Hence for the two reasons, (1) association both in impressions and in petrifactions with Lyginodendron, (2) the structure of the tissue in which the sporangia are embedded, the claim of these clusters to be the fructifications of *Lyginodendron* is overwhelmingly strong.

My thanks are due to Professor F. W. Oliver for the loan of several confirmatory slides.

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ALGOLOGICAL NOTES.—

III. PRELIMINARY REPORT ON THE PHYTOPLANKTON OF THE THAMES.—Freshwater Plankton-investigations, so vigorously prosecuted on the continent, have received little or no attention in England. As far as the writer is aware no paper on this subject has ever been published in this country. The Plankton of the sea has occupied English botanists since some years, and systematic work in this direction is being done at some of our marine stations; but we possess nothing whatever comparable to the inland biological stations established on the continent; take for example Plön in Schleswig-Holstein, which is practically devoted solely to research on the Plankton of the numerous small lakes of this part of the German Empire. This special line of research has here become so proficient and prolific, as to admit of the publication of a separate journal [1] to embody its results.

It was with the intention of drawing attention to this kind of work in our country that I commenced to investigate the Plankton of the Thames—the more as the Plankton of the artificial waters at Kew, which are fed more or less directly from the river, seemed to promise good results. And indeed a little over a month's investigation has given such interesting results that I venture now to publish a general account of the Plankton without being able to say anything as to its periodicity.

Investigations of the Plankton of rivers have not been often carried out as yet. Lauterborn [2] in 1893 published the results of some collecting, performed on the Rhine near Ludwigshafen; his list consists chiefly of animals, two Diatoms being the sole representatives of the vegetable kingdom. It is really Bruno Schröder who first gives

[1] Forschungsberichte aus der biologischen Station zu Plön, edited by the Director Dr. O. Zacharias. Stuttgart. Appeared first in 1893.

[2] Beiträge zur Rotatorienfauna des Rheins und seiner Altwasser. Zoolog. Jahrbücher, 1893.

a clear account of the Plankton-life of a river, the Oder. His first paper on this subject was published in 1897 [1], to be followed in 1899 by a fuller account [2]. In the interval which elapsed between these two papers of Schröder's, Zacharias [3] published a brief general account of the Plankton of rivers (so-called Potamoplankton). This paper gives the results of Plankton-collecting in a number of rivers (Pleisse, Schlei, Trave, Oder, &c.), and terminates with a discussion of the probable origin of the Potamoplankton. Quite recently Brunnthaler [4] has published a short communication on the Plankton of the Danube near Vienna, whilst Zykoff [5] and Bolohoncew [6] have described that of the Volga near Saratow.

Brunnthaler also discusses the possibilities of an independent existence of Plankton-organisms in flowing water, and maintains that in the swift Danube all the Plankton found has been carried down from quiet portions of the stream's course. This view seems very probable, and can also, without doubt, be extended to rivers of less rapid current. Thus in a river like the Thames many of the organisms found floating freely in the main-water of the river have probably been derived from higher and almost stationary parts of its course. Schütt [7] opposes the idea of an independent existence of Plankton in streams, and maintains that all the individuals present have been derived from its stagnant backwaters and slow-flowing tributaries. In rivers which flow as slowly as the Thames, however, reproduction of the Plankton-organisms even in mid-stream undoubtedly goes on. *Pediastrum* and *Eudorina*, two of the commonest among the chlorophyceous Plankton of the Thames, were again and again met with in every stage of reproduction, and I am quite certain that the other organisms reproduce in the same way, but perhaps less frequently. Diatoms were often seen in a state of reproduction,

[1] Ueber das Plankton der Oder. Ber. Deut. Bot. Ges. xv, 1897, p. 482. See here for further literature.

[2] Das pflanzliche Plankton der Oder. Forschungsber., Plön, 1899. Teil vii, p. 16. Recent literature mentioned.

[3] Das Potamoplankton. Zoologischer Anzeiger, No. 550, 1898, p. 41.

[4] Das Phytoplankton des Donaustromes bei Wien. Verhandl. der k. k. zoolog.-botan. Gesellsch. in Wien, Jahrg. 1900, Heft 6, pp. 308–11.

[5] Zykoff, V. Das pflanzliche Plankton der Volga bei Saratow. Biol. Centralbl., Bd. xxii. No. 2, 1902.

[6] Bolohoncew, E. Materialien zur Kenntnis des Phytoplanktons der Volga (bei Saratow). Moscow, 1901. (Russian.)

[7] Das Pflanzenleben der Hochsee. Kiel, 1893, pp. 9–11.

although I must say that the extremely abundant *Melosira* was only found with reproductive organs in a quiet, almost stationary backwater. Undoubtedly it is from these backwaters and tributaries of the upper part of a stream's course that the initial mass of the Plankton is derived; they act, so to say, as reservoirs [1], from which by means of currents or incidentally during storms new supplies are continually being dealt out. It is, however, just as certain that these organisms do afterwards multiply still more, and that a great part (quantitatively) of the Plankton of the Thames is formed when the individuals have already reached the flowing stream. Zacharias holds the same view of the matter and adduces the river Schlei as evidence [2]; each year it becomes covered with a dense stratum of *Clathrocystis*, and it is impossible that this can all have been derived from the few backwaters of the river. Zimmer [3] places the Plankton of rivers in three classes:—

(1) The *eupotamic* Plankton which flourishes and reproduces either in the flowing water of the stream or in stationary water (e. g. *Pediastrum*, *Eudorina*, *&c.*).

(2) The *tychopotamic* Plankton which only reproduces in stationary water, and when swept into the main water of the river continues to live, but not to reproduce (probably many Diatoms).

(3) The *autopotamic* Plankton which has become adapted to life in flowing water (e. g. *Actinastrum Hantzschii*, Lagerh., var. *fluviatile*, Schröd., and *Synedra Ulna* (Nitzsch), Ehrb., var. *actinastroides*, Lemm.[4]).

What then becomes of the Plankton as it gets nearer and nearer to the river's mouth? On most of the Plankton-organisms, found higher up the river, the increasing brackishness of the water [5] will act fatally. In the Thames, in which the tide extends to Richmond or further, this action is noticeable already at Kew. The quantity of Plankton-organisms decreases steadily as we approach the river's mouth. Plankton-hauls from the Thames at Kew showed that many of the Desmids and Pediastrums are either dead or in a dying state, and many of the Diatoms merely consist of the empty frustules. These after some time sink to the bottom of the water, and in this

[1] Cp. Zimmer, Das thierische Plankton der Oder. Forschungsber., Plön, 1899. Teil vii, p. 4.

[2] Zacharias, loc. cit., p. 47.

[3] Zimmer, loc. cit., p. 5.

[4] Cf. Schröder, loc. cit. I have not found either of these varieties in the Thames as yet.

[5] Cp. foot-note on p. 581.

way large numbers of Diatoms are to be found in the mud of the river's bed. These were described as far back as 1854 by Roper[1], who having examined the mud from Hammersmith and from spots lower down the river remarks on the large number of marine species present. Even at Kew a few truly marine species (e.g. *Coscinodiscus radiatus*, *Surirella ovata*, *Rhaphoneis Rhombus*) were found, and had my observations extended over a greater length of time more would probably have been discovered. I do not think that many of the freshwater forms found in the upper reaches of the river will be met with much further down than Kew, although Hensen[2] and Brandt[3] found a number of freshwater Plankton-species, present in some cases in quite considerable quantity, in the slightly brackish water of the Stettiner Haff.

My collecting was performed between Kew and Cookham on six separate days during a period of a little more than a month. The dates, together with the temperature of the water and the nature of the weather, may be mentioned at once so as to save repetition:—

(1) Kew–Richmond: August 14; 18° C; bright, with a few clouds at intervals.

(2) Richmond–Teddington: July 11; 20° C; slightly cloudy.

(3) Hampton Court–Sunbury: July 16; 23° C; overcast.

(4) Shepperton–Weybridge: July 26; 18½° C; cloudy, water very much disturbed.

(5) Datchet–Windsor: August 8; 18½° C; rainy.

(6) Maidenhead–Cookham; August 19; 18° C; bright, with a few clouds at intervals.

All the samples were collected from a rowing-boat with the help of an ordinary funnel-shaped net of fine gauze, the lower narrow end being attached to a glass tube. Samples were collected from the surface of the water, and in some cases from deeper strata, the net being maintained below the surface at a depth of 1–2 feet. The net was usually allowed to remain in the water for a period of about three minutes, during which the boat was rowed at a medium rate. The samples were examined the same day or the day after they were

[1] On the Diatomaceae of the Thames. Trans. Microscop. Soc. of London. New Series, vol. ii, 1854.

[2] Das Plankton der östlichen Ostsee und des Stettiner Haffs. Sechster Ber. der Commission zur wissenschaftl. Unters. deutscher Meere, 1890.

[3] Ueber das Stettiner Haff. Same periodical, vol. ii, 1895 (new series).

collected. In considering the table on pp. 582 and 583 it is necessary to remember that this year has been an abnormal one, that the months July and August have been very rainy, whereas the temperature of the air and therefore of the water also has been considerably below the average. The quantity and quality of the Plankton will therefore in all probability be different from that of a normal summer.

The accompanying table may indicate the distribution and relative number of individuals of the various species found. [i. = isolated; vr. = very rare; r. = rare; rc. = rather common; c. = common; vc. = very common; a. = abundant; — = wanting.]

A few words may now be said on the constitution of the Thames Plankton, and on the distribution of the various species. As in all rivers, as yet investigated, Diatoms play an important part, generally exceeding the other forms in quantity to a great extent. In the neighbourhood of Kew this is not so noticeable, there being perhaps two or three Diatoms to one individual of the other groups, but as we go farther up the stream the former increase rapidly in number, so that at Windsor or Maidenhead the ratio has become about 20·1. Diatoms are especially abundant in the backwaters, although the number of different species is frequently less here than in the main stream. I am only able to account for the great decrease in the number of Diatoms at Kew by the above-mentioned hypothesis—the fresh-water species are dying off, whereas the marine species are not yet common at this point. The samples from Kew and even from Teddington altogether present a very different appearance to those collected higher up; at Kew the stream is full of mud, and when a sample is examined under the microscope nothing but organic and inorganic detritus is found in the field of view, the few living forms being very widely scattered in between these particles[1]. The samples from higher up, on the contrary, are practically free from mud, and the field of view is full of Diatoms, &c. Possibly this mud, occurring in the lower parts of the stream, is partly accountable for the decrease in number of the Diatomaceae.

Fragilaria virescens is very common in all parts of the river examined; the other species, *Fr. mutabilis*, is far less abundant. Next, as regards abundance to the first-mentioned species comes *Melosira varians*; *M. moniliformis* is found very commonly in some parts. *Pleurosigma attenuatum* is another very common form, especially

[1] Zimmer, loc. cit., p. 4.

in the surface layers. The species of *Surirella* are very typical of the Thames Plankton; one or other of them will always be found in the field of view, when a sample is placed under the microscope. *Campylodiscus noricus* is common in many parts. Forms like *Coscinodiscus radiatus*, *Melosira angulata*, *Rhaphoneis Rhombus*, *Synedra Acus* var. *delicatissima*, &c., become rarer as we go higher up stream.

Amongst the green Algae the two species of *Pediastrum* were common in nearly all parts of the river. After that *Closterium moniliferum*, *Cosmarium margaritiferum* and *Scenedesmus quadricauda* are most abundant. *Eudorina elegans* is common higher up, and is probably one of those forms which dies off early when the water becomes brackish. *Pandorina morum* is found sparingly everywhere. The other species of *Scenedesmus* is much rarer than the first, and this is also the case with the other species of Desmids. Most probably the Thames water is too calcareous[1] to admit of a proper Desmid vegetation. This is also the case with the artificial waters at Kew, which yield very few Desmids.

The blue-green forms are commoner in the lower parts of the river. Only the two species of *Microcystis* are present in any quantity. The others are isolated and local. Rather commoner are some of the Flagellates, especially *Euglena viridis*; *Phacus pleuronectes* was also frequently found. *Dinobryon* is rare, but I think it probable that early in the year this and other Flagellates are much more abundant than they are now. No Peridiniaceae were observed, which is worthy of note.

As to the difference between the samples taken from the surface and those taken from deeper layers, I have found that the green forms are less common in the deeper strata, and consequently the Diatoms preponderate the more. Some of these latter, however, are also much rarer, e.g. *Pleurosigma* (cp. table).

The backwaters always present a much more flourishing and

[1] My friend, Mr. L. Guttmann, was kind enough to analyse two samples of Thames water, for which I desire to express my sincerest thanks. The results were as follows:—

First sample from Kew:—

3·0 parts of Cl in 100,000 (most of this is due to Sodium Chloride).

11·70 parts of $CaCO_3$ in 100,000. (Total hardness = 19·13.)

Second sample, from Maidenhead:—

2·20 parts of Cl in 100,000.

16·20 parts of $CaCO_3$ in 100,000. (Total hardness = 22·02.)

	14. Backwater near Cookham; t=18½°C; sunny; 19, viii.	13. Taplow Backwater; t=18°C; cloudy; 19, viii.	12. As in 11; deeper layers.	11. Maidenhead–Cookham; surface layers; t=18°C; sunny; 19, viii.	10. As in 9; deeper layers.	9. Datchet–Windsor; surface layers; t=18½°C; cloudy; 8, viii.	8. Backwater near Weybridge; surface layers; t=15°C; sun; 26, vii.	7. As in 6; deeper layers.	6. Shepperton–Weybridge; surface layers; t=18½°C; cloudy, water much disturbed; 16, vii.	5. Hampton Court–Sunbury; surface layers; t=23°C overcast; 16, vii.	4. Richmond–Teddington; surface layers; t=20° C; slightly cloudy; 11, vii.	3. Backwater near Brentford; surface layers; t=18°C; bright; 14, viii.	2. Kew–Richmond; deeper layers; t=18°C.	1. Kew–Richmond; surface layers; t=18°C; bright; 14, viii.[1]
I. *Chlorophyceae.*														
1. *Scenedesmus quadricauda* (Turp.), Bréb.	vr.	—	vr.	r.	r.	r.	vr.	rc.	c.	c.	rc.	r.	r.	vr.
2. „ *quadricauda*, var. *horridus*, Kirch.	—	—	—	—	r.	—	—	—	—	—	—	—	—	—
3. „ *acutus*, Meyen.	—	—	—	—	—	—	rc.	—	—	—	—	r.	r.	r.
4. „ *acutus*, var. *obliquus*, Rab.	—	—	—	—	—	—	—	—	—	—	—	—	r.	r.
5. „ *acutus*, var. *dimorphus*, Rab.	—	—	—	—	—	—	—	—	—	r.	—	—	—	—
6. *Pediastrum Boryanum* (Turp.), Men.	rc.	c.	rc.	c.	rc.	c.	—	rc.	c.	c.	c.	rc.	rc.	rc.
7. „ *pertusum*, Ktz.	—	rc.	—	r.	r.	r.	—	rc.	c.	c.	c.	c.	c.	rc.
8. „ *pertusum*, var. *clathratum*, Braun.	—	—	—	—	—	—	—	—	—	rc.	—	rc.	rc.	—
9. *Botryococcus Braunii*, Kütz.	—	—	—	—	—	—	—	—	rc.	—	—	r.	rc.	r.
10. *Ophiocytium circinatum*, Wolle.	—	—	—	—	—	—	rc.	—	—	—	—	—	—	—
11. *Rhaphidium pyrenogerum*, Chod. var. *falciforme*	—	—	—	—	—	—	—	—	—	—	—	—	—	i*
12. *Kirchneriella lunaris* (Kirch.), Moeb.	—	—	—	—	—	—	—	—	—	—	—	—	i*	i*
13. *Actinastrum Hantzschii*, Lag.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14. *Chlamydomonas*, spec.	—	—	—	vr.	—	—	—	—	—	—	—	—	—	—
15. *Eudorina elegans*, Ehrb.	rc.	c.	vr.	c.	r.	r.	—	—	r.	rc.	r.	—	—	—
16. *Pandorina morum*, Ehrb.	r.	rc.	vr.	r.	—	r.	—	rc.	rc.	r.	rc.	—	—	vr.
II. *Conjugatae.*														
17. *Closterium acerosum* (Schrank.), Ehrb.	—	—	—	—	r.	—	—	—	r.	r.	vr.	—	vr.	—
18. „ *moniliferum*, Ehrb.	rc.	c.	—	c.	rc.	c.	—	rc.	c.	c.	—	r.	—	vr.
19. „ *Leibleinii*, Kütz.	—	—	—	—	—	—	—	—	i.	—	—	—	—	—
20. *Cosmarium margaritiferum*, Men.	rc.	r.	—	rc.	rc.	r.	—	rc.	rc.	rc.	—	r.	—	vr.
21. „ *ornatum*, Ralfs.	—	—	—	—	rc.	—	—	—	—	—	—	—	—	—
III. *Bacillariales.*														
22. *Coscinodiscus radiatus*, Ehrb.	—	—	—	—	—	—	—	—	—	—	rc.	r.	r.	r.
23. *Melosira angulata*, Rabenh.	—	—	—	—	—	—	—	—	—	—	—	—	rc.	r.
24. „ *moniliformis* (Müll.), Ag.	c.	c.	c.	c.	rc.	rc.	—	r.	rc.	c.	rc.	r.	r.	r.

25. *Melosira varians*, Ag.	rc.	rc.	rc.	c.	vc.	c.	c.	a.[1]	c.	vc.	vc.	vc.	a.	a.
26. *Campylodiscus noricus*, Ehrb.	—	r.	—	rc.	c.	rc.	r.	—	rc.	r.	r.	r.	—	r.
27. *Surirella biseriata*, Bréb.	rc.	r.	r.	rc.	rc.	rc.	rc.	—	rc.	rc.	—	r.	rc.	rc.
28. „ *ovalis*, Bréb.	r.	r.	—	c.	c.	c.	c.	—	rc.	c.	rc.	rc.	rc.	rc.
29. „ *ovata*, Ktz.	—	—	—	vr.	r.	—	—	—	—	—	—	—	—	—
30. „ *splendida* (Ehrb.), Ktz.	r.	r.	—	r.	r.	rc.	r.	—	rc.	rc.	r.	—	rc.	rc.
31. *Cymatopleura Solea* (Bréb.), Sm.	—	r.	r.	r.	r.	rc.	r.	r.	rc.	rc.	rc.	—	—	—
32. *Himantidium faba*, Ehrb.	—	—	—	—	—	—	—	—	rc.	rc.	r.	—	—	—
33. *Cymbella gastroides*, Ktz.	—	—	r.	rc.	rc.	c.	c.	rc.	c.	c.	c.	rc.	r.	c.
34. *Amphora ovalis*, Ktz.	rc.	—	—	rc.	rc.	rc.	rc.	rc.	r.	c.	rc.	rc.	r.	rc.
35. *Encyonema prostratum*, Ralfs.	—	—	—	—	r.	—	r.	—	—	—	—	—	—	—
36. *Cocconeis Placentula*, Ehrb.	—	r.	—	rc.	rc.	rc.	rc.	—	c.	c.	rc.	rc.	rc.	rc.
37. *Fragilaria virescens*, Ralfs.	c.	c.	c.	c.	vc.	vc.	c.	a.	c.	rc.	vc.	vc.	a.	c.
38. „ *mutabilis* (Sm.), Grun.	r.	rc.	r.	rc.	rc.	r.	r.	a.	r.	rc.	rc.	r.	—	—
39. *Rhaphoneis Rhombus*, Ehrb.	rc.	r.	r.	rc.	—	—	—	—	—	—	—	—	—	—
40. *Synedra Acus*, Ktz.	r.	rc.	r.	—	—	—	—	—	r.	—	r.	r.	r.	—
41. „ *Acus*, var. *delicatissima*, Sm.	—	rc.	r.	—	—	—	—	—	—	—	—	—	—	—
42. „ *Ulna*, Ehrb.	r.	—	—	rc.	c.	c.	rc.	c.	rc.	rc.	rc.	rc.	rc.	rc.
43. *Asterionella gracillima*, Heib.	—	—	i*	—	—	—	—	—	—	—	—	—	—	—
44. *Nitzschia sigmoidea* (Nitzsch.), Sm.	rc.	r.	r.	rc.	rc.	rc.	r.	—	rc.	rc.	rc.	rc.	r.	r.
45. *Navicula amphisbaena*, Bory.	rc.	rc.	c.	r.	r.	—	—	—	r.	r.	—	—	—	—
46. „ *gracilis*, Ehrb.	—	—	—	rc.	rc.	rc.	r.	rc.	c.	c.	rc.	rc.	rc.	rc.
47. *Pinnularia viridis* (Ehrb.), Rab.	—	vr.	—	—	rc.	rc.	rc.	rc.	r.	r.	r.	—	r.	—
48. *Pleurosigma attenuatum* (Ktz.), Sm.	r.	—	r.	rc.	c.	vc.	rc.	—	c.	c.	c.	r.	c.	c.
49. *Stauroneis Phoenicenteron*, Ehrb.	—	—	—	—	r.	r.	r.	—	—	—	—	rc.	—	r.
50. *Tabellaria fenestrata*, Ktz.	—	—	—	—	—	r.	—	—	rc.	rc.	rc.	—	r.	r.
IV. *Schizophyceae.*														
51. *Coelosphaerium Kützingianum*, Näg.	—	—	—	—	—	—	r.	—	—	—	—	—	—	—
52. *Microcystis protogenita*, Rabenh.	rc.	rc.	c.	—	—	rc.	—	—	—	—	—	—	—	—
53. „ *marginata* (Men.), Kirch.	r.	—	r.	—	r.	—	—	—	—	r.	—	—	—	—
54. *Clathrocystis aeruginosa*, Henfrey.	—	—	i.	—	—	—	—	—	—	—	—	—	—	—
55. *Merismopedia glauca*, Näg.	—	—	—	—	—	—	—	c.	—	—	—	—	—	—
V. *Flagellatae.*														
56. *Euglena viridis*, Ehrb.	rc.	c.	rc.	rc.	rc.	—	—	—	rc.	—	rc.	—	—	—
57. *Phacus pleuronectes*, Nitzsch.	—	—	r.	r.	rc.	—	—	rc.	—	—	—	—	—	—
58. *Dinobryon Sertularia*, Ehrb.	vr.	—	—	rc.	—	—	—	—	—	—	—	—	—	—
59. *Synura Volvox*, Ehrb.	—	vr	—	r.	—	—	—	—	—	—	r.	—	—	rc.

* Species marked thus were only met with once.

[1] With auxospores.

abundant Plankton than does the main stream, and the species found are sometimes different. They also differ in that animal life is much commoner than in the main stream, which at some points is almost destitute of Zooplankton. These backwaters thus form a kind of transition from the typical Potamoplankton of the flowing river to the Heleoplankton of the ponds of the Thames valley. Thus, if we compare the Thames Plankton with that of the stationary Plankton of the artificial waters at Kew, we find that in the latter the animals and also the green organisms far exceed the Diatoms in number, whereas the latter are far the most abundant in the river. It has been shown[1] that the Potamoplankton approaches in its character more to the Heleoplankton of a pond the slower the stream flows.

One backwater somewhat above Shepperton gave very interesting results. The samples were crowded with *Melosira varians*, *Fragilaria virescens* and *mutabilis*, whereas forms like *Pleurosigma attenuatum* and the three species of *Surirella*, so common in the samples collected in the main river on that day, were quite absent. *Pediastrum* was wanting, the green and blue-green forms being represented by *Scenedesmus quadricauda*, *Scen. acutus*, *Ophiocytium circinatum*, Wolle, and *Merismopedia glauca*, which except for the first were not found in the main stream. The chief reason for this difference in the Plankton is undoubtedly to be found in the fact that the temperature of the water in this backwater was only 15° C., whereas in the main river it was 18½° C. Diatoms flourish well in cold water!

The results embodied in the present note are, of course, of a preliminary nature. The number of species to be found in the Plankton of the Thames is undoubtedly considerably greater than that mentioned in the table. My present object has been to obtain some idea of the distribution of the commoner species, and time was only rarely expended on the determination of isolated forms or on possible new species and varieties. Such observations as have been made in this direction have been retained for future publication after the investigations of Thames Plankton shall have been extended over a year's time and the periodicity of the flora has been determined.

F. E. FRITSCH.

JODRELL LABORATORY, KEW,
August, 1902.

[1] Cp. Zacharias, loc. cit., p. 46; Zimmer, loc. cit., p. 7.