BRITISH STONEWORTS

(Charophyta)

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PREFACE

THIS sketch has been written in response to a request by the Haslemere Natural History Society for a charophyte contribution, under the less formidable title of Stoneworts, to their series of Science Papers.

Haslemere and its fascinating countryside, its Museum, Mr Swanton, Robert Blockey and many other naturalist friends have meant so much to me for over twenty years that I am glad to comply.

Readers who are familiar with *British Charophyta* (Ray Society) will realize how greatly I am indebted to this fine work. The study of charophytes has given me a great deal of pleasure; if this paper helps any others to enjoy a similar experience it will have served its purpose.

I record my sincere thanks to several friends, in particular Mr Gerald Ash, Botanist to our Museum, for their many helpful suggestions for the improvement of the text.

G. O. ALLEN.

St Oswald's,
Enton Green,
Godalming,
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BRITISH STONEWORTS *(Charophyta)*

Stoneworts, usually known to botanists as Characeae or Charophyta, are a decidedly strange and isolated group of aquatic plants growing entirely under water.

They prefer ponds, though occasionally found in running water, and have a partiality for somewhat brackish conditions, such as freshly dug ditches in marshes near the sea. In overgrown waters they soon give way before more vigorous vegetation whilst in a newly formed pool they are frequently the first plants to appear.

They are recognizable without difficulty by their translucent green colour (somewhat greyish in some species due to their marked affinity for lime), their flexibility and the whorled arrangement of the branchlets as the lateral members are termed. Even the totally illiterate Indian who used to accompany me on my pond hunting before I left that country in 1933 has never since sent me among hundreds of specimens one plant that was not a charophyte.

My own collecting of these plants has been mainly done in India, my interest in them originating from my good fortune in meeting the late Mr James Groves when I was on a short stay in the Isle of Wight in 1920. I had never heard of these plants before and was not a little surprised to find that this obscure group had been his chief botanical study for over forty years.

Just about then I was beginning to get interested in the microscope and had naturally turned to pond life as a start. On his suggesting that I might find something of interest to him in Indian ponds, I began on my return to keep a look-out for these plants but met with no success until during a short visit to Srinagar, the capital of Kashmir, in September 1921, when in the beautiful Dhal Lake I found quantities of charophytes and sent off a sample to Groves in weak formalin. These appeared to give him such a thrill that I started a more diligent search in the ponds and marshes of my district in the plains. In a countryside well supplied with pools of shallow clear water and abounding in charophytes I soon made a number of discoveries, and the study of these plants remained my principal pastime till I retired.

It was then that I was greatly looking forward to the opportunity of learning much about this group from Groves in person; we had been corresponding regularly but my visits to him on leave had naturally been few. But it was not to be: he died as I was on my way home. He hoped that I should be able to carry on the study of his favourite plants, and with the invaluable help of his books, notes, correspondence and slide collection I have continued to do what I can.

I could still turn for help to Canon Bullock-Webster, the joint author of *British Charophyta* but unfortunately he was by then extremely ill and within a twelvemonth he too died. During his last year he had very kindly dealt with various queries of mine on British species—he

confined his studies to Europe—and gave me a number of his herbarium sheets and his slide material, largely consisting of oospores in which he was specially interested, and also his fine microscopes which had been declined by a University as being of a different type from those in use by their students.

To return to the charophytes, it may be as well to stress the fact that although the average height of these plants is from one to one and a half feet—a few being only a few inches—their study is essentially a microscopical one, as in spite of many of them being to the practised eye distinguishable in the field, it is on minute points of structure that the species are mainly separated from one another.

They lend themselves well to this as one of their marked characteristics is the simplicity of their structure and they are beautifully translucent: the streaming of the cell-contents (*cyclosis*), first noticed in these plants, is particularly easy to watch.

This suitability for microscopical examination applies of course only to plants in their natural state or preserved in liquid, as once they have been dried and their cells have collapsed it is often exceedingly difficult and exasperating to resuscitate them sufficiently to make out the species. It is essential in my opinion to supplement the usual collection of dried specimens with microscope slides, though I do not know of a public herbarium that is so supplied. The leading American authority, the late Dr T. F. Allen, included in his collection some two thousand slides but when I enquired about them it was only to learn that they had dried up in course of time and had been thrown away.

Groves had what he styled a vast and miscellaneous collection of slides, but they were not permanently mounted and many had dried up long before they came into my possession. It is true that provided the material was originally fresh or preserved in fluid and included a little glycerine, to prevent drying up, an unsealed mount does admit of subsequent re-examination—a point that Groves found of importance more than once in the course of his study of charophytes from all parts of the world: but slides so kept easily deteriorate and are very difficult to transport.

So impressed am I with the importance of micro-slides that I have recently been engaged, with the help of my friend, Mr L. C. Lyon of Enton, on the task of making a few sets of some British species with a view to their distribution to public herbaria where the group has most likelihood of being studied.

When I was once advocating my point and decrying the preservation of sheets only, I was met by the contention that if one did not base one's grasp of the group on dried material it would mean that these vast old collections would lose their value. A herbarium of dried charophytes is of course essential but it is apt to be a rather depressing spectacle unless one is very enthusiastic or the specimens have been well mounted which in the case of old collections is by no means usual. It may be possible no doubt by dissecting out scraps of even the worst to tell the species, but admittedly the label is sometimes the only important part of a specimen; and it is not always even that. I recall the amusement caused some years ago when a specimen determined as a Potamogeton

later on had its specific name altered on the sheet by another expert until yet another subsequently thought it a charophyte and it eventually reached me. It proved to be a charophyte and by dissecting it out I was able to name it.

All that one can expect a dried charophyte specimen to illustrate is its manner of growth and size and perhaps its method of fruiting. Many earlier specimens, however, were casually collected by botanists mainly engaged in the study of other groups. At all times they are rather difficult to preserve, as all except a *Nitella* are liable to be very brittle and hence easily damaged by careless handling. Few plants, as Groves has observed, lend themselves better to mounting provided they are floated out carefully: one has only to look at the beautiful sheets of Groves or the fascicles prepared by Bullock-Webster to appreciate this. One of the finest sheets in my herbarium is of *C. aspera* collected by Groves in Frensham Great Pond in 1883. More use should I think be made of photographing the best sheets.

One cannot pretend that these plants are a popular study, due in part no doubt to their being both inconspicuous and uncommon. I remember an occasion when with some little pride I was exhibiting a slide of an Indian species of great rarity that I had found. An old gentleman looked at it and observed "Oh, it's not alive: the only interesting thing about these plants is watching the movement of the cell contents." I recall too a learned phanerogamic botanist playfully dismissing them as nasty dirty things that you cannot mount. It is all a matter of taste.

Charophytes do normally grow in mud though in clean water only, and they are often smothered in debris or coated with algae and other organisms. Mounting them too at all times entails considerable trouble and some patience. But, as with most things, study begets interest, indeed almost affection. Their extreme variability makes them rather a difficult group which in itself is an attraction.

As they grow entirely under water it is not often in this country that one can admire them as I used to in the clear still water of an Indian pond under a cloudless sky, when the masses of orange-red antheridia (the male reproductive organs) are a fascinating sight: however, I have experienced the same pleasure at Frensham Great Pond on a few occasions.

Many of them can be grown reasonably well in glass jars provided they have plenty of light without much direct sunshine: in their natural state they often form carpets so that their sunlight is entirely from above. There is one on my table that has been growing for over fifty years. About 1896 some dry mud was sent to this country in connection with an experiment in raising some small crustaceans a number of which duly grew up. But the mud also contained some vegetable matter that produced a charophyte. It bore reproductive organs in abundance and was found by Groves to be *Chara macropogon* Br. The history of this plant in a jar at South Kensington became forgotten, and when I was there in 1933 incorporating Groves's plants into the national collection I came across it. In the course of examination I came upon an article by Groves in the *Journal of Botany* for May 1919 on this very plant.

I took a small portion home that continues to flourish. Later on the war and its bombs came and among the minor casualties at South Kensington was this charophyte jar.

This instance is however very exceptional. Personally I have never been very fortunate in growing these plants, probably from not giving them sufficient regular attention. A north light suits them best. Being grown under unnatural conditions, they frequently develop eccentricities, usually becoming attenuated and often poorly developed: if they get too much light they soon die off. There would seem to be scope for the proper cultivation of these plants.

Light is naturally a most important factor affecting the depth at which charophytes grow. They have been found in almost any temperature from ice water to hot springs, from the Arctic circle to the equator, semi-tropical conditions appearing to suit them best of all. Usually they grow in a depth of one or two feet but in Swiss lakes where the water is very clear they have been found as low as sixty feet. The highest locality from which I have had one sent to me was 15,630 feet in a hot spring in Tibet.

Many of them have a very short season. This applies particularly to such countries as India where the annual climatic changes are more marked: in one district where I was able to study them closely during several years, their seasons were so constant that I was able to make a regular chart of their appearance.

One rather curious feature—in some of the *Nitelleae* in particular—is their fugitive nature. Groves was not too pleased with the recorder of the second occurrence in this country, in 1883, of *Nitella gracilis* who was unwilling to disclose the locality for fear of the plant being exterminated. In *British Charophyta* we read of "the practical impossibility on the one hand of ensuring their permanent growth and on the other hand of effecting their extermination." A well known instance is that of *Tolypella intricata* which has the reputation of not occurring two years running in the same spot, one botanist speaking of it as a "vegetable comet."

The oospores can remain viable a long time but are often particular in getting exactly the right conditions before germinating. So far from adversely affecting the oospores, merely being dried up seems to have the opposite effect: the majority of the Indian ponds would get completely dried up in the hot weather and the same thing occurs in South Africa. This capacity to survive was seen locally in 1946 when on Frensham Great Pond gradually filling up again after being drained during the war there was an exceptionally fine growth of *Nitella opaca*. This was in the autumn too whereas the usual period of maturity for this species is May and June but, charophytes being quick growers, it got its chance before other vegetation crowded it out.

Charophytes are divided into two tribes, *Nitelleae* and *Chareae*, comprising in all six genera: two of them, *Nitella* and *Tolypella*, belong to the former and four, *Nitellopsis*, *Lamprothamnium*, *Lychnothamnus* and *Chara* to the latter. All are represented in the British Isles except *Lychnothamnus*.

Of the *Chareae* all except *Chara* are almost single-species genera: from time to time a species has been added but it is considered doubtful whether they are all sufficiently different to warrant specific rank. Charophytes are so variable, due no doubt to slight differences in conditions, that the creation of new species is only too easy. The world total of recognizable species probably does not exceed two hundred and fifty though many more have been described.

British Charophyta, the splendid work of James Groves and Canon Bullock-Webster, recognizes thirty-three species and some twenty varieties; of these species ten belong to *Nitella*, four to *Tolypella* and one each to *Nitellopsis* and *Lamprothamnium*, with seventeen to *Chara*.

Several of the rather small total of British species are very rare: I have not myself found even half of them but my opportunities have been limited. Only two species of *Nitella*—*N. opaca* and *N. flexilis*—can be called common. Even some with a fairly wide distribution have not been collected to my knowledge for a number of years. Especially rich localities are the Cambridge Fens and Norfolk Broads where the assiduous collecting of Bullock-Webster added much to our knowledge of them. The well-watered west coast of Ireland where Bullock-Webster added two new species is another extremely good area.

Apart from the Haslemere region, my chief hunting ground has been the Birchington marshes separating Thanet from the mainland, where the ditches provide ideal conditions for these plants. My two additions there amount to a new locality for the rather scarce *Chara canescens* in 1923—one of the first British charophytes I ever collected and just in time for inclusion in vol. II of *British Charophyta*—and in 1946 for *C. baltica*, also a rare species.

Although charophytes are of no economic importance, some years back considerable interest was temporarily aroused by the propounding of a theory that their presence was inimical to mosquito larvae. Groves never thought there was anything in it, but was pleased since it tended to encourage the collecting of these plants. The late Mr T. B. Blow, a very old friend of the Groves family, who did an immense amount of charophyte hunting all over the world, paid special attention to this question when on a visit to Madagascar, the conclusion he reached after an exhaustive enquiry being that there was no evidence to substantiate the theory.

In the summer of 1946 I sent to the John Innes Horticultural Institution at their request some living plants, and on enquiring the purpose for which they were required was informed that the " chromosome divisions in the antheridial filaments are synchronised " which " makes them particularly suitable for microscopical and X-ray experiments." It is pleasant to hear of their serving the cause of science.

Botanical position.

It has always been a problem how this group ought to be classified. In early days they were placed along with *Equisetum* owing to the superficial resemblance of their both producing whorls. Later they were held to be a genus of *Algae* and though at times they have found them-

selves amongst the mosses and even the flowering plants this position amongst the *Algae* is the view generally held nowadays.

Groves considered the alleged relationship with some of the simpler *Algae* to be little more than guess-work and the authors of *British Charophyta*, following Sachs, regarded them as a separate division. I thought one day I would try this question on an algologist friend of mine and received the prompt and almost scornful reply "Of course they're *Algae*." I have nothing to add on the subject; they have always been charophytes to me. It is the complicated structure of their reproductive organs, the antheridia and oogonia, that chiefly separates them from other groups.

Oogonium (figs. 1-4).

The oogonium which is unlike the fruit of any other plant has persisted unaltered from as far back as the Coal Measures (Nova Scotia), and an American geologist considers some fruits from the Devonian to show definite charophytic affinities.

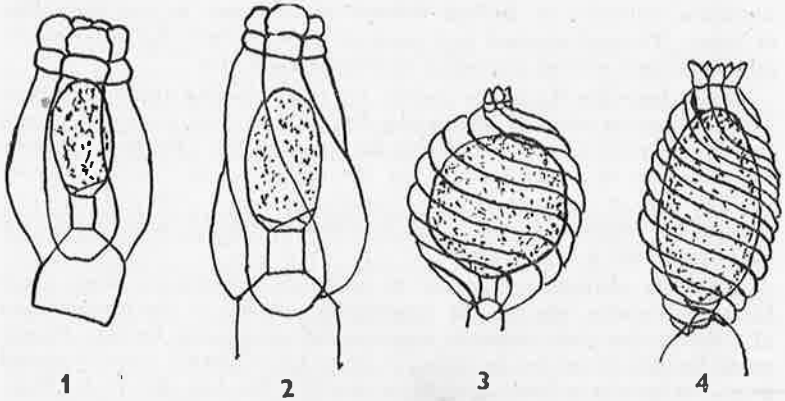

Fig. 1. Oogonium of *Nitella flexilis* in an early stage.
Fig. 2. The same at a later stage (figs. 1 and 2 after Sachs).
Fig. 3. Fully developed oogonium of *Nitella tenuissima* × 140 (after De Bary).
Fig. 4. Fully developed oogonium of *Chara vulgaris* × 60 (after Migula).

The oospore, as it is termed after fertilization, is incased in an envelope of five cylindrical cells which though straight at first soon develop a twist as they elongate, the spiral always ascending from right to left. A horizontal septum appears at an early stage, the lower cell being the one that elongates. These five little cells combine to form a miniature crown, the coronula, at the top of the oogonium. Owing to the upper cell in the *Nitelleae* being divided again by a horizontal septum into two, the coronula in this case consists of a double tier of five cells each, in contrast with the single tier of the *Chareae*. This microscopic feature is the particular one chosen to differentiate the two tribes. Though sometimes deciduous the coronula is quite easy to detect under the microscope but being minute and colourless the double tier of the *Nitellae* cannot always be made out. It is however quite unnecessary

to examine the coronula to tell the two apart as there are other much more obvious distinguishing characteristics.

As the oogonium becomes fully developed narrow clefts are formed between the spiral cells just below the coronula and through these the antherozoids swim in and effect fertilization; when however the coronula is deciduous there is naturally an opening left at the top. After fertilization the five enveloping spiral cells mainly disintegrate to leave the small nut-like oospore, which is usually some shade of yellow or brown or perhaps black.

The inner walls of these enveloping cells apparently fuse with the outer surface of the " nut " to form the membrane, which acts as a sort of shell: this membrane (or rather the outer one of four to be exact) often exhibits a distinctive pattern which is very valuable in the determination of the species in *Nitelleae*. Hence the desirability of collecting some material in ripe fruit where possible.

In the *Chareae* there is not much variety of membrane decoration, which is usually some form of granulation but in the *Nitelleae* the more usual forms are known as granulate, tuberculate or reticulate. To examine the nature of the pattern it is only necessary to select a really ripe oospore, crush it under a cover-glass, tease away the cell contents and use a $\frac{1}{3}$ inch objective or better still a $\frac{1}{6}$; with the $\frac{1}{6}$ it is of course essential to get the light truly central.

Antheridium (figs. 5 and 6).

The antheridium is also a very highly developed organ, " probably the most complex and beautiful structure of the kind throughout the vegetable kingdom." This is an extract from *British Charophyta* which incidentally is the source of so much that appears in this paper.

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Fig. 5. Antheridium.

Fig. 6. Interior view of an antheridial plate with manubrium and some filaments (figs. 5 and 6 after Prósper).

It is spherical in shape, easily visible to the naked eye and commonly of a bright orange colour, its wall composed of eight hyaline triangular convex plates—or rather shields, as from the centre of each there projects inwardly an elongated handle-like cell known as the manubrium. Attached to the inner end of this handle are some twenty long whip-like filaments; these are all twisted together and remind one of a piece of cottonwool. These filaments are divided transversely into 100 or 200

disc-shaped cells, each containing an antherozoid curled round inside: there may therefore be some thirty thousand of them in a single antheridium.

I had now and then tried to see these curly little organisms, with their two very long cilia, swimming about and had broken open what appeared to be a ripe antheridium but without success until I came across a paper on the structure of the Characeae by Charles Bailey, printed in 1882, in which he mentioned that the ripe antheridium usually ruptured in the morning and the antherozoids continued to move for some hours afterwards. So I tried the simple experiment of placing a portion bearing apparently ripe antheridia in a good light and waited till they broke open naturally when it was perfectly easy with a ⅛ to watch these antherozoids and their corkscrew-like movements. It is no use being impatient; you just have to wait till the regular opening hours. Many were struggling to emerge whilst others were whirling round excitedly in their cells: probably in this state of captivity they do not all succeed in escaping.

Differences between Chara and Nitella (figs. 7 and 8).

The two chief genera are very easy to distinguish, especially with British species. Firstly, the stem and branchlets of a *Nitella* are entirely without cortex: it may have some degree of lime incrustation, usually annular in character, but normally the plant is of a clear translucent green colour and more flexible than a *Chara*, which from the greater quantity of incrustation is sometimes decidedly brittle and rough to the touch. Though several ecorticate species of *Chara* exist, only one is British, *C. Braunii*, which is confined to one locality and was probably accidentally introduced. It is not difficult to detect the presence of a cortex; even to the naked eye the longitudinal striping is clearly visible.

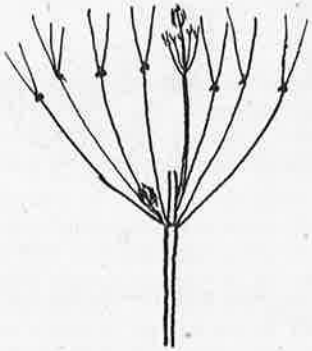

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Fig. 7. Stem-whorl of *Nitella flexilis*, natural size, showing two young branches and fruiting organs at the branchlet forks.

Fig. 8. Stem-whorl of *Chara delicatula*, showing a young branch, unforked branchlets and fruiting organs on the anterior side of the branchlets. × c. 2.

Secondly, the branchlets of a *Nitella* are forked, although in the case of *N. translucens* this is not apparent till examined with a lens as the rays are so minute. The number of furcations is characteristic of the species, some having only one, others two or more. In a *Chara* however the branchlets are never forked; they normally produce bract-cells at the branchlet nodes and these might possibly be confused with forking but the monopodial arrangement of the branchlet of a *Chara* is very obvious.

Amongst other points, normally two branches are produced at the stem-node of a *Nitella* but only one in a *Chara*. *Nitella* oospores too are laterally compressed whereas in a *Chara* they are circular in transverse section.

Differences between Tolypella and Nitella.

Now for some points of difference between the two genera of the *Nitelleae*, *Tolypella* and *Nitella*. A very congested form of a *Nitella* may be mistaken at first sight for a *Tolypella* but normally each has quite a different look, from the habit in *Tolypella* of producing its fruit in dense heads, with the branchlet rays incurved, thus presenting the so-called bird's-nest-like appearance (fig. 9). All our four species exhibit

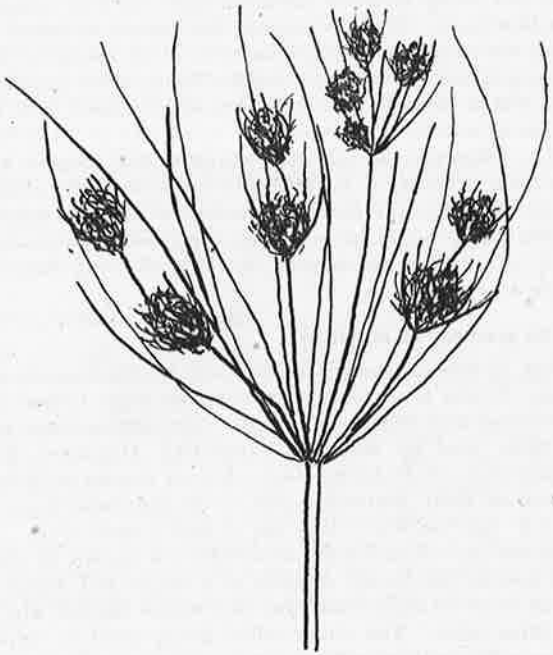

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Fig. 9. Rough sketch of stem-whorl of *Tolypella prolifera*, showing the long simple sterile branchlets and four branches bearing "birds' nests." c. ⅔ natural size.

this but the dense masses are not really very like a bird's nest unless perhaps a magpie's; they seem to me to resemble rather the witches' brooms one sees on the birch.

Several species of *Nitella* form small fruiting heads in addition to the whorls of branchlets but in *Tolypella* this feature is much more marked as in each case the " birds' nests " are more conspicuous and, except for a certain amount of fruiting on a few of the upper whorls of *T. intricata*, the large branchlets are sterile. Moreover, except again for *T. intricata* where they are forked, these sterile whorls are composed of branchlets of a very simple type, being merely a string of cylindrical cells without any nodes, the cells becoming shorter and of smaller diameter.

Another feature of *Tolypella* is the monopodial arrangement of the branchlets, thus showing an affinity with the *Chareae*. The terminal rays of the fertile branchlets also are many-celled whereas in all British species of *Nitella* they consist of one or two cells or in some cases at most three. In a *Tolypella* there are often more than two branches at a stem-node.

To make out the other distinguishing features of a *Tolypella* will probably require a little dissection. Such are the lateral position of the antheridium (in *Nitella* situated terminally in the branchlet fork), the ripe oospore not being laterally flattened and the very unequal length of the branchlet rays. Of these perhaps the easiest to detect under the microscope is the shape of the ripe oospore, which owing to the numerous branches and the reproductive organs being often produced at the base of the whorl as well as at the branchlet nodes, are frequently present in large numbers. Oospores in a variety of positions will be seen but in a *Tolypella* the side-view shape of the oospore will always appear the same, whereas if a portion of a *Nitella* with plenty of ripe fruit on it be similarly examined one is sure to find the majority lying on their sides but here and there one on edge, when its much narrower breadth will be at once noticeable. Incidentally our four species of *Tolypella* are all monoecious.

Characteristic features of Nitelleae.

I turn now to some of the characters used to differentiate species.

The genus *Nitella* is divided primarily into what Groves has styled the *Homoeoclemae* and the *Heteroclemae*, substituting these more exact terms for those used by the great authority Alexander Braun, the *Homoeophyllae* and the *Heterophyllae*. All our species of *Nitella* belong to the former as their branchlets are all of the same kind, with the exception of *N. hyalina* where they are of two distinct sizes.

The ultimate rays of a *Nitella* branchlet are known as dactyls. In four of our species the dactyl consists of a single cell which separates the group off very sharply from the rest whose dactyls are composed of two to three cells. The single-celled group used to be known by Braun's term, *Monarthrodactylae*, but as there is in fact no joint (*arthros*) in a single cell, Groves preferred the term *Anarthrodactylae* for these and *Arthrodactylae* for the rest.

Another separating character, which is only of importance in the case of one British species, *N. capillaris*, is whether the reproductive

organs are enveloped in mucus or not. Although in some extra-British cases, especially if the material has been preserved in fluid, the mucous covering is very obvious, it is not always easy to detect it in dried specimens; hence it is not always a very reliable character, particularly as it is also decidedly variable.

Another sectional division is into dioecious and monoecious, a distinction not always so obvious as one might think as will be pointed out further on.

Other features to be noted in a *Nitella* are the number of times the branchlet is forked, the shape of the apex of the penultimate cell of the dactyl where there is more than one cell to it and the size of the reproductive organs, especially the oospore; also the colour of the oospore.

The markings, or decoration as it is generally styled, of the membrane of the ripe oospore is a character to which importance is being increasingly attached as there is good reason for thinking this is constant for the species. Nordstedt was the first to study this point in a number of species, though his drawings look rather crude beside those so skilfully done by Bullock-Webster. The splendid illustrations of membranes in *British Charophyta* are all his work.

It is not to be supposed that all observers will always agree over their descriptions of the minute markings they are examining. For instance, the membrane decoration is called tuberculate when the granules are non-contiguous as opposed to granulate where they are all contiguous, but it is not always easy to decide whether the little dots are really touching one another or not; it depends to some extent on what magnification is being used.

In the genus *Tolypella* the main division is into those species where the ultimate cell of the rays is conical and those where it is sausage-shaped (allantoid); of British species two belong to each group.

Characteristic features of Chareae (figs. 10-12).

The two virtually monotypic genera of *Chareae*, *Nitellopsis* and *Lamprothamnium* are both so distinct from the genus *Chara* that they can best be dealt with later on.

In the genus *Chara* the first organ to be considered is the stipulodes, a circle of cells at the base of the stem-whorl. They consist of either a single (haplostephanous) or a double row (diplostephanous). In only one of our species, *C. Braunii*, is there but a single row.

The next feature to be studied is the stem-cortex. This is one that presents most difficulty but it is essential that it should be fully understood. The branchlets also usually have a cortex but its structure is much simpler.

The stem-cortex is simply the covering of the internode of the stem proper which latter consists of an inner cylinder of long simple cells, one between each stem-node. It takes the form of a sheath of longitudinal rows of cells that are normally contiguous and adhere closely to the central tube.

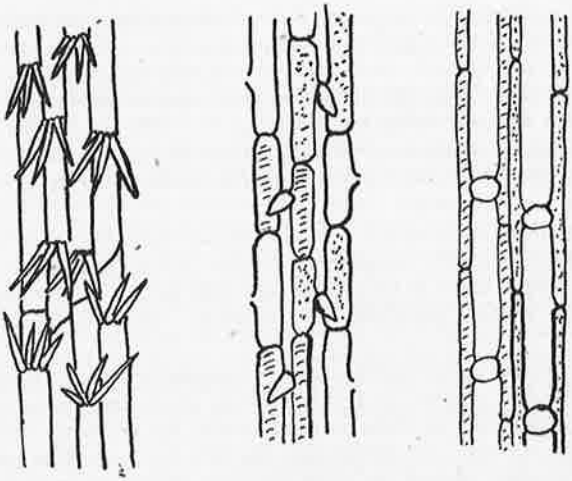

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Fig. 10. Portion of middle part of stem-internode of *Chara canescens*, showing the one-ranked cortex—also the change of direction in which the spine-cells point. × c. 30.

Fig. 11. Portion of stem of *Chara vulgaris*, showing the two-ranked cortex. × c. 20.

Fig. 12. Portion of stem of *Chara delicatula*, showing the three-ranked cortex. (In figs. 11 and 12 two primary cortical rows with their spine-cells are shown in each. Secondary cortical rows are shown as either dotted or shaded to indicate the primary rows from which they arise, the primary rows themselves being left plain.) × c. 50.

When a portion of a stem internode is viewed under the microscope, there may seem at first sight to be a rather bewildering array of tubular cells without any obvious relationship to one another. A little examination, however, will soon disclose that some of the rows bear at intervals projections known as spine-cells. These may sometimes be longer than the width of the stem or so small as to be mere papillae or occasionally may only amount to little inconspicuous cross-bars according to the species concerned.

The rows bearing spine-cells belong to what is called the primary series because these rows originate from certain cells at the base of the branchlets. All the other rows belong to the secondary series and are derived from the rows of the primary series.

It is not however from the growth of a single set of primary rows that the cortex of the whole of an internode is formed. There is, of course, a node, with its whorl of branchlets, at both ends of an internode and from each of these nodes a set of primary rows originates, one from the base of each branchlet, the lower set taking an upward and the upper set a downward direction, with the result that about the middle of the internode these two sets meet though somewhat irre-

gularly. The cortex of each internode is thus a joint production of two adjacent stem-nodes.

Most of these statements about how stem-cortical cells originate have to be taken on trust from the observations of experts who have made a special study of the subject, as of course when even the youngest part of the cortex is examined the cells, though small, are already there. It can usually be seen, however, provided the spine-cells are of an appreciable length, that some change has taken place about the middle of the internode as the direction in which the spine-cells point normally changes at that point (fig. 10). They tend to point away from the stem-node where their primary row originated, i.e., they are usually directed towards the centre of the internode. Another indication that the primary rows do originate as stated above is seen in the very rudimentary cortex of our Irish form of *C. denudata*, where the cortex only succeeds in growing quite a short distance away from the stem-node, the rest of the internode being left ecorticate. This is well illustrated in pl. XXXIV, fig. 3, of *British Charophyta*.

These primary cortical rows are themselves made up of nodes and internodes. It is quite easy to detect this as it is from the node-cell that the spine-cell originates; the internodes just increase in length as the plant grows whilst the node-cells do not elongate but divide in two ways.

One division of the cortical node-cell is on that side of it which is furthest from the centre of the stem and the portion thus cut off gives rise to the spine-cells, each node-cell normally producing one spine-cell but in some species two or more or even a cluster of them.

The other division of the cortical node-cell (except in one species, *C. canescens*, where it does not occur) is at each side of it. From these lateral portions there arise, one on each side of the node-cell, the secondary cortical cells which elongate and arrange themselves longitudinally between the primary rows so that normally the whole stem is covered. It is these secondary rows of cells that tend to be either misunderstood, even by writers on the subject, or found difficult to distinguish, but it is important to grasp their two methods of arrangement.

If these secondary cells, which vary to some extent in length, are roughly about half the length of the internode of the primary row there is room for the ones arising from the node-cells of two adjacent primary rows to accommodate themselves in a single row. The row of secondary cells in this case is thus made up of cells produced partly from the node-cells of the primary row on one side of it and partly from the node-cells of the primary row on the other side of it, the component cells coming alternately from the two adjacent primary rows. This arrangement results in there being one secondary row lying between any two primary rows.

This is known as the two-ranked (diplostichous) system, as by a simple bit of addition it will be realised that for every branchlet there are two rows of cortex, one primary and one secondary. A reference to the sketch (fig. 11) should help to make this clear.

If, however, the secondary cells develop to about the same length as the internodes of the primary row, then obviously there is not room for them to accommodate themselves in a single joint row between the primary rows. They consequently adopt the simple expedient of taking a whole row to themselves. The result in this second stem-cortical system is that between any two primary rows there are two rows of secondary cells, each secondary row in this case being the product of the node-cells of the primary row next to it and not as in the diplostichous system a joint production.

This system is known as three-ranked (triplostichous), there being three rows of cortical cells, one primary and two secondary, to each branchlet.

In the one-ranked (haplostichous) system there is, as mentioned above, no division of the node-cell at the sides to form secondary cells with the result that the whole cortex consists of primary rows, and consequently spine-cells will be found to occur in every row (fig. 10). This is an uncommon arrangement and we have only one species, *C. canescens*, that exhibits this type of structure.

There are therefore three kinds of cortical system. To decide whether a plant under examination has a diplostichous or triplostichous cortex it is only necessary to see whether one or whether two rows of secondary cells occur between two adjacent primary rows. Incidentally where there are two, it will often happen that they are narrower than the primary as this feature is characteristic of four of our six triplostichous species. In any case, more cortical rows occur in the triplostichous system and with a little experience this soon becomes obvious when a portion of the stem is viewed under the microscope.

If this were all, however, it might not sound very difficult to distinguish the three systems, but in practice it is sometimes a little difficult to tell whether a cortex is two-ranked or three-ranked for the simple reason that these secondary cells are not always so regularly arranged as in figs. 11 and 12. If the secondary cells have squarish ends and consequently do not overlap it is easy to tell the system, but in some species the ends of these cells are apt to taper with the result that in what is really a diplostichous cortex there are in places two rows of secondary cells between a pair of adjacent primary rows instead of the orthodox one row.

When this difficulty arises over a cortex it is generally sufficient to study a very young stem internode because it is often only as it grows older that the cortex develops irregularities. In a very spinous species, however, the spine-cells are often so close together in young internodes as to obscure the structure of the cortex.

The relative size of the primary and secondary stem-cortical cells is not infrequently of diagnostic importance. With material that is fresh or preserved in fluid one can usually judge which is the greater by the diameter of the cells as these are all more or less cylindrical: in a diplostichous cortex the smaller series will thus appear to resemble little furrows while the larger will form ridges. The arrangement is known as tylacanthous if the primary series is the more prominent and

aulacanthous if the secondary is the greater (fig. 17, p. 42). In the case of dried material it is often difficult with collapsed cells to decide which is the larger.

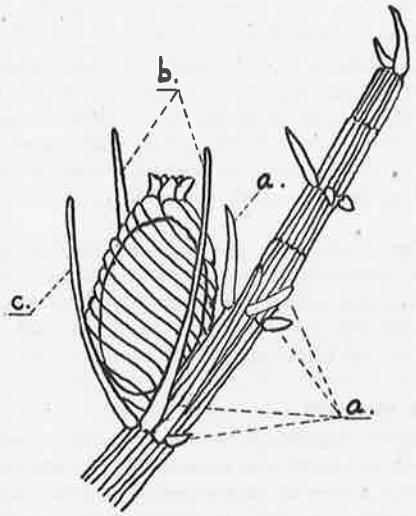

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Fig. 13. Fertile branchlet-node of *Chara aspera* ♀ to show a. bract-cells, b. bracteoles, c. bractlet (after M. Groves and G.R.B.-W). × 45.

Arranged round the nodes of the branchlets are one-celled lateral organs known as bract-cells (fig. 13) which normally project in an upward direction; they vary in size a good deal in the different species but are usually more developed on the anterior side, that is, nearest the stem. A pair of similar cells arise from the node at the base of the oogonium and are styled bracteoles (fig. 13). The bract-cells proper are usually five or seven in number: one cannot, of course, see all round at once but the total can be deduced from the number visible from one side. In many species of *Chara* the two or three terminal branchlet internodes are ecorticate: at such nodes bract-cells are not produced.

In dioecious species there occurs also in the female plant what is known as a bractlet (fig. 13), a small extra central cell below the oogonium, thus taking the place of the antheridium. In *C. aspera* the bractlet is particularly long, usually exceeding the bract-cells.

Another growth that occurs more often in the *Chareae* than in the *Nitelleae* is the bulbil. There are three types. They consist of reserves of starch on the lower stem-nodes or root-nodes, are white in appearance and can give rise to new plants. Their presence is characteristic of some species, e.g., the conspicuous spherical cells found freely on the rooting portion of *C. aspera* or the roundish masses, somewhat resembling minute strawberries in shape, on the root-nodes of *C. fragifera* or the symmetrical star-shaped stem-bulbils of *Nitellopsis obtusa*.

Distribution in Surrey.

Surrey is not a particularly good area for charophytes and some of the localities for old records near London have quite changed their character. Four species of *Nitella*, one of *Tolypella*, *Nitellopsis obtusa* and six of *Chara* have been found.

In the hilly Haslemere district there are not many suitable pieces of water, the ponds having often originated from the damming of streams for the iron works of olden days. Within easy reach by car, however, there are to be found, or at any rate have been recorded, *N. opaca*, *N. flexilis*, *N. translucens* and *N. mucronata*: *T. prolifera*: *C. vulgaris*, *C. hispida*, *C. aspera*, *C. globularis* var. *capillacea* and *C. delicatula*.

There is plenty of scope in the British Isles for further search for fresh records and even for a possible new species. The indefatigable Canon Bullock-Webster added the latest two, *N. spanioclema* in 1916 and *C. muscosa* in 1917, both from Ireland, as well as a new variety *rigida* of *C. baltica* in Hickling Broad in 1898.

Examination of a specimen.

Before turning to the details of the different species, it may be as well to say something about the method of examining a specimen. A portion comprising a few of the younger whorls should be detached. If lime coated, a brief soaking in dilute acid is sufficient to remove it, but a note of its presence or absence should be made as it is occasionally a point of importance.

With a dried specimen of *Chara* I have often found useful a procedure for which I am indebted to my friend, Mr N. I. Hendey, an authority on diatoms. After removing the lime if present, boil the selected portion for a few minutes in a small test-tube containing about half-an-inch of chloral hydrate solution. The dissolving of the cell contents often makes the structure stand out reasonably clearly. The application of a little iodine is also sometimes helpful.

In the case of dried *Nitelleae* Bullock-Webster states that boiling in strong ammonia is sometimes effective but in my experience it is generally very unsatisfactory trying to resuscitate a dried *Nitella*.

When collecting, a few good fruiting whorls should always be preserved in fluid: 2% formalin answers the purpose well. It is only when one has material in this condition, which is practically as good as the living plant, that it is possible to examine a specimen properly under the microscope. Even a low magnifying power would suffice in some cases: I am thinking of a specimen at South Kensington that according to the label purports to bear ripe fruit but to it Groves has appended the comment that the oospores are really beetles.

Some specimens, of course, do not exhibit sufficient characters to admit of their being named but many a sheet of *Nitella* has to remain undetermined simply through the impossibility of resuscitating it satisfactorily. The process moreover of detaching what appears a suitable portion for determining the species inevitably damages the mount to some extent.

I need hardly add that being objects of appreciable thickness the beauty of a specimen under the microscope is greatly enhanced by the use of dark-ground illumination.

When sending a tube of material by post it is most important that it should be completely filled with liquid. This is easily effected by cutting a small groove in the side of the cork. I have received many a specimen completely ruined from its being shaken to bits in a partly-filled tube.

If material will probably reach its destination within two or three days, charophytes may safely be sent fresh in a tin, after merely allowing the surplus water to drain off.

Mounting slides.

Making permanent slides of charophytes is comparatively easy The technique can be learnt from books but a practical demonstration is much better. I shall only refer to the method I have adopted myself, namely, mounting in cells practically without pressure. For initial instruction thirty years ago in the making of fluid mounts I shall always be grateful to my Quekett friend, Mr E. R. Newmarch.

The medium I have used for many years has been weak formalin with the addition of a drop or two of glycerine. Some slides I made twenty-seven years ago are still perfectly sound, but with fluid mounts there is a risk of air bubbles appearing in the course of time.

If the object is thin, such as a *Nitella*, a cell of sufficient depth can be built up by successive ringings with cement on the turntable, preferably one fitted with pins, but with *Chara* specimens I prefer vulcanite cells which are obtainable in various thicknesses. The cement I used in early days was gold size but I long ago discarded this from its tendency to run in and spoil the specimen. The most satisfactory cement I know is Murrayite.

Recently in the making of a set of slides, glycerine jelly was preferred as being less likely to call for subsequent repairs to the mounts; but I have not found it quite so easy to arrange the branchlets with this medium. Before being placed in the jelly the specimen has first to be saturated with pure glycerine; otherwise serious shrinkage will result. This may be effected either by soaking in a weak solution of glycerine and distilled water and gradually increasing the strength or by the quicker method of immersing in a solution of one part glycerine, one part alcohol and two parts distilled water. It is as well also to seal to some extent a glycerine jelly mount.

LIST OF BRITISH SPECIES

NITELLEAE

Nitella Ag.

1. N. capillaris Gr. & B.-W.
2. N. opaca Ag.
   - ,, var. attenuata Gr.
   - ,, var. brachyclema Gr. & B.-W.

3. N. flexilis Ag.
   - ,, var. crassa Br.
   - ,, var. nidifica Wallm.
   - ,, var. Fryeri Gr. & B.-W.
4. N. spanioclema Gr. & B.-W.
5. N. translucens Ag.
6. N. mucronata Miq.
   - ,, var. gracillima Gr. & B.-W.
   - ,, var. heteromorpha Kütz.
7. N. gracilis Ag.
8. N. tenuissima Kütz.
9. N. confervacea Br.
10. N. hyalina Ag.

Tolypella Leonh.

1. T. intricata Leonh.
2. T. prolifera Leonh.
3. T. glomerata Leonh.
   - ,, var. erythrocarpa Gr. & B.-W.
4. N. nidifica Leonh.

CHAREAE

Nitellopsis Hy.

N. obtusa J. Groves.

Lamprothamnium J. Groves.

L. papulosum J. Groves.

Chara L.

1. C. Braunii Gmel.
2. C. canescens Lois.
3. C. vulgaris L.
   - ,, var. longibracteata Kütz.
   - ,, var. papillata Wallr.
   - ,, var. refracta Kütz.
   - ,, var. crassicaulis Kütz.
4. C. rudis Leonh.
5. C. hispida L.
6. C. tomentosa L.
7. C. contraria Kütz.
   - ,, var. hispidula Br.
8. C. denudata Br.
9. C. muscosa Gr. & B.-W.
10. C. baltica Bruz.
    - ,, var. affinis H. & J. Groves.
    - ,, var. rigida Gr. & B.-W.
11. C. aculeolata Kütz.

12. C. aspera Willd.
    ,, var. subinermis Kütz.
    ,, var. lacustris H. & J. Groves.
13. C. desmacantha Gr. & B.-W.
14. C. connivens Br.
15. C. fragifera Dur.
16. C. globularis Thuill.
    ,, var. capillacea (Thuill.) Zanev.
17. C. delicatula Ag.
    ,, var. barbata (Gant.) Gr. & B.-W.
    ,, var. annulata (Wallm.) Gr. & B.-W.

KEYS, DESCRIPTIONS AND DISTRIBUTION

NITELLEAE

KEY TO NITELLA

(Omitting 1. *N. capillaris*, 4. *N. spanioclema*, 7. *N. gracilis*, 9. *N. confervacea* (=*N. batrachosperma*) and 10. *N. hyalina*, all very rare species).

Dactyls one-celled

Dioecious ..... 2. *N. opaca*
Monoecious ..... 3. *N. flexilis*

Dactyls normally two-celled

Branchlets once furcate (inconspicuously) ..... 5. *N. translucens*
Branchlets twice to four times furcate
Base of end-cell of dactyl much narrower than the apex of the lower cell ..... 6. *N. mucronata*
Base of end-cell of dactyl hardly narrower than the apex of the lower cell ..... 8. *N. tenuissima*

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1. **Nitella capillaris** Gr. & B.-W.
(=*N. capitata* Ag.)

Dioecious. Dactyls one-celled. Branchlets once forked. Fertile whorls mostly with very short branchlets and forming dense heads. Reproductive organs enveloped in mucus. Oospore membrane tuberculate. Oospore ridges exceptionally prominent.

Though having the same general appearance as *N. opaca* and *N. flexilis*, it is not at all likely to be confused with them. It is the only British *Nitella* with a tuberculate membrane decoration and the only one with the gametangia substantially enveloped in mucus. The very wide flanges of the oospore are a particularly beautiful sight under the microscope.

The only British locality is a ditch some fifty yards long at Sutton Gault, Cambs., and the immediate neighbourhood. As far as I know no one has collected it since Canon Bullock-Webster's Ely days between 1895 and 1901. He gives the time of maturity as May and June. His diary records finding it in excellent condition at Sutton Gault on 25th

May 1895 and on several other occasions in the next four years here and as far as Mepal Bridge. On 27th April 1899, as a result of the ditch having been cleaned out, it " yielded a splendid growth of the plant in beautiful rather early condition." When I asked him about this species in June 1933 his reply was " whether it is to be found there still is very doubtful."

N. capillaris is found in several European countries and also sparingly in North America.

2. **Nitella opaca** Ag.

Dioecious. Dactyls one-celled. Branchlets once forked into two or three rays, which are about one-third the length of the primary. Fertile whorls with usually shorter branchlets, thus forming more or less dense heads. Oospores mature in May and June. An extremely variable plant.

var. **attenuata** Gr.

A lax slender elongated form with branchlets about as long as the internodes and dactyls about as long as the primary ray.

Recorded from S. Hants and Dorset. Forms of this species occur with very elongated branchlets but without the plants being particularly slender. Few gatherings have been referred definitely to this variety.

var. **brachyclema** Gr. & B.-W.

Quite a distinct form with a very stout stem, elongated internodes and very short incurved branchlets with dactyls often longer than the primary rays. Fruits sparingly.

Usually found in deep water and recorded from the Lake district, north Scotland and north Ireland. This is such a tall form that it somewhat resembles *N. translucens*, its peculiarities being presumably due to the depth at which it grows.

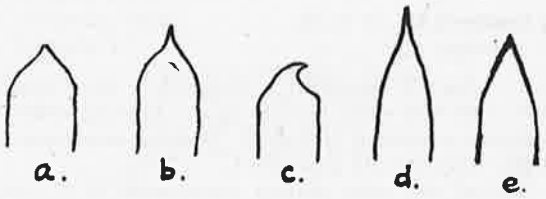

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Fig. 14. Apices of dactyls. a-d. *N. opaca*, a. normal, b and c. abnormal, with small points, d. abnormal, acuminate, e. *N. flexilis*, normal.

Some unusual forms of *N. opaca* have been found in Scotland: for instance a plant collected in 1905 in L. Ken by G. West has a curious little point to the apex of the dactyl. Something of the same kind but with the point strongly hooked occurs in a plant from Barbuster, Shetland, collected by G. C. Druce in 1920.

Instances of the occasional occurrence of forms with the apex of the dactyl acuminate instead of with the usual bluntish shape and a mucronate tip are those collected from Rockcorry, Monaghan, by R. L. Praeger in 1920 and from Little Sea, Dorset, by Bullock-Webster in 1902.

A very peculiar form found in L. a Mhuilinn, Caithness, in 1904 by G. West has twice-divided branchlets, and a male plant found by Miss C. M. Rob in N.W. Yorks in May 1947 also exhibits this unusual feature —with antheridia at both forks and with the apices of the dactyls very acute. Another plant found by Miss Rob at Thirsk in June 1946 has sometimes four secondary rays and as many as four oogonia at a node.

I found most of these exceptional forms amongst Groves's slides. They are not referred to in *British Charophyta* but they have their interest, plants having been elevated to specific rank for less eccentricity than some of these.

In July 1946 in Frensham Great Pond there appeared in quantity in shallow water a very short form of *Nitella opaca* with small round heads smothered in gametangia, very similar to the plant found in Hayle Kembra in the Lizard: the typical form was also growing in another part of the pond.

In general appearance *N. opaca* is not always very distinct from the next species *N. flexilis*, but the tendency to form heads and the more rounded apices to the dactyls serve as a help to distinguish them. (Fig. 14.)

The fact that this species is dioecious and *N. flexilis* monoecious might seem sufficient to settle the matter, but it is possible to be deceived. In the *Journal of Botany* (1938, 48) I erroneously recorded finding *N. opaca* var. *attenuata* at Haslemere on the strength of finding during the winter a plant with long branchlets and bearing only antheridia: later gatherings satisfied me that I had been too hasty. During the colder months *N. flexilis* will often be found bearing only antheridia though these are not fully mature, whilst in the summer one may find it with ripe oospores only.

When fully developed gametangia are present the two species are readily distinguishable as *N. opaca* has a decidedly larger antheridium than *N. flexilis* (650-775μ diameter as against 500-625μ) whereas the oospore is considerably smaller (c. 400μ long and 375μ broad as against c. 550μ long and 450μ broad). The finding of *N. flexilis* in the summer bearing oospores only is simply due to the antheridia having disintegrated, these organs being the first of the two to mature.

There is a minor discrepancy about the oospore in *British Charophyta* which was brought to my notice by Dr R. D. Wood, a young American botanist whom I met during the war when he was over here on military service. In the key (vol. I, 92), *N. opaca* and *N. flexilis*—as also *N. spanioclema*—fall under a subheading that includes the sentence "Ridges of the oospore not prominent" whereas the figures of the oospores in the respective plates in all three cases hardly bear this out, and in the descriptions of *N. flexilis* and *N. spanioclema* the oospore ridges are spoken of as "prominent" and as having "prominent flanges" respectively. The sentence in question is evidently meant to stress the differ-

ences between the ridges of the three species and the remarkably broad flanges of *N. capillaris*.

N. opaca is far the commonest British *Nitella* and is recorded from many countries in Europe and also from a few localities in North America.

3. **Nitella flexilis** Ag.

Monoecious. Dactyls one-celled. Branchlets once forked into usually two or three rays. Internodes once and a half to twice the length of the branchlets. Oospores maturing June and July.

var. **crassa** Br.

A very much stouter form with usually much shorter dactyls that are often single, instead of the normal two or three. A deep water form recorded only from certain northern lakes in Westmorland, Scotland and Ireland.

var. **nidifica** Wallm.

Fertile whorls with branchlets much shorter than the type and forming more or less dense heads, a character normally associated with *N. opaca*. Recorded from a few localities in Ireland and Scotland.

var. **Fryeri** Gr. & B.-W.

Markedly protandrous with a very much larger antheridium, c. 800μ in diameter. Dactyls often with a mucronate apex. Fruiting whorls in more or less dense heads. Oospores often particularly flanged towards the apex. Found in a few localities in the Cambridge Fens. That the plant appears sometimes with only antheridia and sometimes with only oogonia represents "clearly an approach to the dioecious condition."

Under *N. opaca* most of the differences between *N. flexilis* and *N. opaca* have been mentioned. Normally *N. flexilis* is larger and more slender, and much less inclined to form fruiting heads. The membrane decoration does not afford any help in separating them as in both it is variable and they may both be smooth or scabrous with wart-like protuberances.

A plant collected by James Groves at Northfield, Worcestershire which approaches var. *nidifica* exhibits the curious feature of bearing some short adventitious branchlets.

N. flexilis is fairly common, except in Wales, though not nearly so widely distributed as *N. opaca*. It is mainly a European species and also found throughout North America.

4. **Nitella spanioclema** Gr. & B.-W.

Monoecious. Dactyls one-celled. Branchlets very few, usually two or three in a whorl, normally once furcate but occasionally a second node occurring; the forking usually merely consisting of a bifurcation, with one very short lateral ray and the other somewhat longer in a more or less axial direction. Reproductive organs sometimes together but more commonly at different nodes, the rays of branchlets that produce an-

theridia being very short; so that an antheridium usually looks as if it were perched on the end of a short thick stalk. Oogonia either solitary or two or three together, with often one at the base of the whorl as well. Both oogonia and antheridia that have fallen off leave conspicuous scars.

Spiral cells of the oogonium much swollen at the apex. Oospore a rich red brown, showing six ridges with prominent flanges especially at the apex; membrane with wart-like protuberances on a minutely granular base, the "granulation somewhat reticulate in form" though it requires a high magnification to detect this.

N. spanioclema is a curious looking extremely delicate fragile plant about 30 cm. high that has some affinities with *N. flexilis* but with obvious differences. It gives one the impression of being improperly developed but its apparent abnormalities are constant and persistent. The two plates in *British Charophyta*, drawn by Bullock-Webster and Groves's sister, Miss Mary Groves, give a particularly clear idea of the plant.

It was originally discovered by Bullock-Webster in Lough Shannagh and L. Kindrum, West Donegal, in August 1916, and again in the same locality and month in 1917 and 1919. Bullock-Webster's diary for 22nd August 1916 runs "The western side of L. Shannagh yielded an abundance of this plant growing densely in thick banks about six yards from the shore in six or eight feet of water, intermixed with *N. translucens*." He floated out and mounted some fifteen sheets there and then.

The second locality is Loch Lubnaig, Perth, where it was collected by N. Annandale and N. J. G. Smith in July 1921: a curious distribution. It has not been recorded outside the British Isles.

5. **Nitella translucens** Ag.

Monoecious. Dactyls, unlike the four preceding species, two-celled. Sterile and fertile whorls normally very dissimilar. The sterile of four to seven rather long and usually stout once forked branchlets, though to the naked eye they appear simple as the secondary rays are minute (fig. 15). Dactyls usually two to four, though sometimes solitary. The fertile whorls on the other hand usually small and forming conspicuous dense heads; branchlets about six, forking into three to six rays of which one or two may sometimes fork again. Of the two-celled dactyls, the lower cell narrows gradually whilst the apical one is acute. Oogonia two to

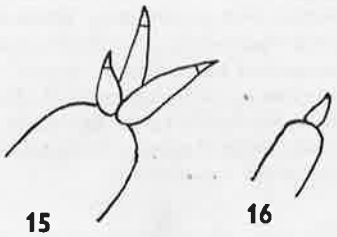

Fig. 15. *N. translucens*, apex of sterile branchlet. × c. 20.
Fig. 16. *N. mucronata*, normal apex of dactyl. × c. 25.

four together; oospore light golden brown, maturing in July. The little heads require careful dissecting out. Membrane decoration minutely reticulate, the first case to be mentioned so far, though the pattern is not nearly so regular as a real net.

N. translucens is a fairly common British species, found mainly in the southern half of England but also in Scotland and Ireland. This is a plant of western Europe. As regards the two local but by no means recent records, Royal Common near Elstead and Vachery Lake near Cranleigh, I have unsuccessfully searched in the former locality.

6. **Nitella mucronata** Miq.

Monoecious. Internodes about twice the length of the branchlets. Whorls of five or six branchlets, once to thrice forked; primary ray about half the length of the whole branchlet. The first fork usually with three rays which divide again into two or three tertiaries of which one or two are sometimes forked a third time into two or three quaternary rays.

Dactyl normally two-celled, the lower cell having usually a characteristic rounded apex with the upper one much narrower, shorter and acute, thus forming the mucro, from which the plant gets its name (fig. 16, p. 29). It may however be occasionally three-celled. Groves has a pencil note in his copy of *British Charophyta* as follows—" In some extra-British forms frequently three-celled, apparently by suppression of forking." I have come across other cases amongst his notes where Groves seemed inclined to attribute to suppression of forking the existence of a more or less occasional third cell to the dactyl.

Oospore dark brown, the membrane decoration being reticulate, somewhat like that of *N. translucens* but with a considerably larger mesh.

var. **gracillima** Gr. & B.-W.

Described as usually more slender than the type but the difference is not very marked. Two characteristic features are the more frequent occurrence of three-celled dactyls and the shape of the cells of the dactyl. The lower of the two cells of the normal dactyl instead of having a rounded apex as in the typical form tapers gradually so that the apex is not much broader than the base of the end-cell. Three-celled dactyls tend to occur more commonly when the secondary rays are simple, thus lending support to Groves's suggestion about suppressed forking.

Found in a small pond near Wickwar, Glos. W., in 1917, but I am told there has been no trace of it there since. When first examined there was a doubt whether it might not be *N. gracilis*, till the oospore membrane markings at once settled the matter.

In April 1949 an interesting second record of this variety was made by Mr J. L. Lyon, son of Mr L. C. Lyon, in an old arm of the Oxford Canal at Newbold-on-Avon, near Rugby. It closely resembles the Wickwar plant though is somewhat less slender.

var. **heteromorpha** Kütz.

Instead of the uniformly lax growth, the fertile whorls form dense heads. This very distinct form plentifully bearing ripe fruit was found

in Powdermill Reservoir, Sedlescombe (erroneously reported by me as Scolescombe in *Journ. Bot.*, 1938, 49) near Hastings by Mr D. F. Leney of Haslemere in August 1937. This variety does not appear to have been found previously in the British Isles although recorded from the continent. In their *Review of the British Characeae*, 1880, H. & J. Groves considered a plant from West Grinstead, West Sussex, to be "near var. *heteromorpha*," but it is not mentioned in *British Charophyta*. The variety is figured in Migula's *Die Characeen* (Rabenhorst's *Krytogamen Flora*), p. 151.

N. mucronata is not likely to be confused with any other *Nitella*, particularly if ripe oospores are obtainable. It is a decidedly rare plant, being recorded from only some ten English counties and one in Ireland. Though found in several countries of Europe and in varying forms in other continents it is apparently very rare as a rule.

I was particularly pleased at finding, in October 1936, one or two clumps of it locally in the River Wey near Little Frensham Pond, in a small patch of slack water below the piles of the footbridge; it was in a sterile condition with many three-celled dactyls. Incidentally I noticed after the gathering had been in a dish for some hours that four young crayfish had been included. Huxley in his *Crayfish*, on the subject of their food, states that "calcareous plants such as the stoneworts (*Chara*) are highly acceptable," but I did not notice any signs of their having eaten the *Nitella*.

There are other instances of this species having been found in running water, an unusual habitat for charophytes. River specimens, however, are apt to be sterile: in the ponds of northern India where the plant is common it fruited very freely.

7. **Nitella gracilis** Ag.

Monoecious. Dactyls two to three celled, the three-celled state being quite common: the end-cell which is long narrowly conical and acute always much the smallest and the lowest cell considerably the longest, the middle one when present tapering appreciably towards the apex. Whorls of five or six branchlets two or three times forked: the primary ray being usually at least half or more than half the length of the entire branchlet and the succeeding rays being short giving the branchlet somewhat the appearance of a little inverted tassel. Oospore light brown with a very fine granulate membrane decoration, maturing in September. Plant very delicate and not more than about six inches high.

N. gracilis most nearly resembles *N. mucronata* but is usually rather shorter, more slender and flexible. The much more frequent occurrence of three-celled dactyls, the end-cell forming a much less conspicuous mucro and the granulate membrane decoration, make it readily distinguishable.

In the genus *Nitella* there is a group, not found in the British Isles but especially common in Australasia, with many cells to the dactyl which Braun called *Polyarthrodactylae* contrasting it with another of his sections, the *Diarthrodactylae* with two-celled dactyls. *N. gracilis*

with its frequent three-celled dactyls may be considered as forming a link between the two.

British Charophyta mentions only three records in England, from Cornwall, Sussex and Shropshire, and two from Irish loughs in Wicklow. In Salmon's *Flora of Surrey*, 1931, there is mentioned a record from Kingston, Surrey, collected by G. Nicholson and reported by J. Groves in the Botanical Exchange Club Report for 1880: the original note referred to it as a "scrap" and Groves appears to have omitted it later. It is found sparingly in Europe, with one or two records from North and South America.

8. **Nitella tenuissima** Kütz.

Monoecious. Dactyls two-celled, long and narrow; apex of the lower cell about as broad as the base of the end-cell which is long and acuminate so that except for its being two-celled the dactyl is usually rather pinlike. Sometimes in a sterile branchlet the dactyl may appear to be three-celled owing to there being only one ray produced at the last node.

Internodes conspicuously long, two to five times the length of the branchlets; very little branching. Whorls of normally six branchlets, when fertile three or four times furcate; primary ray less than half the whole branchlet. Secondary rays six or seven, one of which is central, i.e. prolonging the main axis, all about the same length and similar to the four to six tertiary rays, most of which are unforked though some may fork to form two to five quaternary rays, and one of these may even fork again into three or four quinary rays. The large number of rays often makes the whorls look somewhat globular and in compact forms markedly so.

Reproductive organs often together at the second and third fork but none at the first. Oospore light to rich reddish brown, with seven or eight well-defined but low ridges. Membrane conspicuously reticulate and, when fully developed (not always found in this state), beaded, i.e. the meshes resemble strings of round beads, a decoration that is found in no other British species; oospores maturing in August. Plant very slender and small, often not more than four inches tall, usually densely lime incrusted.

In the second paragraph on p. 117, vol. 1, of *British Charophyta*, where it is mentioned that *N. translucens*, *N. mucronata* and *N. tenuissima* (in its earlier stages) are the only British species with a reticulate membrane pattern, there is a statement that in *N. tenuissima* it soon assumes a different and distinctive form. The pattern is nevertheless still reticulate, the difference in form being that the meshes tend to become beaded when mature. It may be noted that the meshes in this species are far larger than those of the other two mentioned above.

This fascinating little plant is sometimes confused with *N. confervacea* Br. (*N. batrachosperma* Br. in *British Charophyta*) which is also very small. There are however several features which clearly distinguish them. Firstly, in *N. tenuissima* there are no reproductive organs at the first fork, the place of the antheridium being taken by the central ray prolonging the main axis: in *N. confervacea* both oogonia and antheridia are produced at the first fork. Secondly, the number of branchlets

is normally six as against eight. Thirdly, the membrane decoration is reticulate as against granulate.

N. tenuissima is decidedly rare, with one locality in Norfolk and a few in the Cambridgeshire fens and in Anglesey; also in Ireland. Bullock-Webster at one time found it in abundance in Wicken Lode, but on my two visits I failed to find it. It is so small that it may easily be overlooked. It is recorded from various countries of Europe and in North America.

9. **Nitella confervacea** Br.
(=*N. batrachosperma* Br.)

Monoecious. Dactyls always two-celled, the lower narrowing slightly and rather abruptly at the apex so that though only a trifle if anything broader than the base of the end-cell the outside margin of the dactyl is not a continuous straight line: end-cell rather long and ending in a sharp point.

Internodes from one to four times the length of the branchlets. Whorls of eight branchlets, which are twice and sometimes thrice, even rarely four times, forked: occasionally only once forked. Primary ray generally rather short and less than half the entire branchlet. Secondaries four to six, one or two dividing again into three to seven tertiary rays which are conspicuously long and sometimes half the length of the entire branchlet. Oospore reddish brown: six to eight broadly flanged ridges: membrane granulate.

N. confervacea is extremely slender and very small, British specimens not exceeding five cm. in height.

I have already, under *N. tenuissima*, referred to the main differences between these two rather similar species. There is no sign of a mucous covering to the reproductive organs in British examples.

In *British Charophyta*, vol. I, p. 125, the membrane decoration is described as "at first finely granulate, subsequently tending to become thick and reticulate." An inaccuracy has crept in here. On p. 126 it is correctly stated that it "possesses a granular, not a reticulate membrane." To make quite sure about this discrepancy I consulted Canon Bullock-Webster who expressly told me that the decoration does not alter at all, even young stages looking the same, namely granulate.

N. confervacea is a very rare species and the only British *Nitella* not yet found in England. It has been gathered in a few localities along the west coast of Ireland, viz. Kerry (both S. and N.), Mayo W., Galway W. (where Dr Sledge was the first to find it in August 1939) and Donegal W.: and also in one locality in Scotland, viz. Isle of Harris, Outer Hebrides. This scattered distribution following a definite south-west north-east direction is rather remarkable. We have something of the same kind in the case of *Tolypella nidifica* which is recorded from one locality in south Ireland, viz. Wexford, and two in Scotland, viz. Orkney and Shetland. Perhaps wading birds on migration occasionally carry the oospores but curiously enough this minute species in its Irish localities grows in from four to six feet of water and was only collected by chance with a drag.

Bullock-Webster found it in Ireland on three occasions only, his diary for August 1917 recording that seven hours in a boat with a drag in L. Kindrum produced a few pieces only, and in July 1919 in L. Keel he " discovered a few pieces . . . which came up with refuse in the drag in some 4-5 feet of water."

It is recorded from a few continental countries, North America and Australia.

To comply with the International Rules the name *N. batrachosperma* has to be dropped. The Groves brothers in their " Notes on the British Characeae for 1887-9 " (*Journ. Bot.*, 28, 66, 1890) holding that the name *N. batrachosperma* was quite untenable published a new one *N. Nordstedtiana*, but the authors of *British Charophyta* reversed this view and reinstated *N. batrachosperma*. When Dr R. D. Wood recently told me he considered the name *N. batrachosperma* invalid, Mr A. J. Wilmott kindly investigated the matter for me and found that for more reasons than one it could not stand.

In the Key to the *Fragmente*, *N. confervacea* is included amongst the *Gymnocarpae* while *N. batrachosperma* is in the *Gloeocarpae*. Hy, the French authority on the group, made a special study of the question and found that the mucous covering to the gametangia in *N. batrachosperma* was not a constant character and hence considered it the same as the earlier published species, *N. confervacea*. *British Charophyta*, vol. I, p. 125, speaks of the gametangia as " sometimes enveloped in mucilage " but on the following page is the statement that " if present in the British plant " it is very slight. The authors evidently accepted Hy's view; consequently I consider there are sufficient grounds for deciding on the name *N. confervacea* Br.

10. **Nitella hyalina** Ag.

Monoecious. Dactyls always two-celled, the lower narrowing gradually at the apex which is of about the same breadth as the base of the apical cell; this latter being conical and acute and often developing a little twist to one side.

Whorls composed of branchlets of two kinds: usually eight primary branchlets and about twice as many " shorter and simpler secondary branchlets " in two series, the one above, the other below, the primary branchlets. Primary branchlets two or three times forked, the primary ray usually considerably more than half the length of the whole branchlet; secondary rays seven to ten, most of which fork again into four to seven tertiaries of which one or two are sometimes forked again into four or five quaternaries.

Of the accessory branchlets, the upper series usually the shorter and forking once into some five terminal rays, the lower series forking once or twice, with four to six secondaries of which some fork again into five or six tertiary final rays.

Oogonia and antheridia more commonly on the primary branchlets, mainly at the second fork, and enveloped in thin mucus; sometimes occurring on the secondary branchlets. Ripe oospores, which are reddish-brown, have not been found in British plants.

Against the remark in *British Charophyta* (vol. I, p. 128, 1.3) that the oogonia and antheridia are enveloped in "thin" mucus, Groves has a pencil note "often thick" which probably refers to extra-British plants since British plants have very little mucus at all, whereas in India, for instance, where the species is quite common it is so thickly covered with mucus as to render the mounting of specimens, either dried or as slides, rather difficult.

On this same page there is an error, which Groves himself has noted in pencil, about the membrane decoration. The description runs " obscurely reticulate " whereas in the last paragraph of the notes on this page it is mentioned as having a granulated decoration. On my referring this to Bullock-Webster he replied that " it is granulate without doubt and as the drawing Pl. V, No. 7, shows."

The existence of the two kinds of branchlets makes *N. hyalina* very distinctive. Bullock-Webster added this species to the British list when he found it in August 1898 in Looe Pool, Cornwall, near Helston. His diary adds " in considerable quantities growing as detached plants and also in a thick bank in some 5-7 feet of water;" this was in the Penrose arm. He found it again in abundance in July 1908 in the middle of the pool towards the sea and it was still there in 1914 but in June 1920 his four hours' search from a boat yielded only some *N. opaca*. It has been sought for on many occasions since then without success. Towards the end of his life Bullock-Webster wrote to me in August 1933, " It is not much use looking for *N. hyalina* in Looe pool now I think. It seems to have gradually died away. I think it is really an alien. Perhaps fruit brought on birds' feet from France or Spain."

How interested Groves and he would have been to know of a second British locality: for when examining some dried specimens in 1937 I found that N. Douglas Simpson had collected a sterile plant of this species in Llyn Idwal, Carnarvon, in July 1913.

N. hyalina occurs, though usually rarely, in several countries of Europe and in all other continents.

KEY TO TOLYPELLA

Ultimate cell of the rays conical

Sterile branchlets furcate ..... 1. *T. intricata*
Sterile branchlets simple ..... 2. *T. prolifera*

Ultimate cell of the rays sausage-shaped (allantoid)

Ripe oospore small (c. 340 × 275μ) ..... 3. *T. glomerata*
Ripe oospore large (c. 450 × 400μ) ..... 4. *T. nidifica*

1. **Tolypella intricata** Leonh.

Monoecious. Whorls of two kinds; firstly, large lax distant ones, the sterile or the lower fertile, with usually six long branchlets of varying length that have one or two nodes and with each a variable number of shorter usually simple accessory branchlets; secondly, very large dense heads, the upper fertile, with shorter branchlets that have usually two nodes.

Lateral rays at the first branchlet node three or four and at the second node about the same number, as well as the central elongated ray. Ultimate rays of five or six cells which diminish in length and breadth so that the whole ray tapers to a conical apex. Oogonia two to four together at each node and often also in quantity at the base of the whorl. Oospore light golden-yellow, with a very finely granulate membrane decoration and about nine thin prominent ridges; maturing in April and May. Antheridia stalked or sessile at the nodes and at the base of the branchlets. Frequently densely incrusted in lime.

There is a small point in the description in *British Charophyta* that I question. In the branchlet of a *Tolypella* there is always a central axis. Under " Whorls " the authors use the term twice-divided, which presumably refers to the nodes of the axis and not to any division of the lateral rays as under " Branchlets " they speak of the lateral rays at the first node as being simple. The excellent pl. XVII however shows instances of the laterals at the first node of a sterile branchlet being divided and I have myself seen this in a dried specimen.

With regard to the fertile branchlets also, the *Fragmente* and Migula's *Die Characeen* speak of the laterals at the first node being divided, though I can find no illustration depicting this. I have certainly found one instance of this division of a lateral in a fertile branchlet but the material available to me is insufficient to tell whether this feature is at all frequent. I should therefore be inclined to describe the laterals at the first node of a branchlet as usually simple but sometimes divided.

T. intricata is easily distinguishable from the other three British species by the sterile branchlets being divided whereas in the others they are simple.

It is a rare plant, found in shallow pools and ditches and decidedly sporadic in its appearance. There are records of it from about a dozen counties of England and two in Ireland. Outside Europe it has been found only in Algiers.

2. **Tolypella prolifera** Leonh. (fig. 9, p. 15).

Monoecious. Stem very stout: generally a single one, giving rise to a large number of branches. Sterile whorls of some six to twenty unequal branchlets, which are simple and consist of three to five cells, which diminish gradually in length and breadth, the apical cell being sharply conical. Fertile whorls in large dense heads, the branchlets having one or two nodes at which are produced three or more simple laterals, the ultimate ray three to five celled.

Oogonia and antheridia at the branchlet nodes and at the base of the whorl; antheridia usually sessile. Oospore dull brown, membrane without any markings; maturing in June.

This very robust species with its conical end-cells is easily recognizable. It is partial to canals and ditches of rather shallow slowly flowing water, and found in about a dozen English counties with one record from Ireland. It occurs in a few countries on the continent and in North and South America as well as India.

The record in *British Charophyta* from Sussex E., near Eastbourne, is incorrect: Groves has a note that it was a large form of *T. glomerata*.

3. **Tolypella glomerata** Leonh.

Monoecious. Stem fairly stout: two to six branches at a node. Sterile whorls of six to twelve simple branchlets of unequal length, each consisting of three to five cells, the ultimate cell cylindrical with an obtuse apex. Fertile whorls in dense heads of once divided branchlets, some three or four unequal (generally much curved) three-celled lateral rays being produced at the node, the central ray being much longer and larger and three or four celled. These smaller rays often look somewhat like a string of tiny sausages. Oogonia (two to six together and often stalked) and antheridia occur at the nodes of the branchlets, sometimes oogonia also in quantity at the base.

Oospore 300-375μ long and 250-300μ broad, orange or dull brown; membrane granulate, the granules tending to be arranged in lines; maturing in April.

var. **erythrocarpa** Gr. & B.-W.

Differs from the type in the oospore being reddish-brown. Anglesey and two Irish localities are the only records. This is not, in my opinion, a very clearly marked variety.

T. glomerata is of medium height but variable; usually very incrusted. The curved rays are a well marked feature of this species. It is particularly partial to brackish water.

In England and Ireland it is our commonest *Tolypella*; there are two localities only from Wales and a few in north Scotland. It is widely distributed abroad, being found in several European countries and all the continents except South America.

4. **Tolypella nidifica** Leonh.

Monoecious. Sterile whorls of about six stoutish but not very conspicuous simple branchlets; apex of the end-cell blunt. Fertile whorls in dense heads, branchlets with one, rarely two, nodes; basal cell short, and two or three short somewhat incurved three or four-celled laterals, the central ray of three to five cells being much longer; end-cell either short or, if elongated, much narrower than the penultimate.

Oogonia at the node and at the base of the branchlet, nearly globose; coronula large, cells of the upper tier the longer and connivent. Oospore 400-475μ long and 350-450μ broad, of a dark wine-red colour; membrane either without markings or with scattered tubercles. Antheridia large, up to c. 550μ in diameter.

T. nidifica is an extremely rare plant that may be distinguished from *T. glomerata* by the larger oogonium and antheridium, the much larger coronula, the rich wine-red colour of the oospore and the virtual absence of membrane decoration.

Distribution in the British Isles is very curious; being known only from Wexford in south Ireland and Orkney and Shetland. It occurs in a few countries of northern Europe.

CHAREAE

Nitellopsis obtusa J. Groves.
(=*Chara stelligera* Reichb.)

Dioecious. Stem stout, bearing below the surface of the mud large white star-shaped thick nodes with rudimentary branchlets. Entirely ecorticate. Stipulodes none or at any rate none developed. Whorls of five to seven very long branchlets which have only one or two nodes, each producing one or two long thick bract-cells: ultimate cell elongated. No bracteoles. Oogonia solitary or germinate: coronula very small for one of the *Chareae*. Oospore golden brown; no ripe ones have been obtained in the British Isles. Antheridium very large, c. 1000μ in diameter; usually solitary.

This plant is not likely to be confused with any other species, the presence of the peculiar star-shaped stem-bulbils alone being often sufficient indication.

A large deep-water plant that looks more like a *Nitella* than one of the *Chareae*.

In their original account of it in the *Journal of Botany*, 1881, the Groves brothers described the stipulodes as rudimentary and there is a regularly arranged ring of peripheral cells at the base of the whorl that resemble these organs though undeveloped. Dr J. S. Zaneveld in " The Charophyta of Malaysia and Adjacent Countries " (*Blumea* 4, 1-223, 1940) when discussing on p. 116 his closely allied *Nitellopsis sarcularis* refers to his finding a case of one stipulode developed and remarks that this shows that the lower peripheral cells of the stem-nodes are indeed rudimentary stipulodes.

Nitellopsis obtusa is very rarely found except in some of the Norfolk Broads: even there it has not been seen in recent years. It has not been recorded from Scotland or Ireland but occurs in a few continental countries and in Kashmir and Burma.

Contrary to the usual practise, this genus is based on vegetative characteristics only, on the ground of its being so remarkably distinct.

Lamprothamnium papulosum J. Groves.
(=*Chara alopecuroides* Wallm.)

Monoecious. Stem somewhat slender. Lower internodes as much as four times the length of the branchlets but the upper whorls so crowded as to form long dense foxtail-like heads. Entirely ecorticate.

Whorls of six to eight branchlets consisting of three or four nodes with normally five bract-cells produced at all except perhaps the end one. Stipulodes in a single circle and pointing downwards. Oogonia and antheridia usually solitary at the lowest one or two nodes of the branchlets: the oogonium situated below the antheridium and thus in the opposite relative position to all other *Chareae*. Root-nodes producing clustered bulbils.

Oospore markedly cylindrical, black when ripe; maturing in August. Membrane decoration tuberculate, as illustrated in *British Charophyta*, vol. II, pl. XXII, fig. 2, and so stated in vol. II, p. 2, but

which by a slip is referred to in the description of the species as " very finely granulated " and in vol. I, p. 70, as " finely and obscurely granulate."

Lamprothamnium papulosum is a very distinct looking plant of variable size. The oogonia often have a lime-shell with a peculiar truncated top. This lime-shell condition is one in which the spiral lines remain conspicuous but owing to the secretion of a fine deposit of lime within the spiral cells the outer shell of the oogonium presents a porcelain-like sheen.

It is very rare, being known from only three British localities, in two of which it is probably extinct. It was found in the Fleet, Dorset, near Langton Herring, in 1889, and no doubt still exists thereabouts though I have not heard of its having been collected for many years. It was at one time found in pits of disused salterns in the Isle of Wight near Newtown and in a claypit near Hamworthy Junction. Bullock-Webster told me that the Hamworthy pool yielded splendid specimens in days gone by but when he last visited it about 1927 the pool was practically filled up and built over.

It is widely distributed in France and occurs in several other continental countries and South Africa.

KEY TO CHARA

(Omitting three very rare species, 1. *C. Braunii*, 8. *C. denudata* and 9. *C. muscosa*)

Stem-cortex one-ranked (haplostichous) ..... 2. *C. canescens*
Stem-cortex two-ranked (diplostichous)
  Secondary cortical-cells the more prominent (aulacanthous)
    Spine-cells solitary ..... 3. *C. vulgaris*
    Spine-cells two or three together
      Spine-cells mostly geminate, one above the other ... 4. *C. rudis*
      Spine-cells two or three: when geminate, side by side ..... 5. *C. hispida*
  Primary cortical-cells the more prominent (tylacanthous)
    Dioecious ..... 6. *C. tomentosa*
    Monoecious
      Spine-cells and stipulodes short, rather blunt: posterior bract-cells rudimentary ..... 7. *C. contraria*
      Spine-cells and stipulodes long and acute: posterior bract-cells developed.
        Spine-cells solitary ..... 10. *C. baltica*
        Spine-cells in fascicles ..... 11. *C. aculeolata*
Stem-cortex three-ranked (triplostichous)
  Dioecious
    Spine-cells conspicuous
      Solitary ..... 12. *C. aspera*
      Fasciculate (usually three or four) ..... 13. *C. desmacantha*
    Spine-cells rudimentary
      Branchlets of male plants strongly connivent: branchlets of 8 or 9 segments: no bulbils ..... 14. *C. connivens*

Branchlets of male plant not strongly connivent: branchlets of 9 to 13 segments: large root-bulbils ..... 15. *C. fragifera*
Monoecious
Primary and secondary cortical-cells about equal in diameter ..... 16. *C. globularis*
Primary cortical-cells larger than the secondary ... 17. *C. delicatula*

1. **Chara Braunii** Gmel.

Monoecious. Entirely ecorticate. Whorls of eight to ten branchlets, consisting normally of four or five segments, the uppermost very short and about the length of the surrounding bract-cells, thus producing a little crown to the tip of the branchlet that gave rise to its familiar old name of "*coronata*." Stipulodes in a single circle, situated alternately with the branchlets, i.e. between the bases of them, and pointing upwards, acuminate. Oogonia and antheridia at the two or three lowest nodes, often geminate. Oospore rather cylindrical and black when ripe; maturing in summer and autumn.

C. Braunii is very easily recognized by its lack of any cortex and the little crown at the end of the branchlet. It is the only British species of *Chara* with a single circle of stipulodes.

It has been found from only one locality, viz. in tepid water in Reddish Canal, south Lancashire, where its presence may be due to chance introduction with cotton from Egypt where this species occurs. It was first recorded from the canal in 1883, and was still there in 1947. It occurs in most parts of the world.

2. **Chara canescens** Lois. (fig. 10, p. 18).
(=*C. crinita* Wallr.)

Dioecious. Cortex of the stem one-ranked (as are also the branchlets): the only European haplostichous *Chara*. Spine-cells conspicuous, spreading, in clusters of two to five, usually three. Internodes of the stem usually more than twice the length of the branchlets. Whorls of eight to ten short branchlets, consisting of five to eight segments. Bract-cells all well developed, hence conspicuous all round the branchlet. Stipulodes in a double circle, both well developed. Oospore black, maturing in summer and autumn. The male plant has not been found in the British Isles.

C. canescens is a rather small plant with rigid stem and branchlets. It is not likely to be confused with any other of our species of *Chara*, though bearing a superficial resemblance to *C. desmacantha*, as it is the only one that does not develop any secondary stem-cortical cells, so that each row of the cortex bears spine-cells.

Unique in its parthenogenetic reproduction, the male plant having only been found in a very few localities in the world though ripe oospores are freely produced without it.

It is a rare British plant, found near the sea in a few localities in south and east England, west and south-east Ireland and Orkney. It is recorded from a number of European countries, Asia, North Africa and North America.

3. **Chara vulgaris** L.
(=*C. foetida* Br.)

Monoecious. Cortex two-ranked (diplostichous), the primary series less prominent than the secondary so that the spine-cells appear to lie in furrows (fig. 11, p. 18). Spine-cells solitary, variable in length in the different forms and varieties.

Whorls of seven to nine branchlets. Both circles of stipulodes well developed, usually short, stout and rather obtuse; upper and lower circles of about the same size and neatly arranged (fig. 17a, p. 42). Bract-cells usually five, the anterior one or two pairs normally considerably longer than the oogonium, whilst the posterior are much shorter.

Oogonia and antheridia solitary. Coronula inclined to spread. Oospore golden brown to dark brown, the ridges often prolonged at the base to form a sort of open cage. Membrane decoration somewhat variable, granulate with a tendency for the granules to be separate from one another.

var. **longibracteata** Kütz.

Branchlet segments elongated; often the ultimate two or three ecorticate, thus presenting a whip-like appearance. The anterior bract-cells and the bracteoles are conspicuously long, often six times the length of the oogonium. The spine-cells on the other hand are short and may even be rudimentary.

This is much the commonest of the four chief varieties; extreme forms are distinctive but intermediates are often found.

var. **papillata** Wallr.

Cortex irregular, with the secondary series much broader than the primary. Spine-cells long but often tending to be curved or bent down and so keeping close to the stem: deciduous and thus generally only to be seen on the younger parts of the stem. Branchlets usually long with bract-cells rather long. As a rule a large untidy looking plant, usually much incrusted. It is a fairly common variety.

var. **refracta** Kütz.

Spine-cells well developed but considerably shorter than in var. *papillata*. Branchlets short and often inclined to bend over backwards; ultimate segment very short. Bract-cells short. Generally a neat plant with little lime; fruiting very freely. Not very common.

var. **crassicaulis** Kütz.

Internodes long, with branchlets short, stout and incurved. Secondary cortical cells very broad. Spine-cells short, thick and rounded at the apex. Stipulodes very obtuse. Not at all common.

C. vulgaris is much the most variable British species as indicated by the fact that the German botanist, Migula, has assigned names to no less than sixty-nine forms but the authors of *British Charophyta* have contented themselves with including only the four best marked varieties.

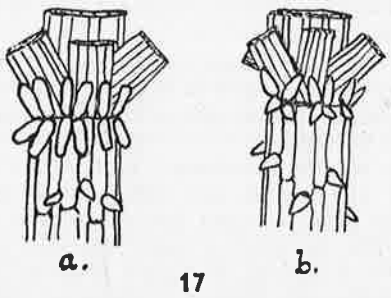

Fig. 17. Stem-whorls. a. *C. vulgaris*, b. *C. contraria*. × c. 20.

This species is quite likely to be confused with *C. contraria*, which is much less common; but normally though not always it is possible to distinguish them fairly easily. In general *C. vulgaris* is inclined to be rather straggly whereas *C. contraria* is usually a more slender and neater plant. One of the most striking differences is microscopic. In *C. vulgaris* the primary stem-cortical series is smaller than the secondary whereas the reverse is the case in *C. contraria* (fig. 17). The ripe oospores of *C. vulgaris* are brown whereas in *C. contraria* they are black.

It is very important to be able to recognize *C. vulgaris* as it is by far the commonest British charophyte and may well be the first to be collected by any botanist. Where the difference in breadth of the two stem-cortical series is inconsiderable, *British Charophyta* suggests that it may be necessary to examine the stem in transverse section, but unless the reader is a skilful microtomist I should not endorse this advice. A difference between the stipulodes of the two species is one upon which I rely when, as often happens with dried material, I cannot readily make out which cortical series is the broader. In *C. vulgaris* the stipulodes tend to be very neatly arranged with those of both circles more or less equal in size and obtuse whereas in *C. contraria*, apart from their being less regular, they tend to be of unequal size, the upper circle being slightly more developed and somewhat pointed (fig. 17).

As far as my experience goes I feel hardly able to agree with the statement in *British Charophyta* (vol. II, p. 2) that the tuberculate membrane decoration of *C. vulgaris* serves as a "valuable" test for distinguishing it from *C. contraria*. In the membranes of *C. vulgaris* that I have examined the decoration is by no means always as shown in plate XXII, fig. 5.

C. vulgaris is recorded from every British county and from nearly all parts of Ireland but is less common in Scotland and Wales. It has a world-wide distribution.

4. **Chara rudis** Leonh.

Monoecious. Cortex regularly two-ranked, the secondary series very much the broader, often more than twice the breadth of the primary. Spine-cells mostly geminate and adpressed, one above the other and pointing in opposite directions, unequal, the one pointing towards the

middle of the internode being the larger. Stipulodes of both series well developed, fairly regular and roughly of equal size. Bract-cells usually five, the posterior ones short; bracteoles usually a little longer than the anterior bract-cells.

C. rudis is a large plant, often three feet high with long plain-looking branchlets. The marked difference in the breadth of the two cortical series and the peculiar arrangement of the spine-cells make this plant quite distinctive. To the naked eye it looks somewhat like *C. hispida* of which it was at one time considered a variety, but *C. hispida* has a much stouter stem and the whole plant has a bristly appearance.

C. rudis is found rarely in England and Wales, but is recorded from a few counties of Scotland with most records from Ireland. It has been found in a few European countries only.

5. **Chara hispida** L.

Monoecious. Stem remarkably stout, often 2 mm. in breadth, with internodes about twice the length of the branchlets. Cortex two-ranked, the secondary series rather the more prominent though somewhat irregular. Torsion of the stem usually very marked, always ascending from left to right; the opposite, incidentally, to that of all oospores.

Spine-cells conspicuous, usually in clusters of two or three and when geminate, side by side, stout acuminate and deciduous. Whorls of nine to eleven long branchlets; segments seven to nine with the last two or three ecorticate. Bract-cells five to seven, the anterior the longer but all well developed so that the plant has a conspicuously spiky appearance; bracteoles prominent, often longer than the anterior bract-cells. Stipulodes of both series about equal, long and rather thin.

Oogonia and antheridia solitary; oospore chestnut-brown, ridges prolonged downwards to form a conspicuous cage; maturing in June. It is generally heavily lime-encrusted.

C. hispida, the largest European species, is easily recognizable by its size and general prickly-looking appearance. It is fairly common throughout the British Isles, the four Welsh records being comparatively recent ones. It is recorded from all over Europe, but elsewhere only from Siberia and North Africa.

There is a European species, *C. papillosa* Kütz. (*C. intermedia* Br.), which one might expect to occur over here. It is less spinous but otherwise has a strong resemblance to *C. hispida* from which it is mainly distinguished by the primary stem-cortex being larger than the secondary. The stem-cortex has unfortunately been incorrectly depicted in pl. 70 of Kützing's fine illustrations of charophytes in vol. VII of his *Tabulae Phycologicae*. A large plant with long branchlets from Hickling Broad was at first thought by the Groves brothers to be this *C. papillosa*, but later it was held to be a hybrid between *C. hispida* and *C. contraria*.

6. **Chara tomentosa** L.

Dioecious. Stem stout, with internodes about once and a half or twice the length of the branchlets. Cortex two-ranked, somewhat irregular, with the primary series very much larger than the secondary. Spine-cells solitary or in clusters. Branchlets six to eight, exhibiting

the marked peculiarity of the lowest branchlet segment having an ascending as well as a descending cortex, the points of junction being clearly visible under the microscope; in all other species the cortex of this lowest segment is a descending one only. Stipulodes, bract-cells and spine-cells are all much of the same type, broadly ovoid-acuminate, or in other words short, swollen and pointed.

Oogonia and antheridia usually solitary at the lowest two or three nodes. Oospore light yellow-brown. Antheridia occasionally geminate, exceptionally large 1325-1425μ in diameter. It fruits in the autumn but never at all freely. Particularly heavily lime-encrusted. A fairly large plant.

Spiral torsion is very conspicuous. Young shoots, when fresh, have a salmon-pink tinge: Bullock-Webster in his diary on one occasion refers to its being "very pink."

The upper two segments of the branchlet are ecorticate, and of these the lower is usually very much swollen, giving the branchlets a very distinctive look under the microscope.

C. tomentosa, a very well marked species, has only been found in the British Isles in the central lakes of Ireland, being particularly abundant in the R. Shannon area. It has been recorded from many European countries as well as from Siberia and Persia.

7. **Chara contraria** Kütz.

Monoecious. Cortex regularly two-ranked, the primary series more prominent than the secondary (fig. 17b, p. 42). Internodes about two or three times the length of the branchlets. Spine-cells solitary obtuse and usually short. Stipulodes often of unequal size, the upper being the larger and more pointed (fig. 17b). Branchlets six to eight with about six segments, the upper two or three being usually ecorticate: in fact there is a marked tendency in this species to poor cortex development in the branchlets. Ripe oospores black, maturing in summer and autumn. Generally much encrusted. A smallish variable plant.

var. **hispidula** Br.

With much larger spine-cells which may be as much as twice the breadth of the stem; considerably longer stipulodes, especially the lower circle, and rather more developed bract-cells. These features are all more noticeable in the younger portions of the plant. It is found sparingly over the British Isles.

C. contraria has a considerable resemblance to *C. vulgaris*, the differences being already mentioned under that species. It is about as widely distributed in the British Isles as *C. vulgaris* but not nearly so common, except in Ireland. It is found in every continent.

8. **Chara denudata** Br.

Monoecious. Cortex very rudimentary but where it is sufficiently developed to be diagnosed, it is two-ranked, but very imperfectly. Branchlets only corticate to the extent of a ring of cells at each fruiting node. Bract-cells very poorly developed. Oospore reddish-brown to nearly black.

C. denudata has every indication of weak development, being thin and largely ecorticate. This peculiar state undoubtedly arises from the depth at which the plant grows. On the one occasion when it was found, in Brittas Lake, Westmeath, in 1892, it was growing at a depth of some twelve feet. It has been found in Switzerland at a depth of sixty feet. It has also been recorded from Italy and South Africa.

When originally found, Braun at first took it to be ecorticate. *British Charophyta* says of it, " Evidently closely related to *C. contraria* of which it should probably be regarded as a subspecies, or possibly only a series of degraded states."

9. **Chara muscosa** Gr. & B.-W.

Monoecious. Cortex regularly two-ranked, the primary series much the more prominent, with conspicuously long, stout spine-cells. Stipulodes well developed, very unequal in size and somewhat irregularly arranged. Branchlets six or seven, of four or five short segments, somewhat incurved. Bracteoles particularly long and rather slender; much longer than the bract-cells. Oogonia and antheridia solitary at the first and second nodes; oospores black. Coronula very large, the cells spreading widely from their base. Usually without any lime incrustation.

C. muscosa is a very small tufted moss-like dark green much branched plant with short internodes. It is the most recent addition to the British list, having been found in Lough Mullaghderg, W. Donegal, by Canon Bullock-Webster in July 1917 and first described in 1924.

This is another instance of peculiar distribution, as since its original discovery it has been found in Orkney. More recently a plant was collected, in August 1938, at Lochmaddy, N. Uist, by I. A. Williams, which differs somewhat from the type in having usually eight branchlets and six or even seven branchlet segments, with considerable and sometimes total absence of branchlet cortex. It agrees with the typical plant however in the exceptionally large primary stem-cortical series, the dark green colour and absence of incrustation. It can therefore, I think, be safely referred to this species especially as examination of further material collected in Lough Mullaghderg by N. D. Simpson and J. P. M. Brenan in 1939 shows that this tendency to ecortication in the branchlet is not an unusual feature.

C. muscosa comes nearest to *C. contraria* and *C. baltica*, but the extremely large primary cortical-cells, sometimes almost obscuring the secondary, alone separate it from both. It is not known from any other locality.

10. **Chara baltica** Bruz.

Monoecious. Stem rather stout with internodes up to twice the length of the branchlets. Cortex regularly two-ranked, with the primary series rather the larger, the secondary usually joining squarely. Spine-cells solitary, occasionally geminate, not large and decidedly acute. Whorls of eight to ten branchlets, with six to eight segments which tend to curve inwards. Bract-cells all developed but none of them long; bracteoles much longer. Stipulodes long and tapering, equal and neatly arranged. Oogonia and antheridia solitary; oospore black but fruiting

sparsely. Often produces characteristic compound root-bulbils. Devoid of any lime incrustation. A rather large dark green plant that has a preference for brackish water.

var. **affinis** H. & J. Groves.

Weaker and more flexible than the typical form, with the two cortical series nearly equal. Spine-cells much longer and less spreading, often two or three together in plants from Kynance, Cornwall, though solitary in the other locality, Guernsey: stipulodes and bract-cells all much longer than in the type.

var. **rigida** Gr. & B.-W.

This form, found by Bullock-Webster in Hickling Broad in 1898, has a rigid brittle stem with internodes two or three times the length of the branchlets, which are straight and rigid; bulbils numerous. Spine-cells solitary and projecting conspicuously from the stem. Mature fruit extremely rare.

C. baltica with its developed spine-cells and stipulodes and the larger primary cortical series rather suggests *C. contraria* var. *hispidula*, but in the latter the spine-cells and stipulodes are far less acute, the whorls further apart and the branchlets more spreading. The curious absence of lime incrustation in *C. baltica* with its resulting clear dark-green colouration is a constant and valuable character for distinguishing the species.

The typical plant has only been found in three places, Dorset (Little Sea), Orkney (Loch Stennis) and, recently, in the Outer Hebrides (N. Uist), and even the plants of the first and third locality are not exactly typical since they have many geminate spine-cells.

In July 1946 I found a curious form of *C. baltica* in the marshes at Birchington, E. Kent, with much longer branchlets than had been recorded for any British plant of this species hitherto. They were as much as 4 cm. in length whereas in the large form from L. Stennis they reach only 2½ cm. It clearly tends towards var. *Liljibladii* (Wallm.) Wahlst., which is found in south Norway; in fact it is exactly like a form of *C. baltica* collected by Nordstedt in September 1876, which he notes as "ad var. *Liljibladii*."

C. baltica has been recorded from a few countries of northern Europe and from the Baltic Sea with its very low salinity.

11. **Chara aculeolata** Kütz.

(=*C. polyacantha* Br.)

Monoecious. Cortex two-ranked but irregular with much overlapping; the primary series considerably the larger. Internodes about two to four times the length of the branchlets. Spine-cells so strongly developed, usually in clusters of three or four, and persistent, that the whole stem looks extremely bristly. Whorls with eight to ten branchlets, the bract-cells acute and all well developed, which adds to the bristly appearance of the plant. Stipulodes long, slender and acuminate. Oospore dark brown to almost black, maturing in June. Usually much encrusted.

C. aculeolata is a fairly large plant that resembles small forms of *C. hispida* but the persistent spine-cells and their profusion give it a far more spinous look.

The authors of *British Charophyta* have rightly discarded the very appropriate old name of *C. polyacantha* in favour of an earlier one. A difficulty however, in my opinion, still remains. In their "Notes on British Characeae for 1885" (*Journ. Bot.*, XXIV, January 1886) the Groves brothers when writing on *C. polyacantha* were of the opinion that Kützing's figure (*Tab. Phyc.*, VII, t. 67, f. 2) of his *C. aculeolata* was more like *C. polyacantha* Br. than *C. papillosa* Kütz. and that it appeared to be a form intermediate between these two. But in *British Charophyta* Braun's view that *C. aculeolata* Kütz. was the same as *C. papillosa* Kütz. is definitely rejected and so our plant is assigned the name of *C. aculeolata*.

Braun's view has been followed by all other continental writers, and personally I am inclined to agree with them, but have not sufficiently studied the point to come to a definite conclusion. If the name "*aculeolata*" is dropped, it seems that the correct name would be the inappropriate one of *C. pedunculata* Kütz.

C. aculeolata is a rare plant occurring in a few scattered peaty localities in England, Wales and Scotland, but considerably commoner in Ireland. It is recorded from a few European countries.

12. **Chara aspera** Willd.

Dioecious. Stem slender. Internodes rather long, generally quite twice the length of the branchlets. Cortex three-ranked, fairly regular though the cells of the secondary series tend to meet obliquely; the primary series usually decidedly larger than the secondary, the cortex thus appearing in surface view as two thin rows between a stouter spine-bearing row. Branchlets eight or nine in a whorl. Bract-cells all developed but very variable in length; bracteoles, as well as the bractlet (fig. 13, p. 21), longer than the bract-cells. Stipulodes well developed and usually rather long, the lower circle slightly shorter than the upper; often somewhat swollen at the base as are also the spine-cells. Spine-cells usually solitary (though occasionally geminate or even three together) long, spreading and acute. Oospore black, maturing in July and August. Numerous white spherical bulbils on the rooting portion. Often much incrusted and very brittle. A fairly small slender spiny plant.

var. **subinermis** Kütz.

Spine-cells very short, sometimes mere papillae. Stipulodes and bract-cells also much shorter and more obtuse than usual. Intermediate forms occur. Mostly found in Scotland and Ireland.

var. **lacustris** H. & J. Groves.

A very distinctive condensed form, growing in tufts about two or three inches tall, with short, stout and much incurved branchlets. Spine-cells short, thick and obtuse. Considerably resembles in general appearance the little var. *annulata* of *C. delicatula*. There are at the same time some very small slender-stemmed forms of *C. aspera* that do not

fall within this variety. Found particularly in Loughs Neagh and Beg, Co. Monaghan, and in several other Irish lakes.

A form with unusually long spine-cells, stipulodes and bract-cells, collected at Holyhead, Anglesey, corresponds with var. *capillata* Br. but the authors of *British Charophyta* evidently did not think it worth listing as a separate variety.

C. aspera is particularly partial to lakes. When the reproductive organs are present, it can hardly be confused with any other species but in forms where the spine-cells, stipulodes and bract-cells are rather stout and blunt and the plant is in a sterile condition it is not easy to distinguish it from *C. delicatula*, particularly as the latter also has a smaller secondary stem-cortical series; about all one has as a guide is that *C. aspera* is a more slender weaker plant and of a paler green colour and the branchlets tend to bend outwards towards the tips.

C. aspera is found in all parts of the British Isles, most of Europe and a few other places in the world north of the equator.

13. **Chara desmacantha** Gr. & B.-W.

Dioecious. Stem fairly stout. Internodes long, two to three times the length of the branchlets. Cortex regularly three-ranked, with the primary series broader than the secondary. Spine-cells, one of the main characteristics of the species, in clusters of two to six, usually three or four though sometimes solitary, very irregular in size but mostly long, slender and acuminate, though in large clusters one or two may be very small and bulbous-based.

Whorls of eight to eleven branchlets, which tend to incurve but often with a marked spreading towards the tips. Bract-cells all long and slender with the bracteoles usually longer and the bractlet slightly shorter. Root-nodes sometimes producing solitary or clustered whitish bulbils as in *C. aspera*. It does not fruit freely, ripe oospores being rare.

C. desmacantha is of medium size, stout and rigid. It bears a close superficial resemblance to *C. canescens*, but is most nearly related to *C. aspera*, of which it was for long regarded as a variety. The clustered spine-cells should separate it clearly as indeed they do in the typical well-developed Irish forms; but there may be some doubt in the more poorly developed forms, especially as the spine-cells in *C. aspera* are not always solitary.

Another important difference between the two is the considerably greater number of nodes in the stem-cortex: ten to twelve in a stem-internode of *C. aspera* and fourteen to eighteen in *C. desmacantha*. It is possible to count these more or less accurately by adding up the number of clusters in opposite ascending and descending rows, though I do not find this easy.

Other characteristic features of *C. desmacantha*, as compared with *C. aspera*, are its more rigid stem and branchlets, the longer internodes, a tendency to a greater number of branchlets, the bract-cells all being long, and its larger and rather more spreading coronula.

C. desmacantha in the British Isles is mainly an Irish plant with a few scattered records elsewhere. It is also recorded from Sweden and Bavaria.

14. **Chara connivens** Br.

Dioecious. Stem slender; internodes very long, about five times as long as the branchlets. Cortex regularly three-ranked, the two series equal in breadth. Whorls of six to nine branchlets of eight or nine segments which are often tumid and strongly incurved, especially in the male plant where the tips often cross one another. Bract-cells usually seven, only the anterior pair developed but not greatly so; bracteoles longer, and the bractlet about the same length as the bract-cells but all much shorter than the oogonium. Spine-cells almost invisible. Stipulodes quite rudimentary.

Coronula remarkably connivent, the cells tapering to the apex. Oospore cylindrical, truncate below; dark brown to black, maturing in June and July. Membrane with numerous clearly defined granules which are non-contiguous and consequently known as tuberculate. Little incrustation, but brittle.

C. connivens is a particularly graceful medium sized plant of light green colour and very connivent branchlets. This very distinctive species has been found in a few scattered localities in the south of England, with three records from Ireland, always near the sea. It occurs in a few European countries, mainly near the coast but occasionally inland, and round the Mediterranean.

15. **Chara fragifera** Dur.

Dioecious. Stem slender and flexible. Internodes normally about twice the length of the branchlets though in unusually large forms the latter are even longer than the internodes. Cortex three-ranked, with the primary decidedly the larger of the two series. Spine-cells and stipulodes both rudimentary. Branchlets six to nine, slender and flexuous, those of the male plant usually shorter and more connivent; segments nine to thirteen. Of the five bract-cells only the anterior pair developed, and considerably shorter than the bracteoles or bractlet.

Spiral cells of the oogonium often reddish orange; a pretty sight in the shallow Lizard pools. Oospores black, maturing in July and August. At the lower nodes and at the root-nodes large compound whitish bulbils, which from their supposed resemblance to strawberries are responsible for its name. No lime incrustation.

C. fragifera is not likely to be confused with any other species. Where the branchlets of the male plant are specially short, there is sometimes a string of antheridia touching one another, and in the male the bract-cells are particularly inconspicuous. Fertile branchlet-nodes are very numerous in this species.

In the British Isles it is known only from the Lizard, West Cornwall. It has been recorded elsewhere from a few countries of south-west Europe and from one locality in Cape Province, South Africa.

16. **Chara globularis** Thuill.

(=*C. fragilis* Desv. var. *Hedwigii* (Bruz.) Kütz.)

Monoecious. Stem fairly stout; internodes considerably longer than the branchlets. Cortex regularly three-ranked, the cells of the two series about the same breadth. Spine-cells and stipulodes normally extremely small (fig. 18a). Branchlets seven or eight, very straight with only the four lowest nodes usually fertile. Of the seven bract-cells usually only the anterior pair developed, but shorter than the oogonium. Oogonia and antheridia solitary. Oospore practically black, maturing in July and August. A large plant that may attain a length of three feet or more.

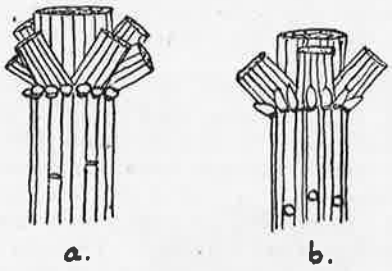

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Fig. 18. Stem-whorls. a. *C. globularis*, b. *C. delicatula*. × c. 20.

var. **capillacea** (Thuill.) Zanev.

(=*C. fragilis* Desv.)

A considerably smaller and commoner form than the type with slightly incurving branchlets and usually only the three lowest branchlet-nodes fertile. It is fairly common in the southern half of England with a few records from elsewhere. It has a world-wide distribution. Extreme forms of *C. globularis* are remarkably different from var. *capillacea* but intermediate forms occur.

Though it is usually easier to tell the relative sizes of the two stem-cortical series by examining a young internode I have now and then had cases where the very young cortex showed a tendency for the secondary series to be slightly the smaller of the two though in the rest of the stem the two series were obviously of about equal breadth.

To comply with the International Rules the familiar old name of *C. fragilis* has had to be dropped.

C. globularis has been recorded from several counties of the British Isles, mainly in the south but as remarked in *British Charophyta*, it is probably to be found in many others.

17. Chara delicatula Ag.

Monoecious. Stem slender with internodes but little longer than the branchlets. Cortex three-ranked and regular, the secondary series only about half the breadth of the primary (fig. 12, p. 18). Spine-cells papilliform. Upper circle of the stipulodes characteristically developed, the

lower remaining rudimentary (fig. 18b). Only the anterior pair of bract-cells developed, not longer than the oogonium. Bracteoles usually longer than the oogonium, though not so shown in *British Charophyta*, pl. XLIV. Oogonia and antheridia solitary, at the three lowest branchlet-nodes. Coronula usually connivent. Oospore black. A smallish, firm, neat looking plant.

var. **barbata** (Gant.) Gr. & B.-W.

This differs from the type in that both circles of the stipulodes are well developed, the lower often nearly as long as the upper and the two series not at all neatly arranged. Bracteoles and bract-cells are also both very long. It is found particularly in Scotland and Ireland.

var. **annulata** (Wallm.) Gr. & B.-W.

A very distinctive densely-tufted little form, often producing root-bulbils. Internodes and branchlets are very short: the latter are much incurved with a characteristic tendency to be tumid. It is known only from the far north of Scotland and from Ireland.

C. delicatula in general appearance is not unlike *C. globularis* var. *capillacea* though it is easily distinguishable as a rule by the secondary stem-cortex being smaller than the primary and by the upper row of stipulodes being developed to some extent (fig. 18b): the spine-cells too of *C. delicatula* though very small are slightly more prominent than those of *C. globularis*.

C. delicatula is one of the commoner species, particularly in Scotland and Ireland where it seems to take the place of *C. globularis* var. *capillacea*. Frequent in the Haslemere district. It has been recorded from various European countries and most continents.

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