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Manuscript No. 2 –

A map of Northern Indian showing distribution of Ultorichales described in this paper. The numbers shwon in the map refer to species as given below.

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1. Binuclearia Tatrana
2. Cylindrocapsa oedogonioides
3. C. scytonemoides
4. Enteromorpha intestinalis
5. Geminella interrupta
6. Hormidium flaccidum
7. Microspora indica
8. M. Terrestris
9. Pearsoniella Kashmiriensis
10. Prasiola Fluviatilis
11. Schizomeris Irregularis
12. Ulothrix Oscillarina
13. U. Subtilissima
14. U. Tennerima
15. U. Tennuissima
16. U. Zonata

Besides the above mentioned species, Rao and Singh have described a number of "formas" of *Spirogyra* and *Zygnema*. While some of these are merely described as "formas", there are others which are described as '*forma nov*. As their names, such as *megaspora*, *inflata*, *maxima*, *crassa* and *tenuis* show, these algae differ from the type only in larger dimensions of zygospores and vegetative cells, or in having narrower cells and zygospores, or greater or lesser inflation of fructifying cells, or slight differences in the shape of zygospores varying from ellipsoidal to subspherical. As has been already discussed these differences are of no great value or importance and in most cases are merely of physiological nature. In fact the dimensions of the vegetative cells and zyggospores of the same species collected from two different ponds seldom agree. The present author is of opinion that these so-called 'formas' which are of little taxonomic value, and (are merely ecological variants)

~~do not~~ deserve any special names. Some workers who base their observations on pickled material alone sent to them from a foreign country are sometimes misled by these ecological variants and habitat forms, and it is not unusual to find some of these elevated into the rank of species.

Collection ~~and~~ Preservation and Microtechnic ~~Mounting~~ of Freshwater Algae.

Algae are universally distributed and are found free-floating or attached to aquatic plants in ponds, freshwater streams, and rivers, growing subaerially on moist soil and the bark of trees. Of all the groups of freshwater Algae, Myxophyceae are the commonest and the most familiar, and we see them nearly all the year round in drains, ponds, and walls of houses. Most of our ancient historical buildings present a dark and dismal appearance, due to the thick coats of Campylonema, Scytonema, and Tolypothrix, which grow upon their domes and walls.

Collection of Algae:— For collecting Algae a very simple outfit is required. A tin-box containing a rack with about two dozen holes accommodating 24 wide-mouthed glass tubes about 2 inches in length and $\frac{1}{2}$ inch in diameter, is necessary. The bottom of the holes should be well-padded with cotton-wool to prevent injury to the glass tubes. There should also be some space provided for a sharp knife, a pair of scissors and ~~[illegible]~~ 1 dozen envelopes inside the box. In one of the small tubes commercial formalin should be stored. [illegible] A wooden rod, made of small pieces about $1\frac{1}{2}$ foot in length which could be screwed on to each other, and with a muslin net attached on one side may also be [illegible]

Besides the above mentioned species, Rao and Singh have described a number of "formas" of Spirogyra and Zygnema. While some of these are merely described as "formas", there are others which are described as 'forma nov. As their names, such as megaspora, inflata, maxima, crassa and tenuis show, these algae differ from the type only in larger dimensions of zygospores and vegetative cells, or in having narrower cells and zygospores, or greater or lesser inflation of fructifying cells, or slight differences in the shape of zygospores varying from ellipsoidal to subspherical. As has been already discussed these differences are of no great value or importance and in most cases are merely of physiological nature. In fact the dimensions of the vegetative cells and zyggospores of the same species collected from two different ponds seldom agree. The present author is of opinion that these so-called 'formas' which are of little taxonomic value, and (are merely ecological variants) do not deserve any special names. Some workers who base their observations on pickled material alone sent to them from a foreign country are sometimes misled by these ecological variants and habitat forms, and it is not unusual to find some of these elevated into the rank of species.

1. Subaerial ~~and~~ Soil Algae and Bark Epiphytes —

The ~~soil~~ algae growing on soil should be scraped from the surface of the soil with a sharp knife. These may be stored in an envelope or in a glass tube ~~with~~ in 4% Formalin solution. On reaching the laboratory they should be placed in a glass trough ~~and pla~~ under a water tap and thoroughly washed till the earth attached is as completely removed as possible. The bark algae are better stored inside ~~in~~ paper envelops, for they are capable of standing desiccation.

2. Freshwater Algae — These are usually found free floating or attached to water plants. Free-floating forms may be best collected with ones hands. On holding the mass of filaments under sunlight in one hand, hollowed down in cup-shaped manner, one can easily detect if the filaments are fertile or merely vegetative. In the case of Spirogyra, Zygnema, and Oedogonium one can see the Zygospores or Oospores in the form of small blackish specks. The colour of the alga, also is an index of its reproductive or vegetative stage. Dark green sheets of algae are always in a vegetative stage of growth, and when they become pale yellow or brownish yellow in colour they show plenty of Zygospores or Oospores as the case may be. So care should be taken to collect only those forms which may be reasonably ... There always to be in a

reproductive stage.

In the case of algae which grow epiphytically on water-plants, small pieces of leaves or stems of the plant may be cut with a pair of scissors, when they are small in size, but when they are big and cannot be put inside a tube, we should scrape the algae with a sharp knife, from their surface and store them inside a glass-tube.

Care should be taken to keep the tubes only $\frac{3}{4}$ full. Then a drop of Formalin should be added, and usually it is found to be quite sufficient to keep the Algae in good condition for a couple of days.

Flagellates and other plankton forms are sometimes found in large numbers inside small ponds and lakes. Sometimes when the water is wholly green with them, one can collect a good quantity by merely dipping a tube inside the water. In some cases a silk net is found useful and one should drag it for a distance of a few paces inside the water and collect a large number of these forms.

Preservation of Algae:— Most of the thick-walled Chlorophyceae and nearly all Myxophyceae are best preserved in a 4% solution of Formalin (Formaldehyde 40%). In the case of more delicate forms like the Flagellates and Chlorococcales 2% solution of Formalin is sufficient. A little copper sulphate may be added to 2% solution of Formalin when it is desired to preserve their natural
... as great an extent as possible

Staining — First wash the Alga in water for about 10 minutes. Then stain with Methylene Blue. I found Methylene Blue to be the best stain for differentiation of the cell details. However when mounted in Glycerine jelly the whole pigment is sucked out and after some months the cell-structure becomes transparent.

Mounting — I found Glycerine Jelly Method to be the cleanest and most satisfactory in the case of filamentous Algae. The filament should be lifted with a fine needle and placed in a ~~k~~ watch-glass in 10% Glycerine (1 part of Glycerine mixed 9 parts of water). and should be covered under a bell-jar to prevent particles of dust from coming inside. The 10% Glycerine solution should be just sufficient to cover the filament, and the watch-glass should be left alone for at least 24 hours to allow the water to fully evaporate. Then a drop of melted glycerine jelly should be placed in the middle of the slide, taking care that no air-bubbles cling to the sides of the drop, and the filament should be transferred at the point of a needle to it. Then it should be covered with a cover-slip. The slide should be ~~left to~~ placed under a bell-jar for at least 8 hours, and the glycerine jelly will set in a very better way. Then the ~~coverslip~~ slide should be placed on a turn-table and a thick ring of Black Varnish should be painted on the sides of the coverslip. Give the turntable a strong

~~Preparation of Glycerine Jelly~~ :-

spin, and touch the slide with a fine brush as far out from the cover as you wish the ring to extend, then gradually approach the coverslip and extend the ring until it is $\frac{1}{16}$" wide on the cover. Put a medium ring not more than two-coats thick.

Preparation of Glycerine-Jelly —

Put 1 part by weight of French gelatin in 6 parts by weight of water and allow it to lie for about 2 hours. Then add 7 parts by weight of Glycerine. For every 100 gramms of the mixture, add 1 gm. of concentrated Carbolic Acid. Heat the whole mixture for about 15 minutes and stir during heating. Filter the jelly while warm. A little of the jelly should be taken in a small tube and placed in a beaker containing boiling water. The jelly would melt and is ready for use in mounting.

The slides which I prepared about seven years ago, using Glycerine-Jelly method are in a state of perfect preservation. The only defect with glycerine is that it abstracts all the stains out of the cells, making them transparent.

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Occurrence and Distribution of the ~~Panjab~~ Freshwater Algae of North India".

I made a collection of the Panjab freshwater Algae from July 1929 to April 1930, and February 1931 to October 1931. from Lahore, Jullundur and Hoshiarpur districts of the Panjab. Then I had another opportunity of making a collection of the freshwater Algae in Saharanpur district of the United Provinces from December 1934 to January 1936. In all about 420 samples were collected comprising 122 species which have been worked out and these include two new genera and sixteen new species. Hoshiarpur and Jullundur districts are situated between Sutlej and Beas rivers, and contain two perennial streams the Siah and the Sufed Ballns these two districts provide unique opportunities for Algal collections, and it is no exaggeration if I call them an Algologists' Paradise. Hoshiarpur and Saharanpur districts contain a chain of ponds in the submontane areas, as well as swamps which are called Chhambs, locally. Saharanpur district is situated between the Ganges on the east and Jumna on the West with two big canals, and numerous small streams meandering in them. The swamps in these districts are annually replenished by rain-water from the hills brought by the Choes, which are seasonal torrential rivers which sweep

Geographically these districts are very much similar being bound by the Siwalik range in the North, and have practically the same sort of climatic conditions.

There are numerous big tanks also made by religiously or charitably-disposed people which ~~give~~ afford ample opportunities for algal collections. In addition there are ponds which are found in practically every village for the use of cattle, and these are also very interesting from the algal point of view. The ponds and ditches found on both sides of the railway lines in many districts are also full of Algae during and after the rainy season.

Climatic Conditions — Hoshiarpur is a submontane district lying between 30°·59' and 32°·5' N, and 75°.30' and 76°.38E. The annual average rainfall is 36", of which 30" fall in the summer months and 6" in the winter months. Jullundur and Lahore resemble each other very much and as compared with Hoshiarpur they are more dry and hot. The hottest months are May and June, with a mean maximum temperature of 106°F. ; the highest temperature recorded being 120°F. The coldest months are December and January, with a mean minimum temperature of 40°F. The rainfall seldom exceeds 25 inches per annum. Saharanpore resembles Hoshiarpur in nearly every way, only difference being that the rainfall is greater in Saharanpore.

Occurrence and Reproduction of Freshwater Algae:— ~~Three~~ Five

main groups of Algae viz. Diatoms, Myxophyceae, ~~and~~ Isokontae, Heterokontae, and Rhodophyceae, have been studied so far by Mr. Abdul Majeed, Dr. S. L. Ghose and the author in Northern India. Diatoms are very abundant during the winter months from the middle of November to the end of February, and my own observations fully corroborate the conclusions reached by Mr. Abdul Majeed in his investigations of the Panjab Diatoms. Forms like Navicula, Cyclotella, Surirella, Synedra, and Nitzschia are found in large numbers on the moist soil of fields after rains and on the drying sites of ponds and ditches. Synedra, Navicula, Cyclotella, Cocconeis, and Gomphonema are also found in large numbers ~~along~~ in stagnant or slowly-flowing sheets of water, ~~or~~ free-floating, or attached to the rotting branches of water plants.

Myxophyceae are met all the year round, but are very abundant after the close of the rainy season in the months of October and November. Members of Myxophyceae are both subaerial as well as aquatic, and in the latter case are found more commonly in stagnant sheets of water. Our knowledge of this group of Algae is mainly based on the work of Dr. S. L. Ghose. According to Dr. Ghose the Myxophyceae in Lahore show great vegetative activity between August and February, and the fruiting season is from February to April. The study of spore bearing forms like Anabaenas

Rivularia, Aulosira, and Nodularia is very interesting from this point of view. According to Dr. Ghose Anabaena variabilis and Rivularia natans produce spores in the months of March and April. My own observations show that forms like Anabaena cylindrica, Anabaena moniliforme, Anabaenothrix epiphytica, and Nodularia spumigena produce numerous spores in the months of February and March. As I have shown in my paper on "Periodicity in the Reproduction of Freshwater Algae," that the spore-bearing Green Algae, like Spirogyra, Zygnema, Chlorella, Sphaeroplea, and Oedogonium produce large crops of Zygospores and Oospores in March and April, the spore-bearing Myxophyceae like the species mentioned above, also, do not lag behind in this respect. In fact these Myxophyceae are as well prepared to meet the drought of May, June and July in the form of thick-walled spores as the Green Algae.

I have already dealt ~~with~~ at great length in a separate paper, with ~~about~~ the periodicity shown by the spore-bearing Green Algae in their reproduction. However forms which multiply vegetatively by fragmentation and zoospores continue their cycle of reproduction intermittently. These algae are found in artificial reservoirs of water, and perennial streams, and show a great luxuriance in growth from October to March.

Ecological Survey of the Freshwater Algae of Northern India.

The following is in brief an ecological survey of the Algae of Northern India, which I have come across during my investigations.

I. Subaerial Associations — Under this heading we shall deal with Algae which grow upon soil, in the form of patches or in some cases in the form of mats. Subaerial forms also include Algae growing upon pieces of moist timber and walls of houses. So we may divide the Subaerial Associations into two main groups; firstly the Soil Algae and secondly the Algae growing on Wood and walls.

A. Soil Algae. — The group of soil Algae includes three kinds of formations in this country.

i. Vaucheria Formation — This is equivalent to Zygogonium ericetorum formation of Europe. From the beginning of December to the last week of February, Vaucheria sessilis and V. geminata are seen covering large areas in lawns and grassy fields in the form of bright-green felt-like mats. Oogonia and Antheridia begin to appear in the first week of January, and by the last week of February most of the filaments become fertile. It is curious that Vaucheria sessilis collected from ponds at about the same time as from the lawns proved to be more fertile, each filament being loaded [illegible] oogonia and antheridia, which has a great liking for moist woodwork ~~and~~ ~~brick~~ ~~walls~~ lime-covered walls of houses, and earthen vessels like gharas and surahis. After the rains this alga may be commonly seen on smooth pieces of wood, from which bark has been removed and the walls of houses. This alga may be found throughout the year on the moist wood-work of Persian wheels, accompanied by Mosses.

ii. Bark Epiphytes — ~~Aphanocapsa.~~

This group of Algae resembles in many features the formation discussed above, but differs in showing an almost exclusive preference for ~~the~~ moist logs of wood and trunks of trees. Aphanocapsa montana appears in the form of light-blue-green patches on smooth trunks of trees from July to August, and the trunks become drier, the alga becomes sapphire-blue in colour. According to Dr. S. L. Ghose Phormidium truncicolum, Scytonema truncicola and Tolypothrix campylonemoides may commonly be seen on the trunks of Acacia modesta in the form of a bluish-green layer, which becomes very slimy and conspicuous after the rains. In the wet season hormogones are plentifully formed, and these produce mucilaginous sheaths which become thick, firm, and coloured. When it becomes dry and warm, the stratum becomes thin and papery, and peels off the trunk of the tree in bits.

II Aquatic Associations –

~~This~~ Under this heading we include all the Algae which are found growing in water, free-floating or attached to other water plants. This includes a large number of forms and we shall deal with only the commonest and most important species. According to their habitat, we divide this group into two main subgroups, viz. – Algal associations of Flowing Water and Algal Associations of Standing Water.

i. Algal Associations of Flowing Water —

This group may be further subdivided into two ~~small~~ subgroups according to the velocity of the current of water in which these Algae grow.

a. Algal Associations of Swiftly Running Water — This group of Algae is characterised by the possession of strong basal cells which very often secrete a sort of cement-like material for fixation to other water-plants, and plenty of aeration. I found a number of Rhodophyceae in the Siah Baeen near Dasuya in Hoshiarpur district, where it flows very rapidly. Attached to blades of rushes, in midcurrent, are found Chantransia chalybea, Compsopogon, Batrachospermum moniliforme, and Stigeoclonium variabile – in the months of August, September, October and November. In December, due perhaps, to excessive cold, these Algae disappear. Cladophora glomerata also belongs to this group and may be seen in big tassels looking like fox-tails attached to fallen branches of water plants and trees in most streams and canals. This group also includes a number of unicellular and colonial Myxophyceae growing ~~on Algal~~ on stones, which are well worth investigating. By developing strong basal cells and likeness for plenty of Oxygen, these Algae exclude other competitors and hold their own against all other Algae.

(4) – Algal Association of Slowly Running Streams –

These Algae are also characterised by fondness for plenty of Oxygen, but not so much as in the last mentioned group, and at the same time basal cells are not so well developed. As compared with the former ~~group~~ one, it is a much more numerous group. Cladophora glomerata, Mougeotia genuflexa, Draparnaldia plumosa, Chaetomorpha aerea, Oedogonium sp., ~~Chaetomorpha aerea~~, and certain attached species of Spirogyra, are very characteristic of this group. Here we may also mention the interesting case of Cladophora glomerata, which grows on the shells of Gastropods in tanks in Shalamar ~~tanks~~ Garden Lahore, and in the still water of the tanks secures its aeration through the help of these animals.

Cladophora glomerata also occurs in the reservoirs of wells fitted with Persian wheels, where the alga is constantly being aerated by the flow of water from the well. Chaetomorpha aerea which generally occurs in freshwater streams may also be quite often seen growing under water taps, where there is a constant flow of water.

II. Algal Association of Ponds, Tanks, and Ditches. — This group contains by far the largest number of Algae. This group may be divided into ~~three~~ four subgroups according to their habit.

a. Plankton forms — These are very tiny Algae, which are found floating in lakes, ponds, and tanks. Some of these Algae have evolved special structures like bristles, flattening of the body, and the secretion of mucilage, for keeping afloat in water. Such bristles and flattened shape may be seen in Pediastrum Boryanum, Scenedesmus obliquus and S. quadricauda. Mucilage helps Volvox aureus and Pandorina morum in keeping afloat. Microcystis aeruginosa, and Clathrocystis aeruginosa are simply flat in shape and has no other special structure. Arthrospira spirulinoides and A. platensis have a spiral like a cork-screw which helps the alga in keeping afloat. In this group of Algae we may also mention the different species of Anabaena, Rivularia, and Cylindrospermum which are found free floating in ponds and lakes though they have no special device as most of the plankton forms have, excepting the secretion of mucilage. This group also comprises numerous Desmids which are practically untouched by any Algologist in this country, and Diatoms which have been partly worked out by Mr. Abdul Rayeed.

b. Benthic and Free-floating forms — Under this heading we shall ~~also~~ consider those Algae which are found free floating near the banks of ponds, lakes, and tanks or simply entangled in branches of water-plants, for they have no special organs in the form of hapterophores or rhizoids for attachment. Zygnemales are very well represented with about nineteen species described by the author alone, and there are surely many more. Spirogyra is the commonest form of these, and then come Ghosella, Zygnema, Debarya, and Mougeotia. Nodularia fertilissima sp. nov. may also be seen mixed with Ghosella indica gen. nov. ~~Oedogonium is very well represented by about fourteen species described by the author~~. Sphaeroplea annulina may also be commonly seen after February, and in April it becomes fertile in such masses that it gives a brick-red colouration to many ponds. Hydrodictyon reticulatum occurs in most of the big ponds and small slowly flowing freshwater streams from the middle of July to the end of April. In November and December most of the freshwater streams are full of glistening daughter-colonies of this alga. There are very few Myxophyceae which are found free-floating. Oscillatoria princeps may be seen in very muddy and stinking puddles formed near most of our village wells or in drains. Aphanocapsa serpentina is found in the shape of light blue gelatinous cylindrical masses filling many ponds in Ferozepore district. Then there are certain species of Anabaena Rivularia and Cylindrospermum which may be found ~~attached to~~ free-floating in flocculent masses in some ponds and tanks.

C. Attached Forms — Under this group we shall consider the ~~spec~~ Algae which are found attached to the bottom of ponds, ~~walls~~ submerged walls of tanks and water-reservoirs, and submerged ~~stems~~ roots, stems, and leaves of water-plants. According to the substratum and object to which they are attached, we subdivide this group into following sub-groups.

i. Algae attached to Submerged soil of Ponds:— In this sub-group we include that small group of algae which are found attached to the bottom of ponds where the water is very shallow and seldom being deeper than two feet. ~~Three~~ So far I have seen only three ~~two~~ members of Myxophyceae which can be dealt with under this subgroup. Of these Lyngbya perelegans grows in the form of dirty-brown cylindrical columns attached to the bottom of tanks, and Anabaenothrix cylindrica in the form of blue-green irregular cylinders attached to the submerged soil of puddles. As there is no specialised organ of attachment, even a slight disturbance in water causes these cylinders to get detached ~~break up~~ from the bottom, and the alga becomes free-floating. ~~I~~ It is only its ~~the~~ method of growth which has given the alga an attached habit. The alga firstly grows on the submerged soil, and then ~~the~~ distal part of the colony grows up towards light, and the mucus of the colony assumes a cylindrical shape. The third alga is Nodularia spumigena which grows in deep blue coralline masses ~~on grass submerged~~ mixed with grass in the shallow water of Budha Nala at Ludhiana.

ii. Algae attached to the Sides of Water-reservoirs and Steps of Tanks — ~~Under~~ This group includes many members of Myxophyceae and some Green Algae which are found attached to the brick-work of the walls of water-reservoirs of wells, and the steps of tanks. Of these Schizothrix mexicana may be seen in deep bluish-green velvet-like bunches on the sides of water-reservoirs, used for watering cattle in villages, adjacent to wells. Another common alga is Rhizoclonium hieroglyphicum which is found on brick-work under water taps. ~~Other important members of this group are four species of Stigeoclonium~~, S. lubricum, S. ~~amoenum~~, S. tenue, and S. subuligerum which ~~may be found~~.

iii. Algae found attached to Sticks and Stones—

The algae which are included in this sub-group ~~show~~ have developed definite organs of attachment in the form of rhizoids or flattened basal cells. Some of them may be found growing attached to the sides of the submerged steps of tanks, but most of them are found attached to stones or dried sticks and branches of trees. Stigeoclonium with its four common species ^ S. lub[…] S. su[…] S. amo[…] S. ten[…] is a typical representative of this group, ~~and~~ Next comes Ulothrix with four species U. zonata, U. tenuissima, U. tennerima, and U. subtilissima.

IV. Epiphytes— Properly speaking it is a misapplication of the term, to call most of the algae as epiphytes. By this term however we mean those algae which grow upon living water plants and algae. This sub-group may be roughly divided into two sections, the difference mainly being that members of the second section are microscopic in size and are not obvious to the naked eye as the members of the first section are.

Section 1. Major Epiphytes— Most of these epiphytes have well-developed basal cells for attachment. Oedogonium is the commonest of these with 14 species of which Oe. cardiacum

Oe. urbicum. Oe. inerme, Oe sociale and Oe. Hirnii are fairly common on leaves of water-plants, and in the month of April they produce a multi-coloured harvest of oospores. Other common members of this section are Schizomeris irregularis, Ulothrix oscillarina, Pithophora kewensis, Cladophora glomerata, Chaetomorpha aerea, and attached species of Spirogyra. It may be marked that most of these algae, which have organs for attachment, are the same as those found in flowing water, and have developed these organs even in a still water environment.

Section B. — Minor Epiphytes — These are algae which are usually microscopic in size, and grow as epiphytes not only on common phanerogamic water plants, but also on other algae like Oedogonium, Cladophora and Pithophora, which do not produce any mucilage and hence become loaded with epiphytes. Mr. Abdul Majeed has studied the epiphytic Diatoms of the Panjab and according to him most of the filamentous algae, and especially those mentioned above are found loaded with species of Synedra, Achnanthes hungarica, Cocconeis placentula, Gomphonema intricatum, G. subapicatum G. constrictum and Epithemia argus. Most of these Diatoms have mucilaginous hyaline stalks by means of which they are attached to other algae and water plants. Other common epiphytes are Aphanochaete repens, Coleochaete soluta

C. dentata, Chaetosphaeridium globosum, Bulbochaete and species of Characium. Myxophyceae are represented by Chamaesiphon filamentosa, Anabaenothrix epiphytica, and Cylindrospermum Michailovskoense.

Literature.

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iii Iyengar. M. O. P. — Presidential Address. Sec. Botany 15th. Indian Science Congress.

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Marked Periodicity in Reproduction ~~and~~ of the Panjab Freshwater Algae.

I made a regular collection of the Panjab Freshwater Algae from July 1929 to May 1930, and since then I have been collecting Algae from December 1934 to December 1935 in Saharanpur district, which is on the boundary line of Eastern Panjab and western part of the United Provinces and has a climate not very different from the eastern submontane districts of the Panjab, like Hoshiarpur and Gurdaspur. My two years experience has shown me, that there is a marked periodicity in the reproduction of spore-forming Chlorophyceae which is closely connected with temperature and rainfall conditions.

A passing reference may also be made about those Chlorophyceae ~~and~~ which donot form spores with hard walls. Of these Hydrodictyon reticulatum is the commonest in ponds and slow-flowing freshwater streams. Its glistening daughter colonies may be found in nearly all months of the year when water is found in the ponds and streams, and I have collected it in all stages of development in all months from July to February. I am excluding from consideration here all Algae

which are found attached to artificial &c.
water-reservoirs and only those are discussed
which are found in natural ponds and streams.

Seasons of Northern India :- I have divided
a year in Northern India into four seasons; ^ Hot
1 Hot Summer ~~months~~ -
Start may be made with the Hot Summer months, months,
which begins from about 15th. May and terminates and S Autumn months
by the middle of July. These months are
characterised by dry heat. ~~which in June~~
June is the hottest month of the whole year
with a mean temperature of 89.7°, while
the maximum may be as high as
107.0°. In these hot dry months ^nearly all the
ponds dry up and only a few streams
show a slow trickle of water. Due to absence
of water no algae can be seen in any ponds
while in some perennial streams Oedogonium
may be found in a vegetative condition.
Most of the algae tide over these hot and dry months perennating
in the form of thick-walled spores.

II Rainy Season - This may roughly
be taken as beginning from the middle
of July and ending by the second week
of September. Due to the Monsoons the mean
temperature falls to 85.°. About 7 inches
of rain falls in these two weeks, and the
ponds and streams become fairly full with
water. The maximum amount of rain
falls in August i.e. about 8.5 inches and all
the ponds and streams overflow with water. The water of most the ponds is usually

The rainy season finishes by the second week of September, the rainfall in these two weeks seldom exceeding two inches and mostly falling in showers. This is the halcyon season for the Myxophyceae. On logs of wood light bluish patches of Aphanocapsa montana may be commonly seen. Campylonema lahorense is found mixed with grass in dark brown patches almost everywhere. In water-troughs & bluish-green fasicles of Schizothrix mexicana may be commonly seen intermixed with Cladophora and Rhizoclonium. On moist pieces of wood green covering of Pleurococcus may also be seen. In some streams, young filaments of Schizomeris and Compsopogon may be seen, the latter being of purple colour, attached to reeds submerged in flowing water. Young filaments of Spirogyra are also seen and in most the chloroplasts donot show full maturity. The same may be said about various species of Zygnema and Oedogonium. It is with considerable effort that the last mentioned algae may be found even in vegetative condition.

III Autumn Flora — These may be taken as beginning with the third week of September and finishing by the middle of November. In the latter part of September the sides of ponds begin to dry up. On the sides of drying ponds Botrydium and

Protosiphon appear in a thick green carpet. In the month of November Protosiphon grows in large numbers on fields which have been lying fallow. Cyst-formation in the subterranean rhizoidal portion takes place in a week, and then the Alga disappears from view. Spirogyra is also seen in a fertile condition in most ponds. I recorded four species of Spirogyra in this month viz. Spirogyra condensata, S. rivularis, S. crassa and S. nitida.

IV Winter Months-

By the middle of November it becomes fairly cold in Northern India, and the mean temperature drops to 50.0. The ponds are usually half full at this time, and the streams and rivers have a regular flow of clear, sparkling, and ice-cold water of the Himalayan snows. In some cold freshwater streams like the Siah Baeen, near Jullundar(?) with a swift current of water, Chantransia chalybea, Batrachospermum moniliforme, Stigeoclonium variabile and Compsopogon sp. are found attached to blades of Typha in the mid-current. These members of Rhodophyceae and Stigeoclonium variabile are provided with well-developed basal cells for attachment. These Algae disappear in December, perhaps due to excessive cold, for the mean temperature may be as low as 45°.

In slowly running streams Cladophora glomerata may be seen in big tassels looking like fox-tails attached to water-plants. All these algae require a good deal of aeration, and I have noticed that where the ~~stream~~ current of water becomes very slow these Algae tend to disappear. Here we may mention the peculiar case of Cladophora glomerata which may be seen in the tanks of the Shalimar Gardens Lahore growing on shells of Gastropods, which move about in the tanks and thus aerate the alga. However in this case the growth of the alga is not luxuriant and it appears to be a mere shadow of ~~the~~ the ~~alga~~ Cladophora glomerata which grows in running streams. Due to slow locomotion of the Gastropod, the alga becomes thickly encrusted with Diatoms and dust particles. Cladophora glomerata also occurs in the water-reservoirs of wells fitted with Persian wheels, where it is constantly aerated by the flow of water from the well.

In December we ~~see~~ usually have a rainfall of 1.5 to 2 inches especially in the last two weeks. After the dry months of October and November, this is very welcome and gives a new lease of bright green felt-like ~~masses~~ mats in lawns gardens and other moist places. Oogonia and Antheridia begin to appear in the first week of January, ~~when~~ and by the last week of February nearly all the filaments become fertile being heavily laden with oogonia, antheridia and oospores. ~~Usually it is thought~~ Vaucheria sessilis is found both in ~~ponds and~~ ~~dry~~ aquatic and terrestrial habitat, and it is curious that specimens of it collected from ponds at about the same time as from the lawns, proved to be more fertile, each filament being loaded with large crops of oogonia and antheridia, while in the case of terrestrial specimens very few sex organs were seen.

V Spring Months —

Spring season may be taken as beginning with the first week of March. As compared with February there is a marked rise in temperature, the mean temperature in March being 62.0° as compared with 49.7° in February. Just as in spring a young man's fancy is supposed to ~~turn to~~ lightly turn to

By the middle of April, Gloeocapsa is all fertile and conjugation canals bulge out with ripe zygospores of an orange-yellow colour. Sirogonium sticticum also produces zygospores in April.

Periodicity in reproduction:—

By the end of May most of the ponds begin to dry up, as there is no rainfall and the mean temperature rises to 81.0°. Now the Algae have to face the hot dry spell of three months beginning with May and ending with the middle of July. To meet this contingency species of Oedogonium, Spirogyra, Vaucheria, Zygnema, Gloeocapsa, Sirogonium, and Sphaeroplea have produced thick-walled oospores which are capable of surviving the high temperatures of June and July. When the rains start in the middle of July, these oospores begin to germinate and produce young filaments. Then for the next four to five months most of these algae show a great vegetative growth with very little reproductive activity.

The month of March provides optimum conditions for their reproduction, and probably this may be due to rise of temperature in March after the cool months of January and February. Thus there is a marked periodicity in reproduction shown by these Algae in Northern India which is connected with more or less distinctly marked seasons. This is a remarkable phenomenon which is not noticeable in England or other temperate countries, where the seasons are not so well-marked, as we have in Northern India.

Reproduction in Green Algae.-(Marked periodicity).

✓Hydrodictyon reticulatum	-	small daughter colonies from April to July.
Cylindrocapsa conferva	-	July.
✓Sphaeroplea annulina	-	April.
Coleochaete scutata	-	End of March.
✓Oedogonium sp.	-	April.
✓Ghosella indica	-	
✓Zygnema sp. CHALYBEOSPORUM	-	
✓Spirogyra sp.	-	
✓Vaucheria		

CHLOROPHYCEAE
APHANOCAPSA MONTANA
CAMPYLONEMA LAHORENSE
SCHIZOTHRIX MEXICANA
CLADOPHORA GLOMERATA

...zoclonium
...eurococcus
...psopogon
...trydium
...tosiphon
...ntransia chalybea
...rachospermum moniliforme
...edogonium variable
...ougeotia genuflexa
Sirogonium sticticum.

A remarkable fact about the algae noted above is that though these are found in a vegetative state for most part of the year especially in the winter months, they produce their sex organs with great regularity from the last week of March and by the middle of April they are all fertile. Various species of <u>Oedogonium</u> produce heavy crops of Oogonia and antheridia by the last week of March and are all in a fertile stage by the second week of April. The same periodicity may be noted in the case of <u>Sphaeroplea</u>, <u>Ghosella</u> and the various species of <u>Spirogyra</u> and <u>Zygnema</u>. This is most probably connected with the rise of temperature in March after the cool months of January and February. As our seasons are distinctly marked, this also affects the sex organs of these Algae, and by April when the temperature rises to 106°F these begin to produce their sex organs. By the month of May most of our ponds begin to dry up and the above Algae are prepared to face this contingency for most of them have produced thick-walled oospores which are capable of resisting the high temperatures of June and July. Most probably when rains start in July these oospores begin to germinate and produce young filaments. This is a remarkable phenomenon which is ~~most~~ not noticeable in England or other temperate countries where the seasons are not so well marked as we have in India.

Rainfall in Hoshiarpur Distt from October 1934 to October 1935.

onths	Dasuha Tahsil	Una Tahsil	Garhshankar Tahsil	Hoshiarpur Tahsil	Tanda town	Mukerian town
ctober/34	.04	-	-	-	-	-
vember/34	-	-	-	-	-	-
cember/34	1.49	1.74	1.28	1.34	.70	1.57
nuary/35	4.36	5.13	4.12	3.50	1.83	5.32
bruary 1935	1.08	1.57	1.70	1.23	.35	1.67
march/35	.38	.44	.16	.34	1.05	.84
pril/35	2.71	2.78	1.55	3.39	1.78	2.58
ay/35	-	-	.09	.27	-	-
ne/35	-	-	.17	.79	-	.20
uly/35	7.45	3.96	4.31	6.14	8.56	13.88
ugust/35	11.41	6.05	5.47	5.10	4.96	9.49
epti/35	.78	3.66	1.76	2.83	-	9.49
ctober/35	.57	.23	.17	.11	-	.06
tal up to June ce: to register	10.06	11.66	9.07	10.86	5.71	12.55

25/11

Hoshiarpu

26.11.35

Sir,

In compliance with

verbal order of S. Kapur

I.C.S. I respectfully beg

give the information

past year's rainfall

October /34 to Octr: /35

desired by you in your

dated 20.11.35 addressed

Kind Sardar Sahib. The

information regarding

temperature for the who

year is not available

Owing to some indispo

Sardar Sahib has got

letter written by me.

will write you on recove

sound health.

Any service?

Your most obe

Servant

Tulsi Ram

{Please see overleaf.}

	15th November	×		
IV Winter Months	15th November	×		
	December	1.5 inches	Pleodorina indica sp. nov.	entangled in the roots of Azolla.
	January	4.5 inches		
	February	1.0 inch	Anabaenothrix cylindrica Vaucheria uncinata sp. nov.	Greenish free floating gelatinous mass. showing aplanospores.
V Spring Months.	March	×		
	April	2.5 inch		
	15th May	×		

	[illegible]		Cylindrocapsa [illegible] [illegible] Chlorella	[illegible] found in a clump.
IV Winter Months	December	1.5 inch	Hydrodictyon reticulatum Anabaena sp. Spirogyra crassa Oedogonium rivulare	mature. Greenish-blue mass free floating. greenish free floating
	January	4.5 inch		
	February	1.0 inch		
V Spring Months	March	×	Oedogonium kashyapii	attached to stems of water plants
	April	2.5 inch		
	15th May.	×		

No.	Month.	M. Temperature	Rainfall	Algae collected	Remarks
I Hot Summer Months	15th. May		×		
	June		×		
	15th. July		×		
II Rainy Season.	15th July		7 inches		
	August		11 inches	Volvox aureus.	free floating in gelatinous mucilaginous masses.
	15th. September		0.5 inch		
	15th. September		×	Anabaena sp.	Blackish flocculent free-floating mass.
	15th. November		×		

Dasuya Tank.

No.	Month.	Average Temperature	Rainfall	Algae collected	Remarks.
I Hot Summer Months	15th. May		×		
	June		×		
	15th. July		×		
II Rainy Season	15th. July		7 inches	Small colonies of Hydrodictyon — Cylindrospermum stagnale Oedogonium sp. attached to Nelumbium leaves.	free floating; glistening colonies in masses attached to water plants light bluish green globules mixed with Lemna fronds.
	August		11 inches —	Schizomeris irregularis — attached to hairs of Nelumbium stalks Anabaena sp.	epiphytic on a species of Spirogyra.
	15th. Sept.		0.5 inches		
III Autumn Months	15th. Sept.		×		
	October		×	Oedogonium rivulare Cylindrocapsa conferta	A bluish-black free-floating mass
	15th November		×	Attached sp. of Spirogyra Chlorella —	attached to stems of water plants — found in a clump.

free floating mass. | months | Cylindrocapsa ... | A bluish-green free floating mass

	16th November	×		
IV Winter Months	15th November	×		
	December	1.5 inches	Pleodorina indica sp. nov.	entangled in the roots of Azolla.
	January	4.5 inches		
	February.	1.0 inch	Anabaenothrix cylindrica sp. nov. Vaucheria uncinata	Greenish free floating gelatinous mass. showing Aplanospores.
V Spring Months.	March	×		
	April	2.5 inch		
	15th May	×		

IV Winter Months	15th November	×	Attached sp. of Spirogyra Chlorella	attached to stems of water plants found in a change.
	December	1.5 inch	Hydrodictyon reticulatum	mature,
			Anabaena sp.	Greenish-blue mass free floating.
			Spirogyra crassa Oedogonium rivulare	greenish free floating
	January	4.5 inch		
	February.	1.0 inch.		
V Spring Months	March	×	Oedogonium kashyapii	attached to stems of water plants
	April	2.5 inch		
	15th May.	×		

No.	Month	Mean Temperature & Fahrenheit	Rainfall and Condition of ponds and streams	Habitat	Algae Collected	Remarks.
I Hot Summer Months	15th. May	86.4 F.	x			
			0.0			
	June	89.7 F	x All ponds dry up.	Stream	Oedogonium sp.	found attached to reeds.
				A water trough of a well	Cladophora glomerata	
	15th. July	87.1 F.	"			
II Rainy Season	15th. July	86.0 F ~~87.1~~	7.5 ~~8~~ inches	Tanks and streams	Hydrodictyon reticulatum	young colonies found.
				Tank.	Oedogonium sp.	young filaments attached to reeds. Purple colour.
				Freshwater stream	Compsopogon	
				On logs of wood	Aphanocapsa montana	appears in light bluish patches on logs of wood.
				Free floating in a pond.	Volvox aureus	in green slimy mass
			8.5 inches	In a grassy lawn	Campylonema Lahorense	Grows in the form of brown patches
	August.	85.6 F	Ponds full Streams with plenty of water	sides of water troughs	Schizothrix mediana	in a dirty pond near a well.
				Tank.	Oscillatoria princeps	free floating with fronds of Lemna.
					Cylindrospermum stagnale	
				Tank	Schizomeris irregularis	found attached to stem of Nelumbium.
				Under a water-tap	Ulothrix oscillarina	
	15th. September	81.8 F	1.5 inch			
	15th. September	80.0 F	x	[illegible]	[illegible] reticulatum	

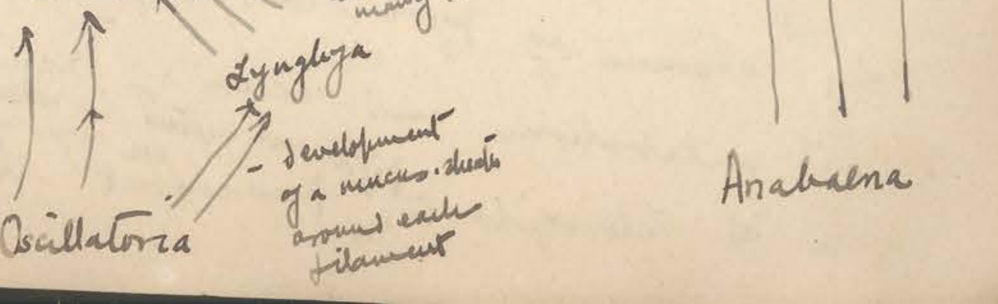
[illegible]				A pond	[illegible]	
	15th. November	57·0	×		Gloeotrichia	
					Spirogyra nitida	Aulosira fertilissima — which nodules free floating
					S. condensata	{ Chara and Nitella — in a fertile condition.
					Oedogonium sp.	
					S. rivularis S. crassa	
				A pond.	Aphanocapsa [illegible]	——— free floating in gelatinous masses.
				"	Rivularia natans	———
IV Winter				Tanks and Ponds	Zygnema sp.	still in a vegetative condition
	15th. November	50·0	×	Pond.	Cladophora glomerata	——— attached to shells of Gastropods
					Batrachospermum moniliforme	
				A freshwater stream very cold water	Chantransia chalybea	— attached to blades of Typha.
					Stigeoclonium [illegible]	
	December	45·3	to 5 inches Ponds half full		Aphanochaete & Bulbochaete	——— mixed with shoots of Hydrilla
					Anabaena sp. Pithophora [illegible] sp. nov	——— attached to roots of [illegible] in a pond.
				Attached to stones in stream	Schizothrix fuscescens uncinata	— fertile — stream.
					Vaucheria [illegible]	
					Chamaesiphon [illegible]	
	January	45·0	4 inches		Chara ornata	——— fertile
					Chara vulgaris	blackish mucilaginous mass attached to rocks
					Draparnaldia glomerata	———
				Tank.	— Spirogyra crassa Oedogonium rivulare.	
	February	49·7	×	lawns.	— Vaucheria sessilis S. condensata S. neglecta	
				stream	— Zygnema chalybeospermum. Mougeotia genuflexa	
					Nodularia spumigena	
				Puddles + Ponds	— Sphaeroplea annulina — red spores.	
					Oedogonium [illegible] Oe. cardiacum.	
V Spring Months	March	62·0	× Ponds half full sides drying.	Freshwater flowing stream	Chantransia chalybea Oe. [illegible]	
				"	Nodularia spumigena Oe. [illegible]	
				"	Sirogonium sticticum.	
				"	Spirogyra affinis S. [illegible] S. [illegible] S. [illegible]	
					Zygnema chalybeospermum —	
					Gloeotila indica Nodularia fertilissima	
	April	75·4	2 inch		Cylindrospermum stagnale Nostoc [illegible]	
					Coleochaete scutata C. soluta Bulbochaete	
					Oedogonium [illegible] Oe. [illegible] — Oe. [illegible], Oe. [illegible] — [illegible]	
					S. [illegible] — all fertile — Oe. [illegible] —	
	15th. May	81·0	× Water at the bottom of ponds only.		[illegible] — fertile in big yellowish masses in ponds.	

"Genus" Anabaenothrix and Parallelism ~~of~~ in Evolution in Freshwater Algae."

During my investigations of the Panjab Freshwater Algae I came across two Anabaena-like ~~Algae~~ species of Blue Green Algae, which however differ from the typical specimens of Anabaena in having a number of trichomes enclosed in a single mucilaginous sheath. Recently Dr. F.E. Fritsch described a species of Anabaena with a mucus sheath, from South Africa, which he calls Anabaena vaginicola sp. nov. (Trans. Roy. Soc. of S Africa Vol XVIII Parts 1 and 2). This so-called Anabaena vaginicola Fritsch resembles Anabaena cylindrica Lemmer. in essential features and the only vital difference is the occurrence of a number of trichomes within a single sheath. The two species which I discovered differ from Anabaena vaginicola Fritsch in the size of the filaments, the shape and size of the vegetative cells, and the form and size of spores and heterocysts. Following is a ~~descripti~~ detailed description of these three species of Anabaena-like Blue-green Algae

i - Insert A.

So here are three species of Anabaena. the Blue Green Algae which have acquired in the course of their evolutionary progress, the same character of enclosure of a number of trichomes in a single sheath. This case clearly illustrates, as suggested by Miss Agnes Arber in her excellent monograph on Monocotyledons, that a Genus is an evolutionary platform on which species of different origin are assembled together. In the case of these Algae, three different species of Anabaena independently acquired the habit of grouping of numerous trichomes in a single sheath. Obviously we are justified in establishing a new Genus, which I call Anabaenothrix, for the same reasons as we have in establishing Schizothrix as a separate genus from Lyngbya or Lyngbya from Oscillatoria. This genus Anabaenothrix is an expression of a tendency parallel to that of Schizothrix viz. the enclosure of a number of trichomes within a common sheath. This parallelism in evolution is very interesting and shows how the habit of secretion of a common mucus sheath by a number of filaments, developed in different families of Myxophyceae, by Schizothrix in Oscillatoriaceae, and Anabaenothrix in Nostocaceae. Members of Genus Lyngbya are nothing but Oscillatorias enclosed in a mucus-sheath. Here the individual filaments developed the habit of secreting ~~individ~~ separate mucus sheaths around themselves, possibly as a protection against drought and dessication. In Schizothrix which marks the next stage, possibly higher, in the evolutionary progress we see a number of filaments secreting a common sheath, ~~Obviously this~~ which means a greater economy of material. This tendency towards collective secretion of a sheath has also expressed itself in Anabaenothrix, the various species of which developed from different species of Anabaena. Though Anabaena is structurally on a higher scale than Oscillatoria or Lyngbya, we find it treading the same evolutionary path as some species of the latter two genera of Myxophyceae. Different species of Oscillatoria and Lyngbya developed into Schizothrix and different species of Anabaena into Anabaenothrix, but both followed independent roads in reaching the same evolutionary goal. Following is the possible evolutionary course among these Algae.



We also note similar parallelism in evolution between a dichotomously divided species of Botrydium from Madras called Botrydium divisum described by Dr. M. O. P. Iyengar some years ago, and Dichotomosiphon. The dichotomous nature of the branching of B. divisum suggested to Dr. Iyengar some distant connection with Dichotomosiphon, a member of Isokontae. However these resemblances of form between Botrydium divisum Iyengar and Dichotomosiphon are purely superficial and comparable to resemblances shown by certain members of Euphorbiaceae e.g. Euphorbia royleana to Cereus triangularis a member of Cactaceae. As a result of similar dry and hot environment these plants, phylogenetically far apart, have developed similar physical characters like succulence of stem and reduction of leaves. Dichotomosiphon, a member of Isokontae is characterised by starch metabolism, presence of pyrenoids and presence of carotin and xanthophyll in the same proportion as in higher plants, while Botrydium a member of Heterokontae, is characterised by absence of pyrenoids coupled with oil metabolism and excess of xanthophyll in its chloroplasts. Differences between Isokontae and Heterokontae are regarded as so fundamental that prominent algalogists

5. hold that Isokontae and Heterokontae had an independent origin among the primitive Flagellates. Most probably the ancestors of Botrydium were some dichotomously branched filamentous coenocytic Heterokontae, possibly some coenocytic Tribonemaceae. Such structures in this hypothetical member of Tribonemaceae and Dichotomosiphon developed quite independently due to a similar response to some unknown environmental conditions and does not mean any phylogenetic relationship between the two, for their differences are more fundamental than their resemblances.

Another striking instance of parallelism in evolution is seen in the case of Protosiphon, a globular member of Isokontae and the common roundish species of Botrydium, which belong to Heterokontae. In this case the resemblance in external appearance is so great that species of Botrydium are often mistaken for those of Protosiphon and vice versa, specially when the chloroplasts have disappeared. The spherical form has been independently evolved in these two Algae to reduce evaporation of water, specially as they subsist on dry mud and they have to economise their water content. These two terrestrial Algae find their parallel in globular Cactaceae of Mexico and South America.

Species have a tendency to evolve along parallel lines when they are subjected to similar environmental stimuli e.g. the same degree of temperature, similar hygroscopic conditions and similar soil constituents. This is clearly seen in the case of Botrydium and Protosiphon. However in some cases the resemblance may be purely fortuitous and may be due to some unknown changes in the CHROMOMERES chromomere of the chromosomes SOME of the nuclei of cells taking place independently in different species of different genera but resulting in similar external physical appearance of the plant-X.

New para The discovery of the fact that species have a tendency to evolve along parallel lines has made it abundantly clear that external physical appearance is no index of phylogenetic PHYLOGENETIC relationship and we should avoid the fallacy of deducing pedigrees and relationships merely on the occurrence of a few common external characteristics. The realisation of the fact of parallelism in evolution has also influenced our concept of Genus. The species of Arabaenotrix clearly illustrate that Genus is an evolutionary platform on which species which have evolved independently from different levels gather together for

"Some Attached Forms of Spirogyra from the Panjab."

Some species of Spirogyra have been described, which are known to produce organs of attachment in the form of hapterophores, but so far, I think there is no record, from India, of a fertile form ~~attached~~ producing rhizoids. ~~In~~ During my investigations of the Panjab freshwater Algae, I came across, a number of species of Spirogyra, growing both in stagnant water of tanks and rapidly flowing freshwater streams, which produce rhizoids for attachment. Delf has described Spirogyra adnata and S. fluviatilis as forms occasionally producing rhizoids, and according to Kny Spirogyra setiformis also sometimes produces rhizoids.

I have frequently observed that Spirogyra affinis Kutz. whose usual mode of reproduction is by lateral conjugation (fig i a) quite often produces rhizoids from its cells. These rhizoids become closely attached to thick and rough filaments of Oedogonium on whom this alga is found as a common epiphyte in ponds. These hapterophores of Spirogyra affinis (fig i. b) are bifurcated, and their ends are frayed. In fact these are not very different from those described by Delf in Spirogyra adnata and by Iyengar in a sterile species of Spirogyra. Their size and ~~central~~ lateral position indicate that quite possibly they are merely modified conjugation canals, though it is difficult to guess as to why the organs which are purely reproductive in function should subserve the function of fixation and support.

I have also come across some filaments of Spirogyra dubia Kutz. producing rhizoids, which are very different from the haptophores of Spirogyra affinis. Fig II a shows a conjugating filament of S. dubia with ripe zygospores. The rhizoids in this case are not short and stumpy as in S. affinis, but are long pillar-like bodies (fig II b) which expand laterally and become frayed when they get attached to some other aquatic plant. The chloroplasts in the rhizoids are never in the form of a spiral, but are in the form of pallish green stretched out thread-like ~~filaments~~ bodies. a. not b.
This alga is found in slowly flowing freshwater streams.

Another interesting species of Spirogyra was found attached to the radial stem of a water plant in the big tank at Dasuya District Hoshiarpore. In this case it is noticeable that the attached habit has been developed in a distinctly still-water environment, where the alga is no danger of being washed away by a rapid current of water. The upper cells of the filament are 30 μ broad and about 4 times as long. The chloroplasts in the upper cells, are

very closely packed (Fig III a), so close in fact,
and III c)
that they donot present the appearance of a spiral at all. It was with considerable difficulty that the alga was identified as a species of Spirogyra, the doubts about its identity being strengthened by its fixed habit. I came across a specimen of Spirogyra in a sheet of water at Dhanouri Tehsil Roorkee District Saharanpore, which resembled the form I have described above in the condensed nature of its chloroplasts. It would be interesting to find out the physiological factors which affect the form of the chloroplast in these attached forms of Spirogyra. The rhizoids of this alga are very highly developed. Some of the rhizoids are long and dichotomously divided (Fig III b. c). Some of them show degenerated thread-like chloroplasts (Fig iii b) while others are absolutely hyaline (Fig iii d.). Some of the filaments show a dichotomously-frayed disc at the bottom (Fig III e). Rhizoids like the above, have been described by Pascher in a species of Mougeotia, but so far they have not been reported in such a complex stage of development in any species of Spirogyra. Here we cannot regard the rhizoids as modifications of

conjugation tubes as in *Spirogyra adnata* or *S. affinis* for they are not lateral in position as in the above forms. In this alga they are definite organs by themselves.

The upper cells of the alga also show conjugation in some case with ripe zygospores (figs. III f and g). ~~The zygospores are oval in shape 28 µ broad~~ Due to the condensed nature of the chloroplasts it is difficult to find out their number and spirals. Possibly it is a new species of Spirogyra.

My experience has shown that fixed habit is quite common in the above species of Spirogyra, both in ponds and streams in Northern India, and especially in the last mentioned form, where it is found as a constant and fixed feature of the alga, rather than as a freak and a curiosity. A fixed habit with rhizoids is a distinct advance as compared with a free-floating habit, and the species of Spirogyra which show this feature must be regarded as structurally on a higher plan.

Before closing I must convey my heartfelt thanks to my esteemed teacher Dr. S. L. Ghose of Lahore, who has been my main inspiration in my work on Algae.

Literature.

i. Delf – / Refer typed paper.

Genus. Ghosella. Randhawa.

1. Ghosella indica. Randhawa.

Vegetative ~~filaments~~ cells 10 - 15 μ. broad, and ~~cells are~~ 4-5 times as long. Each cell with two stellate or more or less rounded chloroplasts surrounding a centrally situated nucleus. (Fig).

Conjugation scalariform. Conjugation canals are very wide, being 18 - 40 μ in width. Deposition of shining mucilaginous lamellae takes place during the process of conjugation as in Debarya americana. Transeau (Fig). Marked geniculation of filaments takes place during conjugation as in certain species of Mougeotia. (Fig) Conjugation between 5-7 filaments at the same time is quite common.

The zygospores are rounded, or oval, and extend into both the gametangia. The zygospores commonly retain the horn-like arms of the gametangia, and joints of the ripened cells get loosened, resulting in detachment of zygospores as in Debarya desmidioides West —

The zygospores are ~~45~~ 36 - 46 μ broad excluding their mucilaginous coats, and inclusive of these may be as broad as 56 μ. ~~Zyg.~~ Ripe zygospores are deep yellow in colour, and show a considerable variety in shape. The zygospore wall is composed of three layers, the exospore is thin and light blue in colour, the mesospore is thick, chocolate brown in colour, and the endospore is yellowish in colour. ~~Fig.~~ The zygospore wall shows punctation ~~(Fig)~~ on its surface. in the form of minute circular depressions (Fig).

Azygospores are also plentifully seen, and these are usually spindle-shaped in appearance (Fig). Some of the zygospores ~~have~~ three arms, and it seems as if these have resulted from the conjugation of a terminal cell of a filament with an intercalary cell of another filament (Fig) Such zygospores are also seen in Debarya americana Transeau ( ).

Delimitation of Genus Ghosella :—

There are ~~three~~ four ~~species~~ other members of Conjugatae, which have been variously described by different authors as belonging to Genus Debarya or Zygnema. ~~All of these~~ These are as follows :-

1. Debarya americana. Transeau. from North America. Czurda ( ) regards it as a species of Zygnema and has named it Z. americanum.

2. Debarya decussata Transeau from North America, ~~called~~ has been named as Z. decussatum by Czurda ( ).

3. ~~Zygnema~~ Debarya spirale (Fritsch) Transeau has been called Z. spirale Fritsch by Czurda ( ).

pseudo-decussatum

Zygnema pseudodecussatum

A New Species of Cylindrocapsa from India
by M. S. Randhawa,

Cylindrocapsa Oedogonioides. sp. nov.

This very rare alga was found entangled in the filaments of a species of Oedogonium, which was growing epiphytically on the blades of Typha plants in Shahniwala Tank at Dasuya, Panjab, during the months of March, and April, 1930, and 1931. During March only sterile filaments were seen, but by the last week of April, some filaments developed oogonia, antheridia, and oospores. So far, ~~as~~ as ~~[illegible]~~ the author knows there has been no record of any species of the rather uncommon genus Cylindrocapsa from India. Possibly this is due to the habit of the alga, for even where it occurs it is found in such a scattered condition, that after a long search under the microscope one may be lucky enough to spot a filament or so.

The filaments are unbranched and consist of a single row of more or less ~~[illegible]~~ rectangular cells, which are enclosed within a lamellose sheath, as in Cylindrocapsa conferta. West. But the cells of this alga differ from those of C. conferta West in having two small pyrenoids at the opposite ends of the cells (Figs 1 and 2), instead of a single massive pyrenoid as in C. conferta West. There is a single massive chloroplast, which is parietal in position, and presents a more or less granular appearance

In most of the cells, a [illegible] well-shaped nucleus may be seen in the middle surrounded by two pyrenoids at the sides (Fig. 2 and 4).

Vegetative cells are 18 μ broad, and 12 – 28 μ long, being considerably narrower than those of C. conferta West.

Reproduction.

This alga is characterised by the presence of a well-developed oogamy. Of the species so far known, sexual reproduction has been worked out only in C. involuta Reinsch. In the present form the method of reproduction differs from that of Cylindrocapsa involuta Reinsch in many details, but antheridia and oogonia develop in the same filament, as in C. involuta Reinsch.

Antheridia:— The antheridia are produced by division of certain cells, and such cells may be distinguished from the normal vegetative cells by their much smaller size (Fig 2a, and 5a). In one filament rows of empty cells were seen alternating with rows of enlarged cells (Fig 4). Probably these represent antheridial cells out of which sperms have escaped.

Oogonia — The oogonia develop from ordinary vegetative cells, which become oval in shape, and increase in size considerably. Sometimes whole rows of cells in some filaments become converted into oogonia (Fig 3), and such filaments show constrictions in the sheath, which makes the alga look like an enlarged Anabaena.

~~The size of the oogonia is~~. The oogonia are — 4 broad and 36 µ long. No lateral pore was observed in any of the oogonia.

~~The ov~~ There is a single ovum in each oogonium, which is produced by the contraction of the protoplasm, and this results in a considerable empty space in the oogonia. The oospores are 28 µ in diameter, being considerably smaller as compared with those of C. involuta Reinsch, and are surrounded with a thick hyaline wall (Figs 6 and 7). In one instance the oospore was seen divided into two cells (Fig 7.0.). The ~~mature~~ filaments with mature oogonia, containing oospores ~~present~~ donot look very much different from the filaments of Oedogonium, and hence the specific name Oedogonioides. The sides of the mature oogonia donot show any lamellation as in C. involuta Reinsch.

Cylindrocapsa Oedogonioides Sp. nov.

Vegetative cells 18 - 20 µ broad, 12 - 28 µ long rectangular or subrectangular in shape, enclosed in a lamellose sheath. A single massive chloroplast parietal in position, with two small pyrenoids in each. Oogonia µ broad, 36 µ - µ long, inflated with no lamellae at the sides. Oospores 28 µ broad with a thick mucilaginous hyaline sheath.

Habit — Found mixed with filaments [of] two species of Oedogonium growing epiphytically [on] blades in Shahniwala Tank Dasuya, District Hoshiarpur Punjab, during March and April 1930 and 1931.

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Explanation of Figures.

Cylindrocapsa Oedogonioides. sp. nov.

Fig 1. A vegetative filament showing cells with two pyrenoids in each.

Fig 2. - A filament showing active division of some cells developing later into antheridia(a) and enlargement of other cells developing into oogonia (o).

Fig 3. — A filament showing a chain of female cells which later develop into oogonia.

Fig 4. — A filament showing some empty cells.

Fig 5. — A portion of a filament showing antheridial cells (a), and two oogonia.

Fig 6. — A mature filament showing an oogonium with an oospore.

Fig 7. — A filament showing three oogonia with oospores.

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Plate II

Zygnema giganteum

Fig 11. — A filament showing chloroplasts X660

Fig 12 — A filament showing enlargement of chloroplasts and ~~sect~~ secretion of mucilage prior to formation of parthenospores. X 660

Fig 13 — A filament showing a chain of brick-shaped parthenospores with two pyrenoids in each. X 660

Fig 14 — A filament converted into a chain of orange-coloured parthenospores. X 660

Fig 15 — Two filaments showing anisogamous conjugation. The male filament shows an alternation of male cells and vegetative cells full of mucilage. X 660

Fig 16 — This shows the abortive conjugation processes given out by the vegetative cells in the ~~f~~ male filament. X 660

Fig 17. — Two filaments showing transitional stages between isogamy and anisogamy. X 660

Fig 18 — Two filaments showing zygospores produced by isogamous conjugation and two azygospores. X 660

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Explanation [illegible]

Plate no. I

Zygnema Czurdae.

Fig 1. — A vegetative filament [illegible] chloroplasts. X 660

Fig 2 — A filament showing cells with conjugation processes. X 660

Fig 3 — A filament showing cells giving out conjugation processes, on both sides. X 660

Fig 4. — A filament showing a bean-shaped zygospore cut off by walls from the remaining part of the cells. X 660

Fig 5 — A filament showing zygospores filling the entire cells. X 660

Fig 6 — A filament showing distinct geniculation and ripe zygospores. X 660

Fig 7 — Three filaments conjugating in a scalariform way. X 660

Zygnema Iyengari.

Fig 8. — A filament showing chloroplasts. X 660

Fig 9 — A filament showing squarish azygospores. X 660

Fig 10 — A filament showing zygospores with a constriction in the middle. X. 660

Zygnema giganteum

Fig 19 — Two conjugating filaments showing pear-shaped zygospores. X 660

A Short Note on an Indian Variety of Sphaeroplea annulina (Roth) Agardh. Var. multiseriata. Var. nov.

A variety of Sphaeroplea annulina (Roth) Agardh was collected by the author from many ponds during the months of March and April in 1930 from Hoshiarpur, Jullundur and Amritsar. During March the filaments become yellowish green in colour, and on examination under the microscope numerous green ova may be seen in most of them. By the end of April nearly all the filaments show red oospores, and they occur in such large numbers that drying banks of most ponds present a crimson red appearance.

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Under the microscope a number of annular chloroplasts may be seen in each coenocyte. Under the high power the ~~rings~~ ~~chloroplasts~~ annular bands of chloroplast show bridge-like inter-connections (Fig i), the whole presenting the appearance of a reticulum as in S. Africana Fritsch A number of pyrenoids may be seen arranged in a row on each chloroplast. One to two nuclei may also be seen in the cytoplasm.

The septa are homogeneous ingrowths of the longitudinal walls (Fig 2) as in typical filaments of S. annulina (Roth) Agardh, and the coenocytes donot intercommunicate by means of any pores. The coenocytes are 60 – 80 µ in diameter being somewhat broader than those reported from Europe.

Sexual Reproduction.

The remarkable feature of the alga are its oogonia, which are formed from the ordinary coenocytes without any change of form. The protoplasm of the coenocytes becomes cleft into numerous green ova, which in the present variety may be seen arranged in three longitudinal rows (fig 3). It is due to this that the author has named this variety of S. annulina (Roth) Agardh as var. nov. multiseriata. Such a multiserial arrangement of ova and oospores is seen only in S. africana Fritsch, and Klebahn's figure of ~~an oos~~ a segment of an oogonium of S. annulina (Roth) Agardh as reproduced by Fritsch in his "The Structure and Reproduction of the Algae," shows only a single row of ova. The ova in the present variety are deep green in colour and have 1 – 3 pyrenoids in each (Fig 3).

Apertures for the entry of the sperms may be seen in the walls of the oogonia. (Fig 40). The ~~fertilized~~ ova

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   Chlorophyceae III. Heft 6.

Explanation of Figures.

Fig 1. — Shows a part of a coenocyte with chloroplasts, pyrenoids (p) and nuclei (n.). X 420

Fig 2. — Shows a septum. X 420

Fig 3. — Shows a part of an oogonium with three rows of ova. X420

Fig. 4. — Shows a part of a mature oogonium with oospores, discarded membranes of oospores (m), and an opening (o) in the wall of the oogonium for the entry of sperms. X 420

Fig 5 — Shows a young oospore enclosed in a primary membrane (m). X 1260

Fig 6 and 7 — Show oospores enclosed in primary membranes. X 1260

Fig 8 and 12 — Show ripe oospores ~~into~~ ~~and~~ the testa

Genus Spirogyra. Link.

Foveolata Section. I.

Species with Replicate Septa.

Spirogyra foveolata (Transeau) Czurda nov. nom. → ~~1.~~ (Spirogyra inflata (Vauch) Rab.) ~~op. cit. Borge Susswasser flora Heft 9.~~ op. cit. Czurda. Susswasserflora Mitteleuropas Heft 9.

Vegetative cells 14-18 u thick, 7-10 times as long, septa swollen and replicate, chloroplast single with 3-6½ spirals, sometimes almost straight (Fig). X Fruiting cells clearly swollen, 28-36 u broad. In fertile stages replication of septa becomes very clear. Zygospore ~~Zygote~~ ellipsoid 26-30 u in diameter. 1¾ to 2 times as long as broad. (Fig). In this specimen only scalariform conjugation was seen, though lateral conjugation is also known in this species.

X new flora.

Habit:- Free-floating in a blackish mass in a pond at V. Shahpur, Distt. Hoshiarpur, in the second week of April 1930. Also collected from Saharanpur in April 1935. A very common form.

2. Spirogyra quadrate (Hass) Petit. op. cit. Borge Susswasser flora Heft 9.

Vegetative cells 28-32 u in diameter, 3-4 times as long. A single chloroplast in each cell with two to six spirals (Fig). Septa replicate, fertile cells clearly swollen, 44-48 u br., and flattened near the middle. Zygospores ellipsoid-elongated, 32-42 u in diameter, 2-2¼ times as long. (Fig).

Habit:- Free-floating in a greenish mass of filaments in a fresh-water stream near V. Kiri, Distt. Gurdaspur. Produces zygospores in the middle of December. Rather rare.

Spirogyra Hassallii (Jenn) Petit. op. & cit.

Czurda. Susswasser flora Mitteleuropa Heft 9 —

Vegetative cells 30 — 32 μ broad, 6-8 times as long. Two ~~chloroplasts~~ chromatophores. Septa of cells replica

Only lateral conjugation is known in this species. Cells containing the zygospores are only very slightly swollen, unlike typical specimens of the species. Zygospores ~~ellipsoi~~ ellipsoid, and very much elongate. Exospore clear, smooth, light-blue in colour. Mesospore smooth, and brownish yellow in colour (Fig). ~~Sg~~ M of the zygospores contain chytridiaceous fungi (Fig).

Zygospores 34-38 μ broad, and 64-1

Habit — Found free-floating in a pond at Manglaur Tehsil Roorkee District Saharanpore during the third week of February 1935.

Male and female cells showing [illegible] occur in pairs, which are separated by a plane wall.

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Section II.

Species with septa not swollen. One chromatophore in each cell.

3. Spirogyra affinis (Hass) Kutz. op. cit. Borge Susswasser flora Heft 9.

Both lateral and scalariform conjugation are seen in this species. Vegetative cells 22-30 u broad. Septa not swollen. Chromatophore single with 2½ to 4 spirals. Fruiting cells swollen on both sides. Zygospores ellipsoid 25-32 u br., 36-46 u long. Placed obliquely in the gametangium, yellowish in colour. Spore-walls smooth. Another interesting feature of the Alga is that many cells give out rhizoids (LXXIII, fig. c.) like those described by Delf by means of which the filaments are attached to coarser filaments of Oedogonium.

Filaments showing lateral conjugation are attacked by rounded endophytic Chytridiaceous Fungi, 2-4 of which are invariably found in each cell which does not contain a zygospore.

Habit:- Found free-floating in a brownish mass in ponds. Collected in the second week of March 1930 at Hamira, and mixed with Oedogonium urbicum at V. Jhingran Distt. Hoshiarpur about the same time. Fairly common.

4. Spirogyra Jurgensii Kutz. op. cit. Borge Susswasser flora Heft 9.

Vegetative cells, 25-30 u thick, 2½ to 5 times as long. Septa occasionally swollen but not replicate. Cells with one chromatophore of two to four spirals. Fruiting cells not swollen on either side. Zygospores ellipsoid elongated 30-32 u thick, twice as long. Zygospore membrane smooth.

Habit:-Collected from Badami Bagh Tanks Lahore free-

Spirogyra Sahnii. sp. nov.

This alga was found mixed with filaments of Sphaeroplea annulina free-floating in Siah Balon, a freshwater stream near Daruya about the middle of March 1931.

Vegetative cells are ~~80μ – 140μ~~ 48 – 72μ broad and ~~80μ – 145μ~~ 40μ – 74μ long. Usually they are broader than long, ~~and~~ they are very much swollen, and are barrel-like in appearance. There is a single chloroplast which is more or less coiled in an irregular fashion (f and only in one cell it showed a spiral and a half. The septa of the cells are plane.

~~Sexual~~ Reproduction — Only lateral conjug has been noticed in this alga, and this is a very interesting type. The neighbouring cells usua give out tent-like protuberances in the usual way, an the female cells containing the zygospores almost always adjoin th male cells (Fig). The female cells containing the zygo become very much swollen and bulge out considerably some cases (Fig) giving the alga an irregula outline. The male and female cells are usually of same size, but in one case the empty male cell was con swollen and much bigger in size. It gave out a di tube which was continuous with a similar structure giv by the female cell, and appeared like a retort used by c for distillation purposes. Such conjugation tubes have been re by de Bary in Zygnema insigne (Hassal) Kutz. (Fig).

Azygospores — Azygospores are also in large numbers ~~surrounding by~~ along with the zygospores (Fig). These are ~~spherical~~ oval in shape like the zygospores, but are very smaller in size, being ~~40µ – 44µ~~ 20 – 22µ broad, and ~~44µ – 74µ~~ 22 – 36µ long. In some cases these are spherical in shape (Fig).

Some of the cells are infested with a fungal parasite, similar to a species of Myzocytium described on a material of Spirogyra affinis by Chaudhari ( ). Some of the zygospores also are full of the cells of the parasite (Fig). It is a curious coincident that both the species of Spirogyra from which this form of Myzocytium has been described, reproduce themselves by lateral conjugation.

Zygospores are ~~44 – 72µ~~ 22 – 36µ broad, and ~~90 – 126µ~~ 44 – 68µ long. The zygospore wall is composed of 3 layers, a smooth hyaline exospore, a thick bluish green mesospore, and a smooth endospore.

In one filament, the cells were noticed to produce conical protuberances, which give them a pear-shaped appearance (Fig). Probably these are abortive conjugation canals.

There are four species of Spirogyra which resemble the present form in some features, and especially in the possession of a single chloroplast and lateral conjugation. Of these it differs from S. longata (Vauch.) Czurda. and S. Lagerheimii Wittrock in the size and shape of vegetative cells and zygospores. S. From S. condensata (Vauch.) Czurda emend. it differs in the shape and size of vegetative cells, the size of zygospores and in the presence of parthenospores.

The [illegible]th species is S. asiatica. Czurda from which the alga differs in the shape of vegetative cells, presence of parthenospores, and the absence of any punctation from the mesospore as well as its bluish green colour,

x I have named this species of Spirogyra after Dr. Birbal Sahni of Lucknow University, who has done so much to raise the prestige of Indian Botany.

Spirogyra Sahnii sp. nov.

Vegetative cells 48-72 μ broad, 40-74 μ long, barrel-shaped in appearance, with a single irregularly coiled chloroplast, septa of cells plane. Only lateral conjugation known, zygospores oval 22-36 μ broad, 44-68 μ long, with a thin smooth, hyaline exospore, a thick bluish green mesospore, and a smooth hyaline ~~mes~~ endospore. Parthenospores also seen.

Hab. Free-floating in Siah Ballen a freshwater stream mixed with Sphaeroplea annulina, near Dasuya, Distt. Hoshiarpur, Punjab, about the second week of March 1931.

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Spirogyra paludosa Czurda. op. cit.

Die Susswasserflora Mitteleuropas. Heft 9. Page 167–

Vegetative cells ~~20–22 μ~~ 18–22 μ broad and 5-8 times as long. There is a single chloroplast in each cell (Fig). Septa of the cells plane.

Conjugation scalariform. Female cells containing zygospores slightly swollen. Zygospore ellipsoid, much longer than broad, being 24– 26 μ broad and 44–46 μ long. Exospore clear, smooth, mesospore light ~~brown~~ brown in colour.

Habit — Found free floating in a pond at V. Badal Distt. Hoshiarpur in the first week of April 1931.

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Spirogyra condensata (Vauch). Czurda-emend. Susswasserflora Mitteleuropa Heft 9 page 178.

Vegetative cells 28 - 45 μ broad 2 - 3 times as long. Septa of the cells plane. There is a single chloroplast of 1 to $2\frac{1}{2}$ spirals in each cell.

Conjugation lateral only. Zygospores usually in pairs. Zygospores oval 32 - 36 μ broad and 60 - 70 μ long. Female cells containing zygospores are not swollen. Exospore hyaline, thick, mesospore brown, and endospore not known. (Fig). The zygospores are slightly smaller than those of the type.

Azygospores may also be seen plentifully, and, are rounded in appearance, and 24 - 26 μ in diameter.

Habit — Free-floating in a freshwater spring at Tahli Sahib Distt. Hoshiarpur in first week of March 1931.

Mougeotia viridis (Kutzing) Wittrock 1872. ~~Czurda~~ op. cit.

Czurda. Susswasserflora Mitteleuropas Heft. 9.

Vegetative cells 6-8 μ broad, Chloroplast plate-shaped, with 3-4 pyrenoids in each. (Fig)

Conjugation scalariform. Zygospores more or less squarish cushion-shaped in appearance, and may be seen free-floating with the four horn-like remains of the gametangia attached to them at the corners. Exospore clear and smooth. Zygospores darkish in colour, 22-26 μ X 22-26 μ. (Fig).

Distribution.- This alga has been reported from Germany, Austria, Czechoslovakia France, Russia, Roumania, and North America, ~~and~~ Almost a cosmopolitan alga.

Habit. - Found free-floating mixed with Zygnema Czurdae. Randhawa. and a species of Oedogonium during the second week of March 1931 in Siah Baeen, a freshwater stream in Jullundur district, Panjab. Rather a rare alga.

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Collection, Preservation and Microtechnic of Freshwater Algae.

Algae are universally distributed and are found free-floating or attached to aquatic plants in ponds, freshwater streams, and rivers, growing subaerially on moist soil and the bark of trees. Of all the groups of freshwater Algae, Myxophyceae are the commonest and the most familiar, and we see them nearly all the year round in drains, ponds, and walls of houses. Most of our ancient historical buildings present a dark and dismal appearance, due to the thick coats of Camptylonema, Scytonema, and Tolypothrix, which grow upon their domes and walls.

Collection of Algae:-

For collecting Algae a very simple outfit is required. A tin-box containing a rack with about two dozen holes accommodating 24 wide-mouthed glass tubes about 2 inches in length and ½ inch in diameter, is necessary. The bottom of the holes should be well-padded with cotton-wool to prevent injury to the glass tubes. There should also be some space provided for a sharp knife, a pair of scissors and 1 dozen envelopes inside the box. In one of the small tubes commercial Formalin (40 % Formaldehyde) should be stored. A wooden rod, made of small pieces about 1½ foot in length which could be screwed on to each other, and with a muslin net attached on one side may also be carried if possible. The method of collection differs with the type of habitat.

i. Subaerial soil Algae and Bark Epiphytes-

The algae growing on soil should be scraped from the surface of the soil with a sharp knife. These may be stored in an envelope or in a glass tube in 4% Formalin solution. On reaching the laboratory they should be placed in a glass trough under a water-tap and thoroughly washed till the earth attached is as completely removed as possible. The bark algae are better stored inside paper envelopes, for they are capable of standing dessication.

2. Freshwater Algae- These are usually found free floating or attached to water-plants. Free-floating forms may be best collected with ones hands. On holding the mass of filaments under sunlight in one hand, hollowed down in cup-shaped manner, one can easily detect if the filaments are fertile or merely vegetative. In the case of Spirogyra, Zygnema, and Oedogonium one can see the Zygospores or Oospores in the form of small blackish specks. The colour of the alga, also is an index

of its reproductive or vegetative stage. Dark green sheets of algae a always in a vegetative stage of growth, and when they become pale yellow or brownish yellow in colour they show plenty of zygospores or Oospores as the case may be. So care should be taken to collect only those forms which may be reasonably expected from their colour to be in a reproductive stage.

In the case of algae which grow epiphytically on water-plants, small pieces of leaves or stems of the plant may be cut with a pair of scissors, when they are small in size, but when they are big and cannot be put inside a tube, one should scrape the algae with a sharp knife, from their surface and store them inside a glass-tube.

Care should be taken to keep the tubes only ¾ full. Then a drop of Formalin should be added, and usually it is found to be quite sufficient to keep the Algae in good condition for a couple of days.

Flagellates and other plankton forms are sometimes found in large numbers inside small ponds and lakes. Sometimes when the water is wholly green with them, one can collect a good quantity by merely dipping a tube inside the water. In some cases a silk net is found useful and one should drag it for a distance of a few paces inside the water and collect a large number of these forms.

Preservation of Algae-

Most of the thick-walled Chlorophyceae and nearly all Myxophyceae are best preserved in a 4% solution of Formalin (Formaldehyde 40%). In the case of more delicate forms like the Flagellates and Chlorococcales 2% solution of Formalin is sufficient. A little copper sulphate may be added to 2% solution of Formalin, when it is desired to preserve their natural colour to as great an extent as possible

Staining-

First wash the Alga in water for about 10 minutes. Then stain with Methylene Blue. I found Methylene Blue to be the best stain for differentiation of the cell details. However when mounted in Glycerine jelly the whole pigment is sucked out and after some months the cell-structure becomes transparent. 1% solution of Magdala Red in water and Delafield's Haematoxylin have been also found to be good stains for showing cell contents.

Mounting-

I found Glycerine Jelly Method to be the cleanest and most satis-

satisfactory in the case of filamentous Algae. The filament should lifted with a fine needle and placed in a watch-glass in 10% Glycerine (1 part of Glycerine mixed with 9 parts of water), and should be covered under a bell-jar to prevent particles of dust from coming inside. The 10% Glycerine solution should be just sufficient to cover the filament, and the watch-glass should be left alone for at least 24 hours to allow the water to fully evaporate. Then a drop of melted glycerine jelly should be placed in the middle of the slide, taking care that no air-bubbles cling to the sides of the drop, and the filament should be transferred at the point of a needle to it. Then it should be covered with a cover-slip. The slide should be placed under a bell-jar for at least 8 hours, and the glycerine jelly will set in a very proper way. Then the slide should be placed on a turn-table and a thick ring of Black Varnish should be painted on the sides of the coverslip. Give the turntable a strong spin, and touch the slide with a fine brush as far out from the cover as you wish the ring to extend, then gradually appreac the coverslip and extend the ring until it is 1/16 " wide on the cover. Put a medium ring not more than two-coats thick.

Preparation of Glycerine-jelly-

Put 1 part by weight ~~of~~ of French gelatin in 6 parts by weight of water and allow it to lie for about 2 hours. Then add 7 parts by weight of Glycerine. For every 100 gramms of the mixture, add 1 gm. of concentrated Carbolic acid. Heat the whole mixture for about 15 minutes and stir during heating. Filter the Jelly while warm. A little of the Jelly should be taken in a small tube and placed in a beaker containing boiling water. The jelly would melt and is ready for use in mounting.

The slides which I prepared about seven years ago, using Glycerine jelly Method are in a state of perfect preservation. The only defect with glycerine is that it abstracts all the stain out of the cells, making them transparent.

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Occurrence and Distribution of the Freshwater
Algae of North India.

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Saharanpur.

(with a map and a photograph)

"Occurrence and Distribution of the Freshwater Algae of North India."

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Saharanpur

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(Communicated by Dr. S.L. Ghose, M.Sc., Ph.D)

I made a collection of the Panjab freshwater algae from July 1929 to April 1930, and February 1931 to October 1931, from Lahore, Jullunder and Hoshiarpur districts of the Panjab. Then I had another opportunity of making a collection of the freshwater Algae in Saharanpur district of the United Provinces from December 1934 to January 1936. In all about 420 samples were collected comprising 122 species which have been worked out and these include two new genera and sixteen new species. Hoshiarpur and Jullunder districts are situated between the Sutlej and Beas rivers, and contain two perennial streams the Siah and the Sufed Baeens. These two districts provide unique opportunities for algal collections, and it is no exaggeration if I call them an Algalogist's Paradise. Hoshiarpur and Saharanpur districts contain a chain of ponds in the submontane areas, as well as swamps which are called 'Chhambs'* locally. Saharanpur district is situated between the Ganges on the east and the Jumna on the west with two big canals, and numerous small streams meandering across the district. The swamps in these districts are annually replenished by rain-water from the hills brought by the 'choes', which are seasonal torrential rivers which sweep down the plains during the rainy season. Geographically these districts are very much similar being bound by the Siwalik range in the North, and have practically the same sort of climatic conditions.

There are numerous big tanks also made by religiously or charitably-disposed people which afford ample opportunities for algal collections. In addition there are ponds which are found in practically every village for the use of cattle, and these are also very interesting from the algal point of view. The ponds and ditches found on both sides of the railway lines in many districts are also full of Algae during and after the rainy season.

Climatic Conditions:- Hoshiarpur is a submontane district lying between 30.59° and 32.5°N and 73.30° and 76.38°E. The annual average rainfall is 36", of which 30" fall in the summer months and 6" in the winter months. Jullunder and Lahore resemble each other very much and as compared with Hoshiarpur they are more dry and hot. The hottest months are May and June, with a mean maximum temperature of 106°F., the highest temperature recorded being 120°F. The coldest months are December and January, with a mean minimum temperature of 40°F. The rainfall seldom exceeds 25 inches per annum. Saharanpur resembles Hoshiarpur in nearly every way, the only difference being that the rainfall is greater in Saharanpur.

Occurrence and Reproduction of Freshwater Algae:- Five main groups of Algae, viz., Diatoms, Myxophyceae, Isokontae, Heterokontae and Rhodophyceae, have been studied so far by Mr. Abdul Majid, Dr. S.L. Ghose and the author in Northern India. Diatoms are very abundant during the winter months from the middle of November to the end of February, and my own observations fully corroborate the conclusions reached by Mr. Abdul Majeed in his investigations of the Panjab Diatoms. Forms like Navicula, Cyclotella, Surirella, Synedra, and Nitzschia are found in large numbers in the moist soil of fields after rains and in the drying sides of ponds and ditches. Synedra, Navicula, Cyclotella, Cocconeis, and Gomphonema are also found in large numbers on the moist soil of fields after rains and on the drying sides of ponds and ditches. Synedra, Navicula, Cyclotella, Cocconeis, and Gomphonema are also found in large numbers in stagnant or slowly-flowing sheets of water, free-floating, or attached to the rotting branches of water plants.

Myxophyceae are met all the year round, but are very abundant after the close of the rainy season, in the months of October and November. Members of Myxophyceae are both subaerial as well as aquatic, and in the latter case are found more commonly in stagnant sheets of water. Our knowledge of this group of Algae is mainly based on the work of Dr. S.L. Ghose. According to Dr. Ghose the Myxophyceae in Lahore show great vegetative activity between August and February, and the fruiting season is from February to April. The study of spore-bearing forms like Anabaena, Rivularia, Aulosira, and Nodularia is very interesting from this point of view. According to Dr. Ghose, Anabaena variabilis and Rivularia natans produce spores in the months of March and April. My own observations show that forms like Anabaena cylindrica, Anabaena moniliforme, Anabaenothrix epiphytica, and Nodularia spumigena produce numerous spores in the months of February and March. As I have shown in my paper on "Periodicity in the Reproduction of Freshwater Algae," that the spore-bearing Green Algae, like Spirogyra Zygnema, Ghosella, Sphaeroplea, and Oedogonium produce huge crops of Zygospores and Oospores in March and April (10), the spore-bearing Myxophyceae like the species mentioned above, also, do not lag behind in this respect. In fact these Myxophyceae are as well prepared to meet the drought of May, June, and July in the form of thick-walled spores, as the Green Algae.

I have already dealt at great length in a separate paper with the periodicity shown by the spore-bearing Green Algae in their reproduction (10). However, forms which multiply vegetatively by fragmentation, and zoospores, continue their cycle of reproduction intermittently. These algae are found in artificial reservoirs of water, and perennial streams, and show a great luxuriance in growth from October to March.

Ecological Survey of the Freshwater Algae of Northern India:-

The following is in brief an ecological survey of the Algae of Northern India, which I have come across during my investigations.

I. Subaerial Associations - Under this heading we shall deal with Algae which grow upon soil, in the form of patches, or in some cases in the form of mats. Subaerial forms also include Algae growing upon pieces of moist timber and walls of houses. So we may divide the subaerial Associations into two main groups; firstly the soil Algae and secondly the Algae growing on wood and walls.

A. Soil Algae.- The group of soil Algae includes three kinds of formations in this country.

1. Vaucheria community - This is equivalent to Zygogonium ericetorum formation of Europe. From the beginning of December to the last week of February, Vaucheria sessilis and V. geminata are seen covering large areas in lawns and grassy fields, in the form of bright-green felt-like mats. Oogonia and antheridia begin to appear in the first week of January, and by the last week of February most of the filaments become fertile. It is curious that Vaucheria sessilis collected from ponds at about the same time, as from the lawns, proved to be more fertile, each filament being loaded with huge crops of oogonia and antheridia, while in the case of terrestrial specimens, very few sex organs were seen.

2. Botrydium-Protosiphon Community. Usually Botrydium and Protosiphon occur together on the sides of drying ponds after the close of rainy season. In fields which are left fallow, one may quite often see almost pure formations of Protosiphon botryoides, in the month of November after rains. Cyst-formation takes place in a week and then the alga disappears. Bright green patches of Protosiphon 2-8 yards in diameter can be seen

growing in the hollow parts of fields.

3. Cylinderospermum Community. Black patches of Cylinderospermum muscicola, accompanied by a species of Riccia, occupy huge areas under the shade of wheat plants in the month of March. Bacteria may also be seen in the mucous sheaths of this Alga.

4. Campylonema Community. Campylonema Lahorense appears in the form of woolly circular patches of a dark chocolate brown colour on the surface of lawns, and these patches expand laterally and form thick brownish sheets. species of Gloeocapsa and Anabaena, may often be found intermingled with the filaments of Campylonema Lahorense.

B. Timber Algae and Wall Algae:-

(1) Pleurococcus community - This consists of yellowish-green incrustation of Pleurococcus vulgaris which has a great liking for moist woodwork, lime-covered walls of houses, and earthen vessels like 'gharas' and 'surahis'. After the rains this alga may be commonly seen on smooth pieces of wood, from which bark has been removed, and the walls of houses. This alga may be found throughout the year on the moist wood-work of Persian wheels, accompanied by Mosses.

(2) Bark Epiphytes - This group of Algae resembles in many features the formation discussed above, but differs in showing an almost exclusive preference for moist logs of wood and trunks of trees. Aphanocapsa montana appears in the form of light-blue-green patches on smooth trunks of trees from July to August, and as the trunks become drier, the alga becomes saphire-blue in colour. According to Ghose (5) Phormidium truncicolum, Lyngbya truncicola and Tolypothrix campylonemoides, may commonly be seen on the trunks of Acacia modesta in the form of a bluish-green layer, which becomes very slimy and conspicuous after the rains. In the wet season Hormogones are plentifully formed, and these produce mucilaginous sheaths which become thick, firm and coloured. When it becomes dry and warm,

the ~~stream~~ stem becomes thin and papery, and peels off trunk of the tree in bits.

II Aquatic Associations - Under this heading we include all the Algae which are found growing in water, free-floating or attached to other water plants. This includes a large number of forms and we shall deal with only the commonest and most important species. According to their habitat, we divide this group into two main subgroups viz., Algal Associations of Flowing Water and Algal Associations of Standing Water. ✗

A. Algal Associations of Flowing Water - This group may be further subdivided into two subgroups according to the velocity of the current of water in which these Algae grow.

1. Algae from Swiftly Running Water - This group of Algae is characterised by the possession of strong basal cells which very often secrete a sort of cement-like material for fixation to other water-plants, and require plenty of aeration. I found a number of Rhodophyceae in the Siah Baeen near Dasuya in Hoshiarpur district, where it flows very rapidly. Attached to blades of rushes, in midcurrent, are found Chantransia chalybea, Compsopogon, Batrachospermum moniliforme, and Stigeoclonium variable -, in the months of August, September, October and November. In December due to excessive cold perhaps, these Algae disappear. Cladophora glomerata also belongs to this group and may be seen in big tassels looking like fox-tails attached to fallen branches of water plants in most streams and canals(~~Fig. 1~~). This group also includes a number of unicellular and colonial Myxophyceae growing on stones, which are well worth investigating. By developing strong basal cells and on account of their ~~likeness~~ liking for plenty of oxygen, these algae exclude other competitors, and hold their own against all other algae.

2. Algae from Slowly Running Streams - These algae are also characterised by fondness for plenty of oxygen, but

not so much as in the last mentioned group, and at the same time basal cells are not so well developed. As compared with the former one, it is a much more numerous group. Cladophora glomerata, Mougeotia genuflexa, Draparnaldia plumosa, Chaetomorpha aerea, Oedogonium sp., and certain attached species of Spirogyra, are very characteristic of this group. Here we may also mention the interesting case of Cladophora glomerata, which grows on the shells of Gastropods in tanks in Shalamar Gardens Lahore, and in the still water of the tanks secures its aeration through the help of these animals(Fig. 1). Cladophora glomerata also occurs in the reservoirs of wells fitted with Persian Wheels, where the alga is constantly being aerated by the flow of water from the well. Chaetomor-pha aerea which generally occurs in freshwater streams may also be quite often seen growing under water-taps where there is a constant flow of water.

B. Algal Associations of Stagnant Water - This group contains by far the largest number of Algae. This group may be divided into four sub-groups according to their habit.

1. Plankton-forms - These are very tiny Algae, which are found floating in lakes, ponds, and tanks. Some of these Algae have evolved special structures like bristles, flattening of the body, and the secretion of mucilage, for keeping afloat in water. Such bristles and flattened shape may be seen in Pediastrum Boryanum, Scenedesmus obliquus and S. quadricauda. Mucilage helps Volvox aureus and Pandorina m rum in keeping afloat. Microcystis aeruginosa is simply flat in shape and has no other special structure. Arthrospira spirulinoides and A. platensis have a spiral like a cork-screw which helps the alga in keeping afloat. In this group of algae we may also mention the different species of Anabaena, Rivularia, and Cylinderospermum which are found free-floating in ponds and lakes through they have

submerged roots, stems, and leaves of water-plants. According to the substratum and object to which they are attached, we subdivide this group into following subgroups:

1. Algae attached to Submerged Soil of Ponds:-

In this sub-group we include that small group of algae which are found attached to the bottom of ponds where the water is very shallow, seldom being deeper than two feet. So far I have seen only three members of Myxophyceae which can be dealt with under this subgroup. Of these Lyngbya perelegans grows in the form of dirty-brown cylindrical columns attached to the bottom of tanks, and Anabaenothrix cylindrica in the form of blue-green irregular cylinders attached to the submerged soil of puddles. As there is no specialised organ of attachment, even a slight disturbance in water causes these cylinders to get detached from the bottom, and the alga becomes free-floating. It is only its method of growth which has given the alga an attached habit. The alga firstly grows on the submerged soil, and then the distal part of the colony grows up towards light, and the mucus of the colony assumes a cylindrical shape. The third alga is Nodularia spumigena which grows in deep blue coralline masses, mixed with grass, in the shallow water of Budha Nala at Ludhiana.

2. Algae attached to the Sides of Water-reservoirs, and Steps of Tanks:- This group includes many members of Myxophyceae and some Green Algae which are found attached to the brickwork of the walls of water-reservoirs or wells, and the steps of tanks. Of these Schizothrix mexicana may be seen in deep bluish-green velvet-like bunches in the sides of water-reservoirs, used for watering cattle in villages, adjacent to wells. Another common alga is Rhizoclonium hieroglyphicum which is found on brick-work under water taps.

3. Algae attached to Twigs and Water-plants.- This subgroup is further subdivided into two sections, according to the nature of the substratum.

(a). Algae attached to Twigs and Dead Branches of Plants:-

The algae which are included in this subgroup have developed definite organs of attachment in the form of rhizoids or flattened basal cells. Some of them may be found growing attached to the sides of the submerged steps of tanks, but most of them are found attached to stones or dried sticks and branches of trees. It has been noticed that these forms show a decided preference for non-living substratum and it is very rarely that they may be seen attached to living aquatic plants. These forms are totally submerged for the most part of their existence. Stigeoclonium, with its four common species, S. lubricum, S. subuligerum, S. amoenum and S. tenue, is a typical representative of this group. Next comes Ulothrix with four species, U. zonata, U. tenuissima, U. tennerima, and U. subtilissima.

(b) Algae attached to Living Plants.- In this sub-group those algae have been dealt with which usually grow on living leaves, stems, and roots of water plants or living filaments of big algae like Cladophora and Sirogonium. This sub-group may be roughly divided into two sections, the difference mainly being that members of the second section are microscopic in size, and are not obvious to the naked eye, while the members of the first section are big in size and conspicuous.

Section 1. Macroscopic Forms.- Most of these Epiphytes have well-developed basal cells for attachment. Oedogonium is the commonest of these with 14 species of which Oe. cardiacum, Oe. urbicum, Oe. inerme, Oe. Sociale and Oe. Hirnii, are fairly common on leaves of water-plants and in the month of April they produce a multi-coloured harvest of oospores. Other common members of this section are Schizomeris irregularis, Ulothrix oscillarina, Pithophora Kewensis, Cladophora glomerata, Chaetomorpha aerea, and attached species of Spirogyra. It may be marked, that most of these algae, which have organs for attachment are the same as those found in flowing water, and have developed these organs even in a still water environment.

Section ii. Microscopic Forms.- These are algae which are usually microscopic in size, and grow as epiphytes not only on common phanerogamic water plants, but also on other algae like Sirogonium, Cladophora, and Pithophora, which do not produce any mucilage and hence become loaded with epiphytes. Abdul Majeed has studied the epiphytic Diatoms of the Panjab and according to him most of the filamentous algae, and especially those mentioned above are found loaded with species of Synedra, Achnanthes hungarica, Cocconeis placentula, Gomphonema intricatum, G. subapicatum, G. constrictum and Epithemia arcus. Most of these Diatoms have mucilaginous hyaline stalks by means of which they are attached to other algae and water plants. Other common epiphytes are Aphanochaete repens, Coleochaete soluta, C. scutata, Chaetosphaeridium globosum, Bulbochaete and species of Characium. Myxophyceae are represented by Chamaesiphon filamentosa, Anabaenothrix epiphytica, and Cylinderospermum Michailovskoense.

Conclusion.

Very little work has been done on the ecology of the freshwater algae of North India, and this is, as far as I know, the first ~~a pioneer~~ attempt in this field. Under such circumstances, it may be expected that considerable variety of opinion be entertained by various algologists as to the best method of arranging the various forms in Groups, Subgroups, Sections and Subsections. The author realises that more intensive work is required in this field, and his conclusions in some cases may not be all what is desired. However, he hopes that his efforts, will stimulate the workers, who have better facilities than he has for this sort of work.

The writer sincerely thanks Doctors S.L. Ghose, H. Chaudhuri and P.L. Ananad of the Panjab University for their advice and criticism.

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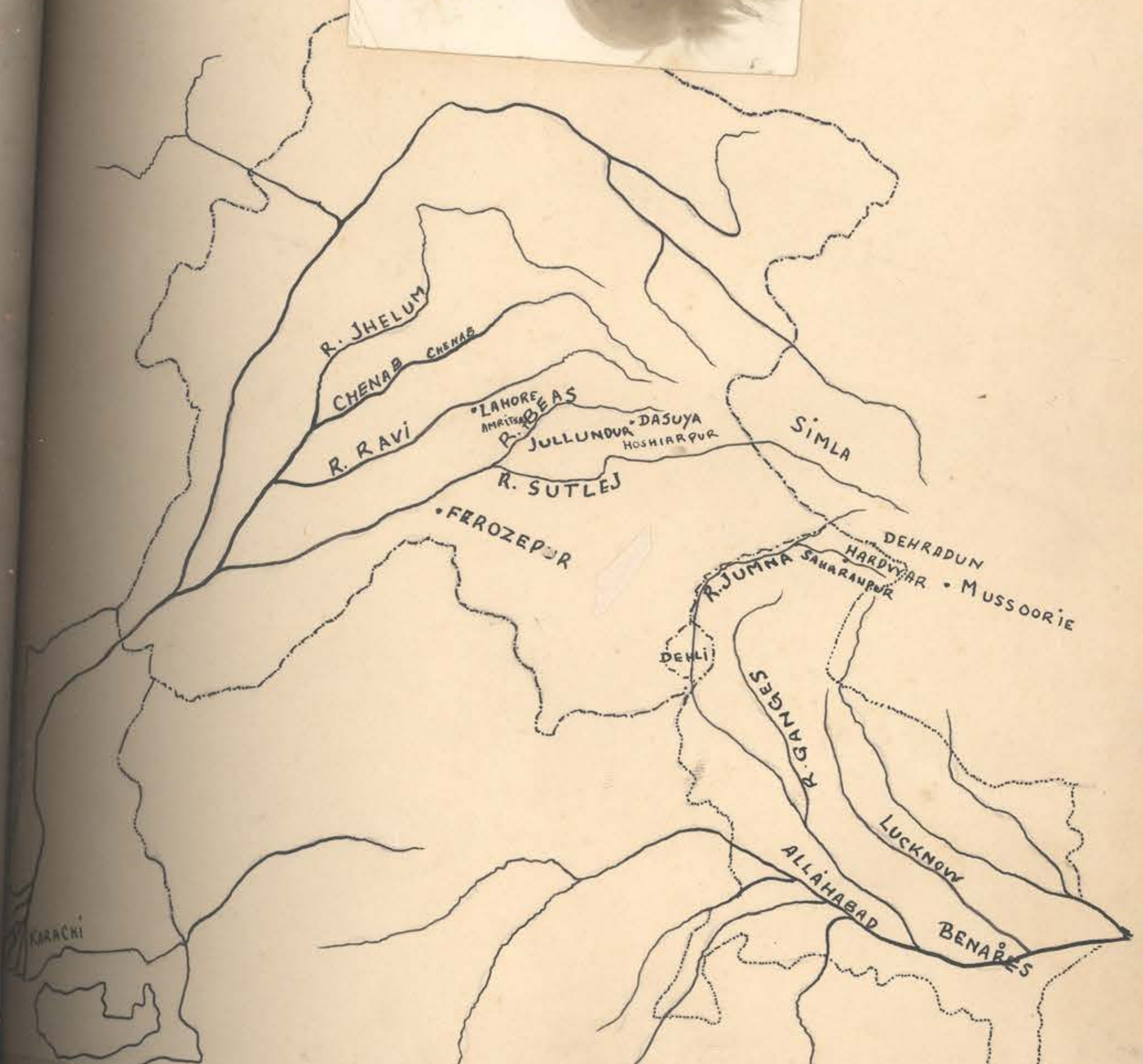
Showing PL tions of Algae were made

1929-1936



of the whole year with a mean temperature of 89.7 , while the maximum may be as high as 107.0 . In these hot dry months nearly all the ponds dry up and only a few streams show a slow trickle of water. Due to absence of water no algae can be seen in any ponds while in some perennial streams Oedogonium may be found in a vegetative condition.

Marked Periodicity in Reproduction of the Panjab Freshwater Algae.

I made a regular collection of the Pnajab Freshwater Algae from July 1929 to May 1930, and since then I have been collecting Algae from December 1934 to December 1935 in Saharanpur district, which is on the boundary line of Eastern Panjab and Western part of the United Provinces and has a climate not very different from the eastern submontane districts of the Panjab, like Hoshiarpur and Gurdaspur. My two years experience has shown me that there is a marked periodicity in the reproduction of Spore-forming Chlorophyceae which is closely connected with temperature and rainfall conditions.

A passing reference may also be made about those Chlorophyceae which do not form spores with hard walls. If these Hydrodictyon reticulatum is the commonest in ponds and slow-flowing freshwater streams. Its glistening daughter colonies may be found in nearly all months of the year when water is found in the ponds and streams, and I have collected it in all stages of development in all months from July to February. I am excluding from consideration here all algae which are found attached to artificial water-reservoirs and only those are discussed which are found in natural ponds and streams.

Seasons of Northern India. I have divided a year in Northern India into five seasons; Hot Summer Months, Rainy Season, Autumn, Winter and Spring. Start may be made with the Hot Summer Months which begins from about 15th May and terminates by the middle of July. These months are characterised by dry heat. June is the hottest month of the whole year with a mean temperature of 89.7 , while the maximum may be as high as 107.0 . In these hot dry months nearly all the ponds dry up and only a few streams show a slow trickle of water. Due to absence of water no algae can be seen in any ponds while in some perennial streams Oedogonium may be found in a vegetative condition.

on fields which have been lying fallow, in bright green patches 2-8 yards in diameter. Cyst-formation in the subterranean rhizoidal portion takes place in a week, and then the Alga diappears from view. Spirogyra is also seen in a fertile condition in most ponds. I recorded four species of Spirogyra in this month viz. Spirogyra Condensata, S. Rivularis, S. Crassa and S. Nitida.

IV Winter Months. By the middle of November it becomes fairly cold in Northern India, and the mean temperature drops to 50.0. The ponds are usually half full at this time, and the streams and rivers have a regular flow of clear, sparkling, and ice-cold water of the Himalayan snows. In some cold freshwater streams like the Siah Baeen near Jullundar with a swift current of water, Chantransia Chalybea, Batrachospermum Moniliforme, Sti-Geoglonium Variable and Comsopogon sp. are found attached to blades of Typha in the mid-current. These members of Rhodophyceae and Stigeoglonium Variable are provided with well-developed besal cells for attachment. These algae disappear in December, perhaps due to excessive cold, for the mean temperature may be as low as 45 . In slowly running streams Cladophora Glomerata may be seen in big tassels, looking like fox-tails attached to water-plants. All these algae require a good deal of aeration, and I have noticed that where the current of water becomes very slow these algae tend to disappear. Here we may mention the peculiar case of Cladophora glomerata which may be seen in the tanks of the Shalimar Gardens Lahore growing on shells of Gastropods, which move about in the tanks and thus aerate the alga. However in this case the growth of the alga is not luxuriant and it appears to be a mere shadow of the Cladophora Glomerata which grows in running streams. Due to slow locomotion of Gastropod, the alga becomes thickly encrusted with Diatoms and dust particles. Cladophora Glomerata also occurs in the water-reservoirs of wells fitted with Persian wheels, where it is constantly aerated by the flow of water from the well.

In December we usually have a rainfall of 1.5 to 2 inches especially in the last two weeks. After the dry months of October and November, this is very welcome and gives a new lease of life to the algae growing in ponds. In January the rainfall is more copious and is seldom less than 4.0 inches, and as the temperature is low and evaporation is less, the ponds become fairly full. The months of January and February are ideal for the growth of algae. Along with the species of Spirogyra already mentioned I also found nine other species of the genus Zygnema which henceforth is usually seen only in a vegetative condition, can be found in a fertile condition. The commonest species of Zygnema is Z. Chalyheosporum which is seen with plenty of zygospores. Mougeotia Genuflexa may also be found at this time. Species of Oedogronium which I never noticed with ripe oospores in any of the above-mentioned months, produce sex organs with great regularity in the month of February and most of the filaments show green oogonia and antheridia in the case of Macrandrous forms, while the Nannandrous forms show numerous Androsporangia and Nannandria growing on the walls of oogonia.

With the coming of winter-rains in December Vaucheria Sessilis and V. Geminata may also be seen in the form of bright green felt-like mats in lawns, gardens and other moist places. Oognia and Anteridia begin to appear in the first week of January, and by the last week of February nearly all the filaments become fertile being heavily laden with oogonia, anteridia and oospores. Vaucheria Sessilis is found both in aquatic and terrestrial habitat, and it is curious that specimens of it collected from ponds at about the same time as from the lawns, proved to be more fertile, each filament being loaded with huge crops of oogonia and antheridia, while in the case of terrestrial specimens very few sex organs were seen.

V Spring Months. Spring season may be taken as beginning with the first week of March. As compared with February there is a marked rise in temperature, the mean temperature in March being 62.0 as compared with ~~xx~~ 49.7 in February. Just as in Spring a young Man's fancy is supposed to lightly turn to thoughts of love, most of the Algae also show great reproductive activity. Various species of Oedogonium produce heavy crops of Oogonia and anteridia, and by the end of March their filaments are laden with red, yellow, and chocolate. coloured oospores. By the middle of April nearly all species of Oedogonium bear ripe oospores. I recorded fourteen species of Oedogonium in these months all in a fertile condition. Sphaeroplea annulina also shows numerous green ova in its oogonia in the beginning of March. By the end of March the ova become fertilised and young oospores, green in colour, enclosed in a thin membrane, may be commonly seen. In April the Oospores become brick-red in colour with a thick hyaline wall produced into 10.15 spines, and arranged in three alternate rows in the Oogonia. This alga shows such an abundance of red Oospores in April that many ponds appear deep red in colour. Ghosella indica, a new member of conjugatae described by me as combining the characters of Debarya and Zygnema, with certain peculiarities of its own, is also found free-floating in dark green masses in the month of March. By the middle of April, Ghsella is all fertile and conjugation canals bulge out with ripe Zygospores of an orange-yellow colour. Sirogonium Sticticum also produces Zygospores in April.

Periodicity in Reproduction:- By the end of May most of the ponds begin to dry up, as there is no rainfall and the mean temperature rises to 81.0 . Now the Algae have to face the hot dry spell of three months beginning with May and ending with the middle of July. To meet this contingency species of Oedogonium, Spirogyra, Vaucheria, Zygnema, Ghosella, Sirogonium, and Sphueroplea have produced thick-walled oospores which are capable of surviving the high temperatures of June and July. When the rains start in the middle of July, these oospores begin to germinate and produce young filaments. Then for the next four to five months most of these algae show a great vegetative growth with very little reproductive activity. The month of March provides optimum conditions for their reproduction, and probably this may be due to rise of temperature in March after the cool months of January and February. Thus there is a marked periodicity in reproduction shown by these Algae in Northern India which is connected with more or less distinctly marked seasons. This is a remarkable phenomenon which is not noticeable in England or other temperate countries where the seasons are not so well-marked, as we have in Northern India.

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"Genus" Anabaenothrix and parallelism in Evolution in Freshwater Algae."

During my investigations of the Panjab Freshwater Algae I came across two Anabaena-like species of Blue Green Algae, which however differ from the typical specimens of Anabaena in having a number of trichomes enclosed in a single mucilaginous sheath. Recently Dr. F.E. Fritsch described a species of Anabaena with a mucus sheath, from South Africa, which he calls Anabaena vaginicola. sp. nov. (Trans. Roy. Soc. of S. Africa Vol. XVIII. Parts 1 and 2). This so-called Anabaena vaginicola Fritsch resembles Anabaena cylindrica . Lemmer in essential features and the only vital difference is the occurrence of a number of trichomes within a single sheath. The two species which I discovered differ from Anabaena Vaginicola Fritsch in the size of the filaments, the shape and size of the vegetative cells, and the form and size of spores and heterocysts. Following is a detailed description of these three species of Anabaena-like Blue-green Algae.

1. Anabaenothrix vaginicola.Fritsch- numerous trichomes in a single sheath rarely a single one in single sheath. Cells elongate cylindrical or sub-cylindrical 4 to 4.5 u br, granular, heterocysts cylindrical 4 to 5 u br, 6 to 10 u long. Spores oblong, barrel-shaped, contiguous to the heterocysts in series of 4-5, 6.5 to 10 u br and 12 to 17.5 u long.

II. Anabaenothrix cylindrica Randhawa.

Numerous trichomes enclosed in a single sheath, breadth of filaments 60-75 U inclusive of the sheath, cells rounded or constricted, dumb-bell-shaped, 5 u br, 6-7 u long with homogeneous contents. heterocysts rounded 9 to 10 u diam. Spores in pairs contiguous to the heterocysts cylindrical in shape 4 to 5 u br, 18-20 u long. Found attached in mud of a pond in long cylindrical columns of blue green colour, which later on become detached, and the Algae becomes free floating.

III Anabaenothrix epiphytica Randhawa and Ghose.

Numerous trichomes enclosed in a single sheath or a single one in a single sheath. Cells rounded with homogeneous contents. 3.5 μ in diam. Heterocysts ellipsoid-rounded, always away from the spores. 5-6 μ in diameter. Spores barrel-shaped in chains of 2-5, 5-11 μ broad 14-18 μ long. Always found epiphytic on other Algae especially Sirogonium.

So here are three species of Anabaena-like Blue Green Algae which have acquired in the course of their evolutionary progress, the same character of enclosure of a number of trichomes in a single sheath. This case clearly illustrates, as suggested by Miss Agnes Arber in her excellent monograph on Monocotyledons, that a Genus is an evolutionary platform on which species of different origin are essembled together. In the case of these Algae, three different species of Anabaena independantly acquired the habit of grouping of numerous trichomes in a single sheath. Obviously we are justified in establishing a new Genus, which I call Anabaenothrix, for the same reasons as we have in establishing Schizothrix as a separate genus from Lyngbya or Lyngbya from Oscillatoria. This genus Anabaenothrix is an expression of a tendency parallel to that of Schizothrix viz. the enclosure of a number of trichomes within a common sheath. This parallelism in evolution is very interesting and shows how the habit of secretion of a common mucus sheath by a number of filaments, developed in different families of Myxophyceae; by Schizothrix in Oscillatoriaceae and Anabaenothrix in Nostocaceae. Members of Genus Lyngbya

"Genus" Anabaenothrix and parallelism in Evolution in Freshwater Algae."

During my investigations of the Panjab Fresh-water Algae I came across two Anabaena-like species of Blue Green Algae, which however differ from the typical specimens of Anabaena in having a number of trichomes enclosed in a single mucilaginous sheath. Recently Dr. F.E. Fritsch described a species of Anabaena with a mucus sheath, from South Africa which he calls Anabaena vaginicola. sp. nov. (Trans. Roy. Soc. of S. Africa Vol. XVIII Parts 1 and 2). This so-called Anabaena vaginicola Fritsch resembles Anabaena cylindrica Lemmer in esential features and the only vital difference is the occurrence of a number of trichomes within a single sheath. The two species which I discovered differ from Anabaena vaginicola Fritsch in the size of the filaments, the shape and size of the vegetative cells, and the form and size of spores and heterocysts. Following is a detailed description of these three species of Anabaena.like Blue-green Algae.

1. Anabaenothrix vaginicola.Fritsch (nov. comb)-numerous trichomes in a single sheath rarely a single one in single sheath Cells elongate cylindrical or sub-cylindrical 4 to 5 u broad 6 to 10 u long. Spores oblong, barrel-shaped, contiguous to the heterocysts in series 4-5, 6.5 to 10 u broad and 12 to 17.5 u long.

II. Anabaenothrix cylindrica Randhawa and Ghose.

Numerous trichomes enclosed in a single sheath, breadth of filaments 60-75 u inclusive of the sheath, cells rounded or constricted, dumb-bell-shaped, 5 broad 6-7 u long with homogeneous contents. Heterocysts rounded 9 to 10 u in diameter. Spores in pairs contiguous to the heterocysts cylindrical in shape 4 to 5 u broad, 18-20 u long. Found attached in mud of a pond in long cylindrical columns of blue green colour, which later on become detached, and the Alga becomes free floating. Fig I A shows a filament of Anabaenothrix cylindrica with numerous trichomes enclosed in a single sheath. In fig. 2 B is shown a part of a trichome highly enlarged with a heterocyst surrounded by a chain of spores on both sides.

III. Anabaenothrix epiphytica Randhawa and Ghose.

Numerous trichomes enclosed in a single sheath or a single one in a single sheath. Cells rounded with homogeneous contents. 3.5 u in diam. Heterocysts ellipsoid-rounded, always away from the spores. 5-6 u broad 14-18 u l long. Always found epiphytic on other Algae especially Sirogonium. In Fig. 3 B is shown a typical filament of Anabaenothrix epiphytica with a number of trichomes enclosed iná a single sheath. Sometimes we come across filaments of this species, showing a single trichome enclosed in a sheath as in Fig 4 A. In Fig 5 C is shown a part of a trichome with a spore and a heterocyst.

So here are three species of Anabaena-like Blue Green Algae which have acquired in the course of their evolutionary progress, the same character of enclosure of a number of trichomes in a single sheath. This case clearly illustrates, as suggested by Miss Agnes Arber in her excellent monograph on Monocotyledons, that a Gēnus is a evolutionary platform on which species of a different origin are essembled together. In the case of these Algae, three different species of Anabaena independently acquired the habit of grouping of numerous trichomes in a single sheath. Obviously we are justified in establishing a new Genus, xk which I call Anabaenothrix, for the same reasons as we have in establishing Schizothrix as a separate genus from Lyngby or Lungbya from Oscillatoria. This genus Anabaenothrix is an expression of a tendency parallel to that of Schizothrix viz. the enclosure of a number of trichomes within a common sheath. This parallelism in evolution is very interesting and shows how the habit of secretion of a common mucus sheath by a number of filaments, developed in different families of Myxophyceae; by Schizothrix in Oscilllatoriaceae and Anabaenothrix in Nostocaceae. Members of

Genus Lyngbya

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"Three New Species of Zygnema" from Northern India.

The Writer came across three remarkable species of genus Zygnema, during his investigations of the Zygnemales of Northern India. The reproductive phase of these algae shows many peculiarities. Following is a detailed description of these three new species of Zygnema.

I.

Zygnema Czurdae- Sp. Nov.

Vegetative cells are 20-27 U broad, and 1½ to 4 times as long. Two more or less rounded chloroplasts with a conspicuous pyrenoid in each, are seen in each cell. When stained with iodine, some of the chloroplasts show the typical zygnemaceous stellate structure (Fig)

Reproduction.

The reproductive phase of this new member of Zygnemales is most remarkable. Both lateral and scalariform conjugation have been noticed in this alga.

i. Lateral Conjugation:-

Lateral conjugation is the commonest mode of reproduction in this alga. The neighbouring cells give out tent-like protuberances (Fig). In most filaments, it is seen, that such protuberances are given out on one side of the filament only (Fig), while in others these are given out on both sides in an alternate fashion (Fig). The protoplasm with the chloroplasts shows a dislocation from its horizontal position, and it has been noticed, that in some cases, it accumulates in the region of the protuberances (Fig). Ultimately the cell-wall separating the two gametes ruptures, the protoplasm and nuclei coalesce, but the chloroplasts with their pyrenoids remain distinct even in the zygospore.

Both the gametes are morphologically as well as physiologically isogamous. In one filament, I noticed that the upper part, which contains a kidney-shaped zygospore, is cut off from the remaining

conjugation, geniculation is noticeable. (Fig)
Sometimes three or more filaments may be seen conjugating together (Fig).

Affinities:- The species of genus Zygnema, which come nearest to the present from, are Zygnema Heydrichii schmidle, and Z. Carteri Czurda. However it differs from both these in that the zygospore is not confined to the conjugation canal, but encroaches upon the whole of middle part of the conjugating cells, when it reproduces by lateral conjugation. From Z.Carteri it differs in the size of vegetative cells and zygospores. Another related form is Z. gedeanum Czurda, which differs from the present form, in that the zygopores produced by lateral conjugation are confined to the upper part of the conjugation canal area only though they are not cut off by any cell-wall from the remaining part of the conjugating cells.

I have named this species after Dr. V.Czurda of Prag who has done such a memorable work in advancing our knowledge of Zygnemals.

Habit:-- This alga was found free floating in a bluish green mass, only with a species of Spirogyra during the third week of February, 1931, in a fresh-water spring at Tahli Sahib, Tehsil Dasuya, District Hoshiarpore, Punjab.

contd.

Zygnema Iyengari Sp. Nov. Randhawa.

Vegetative cells are 18-20 U broad and five to eight times as long. Each cell has two rounded chloroplasts (Fig)

Reproduction.

Sexual reproduction is not known so far, and the alga reproduces itself by means of squarish or cushion shaped azygospores. The azygospores are of various shapes (Fig Fig) and have a consriction in the middle part when fully mature (Fig). The cells assume a spindle-shaped appearance due to the peculiar structure of the azygospores, and are shining white in appearance, possibly due to mucilage secretion, though no lamellation is noticeable.

The azygospores are 26-30 U long and just as broad in some cases (Fig). Three layers are clearly noticeable in the wall of the azygospores, a bluish exosporium, a dark brown, crinkled and sinuous mesosporium, and a hyaline endosporium.

Affinities:- This alga takes its place in the small group IV Reticulata of Genus Zygnema, as classified by Czurda in Heft 9 of Die Susswasserflora Mitteleuropas, due to the absence of sexual reproduction. There are three species in this group viz Zygnema reticulatum Hallas, Z. fertile Fritsch and Rich, and Z. Cylindricum Transeau. From all these this alga differs in the shape and size and structure of the azygospores.

Habitat:- This alga was found free-floating in the form of a bluish mass of filaments at Shahniwala Tank at Dasuya District Hoshiarpore Punjab during the second week of April 1931.

Zygnema giganteum Sp. Nov. Randhawa.

Vegetative cells are 38-48 U broad and $1\frac{1}{2}$ to $2\frac{1}{2}$ times as long. In thinner filaments, the chloroplasts show a typically stellate structure each with a conspicuous pyrenoid.(Fig). In bigger filaments the chloroplasts are loaded with starch granules, and the stellate structure of the chloroplasts is obscured, and they appear to be more or less rounded in appearance. Cell wall is fairly thick as compared with other species of Zygnema. In most filaments protoplasm with chloroplasts and nucleus is restricted to the middle part, the peripheral part being full of shining mucilage, secreted by the retreating protoplasm which forms a homogeneous mass (Fig).

Reproduction- Both sexual and asexual modes of reproduction have been noticed in this alga.

1. Asexual Reproduction:-

Asexual reproductiontakes place by means of brick-shaped parthenospores. Inearly stages, the filaments develop very thick cell-walls, and their chloroplasts become enormously expanded filling nearly the whole of the cell interior. When stained with iodine the chloroplasts become purple, due to the heavy load of starch granules, which envelopes them, and the surrounding parts ta[illegible] up a yellow stain. The parthenospores develop orange-coloured t[illegible]ick walls, which sometimes show two pyrenoids in the middle part (Fig) The parthenospores are 36-45 U broad and 54-96 U in length, and may be rectangular or squarish in shape even in the same filament (Fig). The parthenospores may be seen singly, or in rows of twos or threes, and in later stages whole filaments are converted into chains of parthenospores (Fig).

II. Sexual Reproduction- The sexual mode of reproduction shown by this alga is also of a very interesting type. Material collected from the same habitat shows that in some filaments zygospores are found in the conjugation canals, and in others in the conjugating cells, the conjugation being [illegible] the same alga. The only parallel instance of this type of conjugation has been seen in the case of Zygnema peliosporum Witte. by Fritsch, but even in that case the two different types of conjugation were seen in material collected in different years from the same habitat. In the present case both types of reproduction were seen in the same material, and also transitional stages.

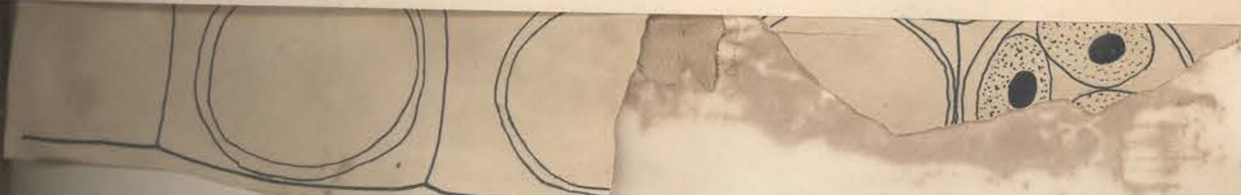
a. Anisogamous conjugation.

This type of reproduction is quite common in most filaments. The conjugation canals do not from a continuous tube but present a ruptured appearance in the middle, surrounded by a granular matter. (Fig). The male filaments ~~xxxxxxx~~ sometimes show an alternation of cells which produce male gametes, and ~~xxx~~ vegetative cells, in which the chloroplasts are surrounded by a shining mucilaginous material and thick walls (Fig) In later stage these sterile cells become loaded with starch granules, and these also produce abortive conjugation canals (Fig). This shows that these cells also are potentially male, though their activity is very much retarded by the development of thick walls. In other cases no cells are left out as purely vegetative in the male filaments, all of them functioning as males (Fig).

The zygospores are 42-46 U and 50-58 U long, and are oval in shape. The zygospore wall is composed of two layers only, a thick hyaline and smooth exospore, and a thin, light blue, and smooth endospore. Mesospore is obviously missing. The ripe zygospores are orange-coloured in appearance like the parthenospores

b. Isogamous conjugation.

This is the commoner mode of reproduction, in this alga. Zygospores are typically egg-shaped in appearance, and project partly



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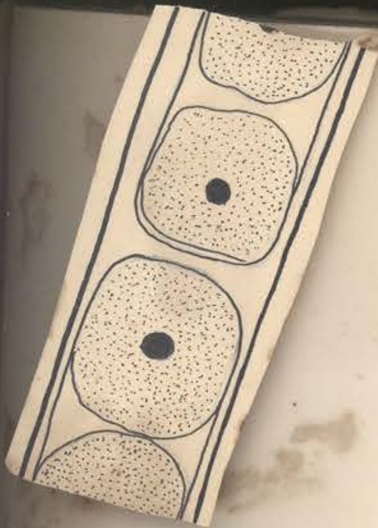

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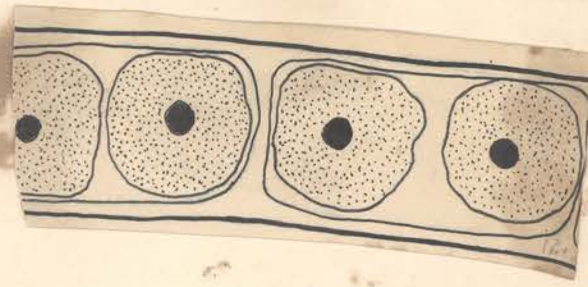

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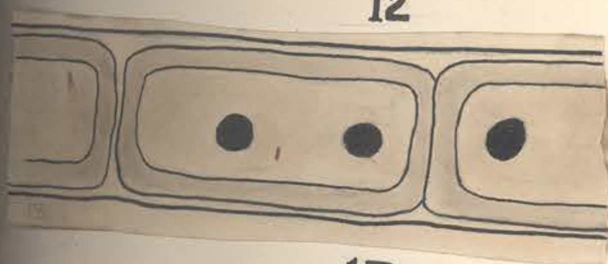

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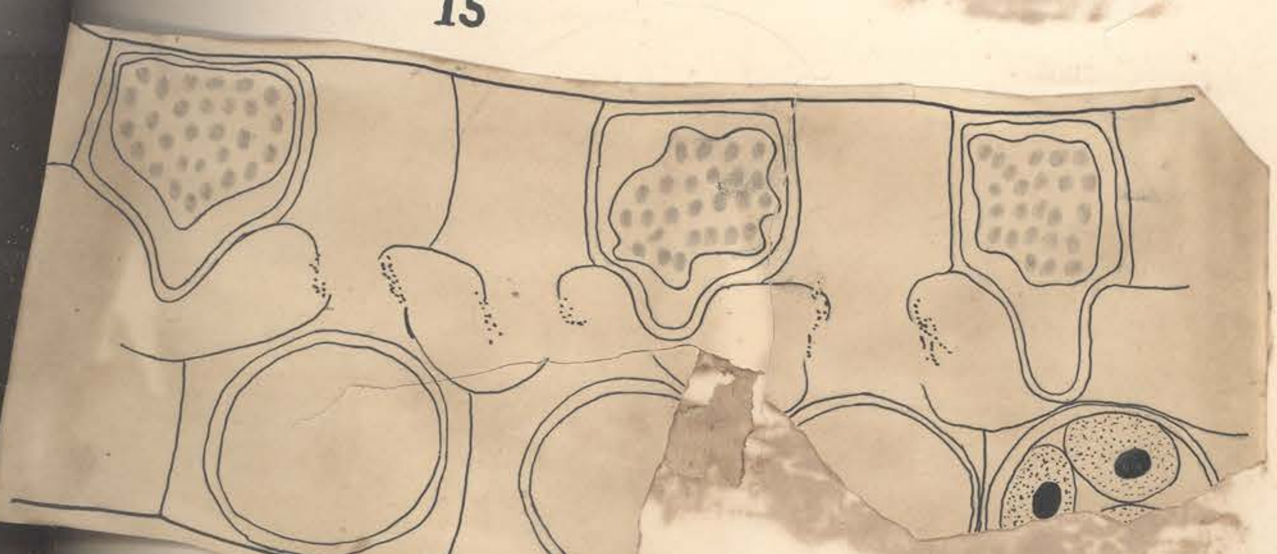

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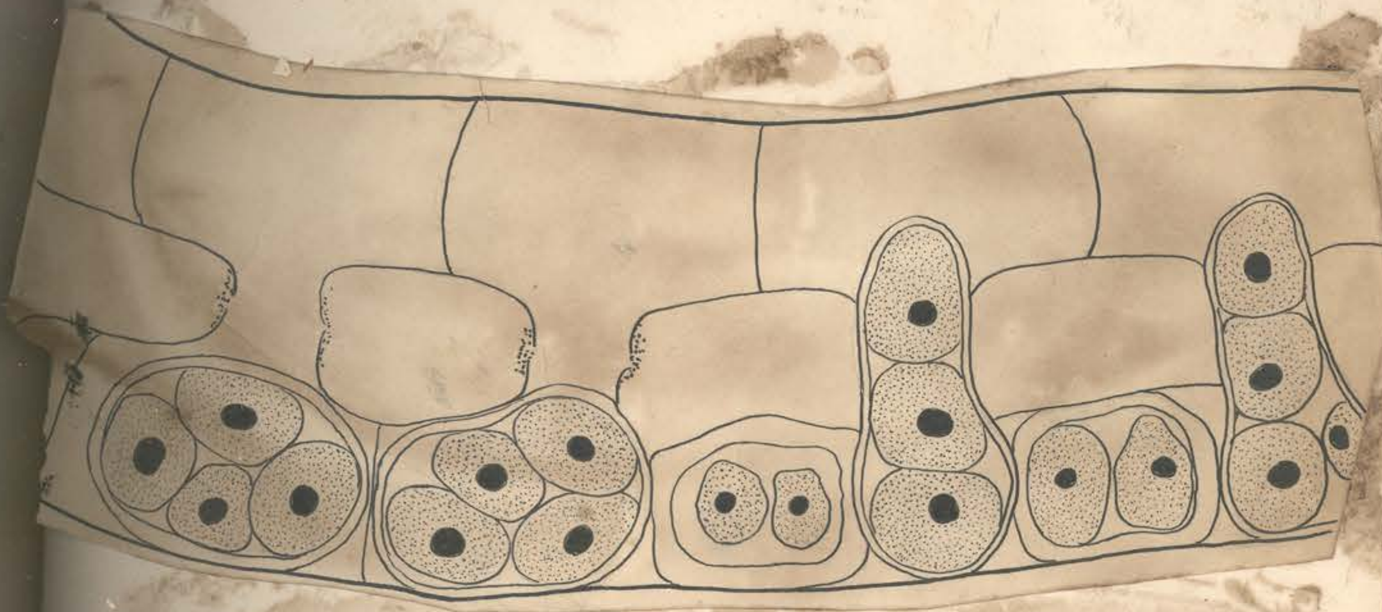

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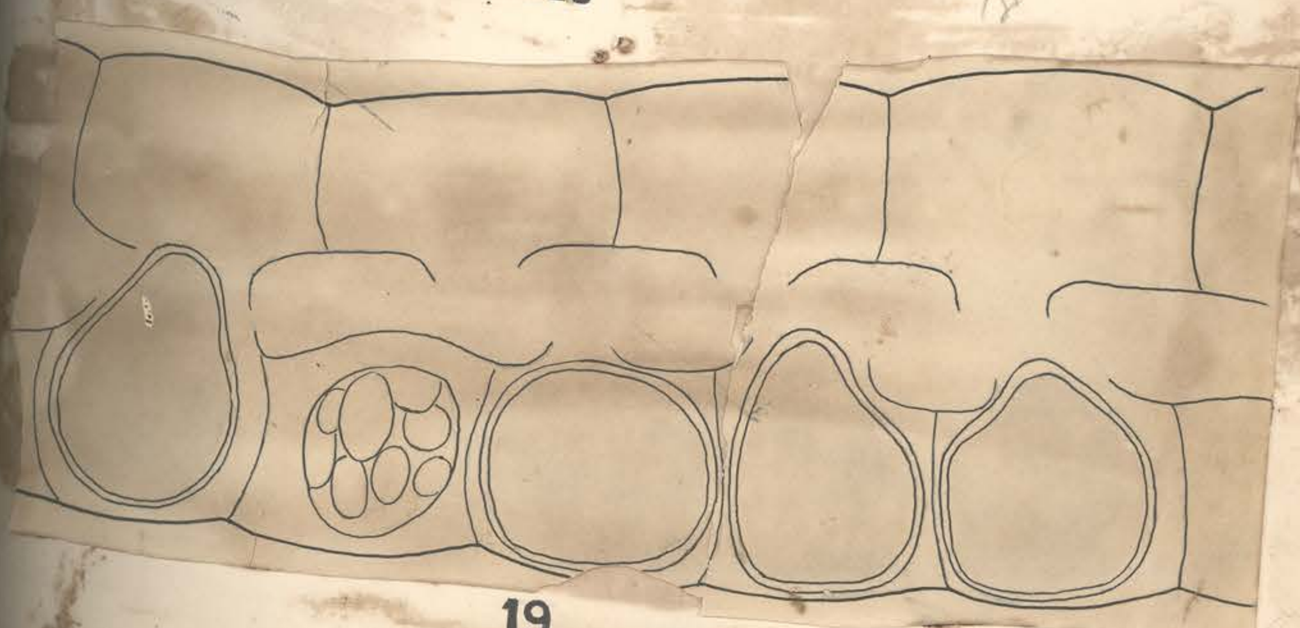

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...iation in this species is very much unsettled; isogamy and anisogamy b... found side by side. In one filament isogamy, anisogamy and many intermediate stages between these both were seen (Fig. 17). While majority of the zygospores were clearly produced by anisogamous conjugation, as is apparent from their being entirely confined to the female gametangium, there are some zygospores which are partly formed in the conjugation canal and partly in the female ...

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THREE NEW SPECIES OF *ZYGNEMA* FROM NORTHERN INDIA.

By M. S. Randhawa, M.Sc., I.C.S.
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(Communicated by Dr. H. Chaudhuri, M.A., Ph.D.)

Received 1936.

The writer came across three remarkable species of genus ***Zygnema***, **during** his investigations of the Zygnemales of Northern India. **The reproductive** phase of these algæ shows many peculiarities. Following is a detailed description of these three new species of *Zygnema*.

I. Zygnema Czurdæ *Sp. Nov.*

Vegetative cells are 20–27 μ broad, and $1\frac{1}{2}$ to 4 times as long. Two more or less rounded chloroplasts with a conspicuous pyrenoid in each, are seen in each cell. When stained with iodine, some of the chloroplasts show the typical zygnemaceous stellate structure (Fig. 1.)

Reproduction.—The reproductive phase of this new member Zygnemales is most remarkable. Both lateral and scalariform conjugation have been noticed in this alga.

(i) *Lateral conjugation.*—Lateral conjugation is the commonest mode of reproduction in this alga. The neighbouring cells give out tent-like protuberances (Fig. 2). In most filaments, it is seen, that such protuberances are given out on one side of the filament only (Fig. 2), while in others these are given out on both sides in an alternate fashion (Fig. 3). The protoplasm with the chloroplasts shows a dislocation from its horizontal position, and it has been noticed, that in some cases, it accumulates in the region of the protuberances (Fig. 3). Ultimately the cell-wall separating the two gametes ruptures, the protoplasm and nuclei coalesce, but the chloroplasts with their pyrenoids remain distinct even in the zygospore.

Both the gametes are morphologically as well as physiologically isogamous. In one filament, I noticed that the upper part, which contains a kidney-shaped zygospore, is cut off from the remaining part of the conjugating cells by means of distinct walls, as in *Zygnema Heydrichii* (Fig. 4). However in most of the filaments the zygospore is seen filling the whole of the conjugation canal area, as well as the lower part of the conjugating cells (Fig 5.). Probably the zygospore enlarges, presses down the lower arched part of the cell-wall, while the lateral parts are torn away partly by the pressure of the zygospore, and partly by the forces exerted by the movement of the filaments in water.

The zygospores are 30–40 μ in diameter, and are oval in shape in early stages (Fig. 5), but later on become rounded. Four chloroplasts with a conspicuous pyrenoid in each, and nucleus in the central part may be observed nearly in all the zygospores (Fig. 5). The zygospore wall is composed of three thin layers, all of which are light blue in colour. The exospore and mesospore are smooth, while the endospore is slightly sinuous. When fully mature the zygospores are perfectly round in shape, and the peripheral area surrounding the chloroplasts is full of granular matter (Fig. 6). The middle-basal part of the conjugating cells becomes flattened and the upper part becomes rounded like a dome (Figs. 5, 6). In some filaments, which become more mature, distinct geniculation may be seen, the flattened basal part ruptures, and the zygospore is liberated into water (Fig. 6). The zygospores thus produced by lateral conjugation look very much like azygospores produced asexually in forms like *Zygnema reticulatum* Hallas and *Z. fertile* Fritsch. If the early stages showing cells with conjugation processes were not seen, and also the four chloroplasts in some zygospores, these might have been easily mistaken for azygospores.

Sexual differentiation in this species is very much unsettled; isogamy and anisogamy being found side by side. In one filament isogamy, anisogamy and many intermediate stages between these both were seen (Fig. 17). While majority of the zygospores were clearly produced by anisogamous conjugation, as is apparent from their being entirely confined to the female gametangium, there are some zygospores which are partly formed in the conjugation canal and partly in the female ...

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III. Zygnema giganteum *Sp. Nov.*

Vegetative cells are 38–48 μ broad and 1½ to 2½ times as long. In thinner filaments, the chloroplasts show a typically stellate structure each with a conspicuous pyrenoid (Fig. 11). In bigger filaments the chloroplasts are loaded with starch granules, and the stellate structure of the chloroplasts is obscured, and they appear to be more or less rounded in appearance. Cell-wall is fairly thick as compared with other species of *Zygnema*. In most filaments protoplasm with chloroplasts and nucleus is restricted to the middle part, the peripheral part being full of shining mucilage, secreted by the retreating protoplasm which forms a homogeneous mass (Fig. 11).

Reproduction.—Both sexual and asexual modes of reproduction have been noticed in this alga.

(i) *Asexual reproduction.*—Asexual reproduction takes place by means of brick-shaped parthenospores. In early stages, the filaments develop very thick cell-walls, and their chloroplasts become enormously expanded filling nearly the whole of the cell interior. When stained with iodine the chloroplasts become purple, due to the heavy load of starch granules, which envelopes them, and the surrounding parts take up a yellow stain (Fig. 12). The parthenospores develop orange-coloured thick walls, which sometimes show two pyrenoids in the middle part (Fig. 13). The parthenospores are 36–45 μ broad and 54–96 μ in length, and may be rectangular or squarish in shape even in the same filament. The parthenospores may be seen singly, or in rows of two or threes, and in later stages whole filaments are converted into chains of parthenospores (Fig. 14).

(ii) *Sexual reproduction.*—The sexual mode of reproduction shown by this alga is also of a very interesting type. Material collected from the same habitat shows that in some filaments zygospores are found in the conjugation canals, and in others in the conjugating cells; the conjugation being isogamous and anisogamous in the same alga. The only parallel instance of this type of conjugation has been seen in the case of *Zygnema peliosporum* Witt. by Fritsch, but even in that case the two different types of conjugation were seen in material collected in different years from the same habitat. In the present case both types of reproduction were seen in the same material and also transitional stages.

(*a*) *Anisogamous conjugation.*—This type of reproduction is quite common in most filaments. The conjugation canals do not form a continuous tube but present a ruptured appearance in the middle, surrounded by a granular matter (Fig. 15). The male filaments sometimes show an alternation of cells which produce male gametes, and vegetative cells, in which the chloroplasts are surrounded by a shining mucilaginous material and thick walls (Fig. 15). In later stages these sterile cells become loaded with starch granules, and these also produce abortive conjugation canals (Fig. 16). This shows that these cells also are potentially male, though their activity is very much retarded by the development of thick walls. In other cases no cells are left out as purely vegetative in the male filaments, all of them functioning as males (Fig. 19).

The zygospores are 42–46 μ and 50–58 μ long, and are oval in shape. The zygospore wall is composed of two layers only, a thick hyaline and smooth exospore, and a thin, light blue, and smooth endospore. Mesospore is obviously missing. The ripe zygospores are orange-coloured in appearance like the parthenospores.

(*b*) *Isogamous conjugation.*—This is the commoner mode of reproduction, in this alga. Zygospores are typically egg-shaped in appearance, and project partly into the gametangia, completely filling the conjugation canals at the same time. Zygospores produced by isogamous conjugation are longer than those produced by anisogamous conjugation, being 70–75 μ long. This is probably due to the fact that in this position more space is available for the lengthwise development of the zygospores (Fig. 18).

In some instances I noticed that male and female gametes instead of meeting and fusing to form zygospores, develop independently into azygospores (Fig. 18).

Sexual differentiation in this species is very much unsettled; isogamy and anisogamy being found side by side. In one filament isogamy, anisogamy and many intermediate stages between these both were seen (Fig. 17). While majority of the zygospores were clearly produced by anisogamous conjugation, as is apparent from their being entirely confined to the female gametangium, there are some zygospores which are partly formed in the conjugation canal and partly in the female gametangium (Fig. 19). In some only a small part of the zygospore is found projecting into the conjugation canal. The pear-shaped appearance of some zygospores with their pointed ends towards the conjugation canals is explained by the fact that anisogamy has not reached its final stage and in these and both the male as well as the female gametes show a certain amount of activity.

This species combines all the four forms of reproduction known in different species of genus *Zygnema*.

(i) Asexual reproduction by the development of parthenospores.
(ii) Sexual reproduction.
  (*a*) By means of development of zygospores produced isogamously.
  (*b*) By means of zygospores produced anisogamously.
  (*c*) By means of zygospores developed from isogamous gametes.

Affinities.—There are two conspicuous peculiarities of this alga. Firstly its modes of reproduction, and secondly its gigantic size.

As regards the combination of isogamous and anisogamous modes of conjugation, it resembles *Zygnema peliosporum* Witt. as recorded by Fritsch from South Africa. But it differs from that species in the shape and size of zygospores and vegetative filaments, as well as in the presence of parthenospores.

As regards its size *Z. inconspicuum* Czurfla with its filaments as broad as 30 μ approaches it, but differences in the shape of zygospores, occurrence of anisogamy with isogamy and presence of parthenospores keep these two forms wide apart. I have named this form as *Zygnema giganteum*, due to its comparatively big size.

Habit.—This alga was found free-floating along with *Zygnema cœruleum* in Siah Baeen, a perennial freshwater stream in Kapurthala State, Panjab, during the second week of March 1931.

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EXPLANATION OF FIGURES.

PLATE I.

Zygnema Czurdæ sp. nov.

Fig. 1.—A vegetative filament showing chloroplasts. × 660.
Fig. 2.—A filament showing cells with conjugation processes. × 660.
Fig. 3.—A filament showing cells giving out conjugation processes on both sides. × 660.
Fig. 4.—A filament showing a bean-shaped zygospore cut off by walls from the remaining part of the cells. × 660.
Fig. 5.—A filament showing zygospores filling the entire cells. × 660.
Fig. 6.—A filament showing distinct geniculation and ripe zygospores. × 660.
Fig. 7.—Three filaments conjugating in a scalariform way. × 660.

Zygnema Iyengari sp. nov.

Fig. 8.—A filament showing chloroplasts. × 660.
Fig. 9.—A filament showing squarish azygospores. × 660.
Fig. 10.—A filament showing zygospores with a constriction in the middle. × 660.

PLATE II.

Zygnema giganteum sp. nov.

Fig. 11.—A filament showing chloroplasts. × 660.
Fig. 12.—A filament showing enlargement of chloroplasts and secretion of mucilage prior to formation of parthenospores. × 660.
Fig. 13.—A filament showing a chain of brick-shaped parthenospores with two pyrenoids in each. × 660.
Fig. 14.—A filament converted into a chain of orange-coloured parthenospores. × 660.
Fig. 15.—Two filaments showing anisogamous conjugation. The male filament shows an alternation of male cells, and vegetative cells full of mucilage. × 660.
Fig. 16.—This shows the abortive conjugation processes given out by the vegetative cells in the male filament. × 660.
Fig. 17.—Two filaments showing transitional stages between isogamy and anisogamy. × 660.
Fig. 18.—Two filaments showing zygospores produced by isogamous conjugation and two azygospores. × 660.

PLATE III.

Zygnema giganteum sp. nov.

Fig. 19.—Two conjugating filaments showing pear-shaped zygospores. × 660.

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1 to 24 + 44 figs in three sheets.

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24
44 Fig in 3 sheets.

Contributions to our knowledge of the Freshwater Algae of Northern India.

1. Oedogoniales.

By

M.S. Randhawa, M.Sc., I.C.S.,
Saharanpur.

Received July 21, 1936

Communicated
by
Dr. S.L.Ghose, Ph.D.,
Botany Department,
Government College,
Lahore.

Group 5. Oedogoniales.

Genus Oedogonium. Link.

Genus Oedogonium.

This alga is found in freshwater ponds, lakes, and streams, nearly all over the world. The filaments have a well-developed basal cell by means of which they get attached to sticks and stones. The filaments are unbranched, and the cells are usually cylindrical or barrel-like in appearance. The genus was described by Link in 1820.

A. Section Dioca nannandria.-

1. Oedogonium striatum sp. nov. Idioandrosporous nannandrous. Oogonia intercalary or terminal in position occurring singly or in pairs, also in threes (Figs 2+3), pronouncedly oval or oval-ellipsoid in shape. Oospore chocolate in colour, oval, almost completely filling the oogonium. Oospore wall very thick bearing obliquely arranged or straight hyaline striations, 10-15 μ in number which often anastomose (Fig 3). Basal cells flattened 45-50 μ br. (Fig 4). Vegetative cells swollen with starch. Androsporangia in rows of 3-6 (Fig I,a). Nannandria 2-6 on the basal cells and the walls of the oogonium (Fig 5). Antheridia always internal. Oospores germinating, to produce 2 zoospores oval in shape, 10 μ br., 18 μ long, (Fig 8).

This alga very much resembles Oe. Wolleanum Wittrock in dimensions of cells and oospores but differs from that form in having an internal antheridium and in having no pore in the wall of the oogonium, The opening taking place by a superior lid, and its peculiar striations.

Diam. veget. cells female plants...28-32 μ br., 4-5 times as long

" " " male " 21-25 μ br. 2-3 times long.

Diam. of Oogonia ....75-80 μ br., 85-90 μ long.

" Oospores ....75 μ br., 85 μ long.

" Androsporangia 23 μ br., 20-27 μ long.

" Nannandria, 18 μ br., 72 μ long.

Habit.- This alga was found epiphytic on submerged radial stems of water-plants, in Shahniwala Tank at Dasuya during the second week of March 1930.

2. <u>Oedogonium</u> <u>multisporum</u>. Wood - Tiffany 1930, p. 131.

Dioecious nannandrous, oogonia 1-3, sub-ovoid or subglobose, pores superior, oospore globose nearly filling oogonia, (Fig. 7d), spore-walls smooth, dwarf male a little curved near or on the oogonium, antheridium exterior 1-4. (Fig. 8).

Distribution.- U.S.A., England.

Vegetative cell of the female plant	14-18 μ broad, 2-3 times long
Oogonia	32-40 μ broad, 28-34 μ long.
Oospore	32 μ broad, 28 μ long.
Nannandria	14-18 μ broad, 2-3times as long.

Habit.- Reported by Mr. Prem Lal from ponds in Lahore and Gujranwala in The first week of December 1933.

B. Section Diocă macrandria,

3. Oedogonium capilliforme Kutz. var. nov. nanum. ~~Randhawa~~. op. cit. Heering. Susswasser flora Heft.6.

Dioecious macrandrous, oogonia single or in pairs. Ovoid to sub-ovoid or even slightly ellipsoid in shape with a superior pore. Oospore globose or ovoid globose completely filling the oogonium (Fig.9). Spore walls smooth. Antheridia 2-4 celled usually alternating with the vegetative cells, two sperms in each division horizontal (Fig.10). This differs from the type in the smaller dimensions of its vegetative cells, oogonia, oospores and antheridia.

Distribution. So far this species has only been reported from Europe and United States of America.

Diam. of female veget. cells 18-20 μ, 2-3 times as long.
" male " " 10-12 μ, 2-4 times " "
" Oogonia, 30-36 μ br., 32-40 μ long.
" oospores, 34-36 μ br., 32-40 μ long.
" antheridia, 10 μ br., 5 μ long.

Habit.- Found growing epiphytically on blades of rushes in a pond in village Shahpur, Tehsil Dasuya, Distt. Hoshiarpur, in the middle of April 1936.

4. Oedogonium cardiacum. Wittrock. op. cit. Heering Susswasser flora Heft. 6.

Dioecious macrandrous, oogonia single ovoid elliptical in shape. Broadened and bulging out laterally. Pore wide situated a little above the middle. Oospore rounded, fire-red in colour not completely filling the oogonium (Fig 11) Oospore membrane smooth. Male filaments a little more slender than the female filaments. Antheridium 2-3 celled (Fig 12). Sperms not seen.

Distribution. So far this species has been only reported from Continental Europe and United State of America.

Diam. of veget. cells of female plants 26-28 μ br. 3-5 times as long
" " male plant ...22-25 μ br., 3-5 times as long.
" oogonia 54-60 μ br. 60-70 μ long.
" oospores 50 μ br., ~~[illegible] long.~~
2 antheridial cells ......8-9 μ long, 23 μ br.

Habit:- Epiphytic on blades of grass, and decaying shoots of trees, mixed with Oedogonium urbicum, Anabaenothrix cylindrica and Zygnema chalybeosporum in a pond at village Jhingran, Distt. Hoshiarpur, in the last week of March 1930.

6. <u>Oedogonium</u> <u>Frankilianum</u>. Wittrock. sec. Hirn., var. <u>Polyspora</u>, var. nov.

Dioecious macrandrous, oogonia single or in groups of 2-3. Globose or ellipsoid globose, opening by a superior pore. Oospores rounded, chocolate in colour when mature, sometimes completely filling the oogonium, sometimes partly (Fig. 13, 14, 15). Oospore wall smooth, Suffultory cell wider than the ordinary cells. Male plant slightly narrower than the female plants. Antheridia 3-4 celled separated by a single vegetative cell. Sperms two, division horizontal (Fig. 16). Vegetative cells distinctly capitellate.

This differs from the type in (a) Bigger dimensions of vegetative cells and oospores (b) having more than one oogonium in a series (c) oospores often not completely filling the oogonium. Hence the new variety has been established.

<u>Distribution</u>: So far this Alga has only been reported from Roumania.

Diam. veget. cells of female plant ..... 9-18 μ br. 4-6 times as long.
" " " male " ..... 7-12 μ br. 4-6 times as long.
" oogonia .... 26-36 μ br. 38-40 μ long.
" oospores .... 24-35 μ broad.
" antheridial cells ...... 10 μ br., 9 μ long.

Habit:- This is rather a rare form, and was found growing epiphytically on the stems of a submerged water plant, along with <u>Eudorina elegans</u> near Beas, during the last week of April 1930.

6. Oedogonium inerme Hirn. var. Polyspora. var. nov. (Section Nicht genugend bekannte Aretn. Heering Susswasser flora Heft. 6.).

Dioecious macrandrous (probably) oogonia 1-3, usually single or in pairs. More rarely in a row of three (Fig. 16, 17, 18). Pore in the middle. Oogonia transversely ellipsoid. Oospore chocolate in colour almost of the same shape as the oogonium which it completely fills. Oospore wall smooth. Vegetative cells not capitellate. Male plants not known.

This differs from the type in having oogonia in a series of two or three and the oospores completely filling the oogonia and in the smaller size of the vegetative cells, oogonia and oospores. Hence this new variety has been established.

Distribution: So far this species has only been reported from France.

Diam. veg. cells ...... 5-9 u br., 4-6 times as long.
" oogonia .... 21 u br., 19 u long.
" oospores .... 19 u br., 16-17 u long.

Habit:- Found attached to decaying leaves of Dalbergia sissoo, in a brownish mass in a rain-water puddle near Hamira, during the second week of March, 1930.

7. Oedogonium lautumnarium. Wittrock. op. cit.
Heering Susswasser flora Heft. 6.

Dioecious, macrandrous. Oogonia always single, globose or slightly expanded in the upper portion. Opening by a superior pore. Oospores yellowish in colour, globose, with a thick opaque whitish smooth wall (Figs. 19, 20). Male plants as big as the female plants or slightly smaller. Antheridia 3-celled, each with 2 sperms, division horizontal (Fig 7.21). Suffultory cells of the same diameter as the vegetative cells. It differs from the type in oospores not completely filling the oogonia.

Distribution: This Alga is so far only known from Finland and Sweden.

Diam. of veg. cells female plant	18-20 μ br. 3-6 times as long.	
" " " male "	14-16 μ br. 3-6 times as long.	
" oogonia	40-42 μ br.,	42-48 μ long.
" oospores	36 μ broad.	
" antheridial cells ..	13-14 μ br.,	5-8 μ long.

Habit:- Epiphytic on water-plants, in a pond near Hamira, along with Spirogyra dubia, Oedogonium lautumnarium and Sirogonium Sticticum, during the middle of April 1930. It is rather a rare alga.

8. Oedogonium Pisanum. Wittrock. op. cit.; Heering Susswasser flora Heft 6.

Dioecious macrandrous. Oogonia single, both terminal and inter-calary opening by a superior lid (Fig 22). Oospore oblong ellipsoid, completely filling the oogonium, oospore membrane smooth. Antheridia 2-celled, sperms 2, division horizontal (Fig 23, 24). Suffultory cells not broader than the vegetative cells.

Distribution: So far the species has only been reported from Europe and the United States of America.

Diam. veget. cell 5-9 μ br., 18-36 μ long.
" oogonia 16 μ br. 36 μ long.
" oospores 14-15 μ br., 24-30 μ long.
" antheridia 4-5 μ br., 3-5 μ long.

Habit:- Epiphytic on decaying leaves of Dalbergia sissoo along with Oedogonium Pisanum and Oe. Hirnii in a puddle near Hamira during the second week of April 1930. The filaments present a greyish appearance.

9. Oedogonium rivulare Hirn. var. nov. Nanum. ~~Randhawa.~~
op. cit. Heering Susswasser flora Heft 6.

Dioecious macrandrous. Oogonia usually single, rarely in pairs. Pore superior, oogonia ellipsoid globose, oospore chocolate in colour ovoid, not completely filling the oogonium, oospore wall smooth (Figs. 25, 26). The suffultory cells not swollen. Male filaments narrower than female filaments. Antheridia 5-7-celled but sometimes very numerous as many as 17 (Fig. 27).

This species differs from the type in its (i) usually single oogonia (ii) oospores almost completely filling the oogonium (iii) smaller size of oogonium (in Oedogonium rivulare Hirn. they are as much as 160 µ br.). So it may be taken as a new variety.

Distribution: So far this species has only been reported from Germany.

Diam. Veget. cells of female plant ... 36-47 µ br. 3-5 times as long.
" " " male " ... 32-34 µ br. 3-5 times as long.
" oogonia .... 81 µ br....... 90 µ long.
" oospore .... 76 µ br....... 80 µ long.
" antheridial cells .. 12 µ long .... 28 µ br.

Habit:- This alga was found free-floating in a blackish mass, along with Cylindrocapsa conferta, in the famous tank at Dasuya Distt. Hoshiarpur during the middle of October 1929.

10. Oedogonium sociale. Wittrock. op. cit. Heering Susswasser flora Heft 6.

Dioecious macrandrous, oogonia single, globose in shape, inter-calary, oospore deep-yellow in colour, completely filling the oogonium (Fig. 28), Oospore membrane smooth, basal cells swollen. Antheridia 1-5 celled, (Fig 29).

This Alga is very social in its growing habit, its individuals occurring in large numbers as epiphytes on water plants.

Distribution: This species is widely distributed in Europe and America.

Diam. veget. cells ..... 9-15 µ br., 3-5 times as long.
" oogonia .... 34-37 µ br.,
" oospores .... 26-30 µ br.,
" antheridial cells .... 12-14 µ br., 10 µ long.

Habit:- This is one of the commonest and mostly widely distributed species of Oedogonium and grows as an epiphyte on the submerged leaves and stems of the aquatic plants. Sometimes we can get pure growths of this alga, showing a harvest of bright yellow oospores, under the microscope. In some cases it is also found mixed with Oedogonium urbicum, and Oe. cardiacum. Collected from nearly all over the Eastern Punjab during the middle of March 1930.

11. Oedogonium fonticola Al. Braun. Pascher 1914. p. 225. Tiffany 1930. p. 163.

Dioecious, macrandrous, oogonia 1-2, obovoid, or globose obovoid, ellipsoid or sub-globose, oospore nearly filling the oogonium, spore-wall smooth. Male filaments very narrow. (Figs. 30 & 31).

Distribution: U.S.A., Australia, Europe.

Vegetative cells of female plant ... 16-18 μ broad, 28-48 μ long.
Vegetative cells of male plant ..... 12-14 μ broad, 2-3 times as long.
Oogonia .... 30-40 μ broad, 32-36 μ long.
Oospore .... 32 μ broad, 32 μ long.
Antheridial cells .... 8-10 μ broad.

Habit:- Found free-floating in a pond at Lahore by Mr. Prem Lal, during the first week of December 1933.

12. Oedogonium glabrum sp. nov.

Dioecious, macrandrous, oogonia always single, globose, pore not seen, though very probably it opens by a pore. Oospore globose, completely filling the oogonium. Oospore wall smooth. Cells of the female filaments very short and rounded, with a thick wall and a conspicuous pyrenoid in the middle, vegetative cells very peculiar (Fig. 33). Male filaments have rows of 5-7 antheridia, separated by long cylindrical cells (Fig. 34). Basal cells elongate (Fig. 32). This species comes nearest Oedogonium suecicum. Wittrock. sec. Hirn. from which it differs in oospore membrane being smooth and not spinous, and vegetative cells being much broader and smaller in length and its sex organs being slightly bigger.

~~Distribution~~:

Diam. veget. cells of female plants...		26-28 µ br., 28-30 µ long.
" " "	male plants...	15-20 µ br., 28-30 µ long.
" oogonia		36-45 µ broad.
" oospores		32-40 µ broad.
" Antheridial cells.....		14-16 µ br., 6-8 µ long.

Habit:- Free-floating in a pond. Collected at V. Jhingran, Distt. Hoshiarpur in the middle of March 1930.

13. <u>Oedogonium</u> <u>rufescens</u>. Wittrock. var. <u>Lundellii</u>.
Tiffany 1930. p. 66. Pascher, p.192.

Dioecious, macrandrous, oogonia 1-3 obovoid or depressed obovoid, globose. Pore median, oospore globose or depressed globose filling the oogonium.

<u>Distribution</u>:- Southern Tibet.

Vegetative cells of the female filaments - 8-10 µ broad
30-40 µ long.

Oogonia .... 22-24 µ broad, 20-26 µ long.

Oospore .... 20-22 µ broad, 17-20 µ long.

Habit:- This alga was found by Mr. Prem Lal, free-floating in a pond at Lahore during the third week of November 1933, and also by the author at Saharanpore during the first week of December 1935.

14. Oedogonium calcareum - Cleve. Pascher 1914. p.192.
Tiffany 1931. p. 67.

Dioecious, macrandrous, oogonia one or rarely two, depressed globose, oospore depressed globose filling oogonium, oospore-wall smooth (Fig. 35).

Grows epiphytically on Chara, (Fig. 36) and is often encrusted with lime (Fig. 36).

Distribution: England, Denmark, and Sweden.

Vegetative cells of the female plant - 12-16 μ broad, 2-3 times as long.

Oogonia .... 32-44 μ broad, 32-36 μ long.

Oospores .... 30-40 μ broad, 32 μ long.

Habit:- This alga was first reported by Mr. Prem Lal from an aquarium at Lahore, growing epiphytically on Chara during the first week of December 1933, and also by the author at Roorkee, in a pond growing on Chara

Chara

Section III. Monoica Macrandria

15. Oedogonium gracillimum. Wittrock & Lund. op. cit. Heering. Susswasser flora Heft 6.

Monoecious, macrandrous, oogonia single, both terminal and inter-calary, opening by a superior lid. Oogonia oblong ellipsoid, oospores of the same shape as oogonia and completely filling them. Oospore walls smooth, antheridia 2-3 celled, each with two sperms, division horizontal. Suffultory cells not swollen (Figs. 37 and 38).

Distribution

Diam. veget. cells .... 9 μ br., 36-42 μ long.
" oogonia ....14-17 μ br., 24-36 μ long.
" oospores ....14-16 μ br., 23-30 μ long.
" antheridial cells .... 4-5 μ br., 7-8 μ long.

bit:- Rather a rare form, found epiphytic on decaying leaves along with Oedogonium Pisanum and Oe. Hirnii at Hamira during the middle of April 1930.

σ ??

16. Oedogonium Hirnii. Gutwinski. sp. cit Heering Susswasser flora Heft 6.

Monoecious, macrandrous, oogonia usually single, occasionally in pairs, globose. Opening with a big superior pore. Oospore globose, not completely filling the oogonium, yellowish in colour, oospore walls smooth. Antheridia 2-celled, each with two sperms, division horizontal. (Figs. 39 and 40).

Distribution: So far this species has only been reported from Europe.

Diam. veget. cell........ 20-22 µ br., 3-6 times as long.
" oogonia .... 32-36 µ br., 36-39 µ long.
" oospores .... 28-32 µ ~~br.~~ broad.
" antheridia .... 18 µ br., 9 µ long.

Habit: Grows as an epiphyte on decaying leaves in puddles along with Oedogonium gracillimum and Oe. Pisanum. Found near Hamira during the middle of April 1930.

17. Oedogonium oblongellum Kirchner. op. cit. Heering Susswasser flora Heft 6.

Monoecious, macrandrous, oogonia single, elliptical, operculate, division at the upper extremity of the oogonium. Oospores ellipsoid, globose, completely filling the oogonium. Oospore membrane smooth. Antheridia 2-celled (Fig. 41), each with two sperms. Vegetative cells not capitellate. Suffultory cell not swollen.

~~Distribution:~~

Diam. veget. cells....... 9-12 μ br., 3-4 times as long.
" oogonia .... 25-28 μ br., 40-46 μ long.
" oospores .... 27 μ br., 31 μ long.
" antheridium cells.. 9-10 μ long.

Habit:- Found epiphytic on grass-blades in a pond near village Shahpur, Distt. Hoshiarpur, during the middle of April 1930. This is a fairly common form.

18. <u>Oedogonium urbicum</u>. Wittrock. op. cit. Heering Susswasser flora Heft 6.

Monoecious, macrandrous, oogonia single, ellipsoid globose, pore superior, oospores rounded, not completely filling the oogonium, of dense black colour, oospore walls smooth. (Fig ~~18~~ 42.).

~~Distribution:~~

Diam. veget. cells ....18-20 μ br., 2-3 times as long
" oogonia ....41-46 μ br., 50-52 μ long.
" oospore .... 40-42 μ br.
" antheridia .... 10 μ br., 5 μ long.

Habit:- Epiphytic on submerged plants and decaying shoots of trees, in a pond near village Jhingran Distt. Hoshiarpur, along with <u>Oedogonium inerme</u> and <u>Vaucheria sessilis</u>. A very common alga during the middle of March.

P. T. O.

Genus Bulbochaete Agardh.

1. Bulbochaete sp. This was found associated with Stigeoclonium nanum. Cells are 16-18 μ br., 18-24 μ long. Each cell bears the characteristic long spines with a bulbous base. (Fig. 43) This is a branched form. The material was indeterminable due to the absence of sex organs.
Habit- Found in a pond near Hamira district Jullunder epiphytic on grass stems along with Stigeoclonium nanum, Coleochaete soluta and C. scutata, in the month of March 1930.

2. Bulbochaete sp. This was found epiphytic on Chaetomorpha. The Alga is in the form of 10-20 celled unbranched filaments. The terminal cells bearing a long trichome with a bulbous base (fig. 44). Cells ~~bearing a long trichome with a bulbous~~ are 8-9 μ in diameter, 2-3 times as long. This is probably the juvenile stage of some Bulbochaete species.
Habit. Found epiphytic on a shoot of Hydrilla along with Aphanochaete repens and Chamaesiphon filamentosa in the tanks in Shalamar Gardens Lahore, in November 1929.

Explanation of figures.
(all figures are magnified 715 times.

Plate I

I. Oedogonium striatum sp. nov.

1. A filament showing androsporangia.

2. A female filament showing a pair of ripe oogonia with oospores.

3. A female filament with a nannandrium germinating on the basal cell.

4. The attachment cell.

5. A female filament showing two dwarf males germinating on the basal cell.

6. A dwarf-male.

7. A germinating oospore with four zoospores inside the membrane.

II. Oedogonium multisporum(Wood)

8. A female filament with oospores, and nannandrium germinating on an oogonium.

III. Oedogonium capilliforme.

9. A female filament

10. A male filament.

IV. Oedogonium cardiacum.

11. A female filament showing a ripe oospore

12. A male filament showing antheridia.

Plate No. II.

variety *polyspora* var. nov.

V. Oedogonium Frankilianum. Wittrock. ~~var. nov.~~ Polyspora. ~~Randhawa.~~

13. A female filament showing a ripe oospore.

14. A male filament showing antheridia.

15. A male filament showing three oogonia in a series.

var. nov.

VI. Oedogonium inerme. var. Polyspora, ~~Randhawa~~.

16, 17, 18. Filaments showing oogonia with ripe oospores.

VII. Oedogonium lautumnarium.

19,20. Female filaments showing oogonia ~~with ripe oospores~~.

21. male filament showing ~~antheridia~~ antheridia

VIII. Oedogonium Pisanum.

~~21~~, 22, 23. Male filaments showing antheridia.

24. A female filament showing oogonia.

IX. Oedogonium rivulare.

25. A filament showing an oogonium with an oospore.

26. A filament showing two oogonia.

27. A male filament showing antheridia.

Plate No. III.

XI. Oedogonium fonticola. Al. Braun.

30. A female filament showing oogonia and an oospore.

31. A male filament showing antheridia.

XII. Oedogonium glabrum. sp. nov. Randhawa.

32. A filament showing the basal cell.

33. A female filament with two oogonia containing ripe oospores.

34. A male filament.

XIV. Oedogonium calcareum (Cleve)

35. A female filament showing an oogonium with a ripe oospore.

36. Basal cell.

XV. Oedogonium gracillianum.

37,38. Filaments showing antheridia and oogonia.

XVI. Oedogonium Hirnii. Gutwinski.

39. A filament showing ripe oospores and antheridia.

40. A filament showing immature oogonia and antheridia.

XVII. Oedogonium oblongellum(Wittrock)

41. A filament showing oogonia and antheridia.

XVIII. Oedogonium urbicum.

42. A filament showing an oogonium with a ripe oospore and antheridia.

~~XV~~ XIX Bulbochaete sp. x.

43. a branched filament.

XX Bulbochaete sp. y.

44. Two unbranched filaments.

A.S.-No. 2, (B 6)—1. H. S. 3171936.

G. Proofs. 1-4 with Mss. 1-24 (Fig) 1-44 with folio 3 Sheets.

CONTRIBUTIONS TO OUR KNOWLEDGE OF THE FRESHWATER ALGÆ OF NORTHERN INDIA.

1. Oedogoniales.

By M. S. Randhawa, M.Sc., I.C.S.
(*Saharanpur*)

Received July 21, 1936.
(Communicated by Dr. S. L. Ghose, M.Sc., Ph.D.)

Group 5. Oedogoniales.

Genus Oedogonium Link.

Genus Oedogonium.

This alga is found in freshwater ponds, lakes, and streams, nearly all over the world. The filaments have a well-developed basal cell by means of which they get attached to sticks and stones. The filaments are unbranched and the cells are usually cylindrical or barrel-like in appearance. The genus was described by Link in 1820.

A. Section *Dioca nannandria.*—

1. *Oedogonium striatum* sp. nov. *Idioandrosporous nannandrous.*—Oogonia intercalary or terminal in position occurring singly or in pairs, also in threes (Figs. 2 and 3), pronouncedly oval or oval-ellipsoid in shape. Oospore chocolate in colour, oval, almost completely filling the oogonium. Oospore wall very thick bearing obliquely arranged or straight hyaline striations, 10–15 μ in number which often anastomose (Fig. 2). Basal cells flattened 45–50 μ broad (Fig. 4). Vegetative cells swollen with starch. Androsporangia in rows of 3–6 (Fig. 1 *a*). Nannandria 2–6 on the basal cells and the walls of the oogonium. Antheridia always internal. Oospores germinating to produce 4 zoospores oval in shape, 10 μ broad, 18 μ long (Fig. 7).

This alga very much resembles *Oe. Wolleanum* Wittrock in dimensions of cells and oospores but differs from that form in having an internal antheridium and in having no pore in the wall of the oogonium, the opening taking place by a superior lid, and its peculiar striations.

Diam. of veget. cells female plants	.. 23–32 μ	broad,	4–5 times as long.
,, ,, ,, male ,,	.. 21–25 μ	,,	2–3 times long.
,, oogonia	.. 75–80 μ	,,	85–90 μ long.
,, oospores	.. 75 μ	,,	85 μ long.
,, androsporangia	.. 23 μ	,,	20–27 μ long.
,, nannandria	.. 18 μ	,,	72 μ long.

Habit.—This alga was found epiphytic on submerged radial stems of waterplants, in Shahniwala Tank at Dasuya, during the second week of March 1930.

2. *Oedogonium multisporum.* Wood.—Tiffany, 1930, p. 131.

Diœcious nannandrous, oogonia 1-3, sub-ovoid or subglobose, pores superior, oospore globose nearly filling oogonia (Fig. 7 *a*), spore-walls smooth, dwarf male a little curved near or on the oogonium, antheridium exterior 1-4 (Fig. 8).

Distribution.—U.S.A., England.

Vegetative cell of the female plant	.. 14-18 μ	broad,	2-3 times long.
Oogonia	.. 32-40 μ	,,	28-34 μ long.
Oospore	.. 32 μ	,,	28 μ long.
Nannandria	.. 14-18 μ	,,	2-3 times as long.

Habit.—Reported by Mr. Prem Lal from ponds in Lahore and Gujranwala in the first week of December 1933.

B. Section *Dioca macrandria.*—

3. *Oedogonium capilliforme* Kutz. var. nov. *nanum.*—*op. cit.*, Heering, *Susswasser flora*, Heft. 6.

Diœcious macrandrous, oogonia single or in pairs. Ovoid to sub-ovoid or even slightly ellipsoid in shape with a superior pore. Oospore globose or ovoid globose completely filling the oogonium (Fig. 9). Spore walls smooth. Antheridia 2-4 celled usually alternating with the vegetative cells, two sperms in each division horizontal (Fig. 10). This differs from the type in the smaller dimensions of its vegetative cells, oogonia, oospores and antheridia.

Distribution.—So far this species has only been reported from Europe and the United States of America. ... 100 μ broad). So it may be taken as a new variety.

... attached to the filaments

Diam. of female veget. cells	.. 18-20 μ		2-3 times as long.
,, male ,, ,,	.. 10-12 μ		2-4 ,,
,, oogonia	.. 30-36 μ	broad,	32-40 μ long.
,, oospores	.. 34-36 μ	,,	32-40 μ long.
,, antheridia	.. 10 μ	,,	5 μ ,,

Habit.—Found growing epiphytically on blades of rushes in a pond in village Shahpur, Tehsil Dasuya, District Hoshiarpur, in the middle of April 1936.

4. *Oedogonium cardiacum.*—Wittrock.—*op. cit.*, Heering, *Susswasser flora* Heft. 6.

Diœcious macrandrous, oogonia single ovoid elliptical in shape. Broadened and bulging out laterally. Pore wide, situated a little above the middle. Oospore rounded, fire-red in colour not completely filling the oogonium (Fig. 11). Oospore membrane smooth. Male filaments a little more slender than the female filaments. Antheridium 2-3 celled (Fig. 12). Sperms not seen.

Distribution.—So far this species has been only reported from Continental Europe and the United States of America.

Diam. of veget. cells of female plants	26-28 μ	broad,	3-5 times as long.
,, ,, ,, male ,,	22-25 μ	,,	3-5 ,,
,, oogonia	.. 54-60 μ	,,	60-70 μ long.
,, oospores	.. 50 μ	,,	
,, antheridial cells	.. 8- 9 μ	long,	23 μ broad.

Habit.—Epiphytic on blades of grass, and decaying shoots of trees, mixed with *Oedogonium urbicum*, *Anabœnothrix cylindrica* and *Zygnema chalybeosporum* in a pond at village Jhingran, District Hoshiarpur, in the last week of March 1930.

5. *Oedogonium Frankilianum.* Wittrock. sec. Hirn., var. *Polyspora*, var. nov.

Diœcious macrandrous, oogonia single or in groups of 2-3. Globose or ellipsoid globose, opening by a superior pore. Oospores rounded, chocolate in colour when mature, sometimes completely filling the oogonium, sometimes partly (Figs. 13, 14, 15). Oospore wall smooth. Suffultory cell wider than the ordinary cells. Male plant slightly narrower than the female plants. Antheridia 3-4 celled separated by a single vegetative cell. Sperms two, division horizontal. Vegetative cells distinctly capitellate.

This differs from the type in : (*a*) Bigger dimensions of vegetative cells and oospores, (*b*) having more than one oogonium in a series, (*c*) oospores often not completely filling the oogonium. Hence the new variety has been established.

Distribution.—So far this alga has only been reported from Roumania.

Diam. of veget. cells of female plants	9-18 μ	broad,	4-6 times as long.
,, ,, ,, male ,,	7-12 μ	,,	4-6 ,,
,, oogonia	.. 26-36 μ	,,	38-40 μ long.
,, oospores	.. 24-35 μ	,,	
,, antheridial cells	.. 10 μ	,,	9 μ ,,

Habit.—This is rather a rare form, and was found growing epiphytically on the stems of a submerged water plant, along with *Eudorina elegans* near Beas, during the last week of April 1930.

greyish appearance.

9. *Oedogonium rivulare* Hirn. var. nov. *nanum.*—*op. cit.*, Heering, *Susswasser flora*, Heft 6.

Diœcious macrandrous. Oogonia usually single, rarely in pairs. Pore superior, oogonia ellipsoid globose, oospore chocolate in colour, ovoid, not completely filling the oogonium, oospore wall smooth (Figs. 25, 26). The suffultory cells not swollen. Male filaments narrower than female filaments. Antheridia 5-7-celled but sometimes very numerous as many as 17 (Fig. 27).

This species differs from the type in its (1) usually single oogonia, (ii) oospores almost completely filling the oogonium, (iii) smaller size of oogonium (in *Oedogonium rivulare* Hirn. they are as much as 160 μ broad). So it may be taken as a new variety.

6. *Oedogonium inerme* Hirn. var. *Polyspora*. var. nov.—(Section Nicht genugend bekannte Aretn. Heering, *Susswasserflora*, Heft 6.).

Dioecious macrandrous (probably) oogonia 1–3, usually single or in pairs. More rarely in a row of three (Figs. 16, 17, 18). Pore in the middle. Oogonia transversely ellipsoid. Oospore chocolate in colour almost of the same shape as the oogonium which it completely fills. Oospore wall smooth. Vegetative cells not capitellate. Male plants not known.

This differs from the type in having oogonia in a series of two or three and the oospores completely filling the oogonia and in the smaller size of the vegetative cells, oogonia and oospores. Hence this new variety has been established.

Distribution.—So far this species has only been reported from France.

Diam. of veget. cells	.. 5– 9 μ broad,	4– 6 times as long.
,, oogonia	.. 21 μ ,,	19 μ long.
,, oospores	.. 19 μ ,,	16 17 μ ,,

Habit.—Found attached to decaying leaves of *Dalbergia sissoo*, in a brownish mass in a rain-water puddle near Hamira, during the second week of March 1930.

7. *Oedogonium lautumnarium*. Wittrock.—*op. cit.*, Heering, *Susswasser ora*, Heft 6.

Dioecious macrandrous. Oogonia always single, globose or slightly xpanded in the upper portion. Opening by a superior pore. Oospores ellowish in colour, globose, with a thick opaque whitish smooth wall Figs. 19, 20). Male plants as big as the female plants or slightly smaller. ntheridia 3-celled, each with 2 sperms, division horizontal (Fig. 21). Sufful- ory cells of the same diameter as the vegetative cells. It differs from the ype in oospores not completely filling the oogonia.

Distribution.—This alga is so far only known from Finland and Sweden.

Diam. of veget. cells female plants	.. 18-20 μ broad,	3–6 times as long.
,, ,, ,, male ,,	.. 14-16 μ ,,	3–6 ,,
,, oogonia	.. 40-42 μ ,,	42–48 μ long.
,, oospores	.. 36 μ ,,	
,, antheridial cells	.. 13-14 μ ,,	5-8 μ ,,

Habit.—Epiphytic on water-plants, in a pond near Hamira, along with *Spirogyra dubia*, *Oedogonium lautumnarium* and *Sirogonium Sticticum*, during the middle of April 1930. It is rather a rare alga.

8. *Oedogonium Pisanum*. Wittrock.—*op. cit.*, Heering Susswasser flora eft 6.

Diœcious macrandrous. Oogonia single, both terminal and inter- ılary opening by a superior lid (Fig. 22). Oospore oblong ellipsoid, completely lling the oogonium, oospore membrane smooth. Antheridia 2-celled, sperms division horizontal (Figs. 23, 24). Suffultory cells not broader than the egetative cells.

Distribution.—So far the species has only been reported from Europe ıd the United States of America.

Diam. of veget. cell	5-9 μ broad,	18-36 μ long.
,, oogonia	.. 16 μ ,,	36 μ ,,
,, oospores	.. 14-15 μ ,,	24-30 μ ,,
,, antheridia	.. 4-5 μ ,,	3-5 μ ,,

Habit.—Epiphytic on decaying leaves of *Dalbergia sissoo* along with *Oedogonium Pisanum* and *Oe. Hirnii* in a puddle near Hamira, during the second week of April 1930. The filaments present a greyish appearance.

9. *Oedogonium rivulare* Hirn. var. nov. *nanum*.—*op. cit.*, Heering, *Sussasser flora*, Heft 6.

Diœcious macrandrous. Oogonia usually single, rarely in pairs. Pore perior, oogonia ellipsoid globose, oospore chocolate in colour, ovoid, not mpletely filling the oogonium, oospore wall smooth (Figs. 25, 26). The ffultory cells not swollen. Male filaments narrower than female filaments. ntheridia 5-7-celled but sometimes very numerous as many as 17 (Fig. 27).

This species differs from the type in its (1) usually single oogonia, (ii) spores almost completely filling the oogonium, (iii) smaller size of oogonium ı *Oedogonium rivulare* Hirn. they are as much as 160 μ broad). So it may taken as a new variety.

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Distribution.—So far this species has only been reported from Germany.

Diam. of veget. cells of female plant	36-47 μ broad,	3-5 times as long.
,, ,, ,, male ,,	32-34 μ ,,	3-5 ,,
,, oogonia ..	81 μ ,,	90 μ long.
,, oospore ..	76 μ ,,	80 μ ,,
,, antheridial cells ..	12 μ long,	28 μ broad.

Habit.—This alga was found free-floating in a blackish mass, along with *Cylindrocapsa conferta*, in the famous tank at Dasuya, District Hoshiarpur, during the middle of October 1929.

10. *Oedogonium sociale.* Wittrock.—*op. cit.*, Heering, *Susswasser flora*, Heft 6.

Diœcious macrandrous, oogonia single, globose in shape, intercalary, oospore deep-yellow in colour, competely filling the oogonium (Fig. 28). Oospore membrane smooth, basal cells swollen. Antheridia 1-5 celled (Fig. 29).

This alga is very social in its growing habit, its individuals occurring in large numbers as epiphytes on water-plants.

Distribution.—This species is widely distributed in Europe and America.

Diam. of veget cells ..	.. 9-15 μ broad,	3-5 times as long.
,, oogonia ..	.. 34-37 μ ,,	
,, oospores ..	.. 26-30 μ ,,	
,, antheridial cells	.. 12-14 μ ,,	10 μ long.

Habit.—This is one of the commonest and mostly the widely distributed species of *Oedogonium* and grows as an epiphyte on the submerged leaves and stems of the aquatic plants. Sometimes we can get pure growths of this alga, showing a harvest of bright yellow oospores, under the microscope. In some cases it is also found mixed with *Oedogonium urbicum*, and *Oe. cardiacum*. Collected from nearly all over the Eastern Punjab during the middle of March 1930.

11. *Oedogonium fonticola.* Al. Braun.—Pascher, 1914, p. 225; Tiffany, 1930, p. 163.

Diœcious macrandrous, oogonia 1-2, obovoid, or globose obovoid, ellipsoid or subglobose, oospore nearly filling the oogonium, spore-wall smooth. Male filaments very narrow (Figs. 30 and 31).

Distribution.—U.S.A., Australia, Europe.

Vegetative cells of female plant	.. 16-18 μ broad,	28-48 μ long.
,, ,, male ,,	.. 12-14 μ ,,	2-3 times as long.
Oogonia	.. 30-40 μ ,,	32-36 μ long.
Oospore	.. 32 μ ,,	32 μ ,,
Antheridial cells	.. 8-10 μ ,,	

Habit.—Found free-floating in a pond at Lahore by Mr. Prem Lal, during the first week of December 1933.

12. *Oedogonium glabrum* sp. nov.

Diœcious macrandrous, oogonia always single, globose, pore not seen, though very probably it opens by a pore. Oospore globose, completely filling the oogonium. Oospore wall smooth. Cells of the female filaments very short and rounded, with a thick wall and a conspicuous pyrenoid in the middle, vegetative cells very peculiar (Fig. 33). Male filaments have rows of 5-7 antheridia, separated by long cylindrical cells (Fig. 34). Basal cells elongate (Fig. 32). This species comes nearest *Oedogonium suecicum*. Wittrock. sec. Hirn. from which it differs in the oospore membrane being smooth and not spinous, and vegetative cells being much broader and smaller in length and its sex organs being slightly bigger.

Diam. of veget. cells of female plants	26-28 μ broad,	28-30 μ long.
,, ,, ,, male ,,	15-20 μ ,,	28-30 μ long.
,, oogonia	.. 36-45 μ ,,	
,, oospores	.. 32-40 μ ,,	
,, antheridial cells	.. 14-16 μ ,,	6-8 μ ,,

Habit.—Free-floating in a pond. Collected at V. Jhingran, District Hoshiarpur, in the middle of March 1930.

13. *Oedogonium rufescens*. Wittrock. var. *Lundellii*.—Tiffany, 1930, p. 66; Pascher, p. 192.

Diœcious macrandrous, oogonia 1–3, obovoid or depressed obovoid, globose. Pore median, oospore globose or depressed globose, filling the oogonium.

Distribution.—Southern Tibet.

Vegetative cells of the female filaments..	8-10 μ broad,	30-40 μ long.
Oogonia	.. 22-24 μ ,,	20-26 μ ,,
Oospore	.. 20-22 μ ,,	17-20 μ ,,

Habit.—This alga was found by Mr. Prem Lal, free-floating in a pond at Lahore, during the third week of November 1933, and also by the author at Saharanpur, during, the first week of December 1935.

14. *Oedogonium calcareum*. Cleve.—Pascher, 1914, p. 192; Tiffany, 1931, p. 67.

Diœcious macrandrous, oogonia one or rarely two, depressed globose, oospore depressed, globose filling oogonium, oosporewall smooth (Fig. 35).

Grows epiphytically on *Chara*, and is often encrusted with lime (Fig. 36).

Distribution.—England, Denmark, and Sweden.

Vegetative cells of the female plant..	12-16 μ broad,	2-3 times as long.
Oogonia	.. 32-44 μ ,,	32-36 μ long.
Oospores	.. 30-40 μ ,,	32 μ ,,

Habit.—This alga was first reported by Mr. Prem Lal from an aquarium at Lahore, growing epiphytically on *Chara*, during the first week of December 1933, and also by the author at Roorkee, in a pond growing on *Chara*.

SECTION C. *Monoica Macrandria*.—

15. *Oedogonium gracillimum*. Wittrock and Lund.—*op. cit.*, Heering, *Susswasser flora*, Heft 6.

Monœcious macrandrous, oogonia single, both terminal and intercalary, opening by a superior lid. Oogonia oblong ellipsoid, oospores of the same shape as oogonia and completely filling them. Oospore walls smooth, antheridia 2-3 celled, each with two sperms, division horizontal. Suffultory cells not swollen (Figs. 37 and 38).

Diam. of veget. cells ..	.. 9 μ broad,	36-42 μ long.
,, oogonia ..	.. 14-17 μ ,,	24-36 μ ,,
,, oospores ..	.. 14-16 μ ,,	23-30 μ ,,
,, antheridial cells	.. 4- 5 μ ,,	7-8 μ ,,

Habit.—Rather a rare form, found epiphytic on decaying leaves along with *Oedogonium Pisanum* and *Oe. Hirnii* at Hamira, during the middle of April 1930.

16. *Oedogonium Hirnii*. Gutwinski.—*sp. cit.*, Heering, *Susswasser flora*, Heft 6.

Monœcious macrandrous, oogonia usually single, occasionally in pairs, globose. Opening with a big superior pore. Oospore globose, not completely filling the oogonium, yellowish in colour, oospore walls smooth. Antheridia 2-celled, each with two sperms, division horizontal (Figs. 39 and 40).

Distribution.—So far this species has only been reported from Europe.

Diam. of veget. cells ..	.. 20-22 μ broad,	3-6 times as long.
,, oogonia ..	.. 32-36 μ ,,	36-39 μ long.
,, oospores ..	.. 28-32 μ broad.	
,, antheridia ..	.. 18 μ ,,	9 μ ,,

Habit.—Grows as an epiphyte on decaying leaves in puddles along with *Oedogonium gracillimum* and *Oe. Pisanum*. Found near Hamira, during the middle of April 1930.

17. *Oedogonium oblongellum* Kirchner.—*op. cit.*, Heering, *Susswasser flora*, Heft 6.

Monœcious macrandrous, oogonia single, elliptical, operculate, division at the upper extremity of the oogonium. Oospores ellipsoid, globose, completely filling the oogonium. Oospore membrane smooth. Antheridia 2-celled (Fig. 41), each with two sperms. Vegetative cells not capitellate. Suffultory cell not swollen.

EXPLANATION OF FIGURES.

All figures are magnified 715 times.

PLATE I.

FIGS. 1-7.—*Oedogonium striatum* sp. nov.

FIG. 1.—A filament showing androsporangia.

FIG. 2.—A female filament showing a pair of ripe oogonia with oospores.

FIG. 3.—A female filament with a nannandrium germinating on the basal cell,

FIG. 4.—The attachment cell.

FIG. 5.—A female filament showing two dwarf males germinating on the basal cell.

FIG. 6.—A dwarf-male.

FIG. 7.—A germinating oospore with four zoospores inside the membrane.

FIG. 8.—*Oedogonium multisporum* (Wood).

A female filament with oospores, and nannandrium germinating on an oogonium.

FIGS. 9-10.—*Oedogonium capilliforme.*

FIG. 9.—A female filament.

FIG. 10.—A male filament.

FIGS. 11-12.—*Oedogonium cardiacum.*

FIG. 11.—A female filament showing a ripe oospore.

FIG. 12.—A male filament showing antheridia.

PLATE II.

FIGS. 13-15.—*Oedogonium Frankilianum.* Wittrock. var. *Polyspora* var. nov.

FIG. 13.—A female filament showing a ripe oospore.

FIG. 14.—A male filament showing antheridia.

FIG. 15.—A male filament showing three oogonia in a series.

FIGS. 16-18.—*Oedogonium inerme.* var. *Polyspora* var. nov.

FIGS. 16-18.—Filaments showing oogonia with ripe oospores.

FIGS. 19-21.—*Oedogonium lautumnarium.*

FIGS. 19-20.—Female filaments showing oogonia.

FIG. 21.—Male filament showing antheridia.

FIGS. 22-24.—*Oedogonium Pisanum.*

FIGS. 22-23.—Male filaments showing antheridia.

FIG. 24.—A female filament showing oogonia.

FIGS. 25-27.—*Oedogonium rivulare.*

FIG. 25.—A filament showing an oogonium with an oospore.

FIG. 26.—A filament showing two oogonia.

FIG. 27.—A male filament showing antheridia.

FIGS. 28-29.—*Oedogonium sociale.*

FIG. 28.—A male filament showing empty antheridia.

FIG. 29.—A female filament showing oogonia with ripe oospores.

PLATE III.

FIGS. 30-31.—*Oedogonium fonticola.* Al. Braun.

FIG. 30.—A female filament showing oogonia and an oospore.

FIG. 31.—A male filament showing antheridia.

FIGS. 32-34.—*Oedogonium glabrum.* sp. nov. Randhawa.

FIG. 32.—A filament showing the basal cell.

FIG. 33.—A female filament with two oogonia containing ripe oospores.

FIG. 34.—A male filament.

FIGS. 35-36.—*Oedogonium calcareum* (Cleve).

FIG. 35.—A female filament showing an oogonium with a ripe oospore.

FIG. 36.—Basal cell.

FIGS. 37-38.—*Oedogonium gracillianum.*

FIGS. 37, 38.—Filaments showing antheridia and oogonia.

FIGS. 39-40.—*Oedogonium Hirnii.* Gutwinski.

FIG. 39.—A filament showing ripe osspores and antheridia.

FIG. 40.—A filament showing immature oogonia and antheridia.

FIG. 41.—*Oedogonium oblongellum* (Wittrock).

A filament showing oogonia and antheridia.

FIG. 42.—*Oedogonium urbicum.*

A filament showing an oogonium with a ripe oospore and antheridia.

FIG. 43.—*Bulbochæte sp. x.*

A branched filament.

FIG. 44.—*Bulbochæte sp. y.*

Two unbranched filaments.

Vol IV, no 3, Section B

"A Note on Some Attached Forms of Spirogyra from the Punjab."

By

M.S. Randhawa, M.Sc., I.C.S., Saharanpur.

Received February 5, 1936

Communicated by Dr. H. Chaudhuri, M.A., Ph.D.,

Species of *Spirogyra* are generally free-floating forms but a few species however grow attached to the various substrata in the water.

Delf (2) has described *Spirogyra adnata* Kutz. and *Spirogyra fluviatilis* Hilse as forms occasionally producing rhizoids. And according to Kny (2) *Spirogyra setiformis* Kutz. also sometimes produces rhizoids. *S.rivularis* (Hass.) Rabenh. (?) and *S.fluviatilis* Hilse var. *africana* Fritsch have been recorded by Fritsch and Stephens (3) as attached forms from Africa. Czurda (1) refers to *S.fluviatilis* Hilse and *S.Grossi* Schmidle as species growing attached. He has also figured the haptera of *S.fluviatilis* (1, Fig.15). Iyengar (4) has described the haptera of a sterile species of *Spirogyra* growing in an artificial tank at Madras. Very recently Jao (5) has described a number of new species of *Spirogyra* from China and among them two species, *S.rhizopus* Jao and *S.rhizobrachialis* Jao, are described as developing rhizoids.

As far as the author is aware, there has been no record of any *fertile* species of *Spirogyra* from India growing in an attached condition. The following three fertile species of *Spirogyra* have been recorded by him from Northern India.

Spirogyra affinis Kutz.

This alga whose usual mode of reproduction is by lateral conjugation (Fig.1, a) quite often produces rhizoids from its cells. These rhizoids become closely attached to the filaments of an *Oedogonium* on which this alga is found as a common epiphyte in ponds. The hapterophores of this alga (Fig.1, b) are bifurcated, and their ends are frayed and are not very different from those described by Delf (2) in Spirogyra adnata. Their size and lateral position indicate that quite possibly they are merely modified conjugation canals, though it is difficult to understand why these structures which are purely reproductive in function should subserve the function of fixation and support.

Spirogyra dubia Kutz.

This alga is found in slowly flowing freshwater streams attached to water plants by means of rhizoids which are very different from those of Spirogyra affinis. The rhizoids are not short and stumpy as in S.affinis, but are long and pillar-like (Fig.11, b) and expand laterally and become frayed when they get attached to any aquatic plant. The chloroplasts in the rhizoids are never in the form of a spiral, but are in the form of palish green, very much elongated and thread-like bodies. The alga was conjugating freely (Fig.II, a).

Spirogyra sp.

This alga, which the author has not been able to refer to any known species and is probably a new species, was found growing attached to the stem of a water plant in the big tank at Dasuya in the Hoshiarpore District. A similar attached form was also found by him in a sheet of water at Dhanauri, Tehsil Roorkee in Saharanpur District. The cells of the filament were 30 u broad and about four times as long as broad. Owing to x the very closely packed condition of the chloroplasts it was not possible to make out their number or the number of their spirals. Conjugation was observed in the upper parts of the filaments and ripe zygospores also were found in a few cells. (Fig.III, f,g). Some of them were long and dichotomously branched (Fig.III, b,c) while others showed a dichotomously frayed disc at the bottom (Fig.III,e). The former somewhat the rhizoids of Mougeotia sp. figured by Pascher (6, p.4, fig. D) and those of S. fluviatilis (1, p. 14, fig. 15, a,b), while the latter showed a certain amount of resemblance to the rhizloids of S. fluviatilis Hilse var. africana Fritsch (3, fig. 22, B,D), S. fluviatilis (1, fig. 15,c), Spirogyra rhizopus Jao (5, fig. 11) and also to those of the sterile species from Madras (4, PI.I, 3,4).

In this case and in the case of S.affinis the attached habit was developed in a distinctly still-water environment where the alga was in no danger of being washed away by a current of water. Iyengar's sterile species also was found by him growing in still-water in an artificial tank at Madras. So by no stretch of imagination can an attached habit be regarded as an adaptation to flowing water. Most probably the formation of rhizoids is a tactile response on the part of the filaments, and there is greater possibility of its successful manifestation in the form of rhizoids, in a still-water environment than in moving water.

My experience has shown that the fixed habit is quite common in the above species of Spirogyra, both in ponds and streams in Northern India, especially in the last mentioned form where it is constant feature. A fixed habit with rhizoids is a distinct advance as compared with a free floating habit; and the species of Spirogyra which show this feature should be considered as more advanced structurally than the free floating ones.

Before closing, I must convey my sincere thanks to Dr. S.L. Ghose, Professor of Botany Government College Lahore.

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H. S. 25-8-1936

A NOTE ON SOME ATTACHED FORMS OF *SPIROGYRA* FROM THE PUNJAB.

BY M. S. RANDHAWA, M.Sc., I.C.S.
(*Saharanpur*.)

Received February 5, 1936.
(Communicated by Dr. H. Chaudhuri, M.A., Ph.D., D.I.C.)

SPECIES of *Spirogyra* are generally free-floating forms but a few species however grow attached to the various substrata in the water.

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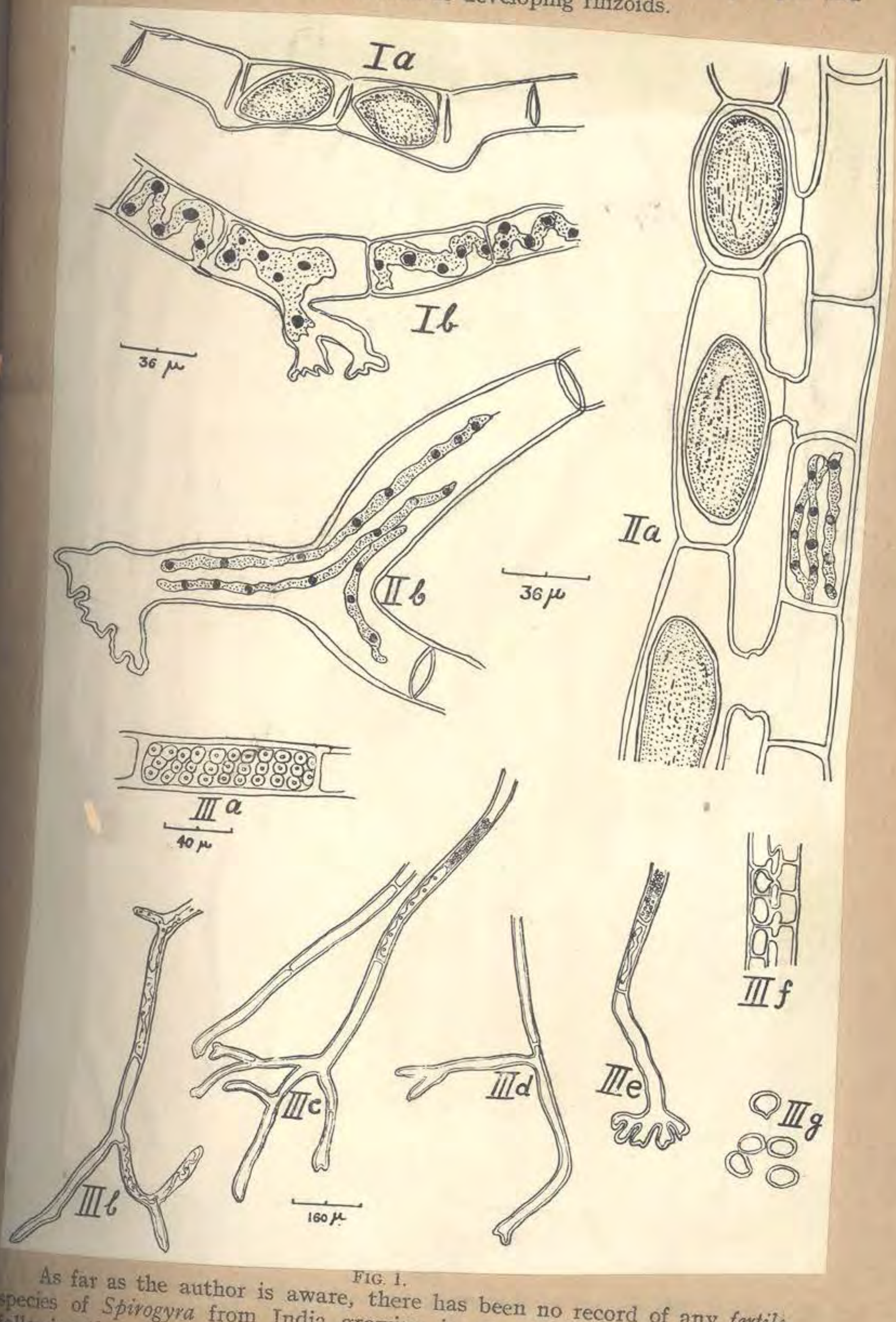

FIG. 1.

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and
50 u
broad. Conjugation between 6-8 filaments is not

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Spirogyra *sp.*

This alga, which the author has not been able to refer to any known species and is probably a new species, was found growing attached to the stem of a water-plant in the big tank at Dasuya in the Hoshiarpore District. A similar attached form was also found by him in a sheet of water at Dhanauri, Tehsil Roorkee in Saharanpur District. The cells of the filament were 30 μ broad and about four times as long as broad. Owing to the very closely packed condition of the chloroplasts it was not possible to make out their number or the number of their spirals. Conjugation was observed in the upper parts of the filaments and ripe zygospores also were found in a few cells. (Fig. 3, *f*, *g*). Some of them were long and dichotomously branched (Fig. 3, *b*, *c*) while others showed a dichotomously frayed disc at the bottom (Fig. 3, *e*). The former resembled somewhat the rhizoids of *Mougeotia* sp. figured by Pascher (**6**, p. 4, Fig. D) and those of *S. fluviatilis* (**1**, p. 14, Fig. 15, *a*, *b*), while the latter showed a certain amount of resemblance to the rhizoids of *S. fluviatilis* Hilse var. *africana* Fritsch (**3**, Fig. 22, B, D), *S. fluviatilis* (**1**, Fig, 15, *c*), *Spirogyra rhizopus* Jao (**5**, Fig. 11) and also to those of the sterile species from Madras (**4**, Pl. I, **3**, **4**).

In this case and in the case of *S. affinis* the attached habit was developed in a distinctly still-water environment where the alga was in no danger of being washed away by a current of water. Iyengar's sterile species also was found by him growing in still-water in an artificial tank at Madras. So by no stretch of imagination can an attached habit be regarded as an adaptation to flowing water. Most probably the formation of rhizoids is a tactile response on the part of the filaments, and there is greater possibility of its successful manifestation in the form of rhizoids in a still-water environment than in moving water.

My experience has shown that the fixed habit is quite common in the above species of *Spirogyra*, both in ponds and streams in Northern India, especially in the last mentioned form where it is a constant feature. A fixed habit with rhizoids is a distinct advance as compared with a free floating habit; and the species of *Spirogyra* which show this feature should be considered as more advanced structurally than the free floating ones.

Before closing, I must convey my sincere thanks to Dr. S. L. Ghose, Professor of Botany, Government College, Lahore.

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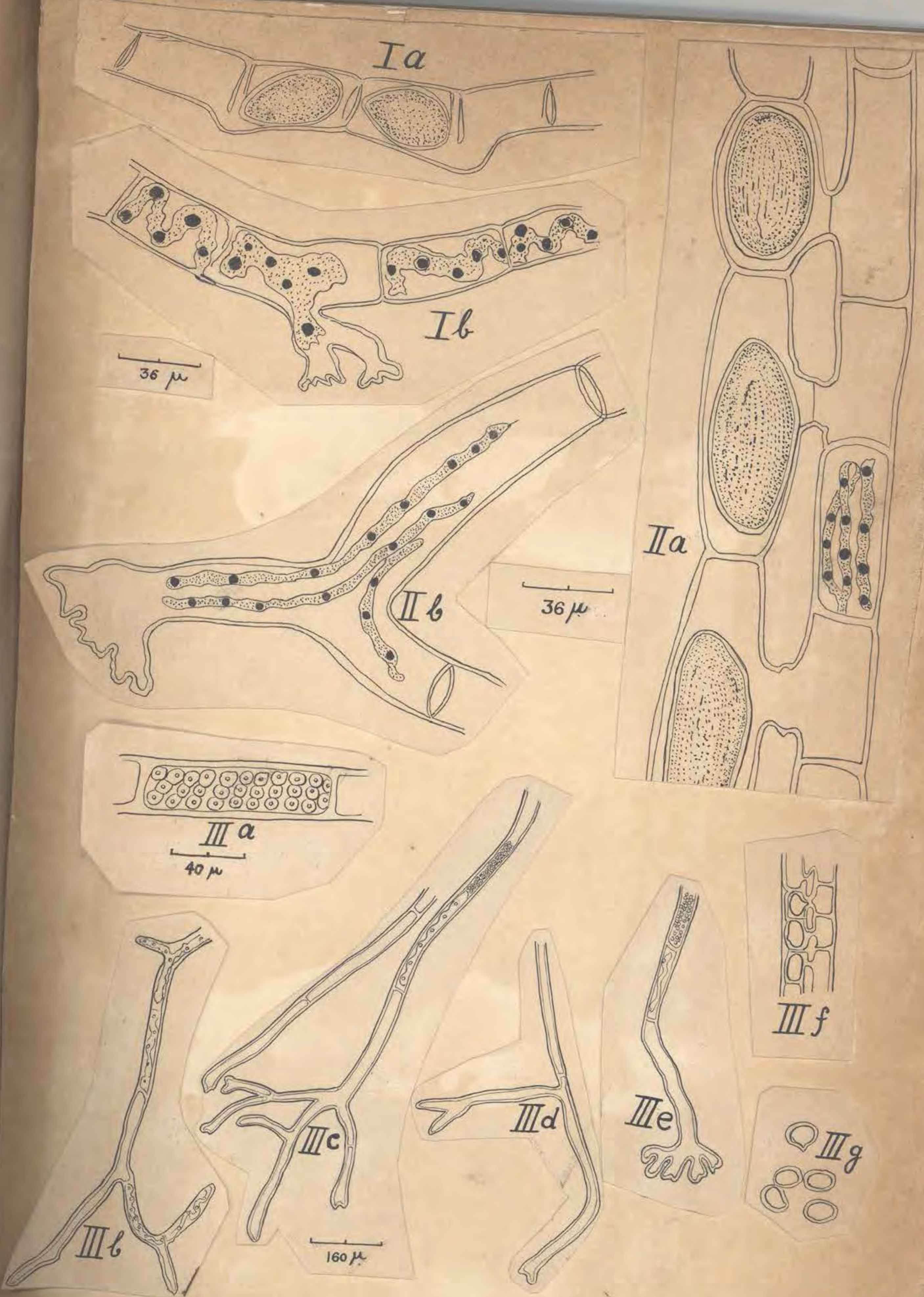
EXPLANATION OF FIGURES

FIG. 1.—*Spirogyra affinis*. *a*, lateral conjugation; *b*, bifurcated hapterophores.

FIG. 2.—*Spirogyra dubia*. *a*, conjugation; *b*, rhizoid.

FIG. 3.—*Spirogyra*, sp. *a*, cell with dense chloroplasts; *b*, *c*, *d*, filaments with long and dichotomously divided rhizoids; *e*, filament with a dichotomously frayed disc at the bottom; *f*, conjugation; *g*, zygospores. Cells with degenerated and elongated chloroplasts are seen in *b*, *c*, and *e*.



The immature zygospores have

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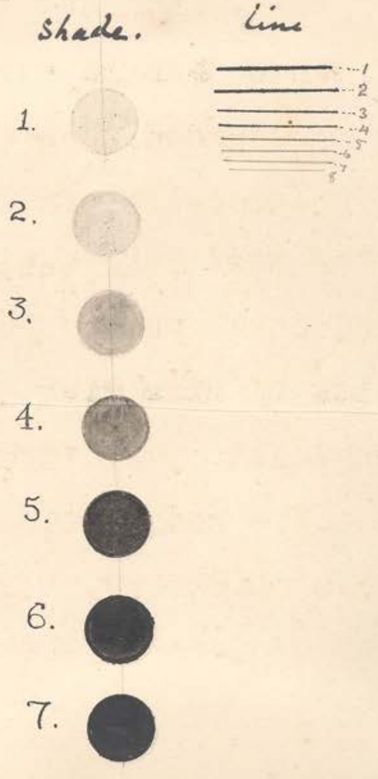

Group 6. Conjugatae.

(2) Zygnemaceae.

Genus. Ghosella. gen. nov.

1. <u>Ghosella</u> <u>indica</u>. Randhawa.(Genus novum). This new genus forms the basis of a separate paper ' A new Genus of Conjugatae from India'. and we shall very briefly discuss its salient features.

The vegetative filaments very much resemble those of Genus <u>Zygnema</u> with their two characteristic stellate or rounded chloroplasts surrounding a nucleus (fig.a). The cells are 10-15 u br. and 4-5 times as long. The most interesting feature of the Alga is its reproductive phase. Two filaments which happen to lie side by side give out protubrances, which xxxxx eventually meet forming conjugation canals about 9 u br. The conjugation canals widens enormously (18-40 u in diameter). In the meanwhile remarkable changes take place in the cell wall which becomes lamellated due to deposition of mucilage, which give the Alga a very beautiful appearance. The filaments become genuflexed as in certain species of <u>Mougeotia</u>, probably due to the enormous width of the conjugation canals. Now the walls of the conjugation canals begin to bulge out laterally (figs. d.e.). The zygospores extend into the gametangia and are ultimately cut off from them. In the meantime the joints of the cells begin to be loosened and these H-shaped zygospores swim off independently as in <u>D</u>. <u>desmidioides</u>. The immature zygospores have 2-4 coats of mucilage and are usually rounded in shape (fig. f.) and are 45-50 u broad. Conjugation between 6-8 filaments is not uncommon (fig. i.) Ripe zygospores are of various shapes as in <u>Debarya</u> <u>africana</u>. West, and are firered in colour when ripe. Azzygospores are also seen in many cases resembling those of Zygnema fertile Fritsch.

This Alga resembles Zygnema spirale Fritsch in many respects. Transeau has transferred this Alga to Genus Debarya calling it D. spirale but in our opinion this Alga has nothing to do with Debarya due to its definitely stellate chloroplasts and the peculiarities of the zygospores. This Alga shows peculiarities which justify its establishment as a separate Genus, which I have named Ghosiella after my esteemed teacher Dr. S.L. Ghose. A full description on the Genus and its affinities forms the basis of a separate chapter.

Following are the peculiarities of the Genus:-

I. Star-shaped two chloroplasts each with one pyrenoid as in Zygnema which certainly are not seen in any species of Debarya.

II. Complex membrane thickenings in the gametangia as in Debarya Hardyi and Z. fertile.

III. Extremely wide conjugation canal as in certain species of Debarya and Mougeotia.

IV. Geniculate-type of conjugation as in Mougeotia.

V. Zygospores not only filling the conjugation canal but also encroaching upon the outermost cell-walls of the gametangia.

VI. Zygospores of very various shapes resembling those of D. africana and D. desmidioides.

VII. Dissociation of the Zygospores from one another.

VIII. The peculiar mucilagenous coverings of the zygospores.

IX. The frequent occurrence of zygospores.

Genus Zygnema. Agardh.

1. Zygnema chalydospermum Hansg. op. cit. Czurda. Zygnemales. Heft 9 in Susswasser flora. Mitteleuropas.

Vegetative cells 20-27 u thick, 1-3 times as long. Chloroplasts typically stellate each with one pyrenoid. Zygospores in the gametangia are more or less rounded in shape middle membrane of the zygospore smooth. Steel blue in colour. Zygospores 28-30 u broad, 30-36 u long. The four chloroplasts can easily be distinguished lying in a quartette inside the zygospore(fig. b.)

Habitat - Free-floating in a pond at V. Ghingran, Distt. Hoshiarpur during the middle of March 1930. Also collected from Hamira from a pond, about the middle of April 1930. A common species of zygnema.

II. Zygenma sp. In this case cells are bigger than those of the former but due to the absence of any fertile material the species could not be determined.

Habitat:- Found free-floating in a pond at Hamira during the middle of April 1930.

Section II.

Species with septa not swollen. One chromatophore in each cell.

3. Spirogyra affinis (Hass) Kutz. op. cit. Borge Susswasser flora Heft 9.

Both lateral and scalariform conjugation are seen in this species. Vegetative cells 22-30 u broad. Septa not swollen. Chromatophore single with 2½ to 4 spirals. Fruiting cells swollen on both sides. Zygospores ellipsoid 25-32 u br., 36-46 u long. Placed obliquely in the gametangium, yellowish in colour. Spore-walls smooth. Another interesting feature of the Alga is that many cells give out rhizoids (LXXIII, fig. c.) like those described by Delf by means of which the filaments are attached to coarser filaments of Oedogonium.

Filaments showing lateral conjugation are attacked by rounded endophytic Chytridiaceous Fungi, 2-4 of which are invariably found in each cell which does not contain a zygospore.

Habit:- Found free-floating in a brownish mass in ponds. Collected in the second week of March 1930 at Hamira, and mixed with Oedogonium urbicum at V. Jhingran Distt. Hoshiarpur about the same time. Fairly common.

4. Spirogyra Jurgensii Kutz. op. cit. Borge Susswasser flora Heft 9.

Vegetative cells, 25-30 u thick, 2½ to 5 times as long. Septa occasionally swollen but not replicate. Cells with one chromatophore of two to four spirals. Fruiting cells not swollen on either side. Zygospores ellipsoid elongated 30-32 u thick, twice as long. Zygospore membrane smooth.

Habit:-Collected from Badami Bagh Tanks Lahore free-floating, about the middle of March 1930. Fairly common.

5. Spirogyra condensata Kutz. var. nov. op. cit. Borge Susswasser flora Heft 9.

Vegetative cells 50-65 u broad, 4-6 times as long, each cell with one spiral chromatophore of 3-8 close turns. Fruiting cells not swollen on either side. Zygospores ellipsoid, 42-45 u br., 70-75 u long with a smooth zygospore membrane. Sterile cells with thickened mucilaginous walls frequently alternate with the cells of the male filaments. The Alga differs from the type in having chromatophores with greater number of spirals and much bigger zygospores hence it is necessary to establish a new variety.

Habit:- Free-floating in a greenish mass, in a pond in V. Nowshehra Distt. Hoshiarpu. One of the early fruiting forms, producing 3 zygospores about the middle of October. A very common alga, often found mixed with Spirogyra nitida.

6. Spirogyra bellis. Cleve. var. nov. Borge op. cit. Susswasser flora Heft 9.

Vegetative cells 60-65 u br., 1½ times as long as broad, with plain septa. Each cell with 5-7 chromatophores, closely packed. spirals rather indistinct as zygospores characteristically arranged perpendicular to transverse walls. Zygospores oval or rounded in shape, 54-64 u in diameter, 80-85 u long. Zygospore walls smooth. Brownish yellow in colour. Fruiting cells strongly swollen on both the sides. This alga closely resembles S. bellis. Cleve in its dimensions but the middle membrane of the zygospore wall is smooth in this case.

Habit:- Free-floating in a pond near V. Bodal Distt. Hoshiarpur. Collected in the second week of March 1930.

9. Spirogyra jugalis (Dillw) Kutz. op. cit. Borge. Susswasser flora Heft 9.

Vegetative cells 100-120 u in diameter. 1½ to 2½ times as long with plain septa. Each cell with 3-6 chloroplasts making 1-2 spirals. Fruiting cells not swollen. Zygospores oval or ovoid-rounded, 80-95 u in diameter. 1½ times as long with a smooth spore wall.

Habit:- Free-floating in a freswater stream called Siah Baeen, in big masses. Collected in the first week of July 1929. A fairly common form.

10. Spirogyra Grevilliana - Hass. Kutz. Pascher 13,p.17

Vegetative cells 31-35 u broad, 2-4 times as long. Cross-walls not swollen, mostly folded, sometimes replicate. Chromatophore single with 3-5 spirals. Vegetative cells showing a swelling towards the septa, mostly towards the side where zygote is situated.

Fruiting cells 36 - 43 u thick, slightly swollen in the middle. Zygospores broadly ellipsoid 28-32 u thick and twice as long. Spore walls smooth. In certain cells an air drop is noticeable. Filaments show lateral conjugation.

Habit:- Free-floating in a pond near Shahdra, Lahore. Produces zygospores in the middle of March. Also collected from Saharanpore in March 1935.

11. Spirogyra neglecta(Hass) Kutz. op. cit. Borge Susswasser flora Heft 9.

Vegetative cells 50-58 u thick. 2-5 times as long. Each cell with three chromatophores with 2-2½ spirals. Fruiting cells slightly swollen. Zygote oval or even rounded 54-58 u in diameter. 1½ times as long as broad.

Habit:- Found in a blackish mass, free-floating in a pond near V. Bhattan Distt. Hoshiarpore, in the second week of Decmmber 1929.

12. Spirogyra nitida(Dillw.) Link. op. cit. Borge Susswasser flora Heft 9.

Vegetative cells 70-90 u in diameter, 1-3 times as long. Septa plain, 3-5 chromatophores with ½ to 1½ spiral in each cell. Zygospores ellipsoid or even slightly ovoid. Fruiting cells slightly swollen on the outside. Zygospores 50-55 u in diameter, 1½ times as long. Zygospores are slightly smaller than in the type.

Habit:- Free-floating in a pond near Tahli Sahib Distt Hoshiarpore, in the second week of October 1929. A very common form.

13. Spirogyra rivularis (Hass). Rab. op. cit. Borge Susswasser flora Heft 9.

Vegetative cells 40-45 u broad, 3-6 times as long. Only three irregular chloroplasts were seen in certain cells, as purely vegetative cells are very uncommon for almost all the cells had conjugated in the material examined. Fertile cells not swollen. Zygote oval-ellipsoid, 45 u broad, 70-75 u long.

Habit:- Found free-floating almost filling a pond near V. Battian Distt. Hoshiarpur in the third week of October 1929. A very common form.

14. Spirogyra setiformis(Roth) Kutz. op. cit. Borge. Susswasser flora Heft 9.

Vegetative cells 90-110 u in thickness, 1-4 times as long. 4-6 chloroplasts with ½ to 1 spiral. Fertile cells not swollen. Zygospores ellipsoid brownish, 90-95 u in diameter.

Habit:- Free-floating in Siah Baeen, a freshwater perennial stream near Hamira, during March 1931.

Genus Sirogonium. Kutz.

1. Sirogonium sticticum Kutz. op. cit. Borge. Susswasser flora Heft 9.

Vegetative cells 40-46 u broad, 2-4 times as long, 3- 5 straight chromatophores each with a number of pyrenoids embedded on it. Conjugation knee-like. Zygospores ellipsoid, 60-72 u broad, 1½ times as long. Deep orange yellow in colour. Filaments are very rough to touch and are commonly loaded with epiphytic Algae as Chaetsphaeridium globosum. The zygospores are about 10 u bigger than the type.

Habit:- Free-floating in a pond. Collected from Hamira and Dhilwan about the middle of March 1930.

(3) Mougeotiaceae.

Genus. Mougeotia Agardh.

1. Mougeotia genuflexa (Dillw.)Ag. 182 op. cit. Czurda Susswasser flora Heft 9. Mitteleuropas.

Vegetative cells 21 to 28 u in diameter, 2-5 times as long. Each cell with a plate-shaped chromatophore bearing 2-to-numerous pyrenoids. Genuflexed filaments are found in great abundance. No zygospores were seen. Another peculiarity of the alga is the readiness with which the individual cells dissociate from one another, as in Debarya desmidioides. West.

Habit:- Found in the form of a greenish mass of filaments many yeards in length in Budha Nala, a preshwater stream near Ludhiana.

Genus Zygnema. Agardh.

1. <u>Zygnema Chalybdospermum</u> Hansg. op. cit. Czurda. Zygnemales. Heft 9 in Sussawasser flora. Mitteleuropas.

Vegetative cells 20-27 U thick, 1-3 times as long. Chloroplasts typically stellate each with one pyrenoid (Fig

Conjugation scalariform zygospores in the gametangia are more or less rounded in shape, middle membrane of the zygospore smooth. Steel blue in colour. Zygospores 28-30 U broad, 30-36 long. The four chloroplasts can easily be distinguished lying in a quartette inside the zygospore(Fig)

Habitat:- Free-floating in a pond at v. Jhingran, Distt. Hoshiarpore during the middle of March, 1930. Also collected from Hamira from a pond, about the middle of April, 1930. A common species of Zygnema.

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Genus. Ghosella--Randhawa.

1. Ghosella indica- Randhawa.

Vegetative cells 10-15 broad, and 4-5 times as long. Each cell with two stellate or more or less rounded chloroplasts surrounding the centrally situated nucleus. (Fig.)

Conjugation sclariform. Conjugation canals are very wide, being 18-40 in width. Deposition of shining mucilaginous lamellae takes place during the process of conjugation as in Debarya americana. Transeau (Fig.). Marked genuflexion of filaments takes place during conjugation as in certain species of Mougeotia. (Fig) Conjugation between 5-7 filaments at the same time is quite common.

The zygospores are rounded, or oval, and extend into both the gametangia. The zygospores commonly retain the horn-like arms of the gametangia, and joints of the ripened cells get loosened, resulting in detachment of zygospores as in Debarya desmidioides West. The zygospores are 36-46 broad excluding their mucilaginous coats, and inclusive of these may be as broad as 56 . Ripe zygospores are deep yellow in colour, and show a considerable variety in shape. The zygospore wall is composed of three layers, the exospore is thin and light blue in colour, the mesospore is thick chocolate brown in colour, and the endospore is yellowish in colour. The zygospore wall shows punctation on its surface in the form of minute circular depressions. (Fig).

Azygospores are also plentifully seen, and these are usually spindle-shaped in appearance (Fig). Some of the zygospores have their arms, and it seems as if these have resulted from the conjugation of a terminal cell of a filament with an intercalary cell of another filament (Fig).

Such zygospores are also seen in Debarya americana Transeau (

Delimitation of Genus Ghosella.-

There are four other members of Conjugatas which have been variously described by different authors as belonging to Genus Debarya or Zygnema. These are as follows:-

1. Debarya americana. Transeau. from North America. Czurda ( ) regards it as a species of Zygnema and has named it Z. americanum.

2. Debarya decussata Transeau from North America, has been named as Z. decussatum by Czurda ( ).

3. Debarya Spirale (Fritsch) Transeau has been called Z.Spirale Fritsch by Czurda ( ).

4. Zygnema pseudodecussatum Czurda. from Bohemia.

All these species are characterised by the presence of mucilaginous lamellae, marked geniculation, very wide conjugation canals, and great variety in the shape and structure of their zygospores. In these characters these algae differ from all other known species of Zygnema, and the author suggests that the best course is to include all these in the new genus Ghosella. Thus genus Ghosella comprises the following five species.

1. Ghosella indica Randhawa.
2. Ghosella spirale (Fritsch) Randhawa.
3. Ghosella decussatum (Transeau) Randhawa.
4. Ghosella americanum (Transeau) Randhawa.
5. Ghosella pseudodeumatum (Czurda) Randhawa.

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Zygnema Czurdae- Randhawa.

Vegetative cells are 20-27 U broad, and 1½ to 4 times as long. Two more or less rounded chloroplasts with a conspicuous pyrenoid in each, are seen in each cell.

Reproduction:-

Both lateral and scalariform conjugation have been noticed in this alga.

1. Lateral conjugation:-

Lateral conjugation is the commonest mode of reproduction in this alga. Both the gametes are mospho-logically as well as physiologically isogamous. In one filament it was noticed that the upper part, which contains a kidney-shaped zygospore, is cut off from the remaining part of the conjugating cells by means of distinct walls. However in most of the filaments the zygospore is seen filling the whole of the conjugation canal area, as well as the lower part of the conjugating cells (Fig).

The zygospores are 30-40 U in diameter, and are oval in shape in early stages (Fig), but later on become rounded. Four chloroplasts with a conspicuous pyrenoid in each, and a nucleus in the central part may be observed nearly in all the zygospores (Fig). The zygospore wall is composed of three thin layers, all of which are light blue in colour. The exospore and mesospore are smooth, while the endospore is slightly sinuous. When fully mature the zygospores are perfect--ly round in shape. The middle-basal part of the conjugating cells becomes flattened and the upper part becomes rounded like a dome (Fig). In some filaments, which become more mature distinct geniculation may be seen, the flattened basal part ruptures, and the and the zygospore is liberated into water, (Fig).

11. Scalariform conjugation

Some of the filaments also show the normal type of scalariform conjugation, with zygospores in the conjugation canal. The conjugation canal becomes distended due to the globose shape of the zygospores (Fig). Geniculation is noticeable (Fig). Sometimes three or more filaments may be seen conjugating together (Fig).

Habit:-

This alga was found free-floating in a bluish green mass, only with a species of Spirogyra during the third week of February, 1931, in a fresh-water spring at Tahli Sahib, Tehsil Dasuya, District Hoshiarpore, Punjab.

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Zygnema Iyengari-Randhawa.

Vegetative cells are 18-20 U broad and five to eight times as long. Each cell has two rounded chloroplasts (Fig).

Reproduction:-

This alga reproduces itself by means of squarish or cushion-shaped azygospores only. The azygospores are of various shapes (Fig), and have a constriction in the middle part when fully mature (Fig). The cells assume a spindle-shaped appearance due to the peculiar structure of the azygospores, and are shining white in appearance, possibly due to mucilage-secretion, though no lamellation is noticeable.

The azygospores are 26-30 U long and just as broad in some cases (Fig). Three layers are clearly noticeable in the wall of the azygospores, a bluish exosporium, a dark-brown, crinkled and sinuous mesosporium, and a hyaline endosporium.

Habit:-

This alga was found free-floating in the form of bluish mass of filaments at Shahniwala Tank at Dasuya District Hoshiarpore, Punjab, during the second week of April, 1931.

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Zygnema giganteum-Randhawa.

Vegetative cells are 38-48 U broad and 1½ to 2½ times as long. In thinner filaments, the chloroplasts show a typically stellate structure each with a conspicuous pyrenoid (Fig). In bigger filaments the chloroplasts are loaded with starch granules, and the stellate structure of the chloroplasts is obscured, and they appear to be more or less rounded in appearance. Cell wall is fairly thick as compared with other species of Zygnema.

Reproduction:- Both sexual and asexual modes of reproduction have been noticed in this alga.

1. Asexual Reproduction:-

Asexual reproduction takes place by means of brick-shaped parthenospores which develop orange-coloured thick walls, and sometimes show two pyrenoids in the middle part (Fig). The parthenospores are 36-45 U broad and 54-96 U in length (Fig). The parthenospores may be seen singly, or in rows of twos or threes, and in later stages whole filaments are converted into chains of parthenospores (Fig).

11. Sexual Reproduction:- In some filaments zygospores are found in the conjugation canals, and in others in the conjugating cells, the conjugation being isogamous and anisogamous in the same alga.

(a) Anisogamous conjugation:-

This type of reproduction is quite common in most filaments (Fig). The male filaments sometimes show an alternation of cells which produce male gametes, and vegetative cells, in which the chloroplasts are surrounded by a shining mucilaginous material and thick walls (Fig). In later stages these sterile cells become loaded with starch granules, and these also produce abortive conjugation canals (Fig). In other cases no cells are left out as purely vegatative in the male filaments, all of them functioning as males (Fig).

The zygospores are 42-46 U broad and 50-58 U long, and are oval in shape. The zygospore wall is composed of two layers only, athick hyaline and smooth exospore, and a thin, light blue, and smooth endospore. Mesospore is obviously missing. The ripe zygospores are orange-coloured in appearance like the parthenospores.

(b) Isogamous conjugation.

This is the commoner mode of reproduction, in this alga. Zygospores are typically egg-shaped in appearance, and project partly into the gametangia, completely filling the conjygation canals at the same time. Zygospores produced by isogamous conjugation are longer than those produced by anisogamous conjugation, being 70-75 U long. Azygospores also may be seen.

Habit:-

This alga was found free-floating along with Zygnema coeruleum in Siah Baeen, a perennial freshwater stream in Kapurthala State, Punjab, during the second week of March, 1931.

Zygnema cecruleum. Czurda op-cit. Czurda. page 107 Die Susswasserflora Milterleuropas Heft 9 Zygnemales.

Vegetative cells 20-24 u broad and 3-4 times as long. Chloroplasts rounded with conspicuous pyrenoids.

Conjugation scalariform. Zygospores in the conjugation canal, completely filling the canal. Zygospores rounded, or ellipsoid in shape. Exospore hyaline, mesospore thick, crinkled with depressions. Endospore not clear. Some of the Zygospores have mucilagenous coating (Fig)

Habit- Found free-floating in a freshwater stream near Beas during the second week of March 1931, along with Zygnema giganteum Randhawa and species of Spirogyra.

Spirogyra stictica (Engl. Bot.) Wille 1884. Czurda.
Susswasser flora Mitteleuropas Heft. 9.

Sirogonium Sticticum Kutz. op. cit. Borge.
Susswasser flora Heft 9.

Vegetative cells 40-46 U broad, 2-4 times as long, 3-5 straight chromatophores each with a number of pyrenoids embedded on it.

Conjugation knee-like. Zygospores ellipsoid, 60-72 U broad, 1½ times as long, deep orange-yellow in colour (Fig) Filaments are very rough to touch and commonly loaded with epiphytic algae as Chaetsphaeridium globosum. The zygospores are about 10 U bigger than the type.

Habit:- Free-floating in a pond. Collected from Hamira and Dhilwan about the middle of March, 1930.

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Spirogyra Seliformis (Roth) Kutz. 1849 op. cit. Gzurda Susswasser flora Mittelearopas Heft 9 = Spirogyra Jugalis (Dillw) Kutz.

Vegetative cells 100-120 u in diameter. 1½ to 2½ times as long with plain septa. Each cell with 3-6 chloroplasts making 1-2 spirals.

Conjugation Scalariform Fruiting cells not swollen. Zygospores oval or ovoid-rounded, 80-95 u in diameter. 1½ times as long with a ~~xxxxxxx~~ smooth spore wall ( ).

Habit:-

Free-floating in fresh water stream called Siah Baeen, in big masses. Collected in the first week of July, 1929. A fairly common form.

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Spirogyra Grevilliana- Hass. Czurda 1930. op. cit. Susswasser flora Mittelearopas. Heft 9.

Vegetative cells 31-35 u broad, 2-4 times as long. Cross-walls not swollen, mostly folded, sometimes replicate. Chromatophore single with 3-5 spirals. Vegetative cells showing a swelling towards the septa, mostly towards the side where zygote is situated.

Fruiting cells 36-43 u thick, slightly swollen in the middle. Zygospores broadly ellipsoid 28-32 u thick and twice as long. Spore walls smooth. In certain cells an air drop is noticeable. Filaments show lateral conjugation.

Habit:-

Free-floating in a pond near Shahdra, Lahore. Produces zygosporesin the middle of March. Also collected from Saharanpur in March, 1935.

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Spirogyra fluviatilis Hilse (in Rabenliorst Alg. Nr. 1476)

(Spirogyra rivularis (Hass) 1 Rab.)
Susswasser flora Mitteleuropas Heft 9. page 199.

Vegetative cells 40-45 U broad, 3-6 times as long. Only three irregular chloroplasts were seen in certain cells, as purely vegatative cells are very uncommon form almost all the cells had conjugated in the material examined.

Conjugation scalariform fertile cells not swollen. Zygote oval-ellipsoid, 45 U broad, 70-75 U long. Exospore thim hyaline, mesospore thick dark brown. Endospore not known.
Habit:-

Found free-floating almost filling a pond near V. Bhattian Distt. Hoshiarpore in the third week of October, 1929. A very common form.

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Spirogyra neglecta (Hass) Kutz. op. cit. Borge Susswasser flora Heft 9.

Vegetative cells 50-58 u thick. 2-5 times as long septa plain. Each cell with three chromatophores with 2-2½ spirals (   ).

Fruiting cells slightly swollen. Conjugation sealoriform. Zygote oval or even rounded 54-58 u in diameter. 1½ times as long as broad.(   ).

Habit:-

Found in a blackish mass, free-floating in a pond near V. Bhattan Distt. Hoshiarpur, in the second week of December, 1929.

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Spirogyra nitida (Dillw) Link.op. cit. Borge Susswasser flora Heft 9.

Vegetative cells 70-90 u in diameter, 1-3 times as long. Septa plain, 3-5 chromatophores with ½ to 1½ spiral in each cell (   ).

Conjugation Scalariform Zygospores ellipsoid or even slightly ovoid. Fruiting cells slightly swollen on the outside. Zygospores 50-55 u in diameter, 1½ times as long (   ). Zygospores are slightly smaller than in the type.

Habit:-

Free-floating in a pond near Tahli Sahib District Hoshiarpore, in the second week of October, 1929. A very common form.

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Spirogyra Sahnii. Sp. Nov.

This alga was found mixed with filaments of <u>Sphaeroplea annulina</u> free-floating in Siah Baeen, a freshwater stream near Dasuya about the middle of March 1931.

Vegetative cells are 48-72 u broad and 40-74 u long. Usually they are broader than long. They are very much swollen and are barrel-like in appearance. Thereis a single chloroplast which is more or less coiled in an irregular fashion (Fig). The septa of the cells are plane.

<u>Reproduction-</u> Only lateral conjugation has been noticed in this alga, and this is of a very interesting type. The neighbouring cells usually give out tent-like protuberances in the usual way, and the female cells containing the zygospores almost always adjoin empty male cells (Figs). The female cells are usually of the same size, but in one case the empty male cell was considerably swollen and much bigger in size. It gave out a distinct tube which was continuous with similar structure given out by the female cell, and appeared like a retort used by chemists for distillation purposes. Such conjugation tubes have been reported by de Bary in Zygnema insigne (Hassal) Kutz. (Fig).

<u>Azygospores-</u> Azygospores are also seen in large numbers along with the zygospores (Fig). These are usually oval in shape like the zygospores, but are very much smaller in size, being broad, and 22-36 u long. In some cases these are spherical in shape (Fig).

Some of the cells are infested with a fungal parasite, similar to a species of Myzocitium described on a material of spirogyra affinis by Choudhari (   ). Some of the zygospores also are full of the cells of this parasite (Fig   ). It is a curious coincident that both the species of spirogyra from which this form of Myzocitium has been described, reproduce themselves by lateral conjugation.

Zygospores are 22-36 u broad, and 44-68 u long. The zygospore wall is composed of 3 layers, a smooth hyaline exospore, a thick bluish green mesospore, and a smooth endospore.

In one filament, the cells were noticed to produce conical protuberances, which give them a pear-shaped appearance(Fig   ). Probably these are abortive conjugation canals.

There are four species of Spirogyra which resemble the present form in some features, and especially in the possession of a single chloroplast and lateral conjugation. Of these it differs from S. longata (Vauch.) Czurda. and S. Lagerheimii Wittrock in the size and shape of vegetative cells and zygospores. From S. Condensata (Vauch.) Czurda emend, it ~~xx~~ differs in the shape and size of vegetative cells, the size of zygospores, and in the presence of parthenospores. The fourthspecies is S. asiatica.Czurda from which the alga differs in the shape of vegetative cells, presence of parthenospores, and the absence of any punctation from the mesospore as well as its bluish green colour.

I have named this species of spirogyra after Dr. Birbal Sahni of Lucknow University, who has done so much to raise the prestige of Indian Botany.

Spirogyra Sahnii sp. nov.

Vegetative cells 48-72 broad, 40-74 u long, barrel-shaped in appearance, with a single irregularly coiled chloroplast, Septa of cells plane. Only lateral conjugation known, zygospores oval 22-36 u broad, 44-68 u long, with a thin smooth, hyaline

Spirogyra parvula (Trans). Czurda nov. comb. op. cit.
Czurda. Susswasserflora Mittèleuropas. Heft 9-

Vegetative cells 20-24 u broad, 2-5 times as long. Each cell with one chromatophone of 2 to 4 times.(Fig).

Only lateral conjugation was observed in the material collected, though both lateral and scalariform conjucation is known to occur in the species. The zygospores occur in pairs at regular intervals, and when they are found singly, they are separated by many vegetative cells. Lateral conjugation in this species is very interesting. The female cell becomes very much swollen, and its contents become rounded (Fig). Thus there is not only a physiological difference between the gametes, but also a mosphological one. The contents of both the male and female cells become very much granular and vacuolated. In some cases the female cells are swollen on both sides and present a flask-shaped appearance. The male gamete passes into the female cell through a pore in the middle of the cell-wall separating the two cells (Fig). The empty male cells may be seen adjoining the female cells containing zygospores.

Zygospore ellipsoid to oval in shape 26 u broad, and 36-54 u long. The zygospore-wall is made up of three layers, a smooth and brown exospore, a smooth and bluish-green mesospore, amd light brown endospore.

Habit:- Found free-floating in a small freshwater spring near V. Fatehpur District Saharanpur in the middle of February 1936.

Spirogyra paludosa Czurda. op. cit. Die Susswasserflora Mitteleuropas. Heft 9. page 167-

Vegetative cells 18-22 u broad and 5-8 times as long. There is a single chloroplast in each cell (Fig). Septa of the cells plane.

Conjugation scalariform. Female cells containing zygospores slightly swollen. Zygospore ellipsoid, much longer than broad, being 24-26 u broad and 44-46 u long. Ex~~o~~ospore clear and smooth, mesospore light brown in colour.

Habit:- Found free-floating in a pond at V. Dodal Distt. Hoshiarpore in the first week of April 1931.

I Spirogyra foveolata (Trameau) Czurda nov. nom (Spirogyra inflata (Vauch) Rab.) op.cit. Czurda Susswasser flora Milteleuropas Heft 9.

Vegetative cells 14-18 u thick, 7-10 times as long, septa swollen and replicate, chloroplast single with 3-6½ spirals, sometimes almost straight (Fig)

Fruiting cells clearly swollen, 28-36 u broad. In fertile stages replication of septa becomes very clear. Zygospore ellipsoid 26-30 u in diameter. 1¾ to 2 times as long as broad (Fig) In this specimen only scalriform conjugation was seen, though lateral conjugation is also known in this species.

Habit:-Free-floating in a blackish mass in a pond at V. Shahpur, distt. Hoshiarpur, in the second week of April 1930. Also collected from Saharanpur in April 1935. A very common form.

Spirogyra quadrate (Hass) Petit. op. cit. Borge Susswasser flora Heft 9.

Vegetative cells 28-32 u in diameter, 3-4 times as long. A single chloroplast in each cell with two to six spirals (Fig) Septa replicate, fertile cells clearly swollen, 44-48 u br., and flattened near the middle. Zygospores ellipsoid-elongated, 32-42 u in diameter, 2-2¼ times as long. (Fig).

Habit:-Free-floating in a greenish mass of filaments in a fresh-water stream near V. Kiri, Distt. Gurdaspur. Produces zygospores in the middle of December. Rather rare.

Species with septa not swollen. One chromatophore in each cell.

Spirogyra affinis (Hass) Kutz. op. cit. Borge Susswasser flora Heft 9.

Both lateral and scalariform conjugation are seen in this species. Vegetative cells 22-30 u broad. Sepa not swollen. Chromatophore single with 2½ to 4 spirals. Fruiting cells swollen on both sides. Zygospores ellipsoid 25-32 u br., 36-46 u long. Placed obliquely in the gametangium, yellowish in colour. Spore-walls smooth. Another interesting feature of the Alga is that many cells give out rhizoids (LXXIII, fig. c.) like those described by Delf by means of which the filaments are attached to coarser filaments of Oedogonium.

Filaments showing lateral conjugation are attacked by rounded endophytic Chytridiaceous Fungi, 2-4 of which are invariably found in each cell which does not contain a zygospore.

Habit:-Found free-floating in a brownish mass in ponds. Collected in the second week of March 1930 at Hamira, and mixed with Oedogonium urbicum at V. Jhingran Distt. Hoshiarpur about the same time. Fairly common.

Spirogyra Jurgensii Kutz. op. cit. Borge Susswasser flora Heft 9.

Vegetative cells, 25-30 u thick, 2½ to 5 times as long. Septa occasionally swollen but not replicate. Cells with one chromatophore of two to four spirals. Fruiting cells not swollen on either side. Zygospores ellipsoid elongated 30-32 u thick, twice as long. Zygospore membrane smooth.

Habit:- Collected from Badami Bagh Tanks Lahore free-floating, about the middle of March 1930. Fairly common.

Spirogyra _bellis_-Cleve. var. nov. Borge op. cit. Susswasse flora Heft 9.

Vegetative cells 60-65 u br., 1½ times as long as broad, with plain septa. Each cell with 5-7 chromatophores, closely packed. Spirals rather indistinct as zygospores characteristically arranged perpendicular to transverse walls. Zygospores oval or rounded in shape, 54-64 u in diameter, 80-85 u long. Zygospore walls smooth. Brownish yellow in colour. Fruiting cells strongly swollen on both the sides. This alga closely resembles _S_. _bellis_. Cleve in its dimensions but the middle membrane of the zygospore wall is smooth in this case.

Habit:- Free-floating in a pond near V. Bodal Distt. Hoshiarpur.

Collected in the second week of March 1930.

Mougeotiaceae.

Genus. Mougeotia Agardh.

1. Mougeotia sp.

Vegetative cells21 to 28 U in diameter, 2-5 times as long. Each cell with a plate-shaped chromatophore bearing 2 to numerous pyrenoids. (Fig). Genuflexed filaments are found in great abundance. No zygospores were seen. Another peculiarity of the alga is the readiness with which the individual cells dissociate from one another, as in Debarya desmidioides. West. Possibly it is M. genuflexa (Pillw) Ag.

Habit:- Found in the form of a greenish mass of filemants many yards in length in Budha Nala, a freshwater stream near Ludhiana.

Spirogyra condensata (Vanch). Czurda emend. Susswasser flora Mitteleuropas Heft 9. page 178.

Vegatative cells 40-65 U broad, 2-5 times as long. Septa of the cells plain. There is a single chloroplast of 1 to 2½ spirals in each cell.

Conjugation lateral as well as scalariform. In lateral conjugation the zygospores usually occur in pairs. Zygospores oval 32-36 U broad and 60-70 U long. Female cells containing zygospores are not swollen. Exospore hyaline, thick, mesospore brown, and endospore not known (Fig.). The zygospores produced by lateral conjugation are slightly smaller than those of the type.

Zygospores in forms reproducing by means of scalariform conjugation are bigger being 42-45 U broad, and 70-75 U long. Sterile cells with thickened mucilaginous walls frequently alternate with the male cells (Fig).

Azygospore may also be seen plentifully, are rounded in appearance and 24-26 U in diameter.

Habit:-

Specimen showing scalariform conjugation were found free-floating in a greenish mass, in a pond in V. Nowshera Distt. Hoshiarpore. It is one of the early fruiting forms, producing zygospores about the middle of October. A very common alga, often found mixed with Spirogyra nitida. Also found free-floating in a fresh-water spring at Tahli Sahib Distt. Hoshiarpore in the first week of March, 1931, reproducing by lateral conjugation.

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Spirogyra condensata Kutz. var. nov. op. cit. Borge Susswasser flora Heft 9.

Vegetative cells 50-65 u broad, 4-6 times as long, each cell with one spiral chromatophore of 3-8 close turns. Fruiting cells not swollen on either side. Zygospores ellipsoid, 42-45 u br., 70-75 u long with a smooth zygospore membrane. Sterile cells with thickened mucilaginous walls frequently alternate with the cells of the male filaments. The Alga differs from the type in having chromatophores with greater number of spirals and much bigger zygospores hence it is necessary to establish a new variety.

Habit:- Free-floating in a greenish mass, in a pond in V. Nowshera Distt. Hoshiarpur. One of the early fruiting forms, producing 3 zygospores about the middle of October. A very common alga, often found mixed with Spirogyra nitida.

Spirogyra condensata (Vanch). Czurda emend. Susswasser flora Mitteleuropas Heft 9. page 178.

Vegetative cells 28-45 U broad, 2-3 times as long. Septa of the cells plain. There is a single chloroplast of 1 to 2½ spirals in each cell.

Conjugation lateral only. Zygospores usually in pairs. Zygospores oval 32-36 U broad and 60-70 U long. Female cells containing zygospores are not swollen. Exospore hyaline, thick, mesospore brown, and endospore not known (Fig). The zygospores are slightly smaller than those of the type.

Azygospore may also be seen plentifully, are rounded in appearance and 24-26 U in diameter.

Habit:-

Free-floating in a fresh-water spring at Tahli Sahib Distt. Hoshiarpore in the first week of March, 1931.

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Mougeotia Viridis (Kutzing) Wittrock 1872- op. cit. Czurda. Susswasser flora Mitteleuropas Heft. 9.

Vegetative cells 6-8 U broad, chloroplast plate-shaped, with 3-4 pyrenoids in each. (Fig).

Conjugation scalariform. Zygospores more or less squarish cushion-shaped in appearance, and may bee seen free-floating with the four horn-like remains of the gametangia attached to them at the corners. Mesospore clear and smooth. Zygospores darkish in colour, 22-26 U X 22-26 U. (Fig).

Distribution:- This alga has been reported from Germany, Austria, Czechoslovakia, France, Russia, Romania, and North America. Almost a cosmopolitan alga.

Habit:- Found free-floating mixed with Zygnema Czurdae. Randhawa. and a species of Oedogonium during the second week of March, 1931, in Siah Baeen, a freshwater stream in Jullundar district, Punjab. Rather a rare alga.

Conclusion.

The study and investigation of the members of Zygnemals with their infinite variety in the shape and size of their chloroplasts and zygospores, apart from its scientific value, gives a great aesthetic pleasure to the worker. The beauty of shape, symmetry and pattern which these algae possess has a fascination of its own.

In recent years considerable interest has been shown in the study of algae in this country, but the group is such a vast one, that it is impossible for any individual worker to devote intensive attention to all the various forms. The author has specially interested himself in the study of the members of Zygnemales, and shall be much obliged to receive collections of these algae from various parts of India C/o the Secretary, Indian Academy of Sciences, Bangalore.

Before concluding the author expresses his thanks to his sister-in-law Mrs. Ilse Randhawa she gave to him in his investigations by translating into English the various German books on algae.

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" A Short note on an Indian Variety of Sphaeroplea annulina (Roth) Agardh. Var. Multiseriata, Var. Nov. "

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" A Short note on an Indian Variety of Sphaeroplea annulina (Roth) Agardh. Var. Multiseriata, Var. Nov."

A variety of Sphaeroplea annulina (Roth) Agardh was collected by the author from many ponds during the months of March and April in 1930from Hoshiarpore, Jullundar and Amritsar. During March the filaments become yellowish green in colour, and on examination under the microscope numerous green ova may be seen in most of them. By the end of April nearly all the filaments show red oospores, and they occur in such large numbers that drying banks of most ponds present a crimson-red appearance.

Under the microscope a number of annular chloroplasts may be seen in each coenocyte. Under the high power of the annular bands of chloroplasts show bridge-like inter-connections (Fig.1), the whole presenting the appearance of a veticulum as in S.africana Fritsch. A number of pyrenoids may be seen arranged in a row on each chloroplast One to two nuclei may also be seen in the cytoplasm.

The septa are homogeneous ingrowths of the longitudinal walls (Fig. 2) as in typical filaments of S.annulina (Roth) Agardh, and the coenocytes do not inter-communicate by means of any pores. The coenocytes are 60-80 in diameter being somewhat broader than those reported from Europe.

Sexual Reproduction.

The remarkable feature of the alga are its oogonia which are formed from the ordinary coenocytes without any change of form. The protoplasm of the coenocytes becomes cleft into numerous green ova, which in the present variety may be seen arranged in three longitudinal rows (Fig. 3). It is due to this that the author has named this variety of S. annulina (Roth) Agardh as Var. Nov. multiseriata. Such a multiserial arrangement of ova and oospores is seen only in S. africana Fritsch, and Klebahn's figure of a segment of an oogorium of S. annulina (Roth) Agardh as reproduced by Fritsch in his "The structure and Reproduction of the Algae," shows only a single row of ova. The ova in the present variety are deep green in colour and have 1-3 pyrenoids in each (Fig.3).

Apertures for the entry of the sperms may be seen in the walls of the oogonia (Fig. 40). The ova are 17-27 in diameter.

The young oospores are green in colour and are often found enclosed in a thin hyaline membrane (Figs. 5 and 6), which is later shed, and may be found in large numbers alongside of the oospores (Fig. 4.M.). The oospores are spherical in shape, and the outer hyaline wall is produced into 10-15 blunt spines. The number of spines in the present variety, is fewer as compared with S. annulina (Roth) Agardh as figured by Fritsch and Rich ( ). Under an oil immersion lens, the surface of the oospores shows distinct aereolotion (Figs. 7, 8, 9, 10, 11 ans 12).

This form differs from the type in the disposition of its ova and oospores in 2-3 rows, fewer number of teeth on the oospore wall, and the slightly broader size of its coenocytes. Hence I have named it as Var. Multiseriata Var. Nov. This is also, so far as I know, the first report of this Alga from India.

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Explanation of Figures.

Fig. 1.-Shows a part of a coenocyte with chloroplasts, pyrenoids (p) and nuclei (n) 420

Fig. 2.-Shows a Septum. 420.

Fig. 3.-Shows a part of an oogonium with three rows of ova. 42

New Species of Cylindro[illegible]

M.S. Randhawa,
M.Sc., I.C.S.

Cylindrocapsa oedogonioides.

Sp. Nov.

This very rare alga was found entangled in the filaments of a species of oedogonium, which was growing epiphytically on the blades of Typha plants in Shahniwala Tank at Dasuya, Punjab, during the months of March and April, 1930, and 1931. During March only sterile filaments were seen, but by the last week of April, some filaments developed oogonia, antheridia, and oospores. So far as the author knows there has been no record of any species of the rather uncommon genus Cylindrocapsa from India. Possibly this is due to the habit of the alga, for even where it occurs it is found in such a scattered condition that after a long search under the microscope one may be lucy enough to spot a filament or so.

The filaments are unbranched and consist of a single row of more or less sub-rectangular cells, which are enclosed within a lamellose sheath, as in Cylindrocapsa conferta. West. But the cells of this alga differ from those of C.conferta West in having two small pyrenoids at the opposite ends of the cells (Figs 1 and 2), instead of a single massive pyrenoid as in the former. There is a single massive chloroplast, which is parictal in position, and presents a more or less granular appearance. In most of the cells a dumb-bell shaped nucleus may be seen in the middle surrounded by two pyrenoids at the sides (Figs.2 and 4). Vegetative cells are broad, and 12-28 U long, being considerably narrower than those of C. conferta West.

Reproduction.

This alga is characterised by the presence of a well developed oogamy. Of the species so far known, sexual reproduction has been worked out only in C. involuta Reinsch. In the present form the method of reproduction and the sex organs differ from that of Cylindrocapsa involuta Reinsch in many details. The filaments may be monoccious; the antheridia and oogonia developing in the same growing epiphytically on Typha blades in Shahniwala Tank Dasuya, district Hoshiarpore, Punjab, during March and April, 1930 and 1931

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Explanation of Figures.

Cylindrocapsa Oedogonioides. Sp. Nov.

Fig.1. A vegetative filament showing cells with two pyrenoids in each.

Fig. 2. A filament showing active division of some cells developing later into antheridia (a) and enlargement of other cells developing into oogonia (O).

Fig. 3. A filament showing a chain of female cells which later develop into oogonia.

Fig. 4. A filament showing some empty cells.

Fig. 5. A portion of a filament showing antheridial cells (a), and two oogonia.

Fig. 6. A mature filament showing an oogonium with an oospore.

Fig. 7. A filament showing three oogonia with oospores.

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