a description and picture which again leads us to plants in the form series of Cl. flexuosa. It is of no use trying to solve this puzzling riddle. From Farlow on, Cl. expansa has been a name used for detached forms of Cl. flexuosa and in this meaning it is put in my list of references.

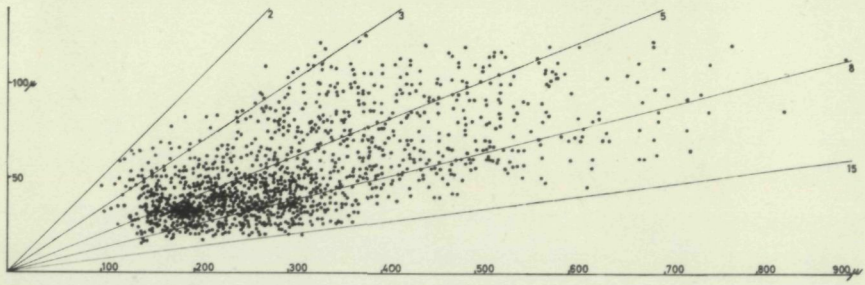


Fig. 90. Sizes of cells from 15 specimens of Cl. flexuosa. (The same specimens as in table 5.)

Another name used to denote entangled forms of Cl. flexuosa is C. vadorum Areschoug. Areschoug himself placed it 1850 as a form of C. gracilis. A branch from one of Areschoug's specimens is seen in fig. 82.

Cl. Rudolphiana in Harvey and Cl. crystallina in Hauck have already been commented upon under Cl. oblitterata. C. Bruzelii C. Agardh and C. heteronema C. Agardh are placed here as the result of a study of authentic specimens.

Description

Cladophora flexuosa is in habit extremely variable, appearing as ordinary attached tufts as well as loose and tangled skeins. The size of cells varies with age and supply of nourishment (the coarsest specimens have been found during the autumn in polluted water outside Gothenburg). The ramification also varies, the tangles having wider angles between the branches. It may at first seem questionable that these tangles really are the same species as the soft slender tufts, but I have found a few specimens with both types of ramification and several intermediary forms. To divide Cl. flexuosa into varieties or even forms is therefore not possible, at least not on the basis of the material I have at hand.

The sizes of cells have been found to be: In younger branches $15-65 \times 100-500 \mu$; in the main branches $40-125 \times 170-980 \mu$. In the diagram (fig. 90) the smallest cells are 15×140 respectively $45 \times 100 \mu$, the biggest 115×895 respectively $125 \times 350 \mu$. Farlow (1881 p. 55) reports diametres up to 160μ and Hamel (1930 p. 41 Cl. expansa) up to $150(-200) \mu$, but I suppose those are exceptions; all the species belonging to Cl. flexuosa in Kützing 1849 (Cl. divaricata, patens, pectinicornis, vadorum, gracilis, Bruzelii and hirta) have measurements below or up to 125μ.

Secondary divisions occur regularly in the many-celled ultimate branchlets. Usually the cells divide when they have reached a relative length in the region of 8. The result is a trapezium form in the diagrams of the single specimens (fig. 4), and observe that the trapezium form is not quite destroyed even when 15 different specimens covering the whole form series of Cl. flexuosa are put together. In rapidly

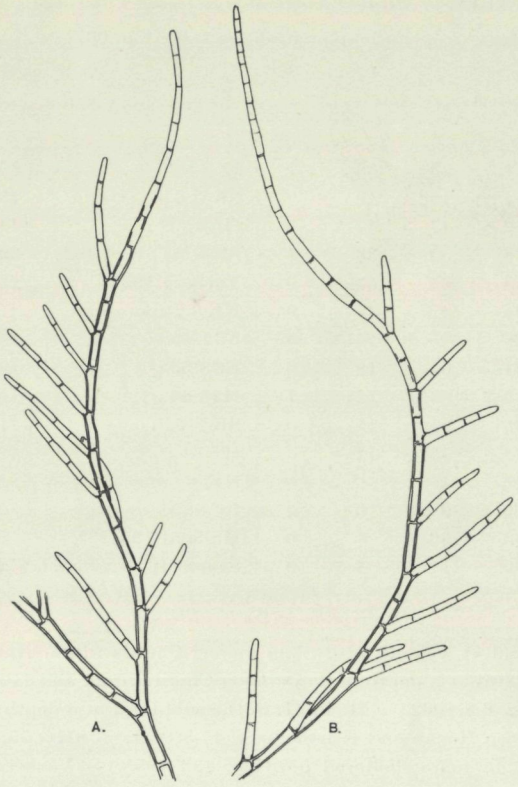


Fig. 91. Cl. flexuosa, coarse and short-celled specimens from dirty water, A. Kanaal door Zuid Beveland, the Netherlands, leg. G. Michanek 28.9.1961, B. The archipelago immediately outside Göteborg, 11.9. 1961. ×20.

growing specimens the ultimate branches sometimes lack secondary divisions (fig. 86).

The relative length of the cells (table 5) varies between 2 and 15 but the majority of the cells have a length-breadth ratio of 3—8.

Many algologists have confused Cladophora flexuosa with especially Cl. glaucescens and Cl. oblitterata, and in the entangled forms also with Cl. fracta and Cl. glomerata. The methods by which these four species can be distinguished from Cl. flexuosa have already been stated in connection with the descriptions of the species in question, but may be summed up here. Cl. flexuosa — Cl. oblitterata: Cl. flexuosa has many-celled ultimate branchlets where secondary cell divisions occur regularly, it also as a rule is more short-celled. Cl. flexuosa — Cl. glaucescens: Cl. flexuosa has secondary celldivisions dependent on the relative length, while in Cl. glaucescens they occur at a certain actual length, specific for each specimen, but as a rule in the region of 200 μ. Cl. flexuosa differs also ecologically from Cl. glaucescens, flexuosa being a sublitoral plant, glaucescens hydrolitoral and preferring moderately wave-exposed

TABLE 5. *Relative length of cells from Cl. flexuosa.*

(For explanation see table 1 p. 00)

— 2	— 3	— 5	— 8	— 15 —			>8	<5	3—8
0	0	11	33	55	1	EC3d/55	56	11	44
0	0	4	48	48	0	SKV/62a	48	4	52
0	0	9	47	44	0	H54q/51	44	9	56
0	0	6	55	38	1	SKÖ/55	39	6	61
0	0	13	64	23	0	Varberg 1932	23	13	77
0	0	26	47	27	0	NK/62-sporophyte	27	26	73
0	0	26	48	26	0	N72/60	26	26	74
0	0	21	61	18	0	EC8/55	18	21	82
0	1	23	63	12	1	H46/56	13	24	86
0	6	26	57	11	0	SKV/62b	11	32	83
0	4	29	55	12	0	H1/61	12	33	84
0	5	46	47	2	0	NK/62	2	51	93
0	9	60	31	0	0	EC4a/55	0	69	91
1	6	63	30	0	0	Holland 1961	0	70	93
0	27	59	11	3	0	Styrsö 1961	3	86	70

Description of the localities.

EC3d/55, in the sublitoral at a depth of 2—3 m among Chorda filum, Hallands Väderö, 26.7.1955. — SKV/62 a, in the sublitoral at a depth of 2 m among Chorda filum and Laminaria saccharina, small skerry outside Kristineberg, 6.8.1962. — H54q/51, in the sublitoral at a depth of 1.25 m among Zostera marina, tidal stream between Henån and Kristineberg, 17.8.1951. — SKÖ/55, on Fucus serratus in the same locality as SKV/62 but more sheltered position, 23.8.1955. — Varberg 1932, Getterön, leg. T. Levring 6.8.1932. — NK/62-sporophyte emanating from NK/62 below, 9.3.1963. — N72/60, in the sublitoral among Chorda filum, narrow sea loch, Espegrend, 12.7.1960. — EC8/55, in the sublitoral at a depth of 2.5 m together with Enteromorpha sp., Kungsbackafjorden, 1.8.1955. — H46/56, sublitoral cavity in a steep rock, Borgila fjord near Henån, 10.8.1956. — SKV/62 b, the same population as SKV/62 a, but a more spread specimen, 6.8.1962. — H1/61, in the sublitoral on steep rock in a tidal stream between Henån and Kristineberg, 8.7.1961. — NK/62, in the sublitoral at a depth of 1.5 m together with Polysiphonia nigrescens, east side of Koster, 14.9.1962. — EC4a/55, on Halidrys siliquosa in a stony bay, Glommen, 28.7.1955. — Holland 1961, in a salt water canal with polluted water, Kanaal door Zuid Beveland, the Netherlands, leg. G. Michanek 28.9.1961. — Styrsö 1961, in the sublitoral at a depth of 1 m, abundant, polluted water outside Göteborg, 11.9.1961.

shores. Cl. flexuosa — Cl. fracta: Cl. flexuosa is the bigger plant though sometimes cells with the same diameter as in Cl. fracta may be seen. In that case a study of the relative length of the cells must be made, when fracta can be told apart by its having shorter cells in the main filaments than in the ramuli. Cl. flexuosa — Cl. glomerata: The detached forms of Cl. glomerata that I have found have all had very long cells, often more than 1000 μ, whereas even cells of 800—900 μ length are rarieties in Cl. flexuosa.

A species that I have not seen mentioned in connection with Cl. flexuosa is Cl. laetevirens. The more gracile forms of the latter (fig. 110 and 116) can look similar to

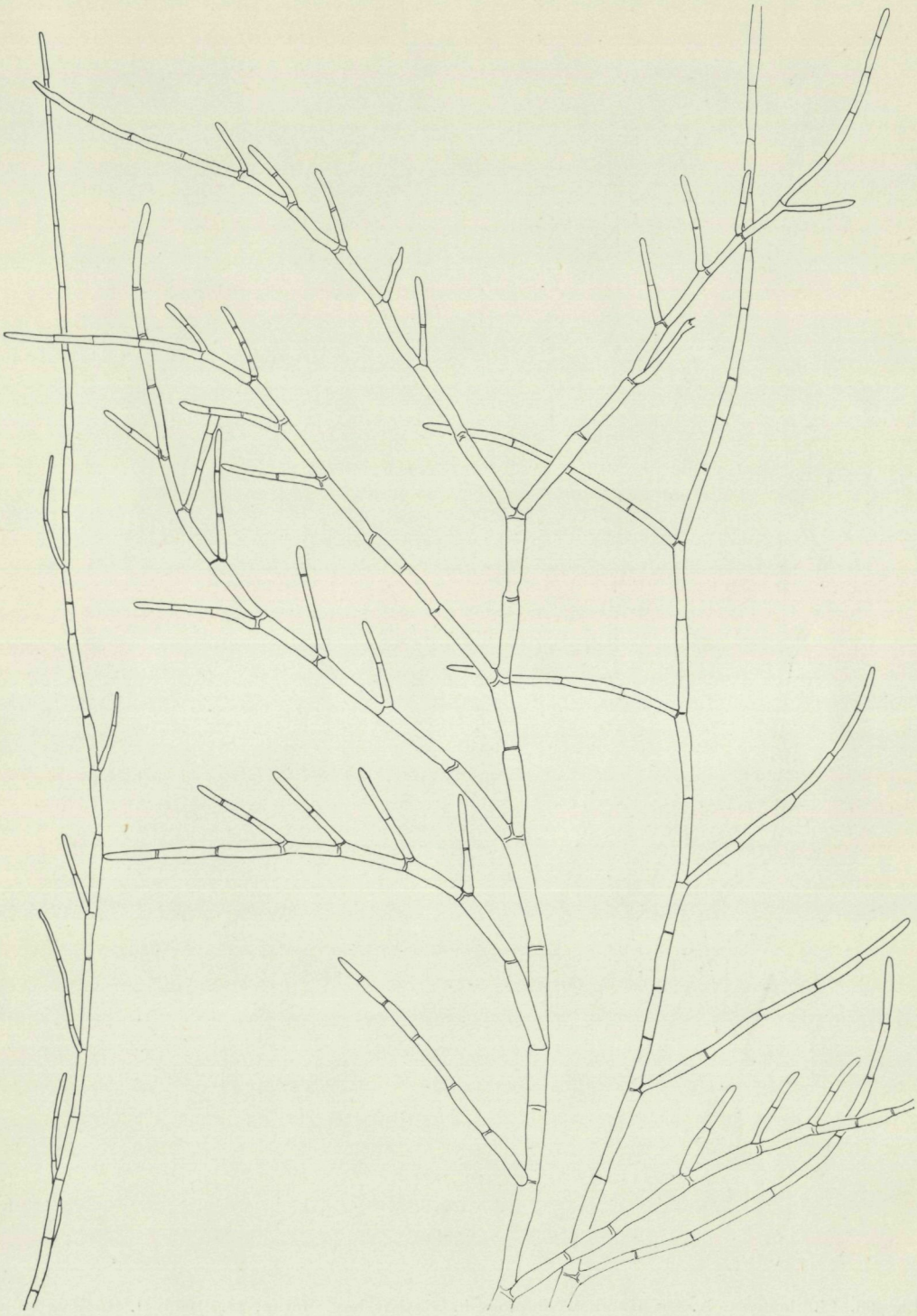


Fig. 92. Cl. flexuosa, different types of branches from one and the same semi-detached skein, Kristineberg, 23.8.1955. ×20.

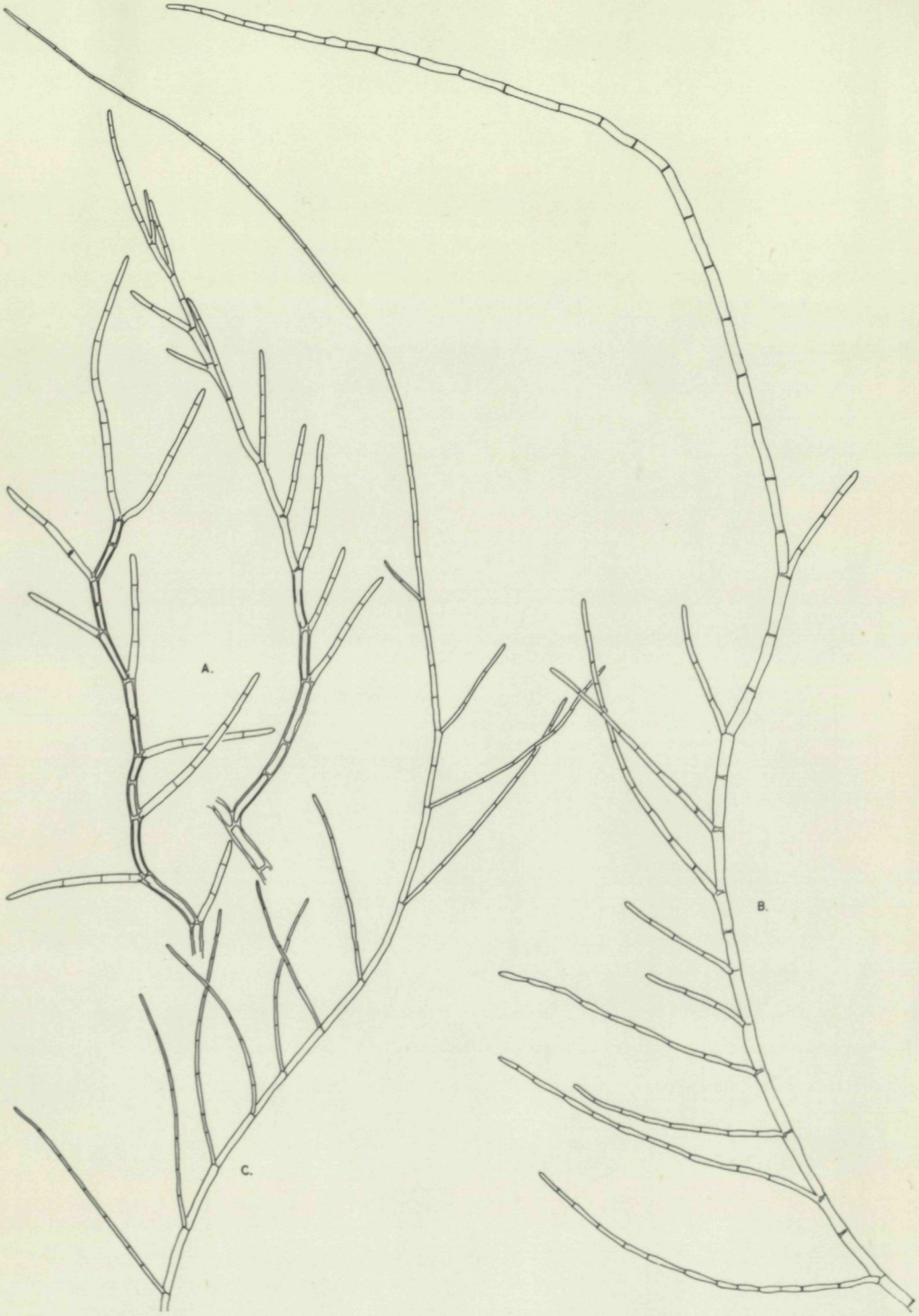


Fig. 93. Cl. flexuosa, A. On Halidrys siliquosa in a stony bay, Morup, 28.7.1955, B. Hanging on a steep rock, Henån 8.7.1953, C. Semi- detached among Chorda filum, Hallands Väderö, 26.7.1955. ×20.

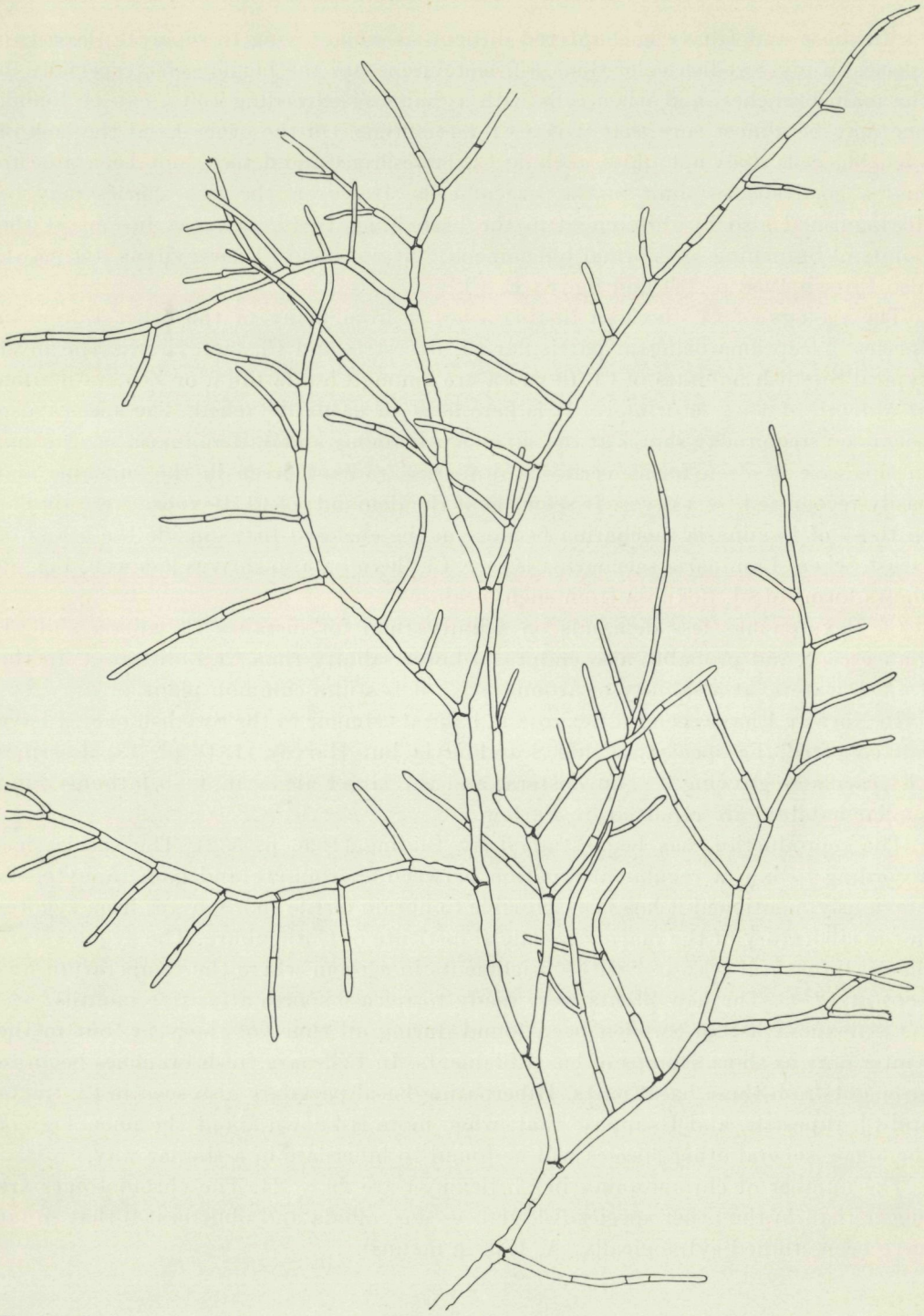


Fig. 94. Cl. flexuosa, old detached specimen among Zostera marina in a tidal stream between Henån and Kristineberg, 17.8.1951. ×20.

Cl. flexuosa and I have encountered difficulties when trying to separate those two species in my Swedish collections. Cl. laetevirens has the bigger cells, especially in the main branches, and when cells with a diameter exceeding 150 μ can be found, one may be almost sure that it is a Cl. laetevirens. On the other hand the lack of such big cells does not quite exclude Cl. laetevirens and I have not been able to find a good species limit in the size of cells. However, the two species may be distinguished also by differences in the branching. In Cl. flexuosa fusions at the points of branching are normal phenomena, but not so in Cl. laetevirens (fig. 88 cf. also Fritsch 1956 p. 234 and fig. 68 E, F).

The ecology of Cl. flexuosa distinguishes it from many of the other European species, exceptions being in particular Cl. rupestris and Cl. laetevirens. The most typical Swedish habitats of Cl. flexuosa are among Chorda filum or Zostera marina at a depth of 1—2 m or more. It is here loose or easily detached. The species also occurs on steep rocky shores at the same depth among and on Laminaria saccharina; in this case it often forms veritable draperies, radiant green in the sunshine and easily recognized by a diver. It seems as if the demands of Cl. flexuosa were similar to those of Laminaria saccharina because in the enclosed firths inside the island of Orust, where Laminaria saccharina is rare, Cl. flexuosa also thrives less well. Fig. 89 shows forms of Cl. flexuosa from such localities.

Cl. flexuosa has less demands on salinity than for instance Cl. albida and Cl. glaucescens, and probably also endures a lower salinity than Cl. oblitterata. In the Danish waters, at a salinity of around $8\,^0/_{00}$, it is still a common plant.

In Norway I have seen Cl. flexuosa in habitats similar to the Swedish ones. I have not collected the species outside Scandinavia but Harvey (1846 pl. 18) describes Cl. gracilis as growing "— on Zostera, and the larger algae, in 4—5 fathoms" and similar habitats are reported by Farlow.

The reproduction has been studied by Bliding (1936 p. 532). The species has according to him a regular alternation between sporophyte and gametophyte. As previously mentioned it has been possible to obtain fertile sporophytes from zygotes in the laboratory of the marine botanical institute of Gothenburg. The zygotes were placed in natural seawater with enrichments in a room where the temperature was kept at 12° C. The new plants were ready to release spores after five months.

Cl. flexuosa has in Sweden been found during all times of the year, but in the winter only as short stumps of basal filaments. In February fresh branches begin to grow out from these basal parts. Hibernating basal parts are also seen in Cl. fracta and Cl. rupestris, and I suppose that, when more is known about the phenology of the algae, several other species will be found to hibernate in a similar way.

The number of chromosomes in Cl. flexuosa are $2n = 24$. The chromosomes are bigger than in the other species (Cl. glaucescens, albida and oblitterata) that so far have been studied cytologically (A. Wik in manus).

Cladophora rupestris (L.) Kützing

Conferva rupestris Linnaeus 1753 p. 1167.
Cladophora rupestris Kützing 1843 p. 270.

References and synonyms

Conferva rupestris in Dillwyn 1809 pl. 23. — Lyngbye 1819 p. 156 (exclusive the variety flexuosa) and tab. 54. — C. Agardh 1824 p. 117. — Areschoug 1850 p. 194.

Cladophora rupestris in Kützing 1849 p. 396 and Tab. Phyc. IV:3. — Harvey 1849 pl. 180. — Farlow 1881 p. 51. — Kjellman 1883 p. 377. — Hauck 1885 p. 452. — Kylin 1907 p. 28. — Hylmö 1916 p. 32. — Hamel 1930 p. 19. — Newton 1931 p. 83. — Levring 1940 p. 12. — Kylin 1949 p. 51. — Waern 1952. p 80. — Taylor 1957 p. 88.

Investigated herbarium specimens

"Conferva rupestris, Leg. I. Vahl Grönland", Herb. Alg. Ag. 8633. — "Conferva rupestris, Leg. Berggren Godhavn", Herb. Alg. Ag. nr 8631. — Exsicc. Wittrock & Nordstedt nr 619 "Cladophora rupestris a) Skarsvaag prope Nordkap b) Pasvig in Finnmarkia orientalis. 1882", Brit. Museum. — "Cladophora rupestris (L.) Kütz. Halmstad 16.6.1904, — Nordkoster 6.7 1905, — Kristineberg december 1905, leg. & det. H. Kylin", Bot. Museum Lund, — "Cladophora Neesiorum var. humilis. Batters" (several specimens) Brit. Museum.

Taxonomical remarks

As Cl. rupestris is one of the few species of Cladophora that without difficulty can be recognized by its habit it has not been entailed with taxonomical difficulties. Some few diverging forms have been ascribed to other species, as for instance, Cl. Neesiorum var humilis Batters, which in the herbarium seemed to be coarse, perhaps old, specimens of Cl. rupestris. I have not listed it above among the references because it would look peculiar as the original C. neesiorum C. Agardh previously has been said to be a synonym to Cl. albida (Huds.) Kütz. Kützings wrong conception of C. Neesiorum has been adopted by many algologists and it is in Kützing's meaning that Batters gives it a variety.

Hamel has embodied Kützing's Cl. humilis, Cl. ramosissima and Cl. neesiorum (1849 p. 396 and Tab. Phyc. IV:4 and 5:) in Cl. ramosissima (Drap.) Kützing. All the three plants have, however, in Kützing's descriptions, much lesser diameter values than Hamel reports for Cl. ramosissima (Drap.) Kütz.; nor is Hamel's picture similar to Kützing's. Gayral (1958 p. 166) reports a Cl. ramossisima from Morocco. Her plants have the same diameter values as Hamel's and her picture resembles Hamel's. Cl. ramosissima in sensu Hamels sems to be a species of its own and probably not at all found on the Channel coasts as Hamel assumes. The measurements reported by Newton (1931 p. 83) for Cl. Neesiorum I assume to be borrowed from Hauck. They are not in keeping with the values given by Kützing and have reference to an Adriatic plant, perhaps the same as Cl. Neesiorum in Hamel.

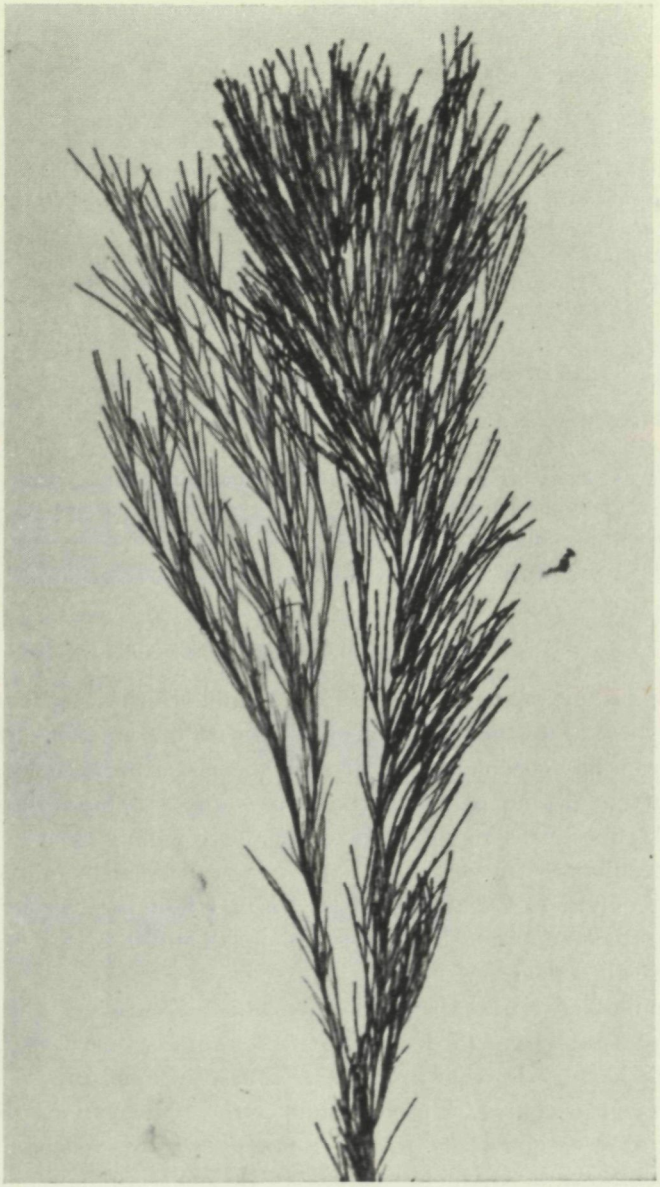


Fig. 95. Cl. rupestris, in the Fucus serratus belt in the inlet to Lough Ine, 24.7.1957. ×5.

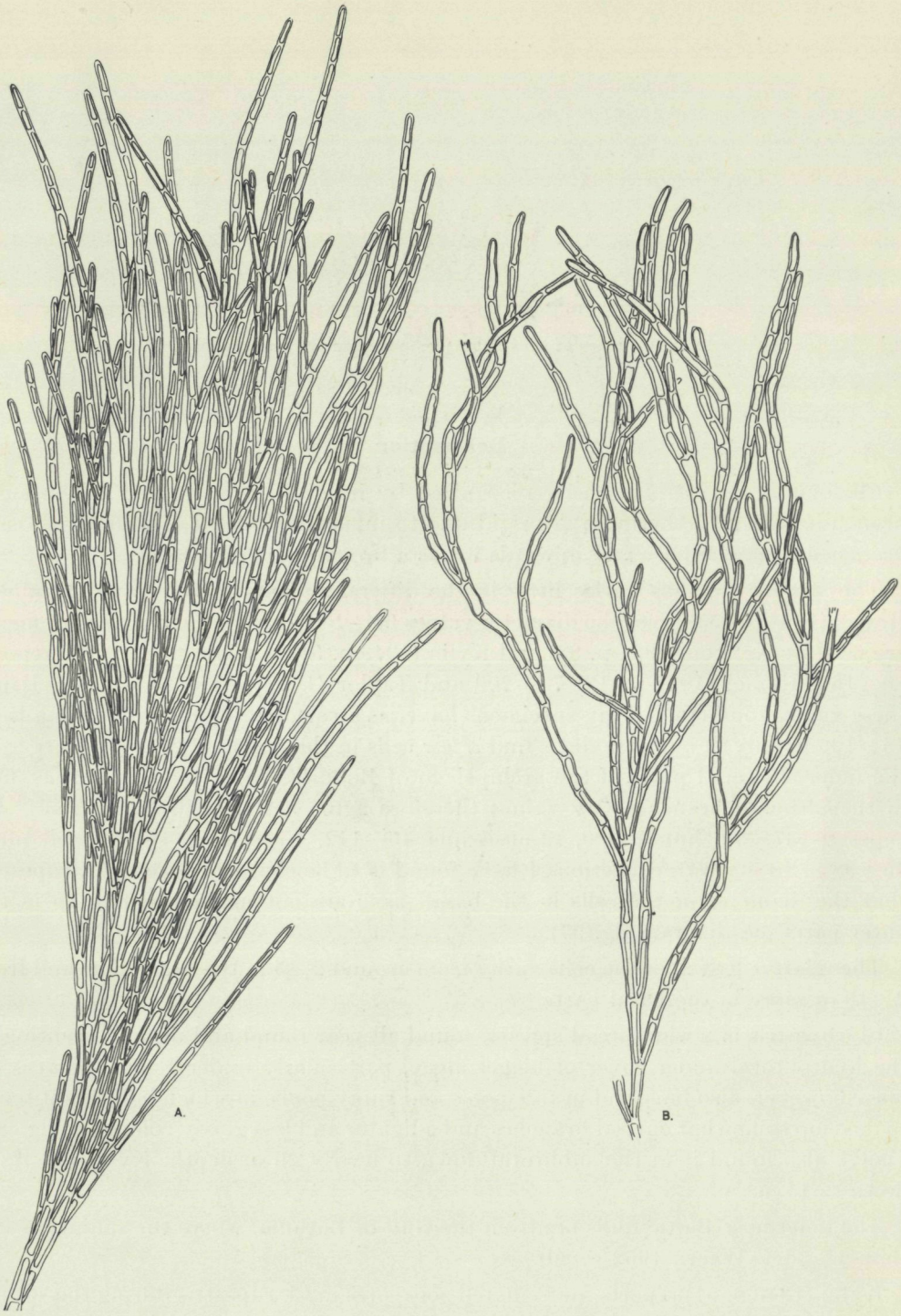


Fig. 96. Cl. rupestris, A. In the shadow under Fucus serratus, B. In a sunny pool, both from Hallands Väderö, 26.7.1955. ×20.

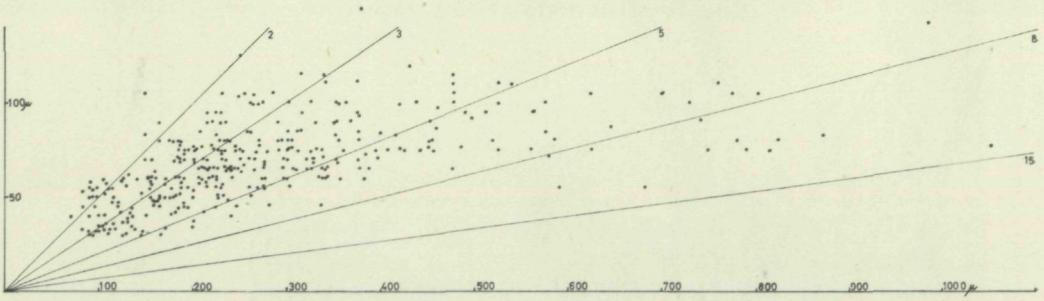


Fig. 97. Sizes of cells from five specimens of Cl. rupestris.

Description

Cladophora rupestris is easily recognized by its dark green colour and straight branches, which furthermore are rigid due to unusually thick cell walls. Copiously branched from the base and upwards it has a broom-like appearance.

The size of the cells varies little in the different plants that I have examined. Hauck (1885 p. 453) gives the diameter values 60—150 μ and the same measurements are used by Newton (1931 p. 83) and Kylin (1949 p. 51). Farlow (1881 p. 51) reports 80—160, Hamel (1931 p. 19) 70—200 and Taylor (1957 p. 88) 65—185 μ. I find these values too high. All my specimens have, as a rule, had diameters ranging from 45—125 μ; only in one case did I find a few cells in the region of 150 μ. Plants from the inner sheltered parts of the archipelago of Bohuslän have been as thin as 30 μ in the ultimate branches. My values therefore agree better with Kützing's — Cl. rupestris 37—90, humilis 90, ramosissima 45—112, Neesiorum 41—80 and nuda 45—98 μ. In my own collections I have found it to be characteristic of Cl. rupestris that the diameter of the cells in the basal parts are not much bigger than in the outer parts (cf. diagram fig. 97).

The relative length of the cells varies from around 2—5 in the branchlets and from 2—10 or more in the basal parts.

Cl. rupestris is a widespread species, found all year round and usually occuring in the hydrolitoral under cover of bigger algae, particularly under Fucus serratus. It may, however, also be found in tide pools and spray pools, in which habitats it tends to develop somewhat curved branches and a lighter and less glossy colour (cf. fig. 96). I have also found it in the sublitoral down to nearly 20 m depth; Kylin reports it down to 15 m.

The innermost Baltic finds are from the Gulf of Bothnia, where the salinity is less than 4‰ (cf. Waern 1952 p. 80).

Kylin (1949 p. 51) reports four-ciliated zoospores in Cl. rupestris during the spring. In a note in the herbarium of the British Museum R. Patel has given the number of chromosomes as $n = 12$, $2n = 24$.

Cladophora pygmaea Reinke

Cladophora pygmaea REINKE 1888 p. 2.

References

Cladophora pygmae in REINKE 1889 a p. 84. — REINKE 1889 b pl. 24. — WAERN 1940 p. 1.

Taxonomical remarks

No remarks necessary, apart from what is already written by Waern.

Description

Cl. pygmaea is a dwarf among the marine species of the genus. A similar small species — Cl. basiramosa Schmidle (cf. Waern 1939 p. 44 and fig. 4) — is known to frequent fresh waters but otherwise Cl. pygmaea stands alone in the genus. The tufts are only a mm high and Waern therefore assumes that the species is often overlooked. The diameter of the cells is said by Reinke to be 25—50 μ, Waern's specimens, which were collected in July, measured 25—75 μ. My own specimens were collected in February and were partly thinner than Waern's, some end cells in my specimens having a diameter of only 14 μ. The size of these cells is about the same as in Cl. albida, but I do not think that the plants represent young states of either this or any other species, as the cells grow in quite a specific manner (see diagram fig. 98). The intercalary divisions and the thickening of the threads from the base upwards has led Waern to a discussion of a possible relation to Chæto-

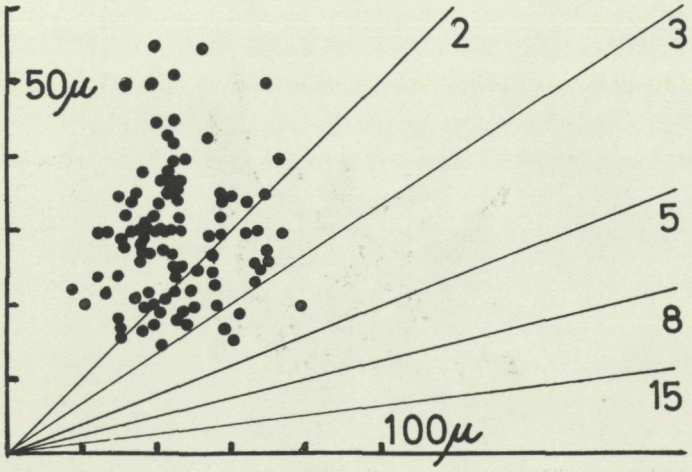


Fig. 98. Sizes of cells from the specimens of Cl. pygmaea shown in fig. 100—102.

Fig. 99. Cl. pygmaea, young plant on Ralfsia-crust. Locality see text. × 55.

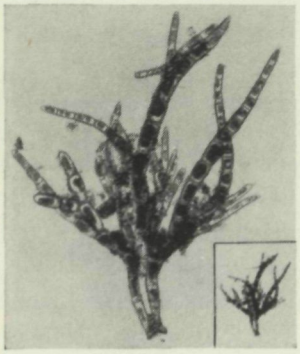


Fig. 100.

Fig. 101.

Fig. 100. Cl. pygmaea, intercalary divisions have barely started. × 55; incised the same specimen × 15, the enlargement used in the majority of the microphotographs.

Fig. 101. Cl. pygmaea, the branches broaden in the outer parts, note also the triangular basal cells. × 55.

Fig. 102. Cl. pygmaea, old specimen, the clustered appearance is mostly due to the broadening of the branches. × 55.

morpha. However, neither the intercalary divisions nor the fact that the branches thicken uppwards are unknown in other species of the genus, and the young branches of Cl. pygmaea show the normal aspect of Cladophora (fig. 99).

Reinke found Cl. pygmaea at a depth of 7—20 m in the bay of Kiel. Waern, who detected the species in Sweden in some narrow passages with tidal streams near Kristineberg, gives the depth as 6—7 m. My own find was made on 15. 2. 1957 near Henån (see map) in the enclosed system of small firths, connected with the outer parts of the archipelago of Bohuslän through the above-mentioned narrow passages. My find was not made at the depths reported by Reinke and Waern, but at 0.5 m in the Fucus serratus belt. Cl. pygmaea grew here on stones covered by a crust of Ralfsia verrucosa.

Cladophora laetevirens (Dillw.) Kützing

Conferva laetevirens Dillwyn 1809 pl. 43.
Cladophora laetevirens Kützing 1843 p. 267 (Nomen sed non specimen).

References and synonyms

Conferva laetevirens in Harvey 1841 p. 136.
Cladophora laetevirens in Harvey 1849 pl. 190. — Harvey 1857 p. 82. — Farlow 1881 p. 53. — Taylor 1957 p. 87.
Cladophora utriculosa Kützing 1843 p. 269, 1849 p. 393 and Tab. Phyc. II:95:1. — Hauck 1885 p. 454 (partim?). — Hamel 1930 p. 25. — Newton 1931 p. 85.
Cladophora falcata Harvey 1849 pl. 216. — Kützing 1849 p. 399 (exclusive the reference to Harvey Phyc. Brit. pl. 124) and Tab. Phyc. IV:14:I.
(Non Cladophora laetevirens in Kützing 1849 p. 400 and Tab. Phyc. IV:15:I, nec Cl. laetevirens Kylin 1907 p. 29.)
Cl. sericea Hamel 1930 p. 33.

Investigated herbarium specimens

"C. laetevirens Holyhead" (A note on the sheet shows a possibility that this specimen had been seen by Dillwyn), Herb. H. Davies, Brit. Museum. — "Conferva laetevirens" several specimens, Herb. Harvey, Trinity College, Dublin. — "Conferva falcata Dingle Bay", Herb. Harvey, Trinity College, Dublin. — "Cladophora utriculosa det. G. Hamel", Biol. Station, Dinard. — "Cladophora, Bohuslän, Kristineberg, 28.8.1931, Leg. S. Suneson, Bot. Mus. Lund. — "Cladophora gracilis (Griff.) Kütz.? Bohuslän, Kristineberg, 10 m. 27.7.1945. — Ibid. Nordkoster, 2 m. 12.8.1945, Leg. T. Levring", Marine Bot. Inst., Göteborg. Exsicc.: Wyatt Alg. Danmon. nr 143 "Conferva glomerata".

Taxonomical remarks

The nomenclatural connection between C. sericea Hudson and C. laetevirens Dillwyn has been commented upon under Cl. glomerata. The name sericea is a very good example to article 65 in the nomenclatural code — "A name must be

Fig. 103. Cl. laetevirens, tide pool in the lower hydrolitoral, Ballydonegan 4.8.1957. (Compare this fig. with the Cl. glomerata in fig. 28 and 30 B.) ×15.

rejected if it is used in different senses and so has become a long persistent source of error."

When Kützing transferred C. laetevirens Dillwyn to Cladophora he made a description that does not apply to Dillwyn's plant, but as he clearly indicates that he meant to transfer Dillwyn's species the combination Cl. laetevirens (Dillw.) Kützing is correct according to rule 55 in the code.

Hamel (1930 p. 21) writes the following about Conferva Neesiorum C. Agardh: "Hauck qui a étudié un échantillon authentique conservé dans l'herbier du Muséum de Paris, rapporte le C. Neesiorum Ag. au Cl. albida Kütz. Le nom de Cl. Neesi-

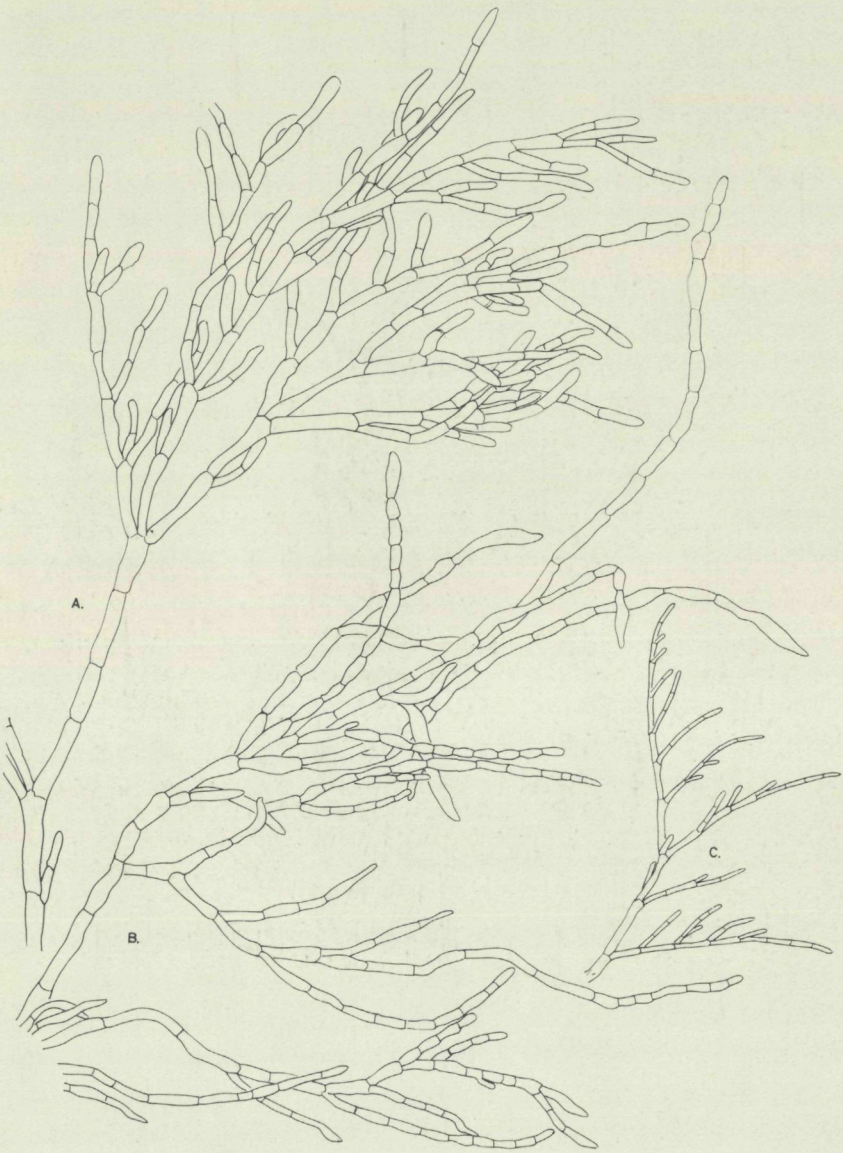


Fig. 104. Cl. laetevirens and Cl. glomerata. A. Nr 143 "Conferva glomerata" in Wyatt Alg. Danmon, the basis for Cl. laetevirens in Harvey, B. Old branch from a specimen of Cl. glomerata from Bohuslän (Henån 25.6.1951) which indeed is very difficult to tell apart from A, but C shows a young branch from the same population and that is clearly a Cl. glomerata-branch, often a single specimen is not sufficient as a basis for a determination. $\times 20$.

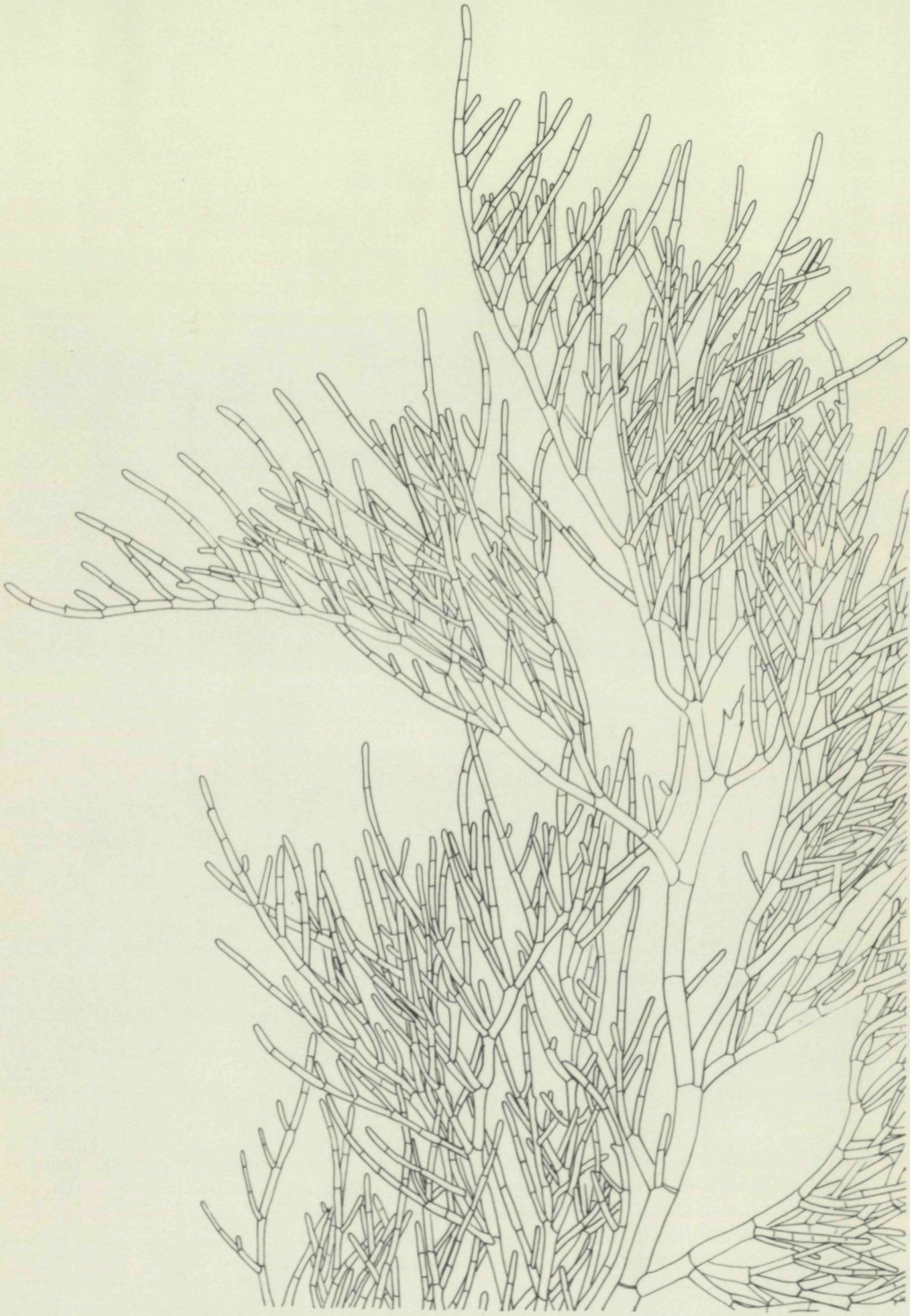


Fig. 105. Cl. laetevirens, a drawing made from the specimen in fig. 103. Note the points of branching which are of another type than in Cl. flexuosa. ×20.

Fig. 106. Cl. laetevirens, A. At a depth of 3 m on east side of skerry Bonden outside Kristineberg, 22.8.1955. B. At a depth of 10 m, leg. T. Levring, Kristineberg, 27.7.1945. C. Tide pool in the lower hydrolitoral, Cahirciveen, 8.8.1957. D. Coarse specimen from a small tidal stream in the lower hydrolitoral, Dinard, 20.6.1962. E. Short-celled specimen from a tide pool in the middle of the hydrolitoral, Plymouth, 16.7.1962. × 20.

Fig. 107. Cl. utriculosa and Cl. sericea as pictured by Hamel (1930 fig. 8 and 11). The two drawings to the left are of Cl. utriculosa and Cl. utriculosa var. lutescens, the two to the right Cl. sericea and Cl. sericea var. Ruchingeri.

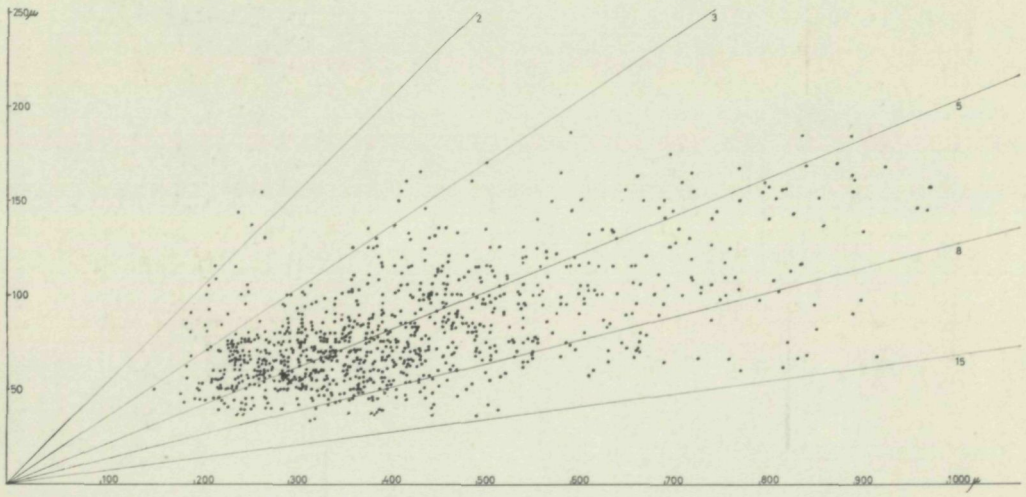


Fig. 108. Sizes of cells from 10 specimens of Cl. laetevirens. (The same specimens as in table 6.)

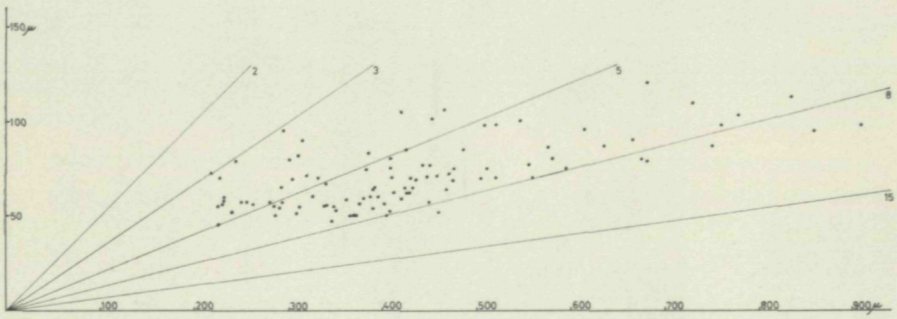


Fig. 109. Sizes of cells from the specimen shown in fig. 111. The size of the cells does not quite exclude Cl. flexuosa.

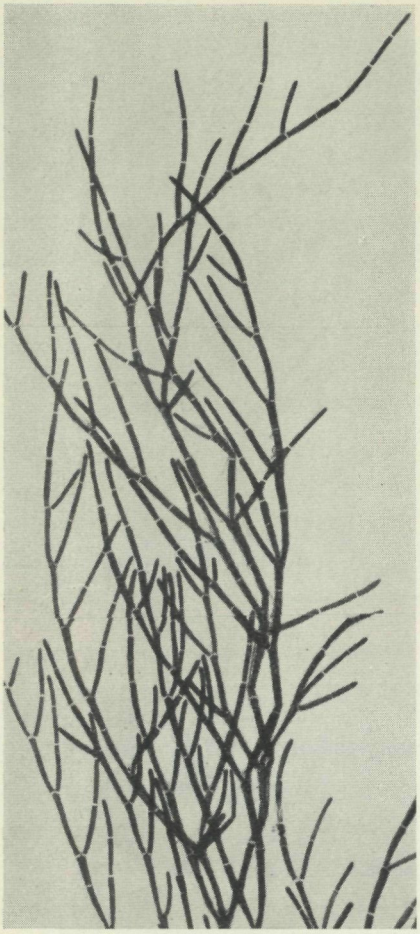


Fig. 110.

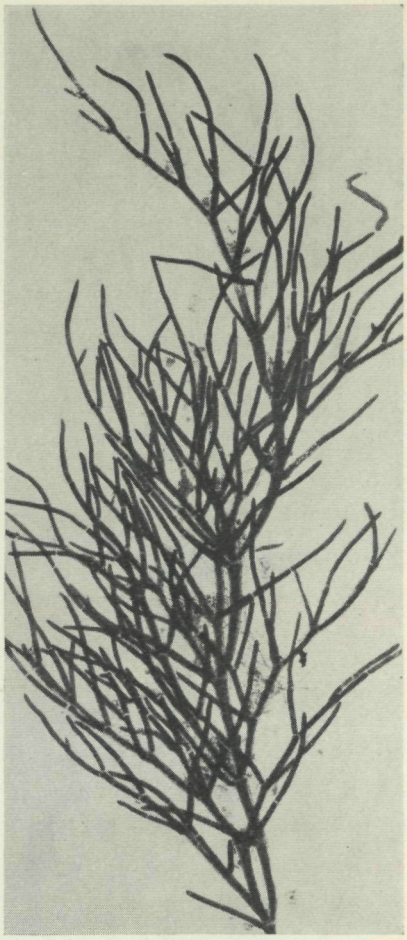


Fig. 111.

Fig. 110. Cl. laetevirens, at a depth of 3 m on east side of Skerry Bonden, outside Kristineberg, 22.8. 1955. This is the thinnest and most flexuosa-like branch that I have found, compare with fig. 111, which shows a coarser specimen from the same locality and also fig. 84, which shows a Cl. flexuosa from a similar locality at Koster. Cl. laetevirens is somewhat bigger, and the cells in the main branches are more triangular-shaped; add to this the difference at the points of ramification shown in fig. 88 and it will be possible to tell them apart. ×15.

Fig. 111. Cl. laetevirens, the same locality as in fig. 110. A coarser and more typical branch. ×15.

orum doit donc disparaitre et il est curieux que Hauck l'ait conservé." The same words could be used about Cl. utriculosa, a name that is used by Hamel. Hauck, when describing Cl. utriculosa, included Cl. laetevirens Harvey, and Hamel assumes that Cl. falcata Harvey, a species that Harvey himself could not with certainty distinguish from Cl. laetevirens, is a form of Cl. utriculosa Kützing. Hamel seems to have overlooked that C. laetevirens emanated from Dillwyn and tried to reject

Fig. 112

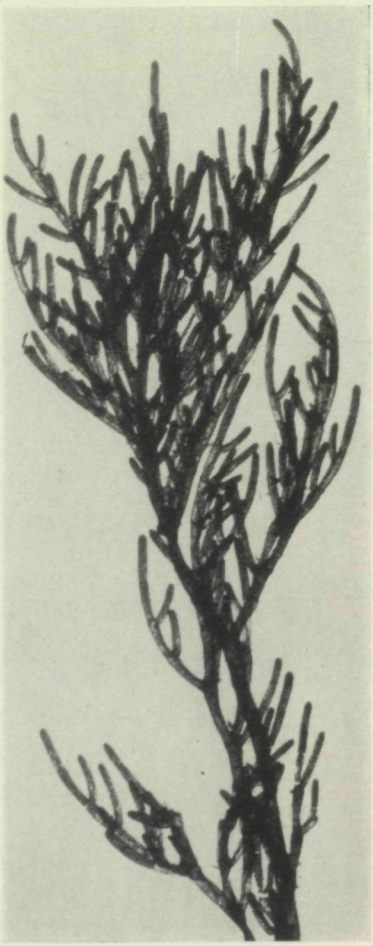


Fig. 113.

Fig. 112. Microphotograph of the plant also shown in fig. 106 C. ×15.

Fig. 113. Cl. laetevirens, lowest hydrolitoral, Wembury, Plymouth, 20.7.1962. This specimen has sizes of cells approaching the values in Cl. Hutchinsiae, but the ramification is similar to more ordinary specimens of Cl. laetevirens. ×15.

the name laetevirens on the ground that he had found that the specimens of nr 143 "Conferva glomerata" in Wyatt's exsicc. were of two types. This has naturally nothing to do with Dillwyn's original taxon. Hamel's discussion on Wyatt's specimens is also in other respects difficult to follow. One of the specimens he found to have cell diameters of the size 100—250 μ and this plant he meant must be a Cl. utriculosa. These measurements, however, do not distinguish it from Cl. Hutchinsiae, which even in Hamel's own description is only a little coarser. The other Wyatt specimen that Hamel examined was found to have diameters of the size 60—125 μ. He assumed this plant to represent what Harvey described as Cl. laete-

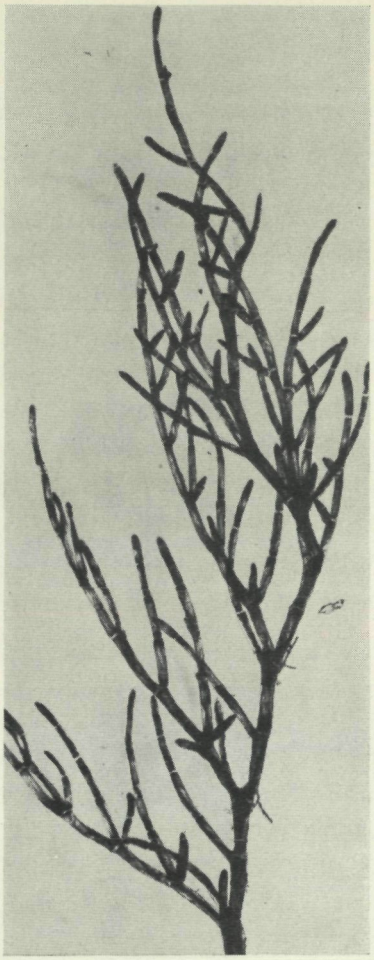


Fig. 114. Cl. laetevirens, at a depth of 10 m, Kristineberg, 27.7.1945. Leg. T. Levring. (The picture is made from a dried plant which has been softened in water.) × 15.

virens and Hamel called it Cl. sericea. However, if Hamel's pictures of Cl. utriculosa and Cl. sericea are compared on the same scale it is evident that no difference in the size of the cells exists between the two, Cl. sericea appears even a little coarser than Cl. utriculosa (fig. 107). I have therefore united Cl. utriculosa in Hauck, Cl. utriculosa in Hamel and Cl. sericea in Hamel under Cl. laetevirens sensu Harvey, whose opinion of Dillwyn's plant seems to be correct. It is, however, quite possible that forms of Cl. Hutchinsiae (Dillw.) Kützing are included in both Hauck's and Hamel's utriculosa and that can explain the reported measurements.

I do not think it possible to keep apart Cl. falcata Harvey from Cl. laetevirens (Dillw.) Kützing. The curved branches pictured by Harvey are certainly only modifications due to the environment. I observed on the Irish west coast specimens with

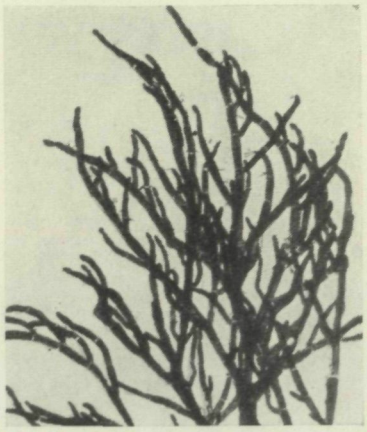


Fig. 115. Cl. laetevirens, somewhat exposed tide pool in the lower hydrolitoral, Roundstone, 12.8.1957. Judging by its epiphytes on the basal parts and thickenings in the cellwalls, this was an old specimen. The end cells show irregularities similar to what is pictured by Kützing in Cl. utriculosa, Tab. Phyc. III:94:I. ×15.

curved end branches in wave-exposed localities (fig. 117) as well as a gradual change to normal specimens of Cl. laetevirens. I also suspect that Cl. dalmatica Kützing (cf. Hamel 1930 p. 31) belongs here.

Description

Cladophora laetevirens forms dense tufts of a dull yellow-green colour; some specimens have a more clear green colour and occasionally specimens may be found that are a little glossy. In the specimens that I have referred to Cl. laetevirens the size of the cells varies from 35—125 × 185—900(—1250) μ to 60—265 × 240—1400 μ. The more gracile forms therefore do not differ in this respect from coarser forms of Cl. flexuosa. However, such long basal cells as are seen in Cl. laetevirens are exceptions in Cl. flexuosa and there is also a difference in the ramification (fig. 88). It is more difficult for me to state the difference between Cl. laetevirens and Cl. Hutchinsiae. My material, especially of the last named, is too restricted. Two plants collected in the same pool in the lowest hydrolitoral at Wembury near Plymouth (nr P40/62 in the table and fig. 123 A and C), have been particularly difficult. They differ very little both in actual size of the cells and in relative length of the cells. However, one of them (fig. 123 C) has the clustered and somewhat curled branches that are characteristic of Cl. laetevirens in exposed localities, while the other has the same appearance as some of the more typical and coarser Cl. Hutchinsiae that I have collected in the tidal streams in the entrance to Lough Ine. As shown in table 6, there is a slight difference in the thickness of the two plants, the one I suppose to be Cl. laetevirens has considerably more cells with a diameter below 80 μ. This measure I give as a proposal for a limit between Cl. laetevirens and Cl. Hutchinsiae. More investigations are necessary, however, before a more definite statement can be made.

Fig. 116. Cl. laetevirens, from the same pool as in fig. 115. Like the plant in fig. 110 this might be mistaken for Cl. flexuosa. ×15.

Cl. laetevirens is in western Europe a plant that inhabits the tide pools in the middle of the hydrolitoral, on the Swedish west coast, where the hydrolitoral is restricted to some few dm, the few specimens found have grown in the sublitoral at a depth from 2—10 m. It is not found in brackish water.

R. Patel (note in herb. Brit. Museum) has reported the number of chromosomes to be n=12, 2n=24. He called his plant Cl. sericea, but to me it seemed identical with the Cl. laetevirens in Harvey's herbarium.

TABLE 6. *Relative length of cells and percentage of cells with a diameter below 80 μ in some specimens of Cl. laetevirens and Cl. hutchinsiae.*

(For explanation see table 1 p. 46)

Cl. laetevirens									
— 2	— 3	— 5	— 8	— 15	—		<3	3—8	<80 μ
0	0	21	75	4	0	Kristineberg 1945	0	96	61
0	0	25	68	7	0	B6/55	0	93	72
0	3	34	58	5	0	Eir74/57	3	92	76
0	2	36	45	16	0	Din19/62	2	81	53
0	0	46	53	1	0	Kristineberg 1931	0	99	10
0	2	50	44	4	0	Eir51/57	2	94	61
0	1	64	32	3	0	Eir74/57 (old)	1	96	72
0	6	71	16	7	0	Din13/62	6	87	32
4	13	64	19	0	0	P8/62	17	83	51
3	12	68	17	0	0	P40/62a	15	85	21
Cl. hutchinsiae									
— 2	— 3	— 5	— 8	— 15	—		<3	3—8	<80 μ
1	25	47	27	0	0	Holland 1961	26	74	2
0	16	70	13	0	0	P40/62b	16	83	1
0	36	63	1	0	0	Din6/62	36	64	0
9	47	41	3	0	0	Eir4/57	56	44	0

Description of the localities.

Kristineberg 1945, at a depth of 10 m, leg. T. Levring, 27.7.1945. — B6/55, sublitoral at a depth of 3 m, east side of skerry "Bonden" outside Kristineberg, 22.8.1955. — Eir74/57, somewhat exposed tide pool in the lower hydrolitoral, Dogs Bay, Roundstone, 12.8.1957. — Din19/62, tide pool in the lower hydrolitoral, Dinard, 22.6.1962. — Kristineberg 1931, leg. S. Suneson (measured on a drawing made from a hard pressed specimen). — Eir51/57, tide pool, about 1 m above l.w.l., Ballydonegan, 4.8.1957. — Eir74/57, the same locality as Eir 74 above but a seemingly older specimen, Roundstone 12.8.1957. — Din13/62, in a small tidal stream in the lower hydrolitoral, Dinard 20.6.1962. — P8/62, tide pool in the middle hydrolitoral, Plymouth 16.7.1962. — P40/62, pool at l.w.l., Wembury, Plymouth, 20.7. 1962. — Holland 1961, salt water canal with polluted water, Kanaal door Zuid Beveland, the Netherlands, leg. G. Michanek, 28.9.1961. — P40/62 b, the same locality as P40 above, Plymouth, 20.7.1962. — Din6/62, in a big tide pool in the middle of the hydrolitoral, Dinard 19.6.1962. — Eir4/57, in "The Rapids", Lough Ine (for further information concerning this locality see Ebling, Kitching, Purchon and Bassindale 1948), among Laminaria saccharina and Himanthalia lorea a little beneath l.w.l., 24.7. 1957.

Fig. 117. Cl. laetevirens, tide pool in the lower hydrolitoral, Ballydonegan, 4.8.1957. This picture shows the form of Cl. laetevirens that Harvey must have meant with Cl. falcata. × 15.

Cladophora Hutchinsiae (Dillw.) Kützing

Conferva Hutchinsiae Dillwyn 1809 pl. 109.
Cladophora Hutchinsiae Kützing 1845 p. 210.

References and synonyms

Conferva Hutchinsiae in C. Agardh 1824 p. 120. — Harvey 1841 p. 135.
Cladophora Hutchinsiae in Harvey 1849 pl. 124. — Kützing 1849 p. 391 and Tab. Phyc. III:87:I. — Farlow 1881 p. 53. — Hamel 1930 p. 11. — Newton 1931 p. 82. — Taylor 1957 p. 88.
Conferva diffusa in Dillwyn 1809 pl. 21. — Harvey 1841 p. 136. (Non Conferva diffusa Roth 1800 p. 207).
Cladophora diffusa in Harvey 1849 .— Kützing 1853 Tab. Phyc. III:88:I.
Conferva distans C. Agardh 1824 p. 120.
Cladophora Macallana Harvey 1846 pl. 84. — Kützing 1849 p. 392. and Tab. Phyc. III:86:II. — Hamel 1930 p. 15. — Newton 1931 p. 82.
Cladophora hormocladia Kützing 1849 p. 391 and Tab. Phyc. III:87:II.

Investigated herbarium specimens

"Conferva Hutchinsiae leg. L. W. Dillwyn" (type specimen), Brit. Museum. — "Conferva Hutchinsiae Bantry Bay, Ellen Hutchins.", Herb. Alg. Ag. nr 9325. — "Cladophora diffusa Roundstone 1846, M'Calla", ibid. Valentia 1845 (Harvey?)", Herb. Harvey, Trinity College, Dublin. — "Cladophora Macallana Roundstone 8/46, W. H. Harvey.", Brit. Museum. — "Conferva distans", Herb. Alg. Ag. nr 9291—9315. — "Mazé: Guadeloupe, Cl. fascicularis", Taylor has noted "axis 400 μ diameter Ram. 100—154 μ, Cl. Hutchinsiae fa?", Brit. Museum.

Taxonomical remarks

Cladophora Hutchinsiae is usually easy to recognize and what problems there are have arisen out of less typical forms. Harvey separated Cl. Hutchinsiae and Cl. diffusa on the ground that the latter was less branched. The two were united by Kützing in 1849, but in Tab. Phyc. the name diffusa is reinstated. Later on they were again united by Farlow. I studied Cl. Hutchinsiae in the inlet to Lough Ine, where the species was abundant in July 1957, and found several forms intermediary between the marked Hutchinsiae and diffusa plants. My impression was that the long branches without branchlets represented a younger state.

C. Agardh who possessed an authentic specimen of C. diffusa Roth considered C. diffusa Dillwyn to be another species and so he named the latter C. distans. Kützing rightly put C. distans as a synonym to Cladophora diffusa Harvey. C. diffusa Roth he made a variety of Cl. utriculosa Kützing which coincides with my opinion that C. diffusa Roth belonged to Cl. flexuosa (Müll.) Kütz., and that in extreme cases Cl. Hutchinsiae and Cl. laetevirens are difficult to separate. Cladophora Lehmanniana (Lindenberg) Kützing is an example of these difficulties. Judging by the picture (Tab. Phyc. III:90:I) and the measurements — 84—188 μ diameter —

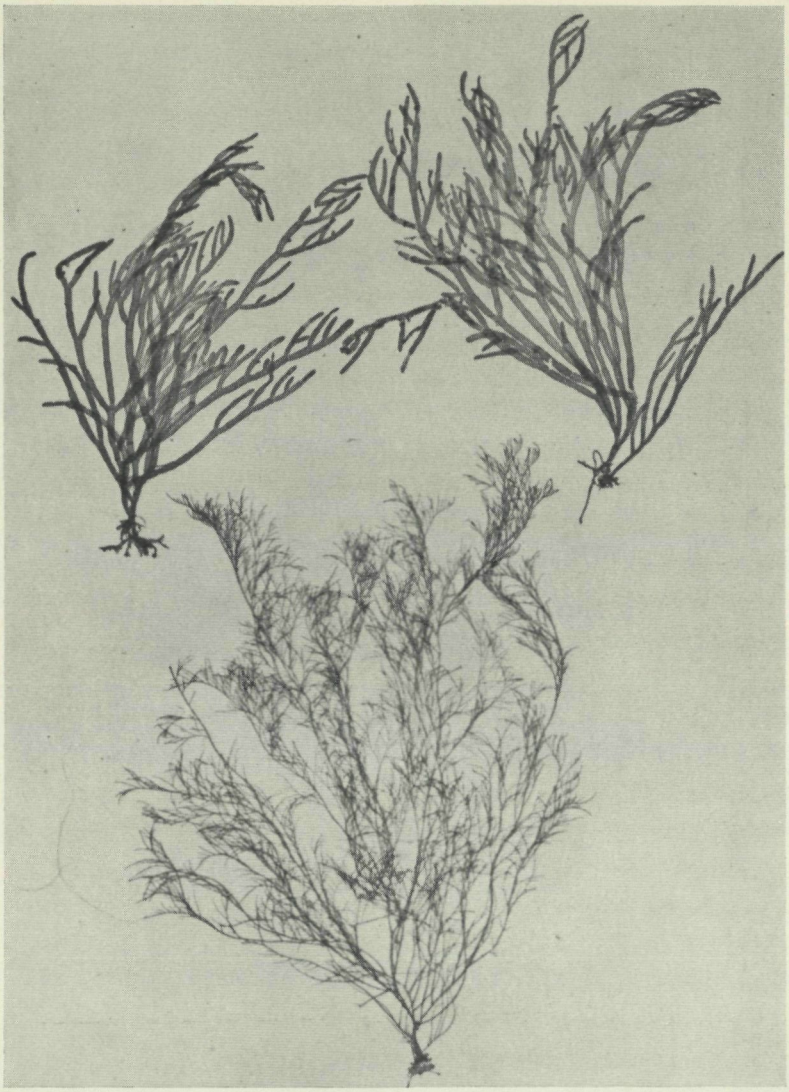


Fig. 118. Cl. Hutchinsiae and Cl. albida. "The rapids", Lough Ine, 24.7.1957. Already the small plants of only a few mm to a cm height have the big cells characteristic of Cl. Hutchinsiae. ×6.

it looks like a Cl. Hutchinsiae, but if one takes into consideration that Kützing probably measured a pressed specimen the measurements do not exclude a well-grown Cl. laetevirens. I have therefore not listed it among the synonyms, though I am quite convinced that it is not a distinct species.

Judging by the specimen mentioned above, Cl. Macallana is only a modification of Cl. Hutchinsiae. Cl. hormocladia was Kützing's name for Cl. Hutchinsiae var. divaricata Harvey Herb., and was based on a specimen sent by Harvey.

Fig. 119. Cl. Hutchinsiae, in the uppermost sublitoral among Laminaria saccharina and Himanthalia lorea, "The rapids", Lough Ine 25.7.1957. The plant to the left represents what Harvey called Cl. diffusa, the one to the right is more branched. Note that the latter probably is older as it has released spores in the top branches. × 5.

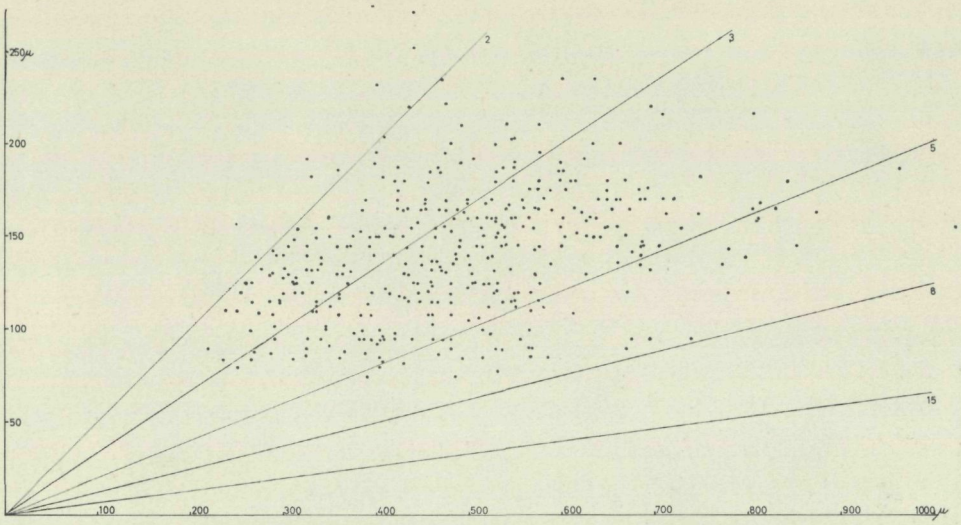


Fig. 120. Sizes of cells in four specimens of Cl. Hutchinsiae. (The same specimens as in table 6.)

Description

I have only collected Cl. Hutchinsiae in three localities and therefore cannot add much to the existing descriptions. The specimens that I have referred to Cl. Hutchinsiae have all been characterized by great cell diameters and cells with a low relative length (Diagram fig. 120 and table 6). I have under Cl. laetevirens proposed 80 μ as the lower limit for Cl. Hutchinsiae. (Kützing 90—285, Farlow 100—240, Hamel 125—400, Taylor 90—400 and my own measurements 75—275 μ).

Another species which may be confused with Cl. Hutchinsiae is the subtropical Cl. fascicularis. Regarding Cl. Lehmanniana, Kützing says that it can hardly be distinguished from Cl. fascicularis, and I have found many herbarium specimens called Cl. fascicularis to be nearly identical with Cl. Hutchinsiae. If Cl. fascicularis is a distinct species or not I cannot discuss, since I know nothing about the subtropical flora besides what little can be learnt out of herbariums.

Harvey and Farlow both report Cl. Hutchinsiae from tide pools in the lower hydrolitoral. I have also collected it in such habitats, but I found more beautiful specimens at Lough Ine in tidal streams, growing among Laminaria saccharina and Himanthalia lorea in the upper sublitoral. No finds from Scandinavian waters are known to me; the Cl. diffusa in Kylin 1949 I regard as a form of Cl. flexuosa and I am quite convinced that the diameter values that are mentioned by Kylin have not hitherto been seen in Sweden. The description that Kylin gives to Cl. diffusa was originally used by Hauck (1885 p. 453) for Cl. Hutchinsiae β distans. I found no plant answering to this description in Kylin's herbarium.

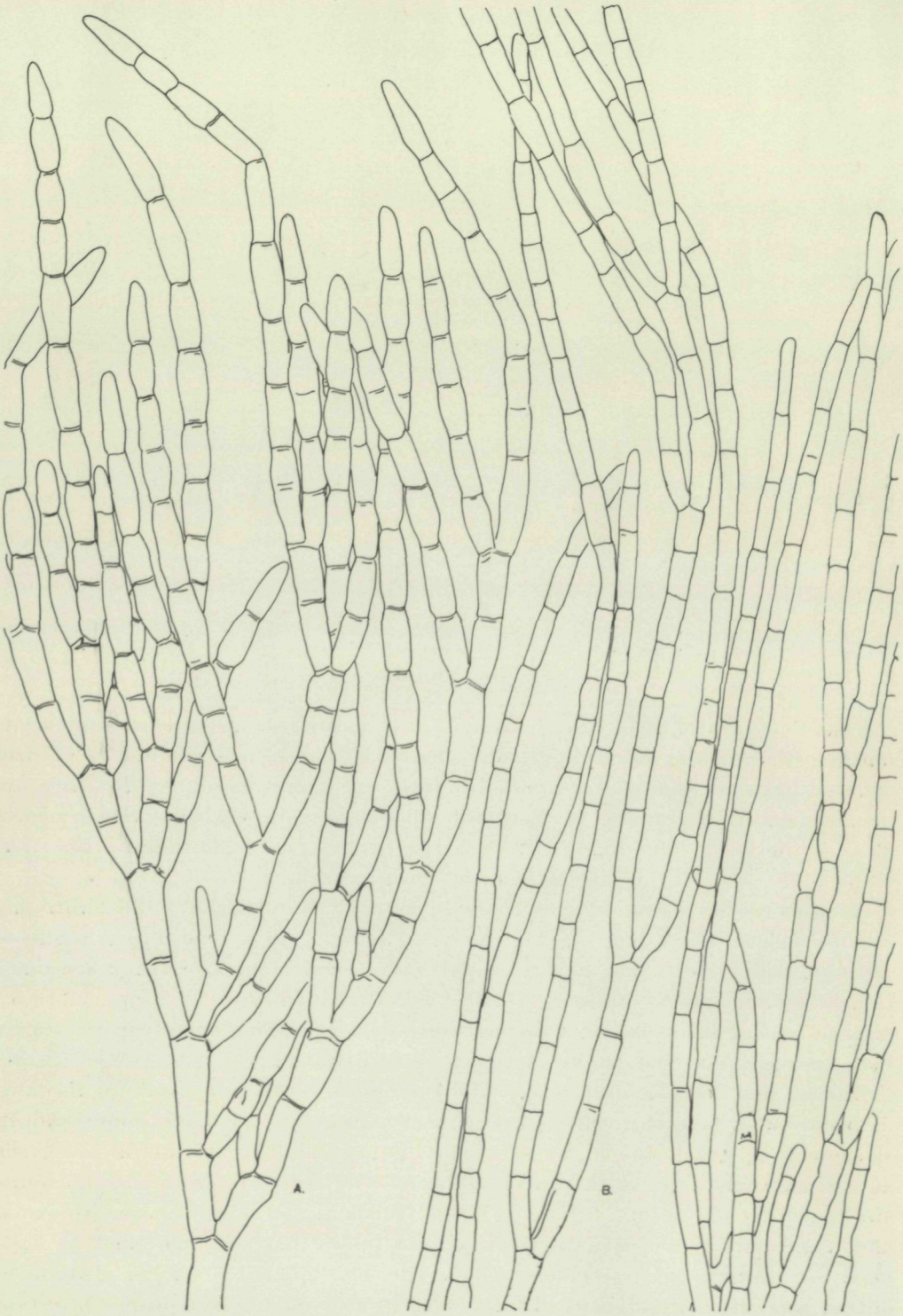


Fig. 121. A. Cl. Hutchinsiae from a big tide pool in the middle of the hydrolitoral, Dinard, 19.6.1962. B. Cl. Hutchinsiae from the uppermost sublitoral in "The rapids", Lough Ine, 24.7.1957. The plant to the left seems to be difficult to tell apart from the mediterranean Cl. catenata as this species is pictured by Hamel 1930. $\times 20$.

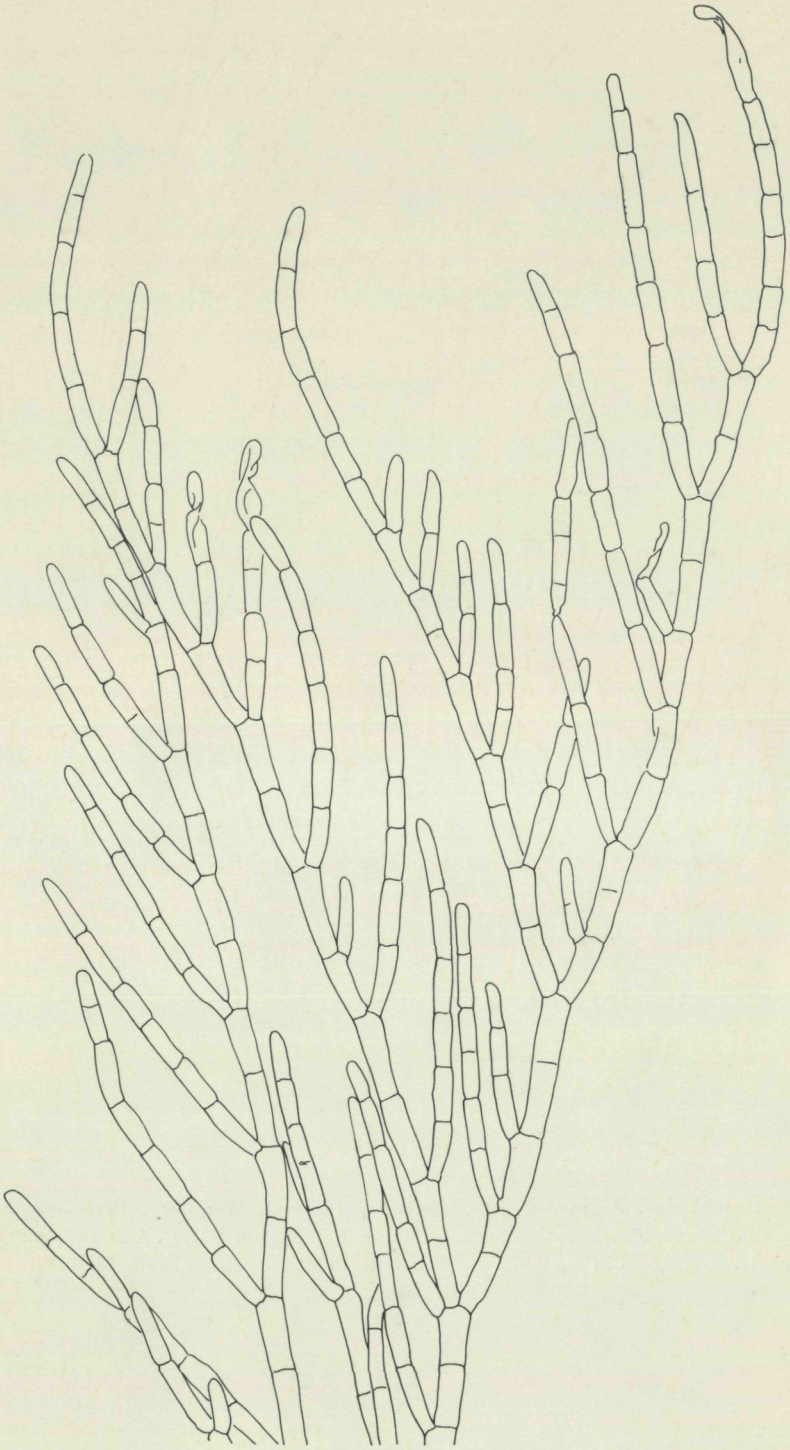


Fig. 122. Cl. Hutchinsiae, ordinary branched plant from "The rapids", Lough Ine, 24.7.1957. ×20.

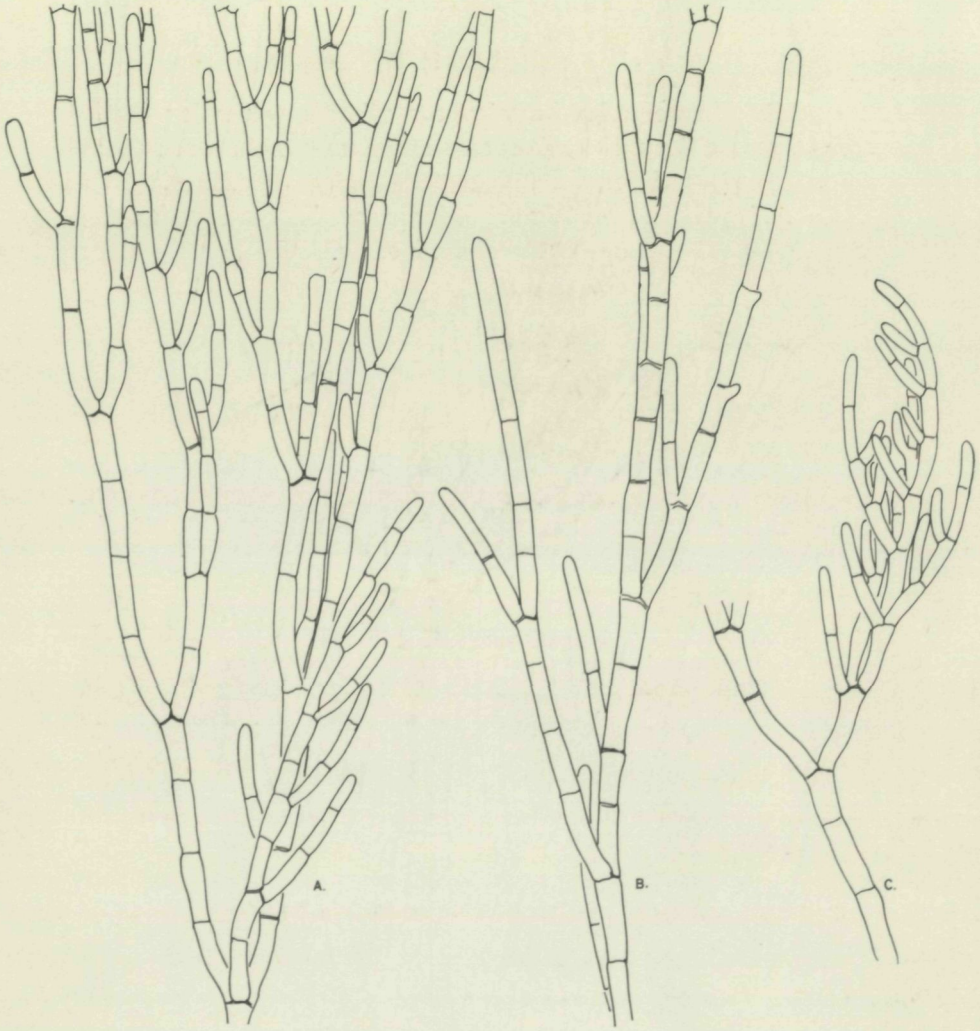


Fig. 123. Cl. Hutchinsiae. A. pool in the lowest hydrolitoral, Wembury, Plymouth, 20.7.1962. B. Kanaal door Zuid Beveland, the Netherlands, leg. G. Michanek 28.9.1961. C. A branch from the specimen of Cl. laetevirens also shown in fig. 113. The difference in size of cells is negligible but the ramification is different. $\times 20$.

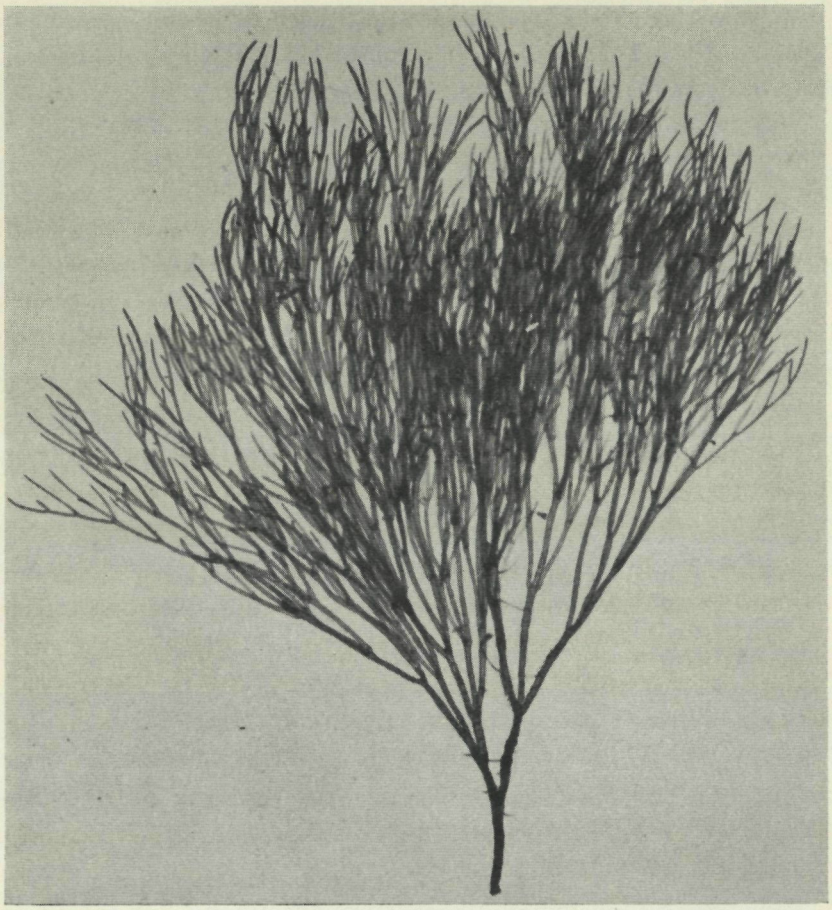


Fig. 124. Cl. pellucida, tide pool in the lower hydrolitoral, Ballydonegan, 4.8.1957. × 5.

Cladophora pellucida (Huds.) Kützing

Conferva pellucida Hudson 1778 p. 601.
Cladophora pellucida Kützing 1845 p. 208.

References

Conferva pellucida in Dillwyn 1809 pl. 90.
Cladophora pellucida in Harvey 1849 pl. 174. — Kützing 1849 p. 390 and Tab. Phyc. III:83:II. — Hamel 1930 p. 3. — Gayral 1958 p. 164.

Remarks

This and the following species are considered rare on the Atlantic shores of Europe. They should probably be regarded as subtropical species occasionally found in the south part of the temperate region. It is significative that they have not been

found on the shores of New England, though at least Cl. prolifera is reported from North Carolina (Hoyt 1920 p. 429). The northernmost European finds are from Clare Island (Cotton 1912 p. 93).

Description

Cladophora pellucida is easily recognized by its long basal cells and regular branching. It has a more pure green colour than Cl. prolifera. Kützing reports the diameter of the cells to be 90—285 μ and Hamel 150—500 μ. In a specimen from Dinard that I myself measured I found the following sizes of cells: end cells 60—90 × 450—960 μ, cells in the branches 100 — 250 × 1200—7000 μ. The basal cell was 375 × 7200 μ.

The usual habitat of Cl. pellucida seems to be rock pools in the lower hydrolitoral.

Gayral reports four-ciliate zoospores and bi-ciliate gametes from different plants.

Cladophora prolifera (Roth) Kützing

Conferva prolifera Roth 1797 p. 182 and Tab. II fig. 2.
Cladophora prolifera Kützing 1845 p. 207.

References

Cladophora prolifera in Kützing 1849 p. 390 and Tab. Phyc. III:82:III. — Cotton 1912 p. 111. — Hamel 1930 p. 5. — Gayral 1958 p. 169.

Investigated herbarium specimen

"Conferva prolifera R. Cat. Bot. Tom. 1. pag. 182 e mari Mediterrani. Prof. Mertens jan. 1801", Kew Herb.

Remarks

Roth informs us that Cladophora prolifera was first collected in Corsica by Mertens. I suppose the above-mentioned specimen may therefore be used as a neotype. Cl. prolifera has sometimes been confused with Cl. pellucida, which sometimes has a darker colour for instance than Dillwyn describes and it has also the long basal cells in common with Cl. prolifera. Turner (in Dillwyn 1809 pl. 90) thought that C. prolifera β tenuior Roth belonged to C. pellucida. Furthermore specimen called "Conferva prolifera Roth var viridis" by Mertens looked to me just the same as Hamel describes Cl. catenata.

I have not collected this species myself. Cotton found it in shady rock pools. It seems to be a not uncommon plant in subtropical and tropical waters.

Gayral reports the reproduction to be similar to that of Cl. pellucida.

Cladophora rectangularis (Griff. ex Harvey) Harvey

Conferva rectangularis Griffiths ex Harvey in Hooker 1833 p. 10.
Cladophora rectangularis Harvey 1846 pl. 12.

References and synonyms

Cladophora rectangularis in Kützing 1849 p. 395 and Tab. Phyc. III:100:II. — Hamel 1930 p. 14.
Cladophora Crouanii Kützing 1853 Tab. Phyc. III:100:I.

Investigated herbarium specimens

"Conferva rectangularis" several specimens from Roundstone Bay, Herb. Harvey, Trinity College, Dublin.

Remarks

This species is so easily recognized and has such a peculiar ramification that I cannot imagine it to be overlooked in a collection of algae. As it is only reported from the Channel coasts and the Irish west coast, Cl. rectangularis seems to be an example of a Cladophora species with a local distribution. I have only seen herbarium specimens and for a description I refer to Harvey.

Cladophora boodleoides Børgesen

Cladophora boodleoides Børgesen 1925 p. 56.

References

Cladophora boodleoides in Hamel 1930 p. 41.

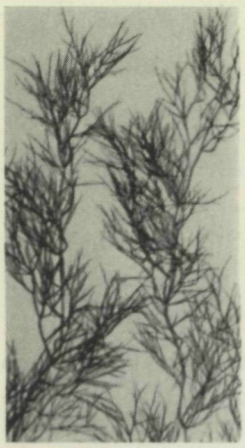
Investigated herbarium specimens

"Cladophora boodleoides leg. & det. Børgesen 1921 Teneriffa.", Brit. Museum.

Remarks

Hamel has reported this species from Brest and it must therefore be taken into consideration as a probable species among the European Cladophora. I am, however, not quite convinced that it is a distinct species. The irregular branching and the terminal and lateral rhizoids described by Børgesen are just such characters as one could expect to be the result of the plant growing in a milieu which it barely can endure. Terminal rhizoids have been found by Humm and Taylor (1961 fig. 7 G) in a different species from Florida. The specimen that I examined I found extremely difficult to separate from an authentic specimen of Cladophora crispula Vickers. I might also mention here Cl. Magdalenae Harvey 1851 pl. 355 A which is another of the plants that are matted together. Hamel reckoned with a Cl. Magdalenae (1930 p. 39) and referred to Harvey's plate, but he must have made some

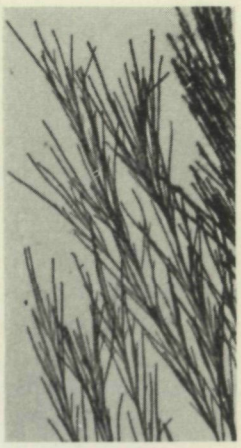
mistake, as his picture shows a plant that is more similar to Harvey's pl. 355 B, which is Cl. Gattyae. On the last named Harvey made the comment, "I am not prepared to say whether it be not some species in dilapidated condition". I for my part can do no more than mention these taxa whilst I express my doubts as to their being distinct species.



Cladophora oblitterata Söderström.

Cladophora glaucescens Harvey.

Cladophora flexuosa (Müll.) Kütz.



Cladophora rupestris (L.) Kütz.

Cladophora albida (Huds.) Kütz.

Cladophora hamosa Kütz.

Cladophora laetevirens (Dillw.) Kütz.

Cladophora Hutchinsiae (Dillw.) Kütz.

Fig. 125. For a careful determination of a specimen of Cladophora one needs a microscope equipped with a micrometer. In some cases, however, a simple magnifying-glass may be sufficient. These pictures show eight of the species enlarged five times. Wide angles and branches in whorls distinguishes Cl. oblitterata from Cl. glaucescens which in turn is more branched than Cl. flexuosa. The broom-like appearance of Cl. rupestris is sometimes also seen in Cl. glaucescens but Cl. rupestris is darker and more rigid. Cl. albida and Cl. hamosa have the type of ramification in common, but Cl. hamosa is the coarser plant. Ordinary specimens of Cl. laetevirens can be telled apart from Cl. Hutchinsiae through their smaller cells and richer branching.

Key to the species.

It has been impossible to make a key in which all forms are included, in many cases it is therefore necessary to study the descriptions.

A. End-cells thinner than 20 μ lacking.

B. Branchlets more than 80 μ.

C. Extremely long cells at the base.

1) Without rhizoids ..... Cl. pellucida
2) With rhizoids ..... Cl. prolifera

CC. Ordinary cells.

1) Ordinary tufts ..... Cl. Hutchinsiae
2) Rectangular branches. ..... Cl. rectangularis

BB. Branchlets 25—80 μ.

D. Straight branches with acute angles.

1) Soft and pure green ..... Cl. glaucescens
2) Harsh and dark green ..... Cl. rupestris

DD. Ramification varying.

1) Detached or spread tufts with long branchlets ..... Cl. flexuosa
2) Well branched soft tufts ..... Cl. laetevirens
3) D:o in brackish water ..... Cl. glomerata
4) Tufts somewhat matted together by many branchlets ..... Cl. hamosa

AA. End-cells thinner than 20 μ occur.

E. Main branches more than 60 μ.

F. Ultimate branchlets without intercalary celldivisions ..... Cl. oblitterata

FF. Intercalary celldivisions occur in the ultimate branchlets.

1) Cells 100—200 μ long ..... Cl. glaucescens
2) Cells 4—8 diameters long, easily detached tufts ..... Cl. flexuosa

FFF. The shortest cells in the main branches, usually detached, in brackish water ..... Cl. fracta

EE. Main branches less than 60 μ.

1) Many cells more than 8 diameters long ..... Cl. oblitterata
2) Most cells less than 5 diameters long ..... Cl. albida
3) The shortest cells in the main branches ..... Cl. fracta

G. Matted tufts with terminal and lateral rhizoids ..... Cl. boodleoides

H. Whole plant only a mm high ..... Cl. pygmaea

PART III

GEOGRAPHICAL DISTRIBUTION

This part is only meant as a summary of the preceding pages and an outline of the distribution of the North Atlantic species of Cladophora. The impression I have is that many of the species are more wide spread than it appears when one reads the floras from different regions, and I have been tempted to try making a survey comprising the tropical parts of the Atlantic as well as the Pacific. The incongruities that follow several names however, make, such a survey nearly impossible and at least it is certain that the result would be trifling compared with the required work. Even when a restricted area as the North Atlantic is made the basis for a study of the geography of Cladophora one is bound to meet with great difficulties. Yet I have ventured to give an outline of the distribution with the aim of giving a starting point for further studies.

Kjellman (1883 p. 377) reports two species from Novaya Zemlya, viz. Cladophora rupestris and Cl. diffusa. This Cl. diffusa must without doubt be a form of Cl. flexuosa. From the Norwegian north coast he reports, besides the two already mentioned species also Cl. glaucescens and gracilis. Judging by Kjellmans description Cl. glaucescens is the same plant as is called with this name here and Cl. gracilis represents some of the many forms of Cl. flexuosa.

From Godhavn and adjacent parts of West Greenland Kolderup Rosenvinge (1893 p. 909) reports Cl. rupestris, hirta, gracilis and glomerata. No doubt hirta and gracilis both belong to Cl. flexuosa and I even suspect that Cl. glomerata in this case belongs to the same species.

From Iceland Jónsson (1912 p. 23) has, besides the same species as Kolderup Rosenvinge, also listed a Cl. sericea (Huds.) Areschoug. As Areschoug's sericea comprised at least four of the species that I reckon with, it is difficult to do more than guess, but probably Cl. sericea in Jónsson also belongs to flexuosa.

From East-Finmarken in the northernmost Norway, Foslie (1890 p. 135) reports Cl. gracilis, glaucescens and rupestris and they hardly need any comments. He also reports Cl. Hutchinsiae, but I am quite convinced that it is not the same plant as is known by this name in Great Britain and France. Cl. hutchinsiae is certainly a plant with a southern distribution in Europe so that probably Foslie used the name for coarse forms of Cl. flexuosa.

In order to get a knowledge of the Cladophora on the Norwegian west coast I have used the works by Kylin (1910 p. 8), Printz (1926 p. 249), Hygen and Jorde (1934 p. 12) and Levring (1937 p. 33), as well as my own investigations during July 1960.

The species Cl. rupestris, flexuosa and glaucescens appear as in the previously cited works. The Cl. crystallina mentioned by Printz I take to be thin forms of Cl. flexuosa, because it is said to grow one meter below the low water line and this weighs more than the reference to Wittr. & Nordst. Alg. exsicc. nr 1031 which is Cl. oblitterata. It is more difficult to say anything definitive about Cl. refracta in Printz. This may be either what I have called Cl. hamosa or it may be Cl. albida. I found both at Espegrend. A questionmark must also be put to Cl. laetevirens in Hygen and Jorde. I have not seen the specimen in Schiffner's exsiccat that they mention, but they refer to Kützing and Kylin and therefore it is probably not the same as Cl. laetevirens sensu Dillwyn and Harvey. Cl. oblitterata has been found in the Espegrend region though it is by no means common there.

The Cladophora species of the Swedish west coast are, after excluding the brackish species: Cl. oblitterata, albida, hamosa, glaucescens, flexuosa, rupestris, pygmaea and laetevirens.

A long discussion of the genus Cladophora in the Netherlands appears in Van Goor (1923 p. 113—129). As his work was carried out in a region with a salinity ranging from 30 to less than 10 $^0/_{00}$, Cl. glomerata and fracta may be expected to occur. Cl. fracta appears in Van Goor to be a mixture of detached Cl. flexuosa and Cl. fracta, while his Cl. penicillata may be a form of Cl. glomerata. Of the other species that are listed by Van Goor Cl. crystallina, nitida, glaucescens and gracilis are difficult to distinguish from each other on the basis of the descriptions. However, Cl. oblitterata, glaucescens and flexuosa are probably all to be found in the Netherlands. Cl. refracta is in Van Goor the same as Cl. albida var. refracta and Cl. utriculosa the same as Cl. laetevirens in Harvey. It is more difficult to understand what Van Goor meant with Cl. laetevirens (Dillw.) Kütz. It seems to be about the same as C. sericea in Areschoug, a mixture of Cl. flexuosa, glomerata, and perhaps some more species.

A short list of the Netherlands' marine Cladophora species has also been published by Slootweg (1948). An accident with the magnifying scales of the pictures makes it difficult to understand the listed species. However, if Slootweg's and Van Goor's works are combined the following species seem to appear in the Netherlands: Cl. oblitterata, albida, glaucescens, flexuosa, rupestris, laetevirens and Hutchinsiae. This species is perhaps also found on Helgoland, as Cl. Lehmanniana Kützing might be the same as Cl. Hutchinsiae.

The species on the British and French coasts have been discussed in the preceding part. To the already mentioned species from Sweden and the Netherlands only Cl. pellucida, prolifera and rectangularis need be added. Cl. prolifera is clearly a southern species and Cl. pellucida as well as Cl. Hutchinsiae, are said by Newton (1931 p. 82) to be rare in Scotland. Further northwards, on the Faeröes, these species are lacking. Børgesen (1902 p. 513) only reports three species from the Faeröes and judging by the descriptions they must be Cl. rupestris, glaucescens and flexuosa.

From the American Atlantic coast we have a good account of the species of Cladophora in the works of Farlow (1881 p. 50) and Taylor (1957 p. 82). Much

work on Cladophora was put down by Collins (1902 and 1909), but unfortunately this work resulted in his dividing the genus in more than 50 species, many of them in turn divided in forms. Four species have been listed, together with descriptions by Hoyt (1920 p. 427), in a work on the marine algae of Beaufort in North Carolina.

To try to analyse Collins' species is outside the scope of this brief survey. From the works of Farlow and Taylor it is however evident that the same species of Cladophora appear on the northeastern coast of North America as on the European coasts. The only exception is Cl. pellucida which is not reported from America. I might mention here that Farlow and Taylor, who both have listed Cl. magdalenae, describe this species in a way that makes it very possible that in this case it represents winter branches of some species.

It is interesting to see that Hoyt has not found Cl. rupestris in his area. Taylor reports Cl. rupestris from Long Island, but only in dwarfed forms. This species evidently has a northerly distribution as it is also unknown on the African coast (Gayral 1958), the Canary Islands (Børgesen 1925) and the Azores (Schmidt 1931).

It is now possible to discern zones in the distribution of Cladophora (see map). In the northernmost, arctic, zone only Cl. rupestris and Cl. flexuosa are found. On the coasts of North Norway and of Labrador Cl. glaucescens appears and seems to be a sign that we have reached a subarctic zone. To this zone also belongs the Faeröes. Further south Cl. albida and oblitterata are the characteristic new-comers, the last named in the beginning only in warm pools or small warm bays. Cl. oblitterata in particular is an indication of a temperate zone which then extends southwards to the coast of Portugal in Europe and to the neighbourhood of Cape Hatteras in America, its southern border being indicated by the disappearance of Cl. rupestris. It is, however, also possible to divide this temperate zone in a north and a south part, with the limit where Cl. Hutchinsiae appears. The occurence of Cl. pellucida and Cl. prolifera is characteristic of the south temperate zone.

The zones that are outlined here coincide to some extent with Børgesen's and Jónsson's groups (1905). According to those authors the southern limit of the arctic flora goes from north Norway to the south east of Iceland and somewhere on the north-eastern coast of North America. They assume that a border area extends southwards to Cape Cod. As far as Cladophora is concerned Newfoundland, however, seems to be equivalent to North Norway, while on the other hand the appearance of Cl. oblitterata on the coast of Maine indicates that this part belongs to the temperate zone. The south limit of the cold boreal group, Børgesen and Jónsson described with the words: "West France—England". Cotton's finds of Cl. pellucida and Cl. prolifera in Clew bay and on Clare Island makes it difficult for me to accept a border line south of Ireland. The disappearance of Cl. rupestris (and the occurence of several other algae, for instance, Valonia utricularis see Schmidt 1931) seems to me so significant that I have drawn my southernmost limit after this and thus placed it more northerly than the southern limit of Børgesen's and Jónsson's Boreal-arctic group.

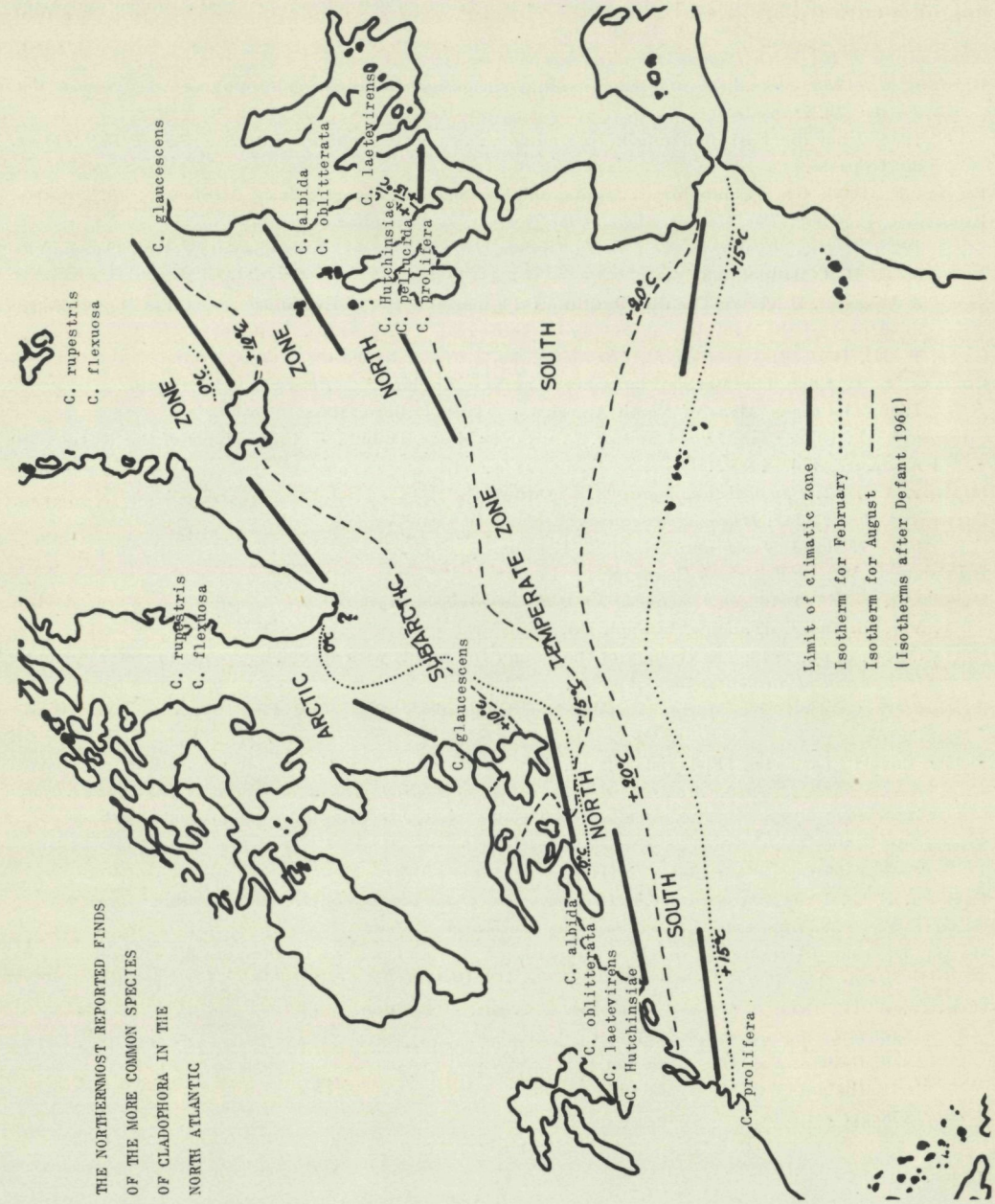
The more important species in the different zones.

The arctic zone: Cl. rupestris, Cl. flexuosa.

The subarctic zone: Cl. rupestris, Cl. flexuosa, Cl. glaucescens.

The north temperate zone: Cl. rupestris, Cl. flexuosa, Cl. glaucescens, Cl. oblitterata, Cl. albida, Cl. laetevirens.

The south temperate zone: Cl. flexuosa, Cl. glaucescens, Cl. oblitterata, Cl. albida, Cl. laetevirens, Cl. Hutchinsiae, Cl. prolifera and in Europe Cl. pellucida and Cl. rectangularis.



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Reference map showing places mentioned in the text.

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