Further Observations on the Phytoplankton of the River Thames.

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THE present year, with its unusually great rainfall and consequent heavy floods, has not been very favourable for comparative investigations of the river Plankton. The disturbing influence due to the height of the water and the strength of the current has been very noticeable in some of the samples collected, especially in those of May 2. The speed of the current on that day was quite four times the usual one, and it is a well-known fact that the quality of the Plankton is considerably dependent on the rate of the stream (cf. Zacharias, '98, p. 46 ; Zimmer, '99, p. 7) ; a continuation of such conditions for several days would probably have a very considerable effect on the composition of the Plankton, and this would most likely last for some time after the restoration of the normal state of affairs. It is therefore probable that, although the main features of the periodicity are sufficiently evident, observations under more normal conditions would have disclosed a number of minor points which have been obscured this year. The object of the present paper is primarily to touch upon the main points in the periodical development of the Plankton of the River Thames.

Detailed investigations of the periodicity of river Plankton as yet scarcely exist, although Schröder has examined the

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Oder to some extent from this point of view, and observations of this kind are at present being carried out on the river Volga (cf. Zykoff, '02, p. 60). With regard to the Oder at Breslau, Schröder ('98, p. 525, '99, pp. 22–23), gives the following data :—

I. December–February :—nothing or exceptionally *Synura* and *Eudorina*.

II. March–May :—*Synedra* and a few brown Flagellates.

III. June–August :—*Asterionella* ; a few green and occasional blue-green forms.

IV. September–November :—*Synedra* and a few brown Flagellates.

During the winter months the only living elements occurring in the Plankton are a few Rotifers, intermingled with large quantities of organic detritus and muddy particles, whilst Algae are almost alone represented by detached portions of filamentous forms. During March *Melosira varians* and *Fragilaria virescens* appear in some quantity, but near the end of the month *Synedra delicatissima* is the most abundant form ; only a few specimens of green Algae (*Chlamydomonas tingens*, *Pandorina morum*, *Eudorina elegans*, and *Volvox minor*) occur, whilst Flagellates are rather commoner at this time of the year (*Synura uvella*, *Uroglena Volvox*, *Dinobryon sertularia* and *Chrysomonas ovata*). In the summer months *Asterionella* plays an exceedingly important part, and is accompanied by a quantity of other Diatoms (*Diatome tenue*, *Fragilaria capucina* and *F. crotonensis*, *Melosira granulata*, *Stephanodiscus Hantzschianus*) ; of the green forms *Actinastrum Hantzschii*, var. *fluviatile*, and *Dictyosphaerium Ehrenbergii*, alone are at all abundant. As the autumn comes on the Plankton again acquires the spring character, and by a decrease in number of individuals gradually merges into that of the winter months.

In the Danube, the Plankton of which has been examined by Brunnthaler ('00, pp. 310–311), the periodicity is somewhat different. In the clear water, occurring during the winter months, life is almost entirely wanting. In February *Synedra*

appears, and at the same time a few individuals of *Melosira*. In the next months *Melosira* and *Fragilaria* increase in numbers, whilst the prevalent *Asterionella* of the succeeding summer months is as yet only slightly represented. In the height of the summer this latter form is accompanied by *Ceratium*, *Dinobryon*, *Clathrocystis*, and *Fragilaria*, in subordinate numbers. With the autumn a decrease in number of individuals again becomes noticeable. Green forms only occur in any considerable amount during the summer months.

To come now to the River Thames (see table), an important difference in contrast to the two rivers just discussed at once appears. There is a well-marked living Plankton all the year round! The Diatoms, which form such a very large percentage of the organic life of the Thames, are always present in appreciable numbers, even though from December to February about two-thirds of the individuals are dead and only represented by an empty frustule. At the same time, however, more or less abundant living representatives of all the species mentioned in the table for these months were observed, and samples, when examined under the microscope, always exhibited a number of live Diatoms in the field of view. This difference in the Thames Plankton as opposed to that of the Oder and Danube may most probably be ascribed to the mildness of our winter in contrast to the continental one; for the sample collected on February 4, 1903 a few days after the cessation of a heavy frost, showed no change in the living element in the river, and it is only rarely that we exceed the degree of cold attained on this occasion. It is easy to understand how a frost of long duration, converting the backwaters and other sources of the river's Plankton into a thick sheet of ice, would reduce the organic life in the river to a minimum by the temporary congealment of the reservoirs, from which it is in the main derived; this is undoubtedly the case with the continental rivers, and it will be interesting to see what effect a protracted frost (of say three to four weeks), as occasionally occurs, will have on the Plankton of the Thames.

The following observations on the periodicity of the Thames Plankton were all made on the stretch of river lying between Teddington Lock and Kingston, and were carried out on seven separate occasions, from October to the beginning of July, at intervals of from one to two months. More frequent visits would have been desirable, but were prevented by the state of the river; unfortunately it is also impossible to undertake any further investigations during this year, and I have therefore added the results of my dredging in July of last year (Fritsch, '02), to complete the table to some extent. These latter were obtained from the river below Teddington Lock, the Plankton of which, however, shows no marked difference from that above the lock. All the samples were taken from the surface-layers only.

In the samples, collected in October, abundant life was still present; in addition to a number of green forms, of which *Pandorina morum* and *Pediastrum Boryanum* were most frequently met with, the Diatoms, *Melosira varians* and *Fragilaria virescens,* were exceedingly common. The three species of *Surirella* and *Stephanodiscus Hantzschianus* are also very characteristic of the Plankton at this time of the year, whilst other rather abundant forms are *Synedra Ulna*, *Nitzschia sigmoidea*, and *Pleurosigma attenuatum.* On the whole it is scarcely possible at this time to point out any one species as preponderating considerably over the others, although perhaps the two filamentous Diatoms are the most striking forms in the samples collected in this month. In December the green and blue-green forms had become exceedingly rare, whilst the Diatoms, as already stated above, although still occurring in appreciable numbers, are to a considerable extent present as empty frustules. *Melosira varians* is still very abundant, whilst *Fragilaria virescens* is less evident, and the species of *Surirella* are decreasing in numbers. The most noticeable point about the Plankton at this time of the year, however, is the appearance of *Asterionella gracillima* in small numbers; no trace of it was observed in the October samples. In February the Plankton practically

Table illustrating periodicity of Thames Plankton[1].

	Oct. 11, 1902; t = 12°C.	Dec. 4, 1902[2]; t = 4·75°C.	Feb. 4, 1903; t = 5·5°C.	Mar. 14, 1903; t = 7·5°C.	May 2, 1903[3]; t = 12°C.	June 3, 1903; t = ?	June 29, 1903[3]; t = 21·5°C.	July 11, 1902[4]; t = 20°C.
I. Chlorophyceae.								
Scenedesmus quadricauda (Turp.), Bréb.	r.	r.	i.	—	i.	—	r.	rc.
Pediastrum Boryanum (Turp.), Men.	rc.	r.	i.	vr.	i.	rc.	rc.	c
,, *pertusum*, Ktz.	rr.	—	—	i.	—	rc.	rr.	c.
,, *pertusum*, var. *clathratum*, Braun	rr.	—	—	—	—	rr.	rr.	—
Chlamydomonas Braunii, Gorosch.	r.	—	—	—	—	rc.	—	—
Eudorina elegans, Ehrb.	rc.	—	—	vr.	—	rr.	r.	r.
Pandorina morum, Ehrb.	c.	—	—	i.	—	—	r.	rc.
Gonium pectorale, Müll.	—	—	—	—	—	—	vr.	—
II. Conjugatae.								
Closterium acerosum (Schrank), Ehrb.	r.	—	—	—	—	—	—	vr.
,, *moniliferum* (Bory), Ehrb.	rr.	—	—	—	—	rc.	—	vr.
III. Bacillariales.								
Coscinodiscus radiatus, Ehrb.	vr.	—	—	—	—	—	—	rc.
Stephanodiscus Hantzschii, Grun.	c.	rr.	rc.	—	—	—	rc.	?
Melosira moniliformis (Müll.), Ag.	rr.	rr.	rc.	rc.	rc.	rr.	r.	rc.
,, *varians*, Ag.	vc.	vc[5].	c[5].	c.	a.	a.	rc.	c.
Campylodiscus noricus, Ehrb.	rc.	rr.	r.	rc.	rc.	rr.	r.	rc.
Surirella biseriata, Bréb.	c.	c.	rc.	rc.	rr.	rr.	r.	rc.
,, *ovalis*, Bréb.	c.	c.	rr.	rc.	rr.	r.	r.	c.
,, *splendida* (Ehrb.), Ktz.	c.	rc.	rr.	rc.	rr.	rc.	r.	r.
Cymatopleura Solea (Bréb.), Sm.	rr.	r.	r.	r.	r.	rr.	—	r.
Cymbella gastroides, Ktz.	r.	rr.	rr.	rr.	—	—	—	rc.
Amphora ovalis, Ktz.	rr.	rr.	rr.	rc.	rr.	rr.	r.	rc.
Fragilaria virescens, Ralfs	vc.	c.	rc.	c.	rc.	rc.	r.	c.
Grammonema spec. (long cell = 16 μ)	rc.	rc.	rc.	r.	—	—	—	—
Pleurostaurum acutum (Sm.), Rabenh.	r.	r.	rc.	rc.	—	—	vr.	—
Synedra Acus, Ktz.	—	—	—	rc.	rr.	rr.	a.	?
,, *Acus*, var. *delicatissima*, Sm.	—	—	—	rc.	rr.	—	c.	—
,, *Ulna*, Ehrb.	c.	c.	rc.	rc.	c.	c.	a.	rc.
Asterionella gracillima, Heib.	—	rc.	c.	r.	—	—	—	—
Nitzschia sigmoidea (Nitzsch), Sm.	c.	c.	c.	rc.	rc.	rc.	r.	rc.
Pinnularia viridis (Ehrb.), Rabenh.	—	—	—	r.	—	—	vr.	—
Pleurosigma attenuatum (Ktz.), Sm.	c.	c.	c.	rc.	rc.	rc.	r.	rc.
,, *Fasciola* (Ehrb.), Sm.	—	—	—	rr.	—	—	—	—
Tabellaria fenestrata, Ktz.	—	—	—	rr.	rr.	r.	—	—
IV. Schizophyceae.								
Microcystis marginata (Men.), Kirchn.	—	i.	—	—	—	—	—	—
Merismopoedia glauca (Ehrb.), Näg.	r.	vr.	—	—	—	—	—	—
V. Flagellatae.								
Euglena viridis, Ehrb.	—	vr.	—	i.	—	—	—	rc.
Phacus pleuronectes, Nitzsch	r.	vr.	—	—	—	—	—	r.
Synura Volvox, Ehrb.	—	—	—	vr.	—	—	rc.	r.

[1] a. = abundant; vc. = very common; c. = common; rc = rather common; rr. = rather rare; r. = rare; vr. = very rare; i. = isolated.

[2] The weather had only just become cold the day before, having been mild and foggy previously; so that not too much stress should be laid on this temperature.

[3] River high and current very strong.

[4] Added in order to complete table as far as possible, cf. text.

[5] With auxospores.

consisted of Diatoms only; the green species, mentioned in the table, were both only observed once, groups of green Pleurococcoid cells being somewhat more frequent. Of the Diatoms observed, about two-thirds of the individuals were dead; *Melosira varians*, *Fragilaria virescens*, and the species of *Surirella*, had decreased very much in amount, whilst *Asterionella gracillima* is far commoner, being very characteristic of the Plankton at this stage. Its reign is apparently short, however, for samples collected in the middle of March showed a very great decrease in the number of individuals of this species; otherwise the Plankton remains very much the same, the two filamentous Diatoms still preponderating over the others. At the same time *Synedra Acus*, var. *delicatissima* is present in sensible numbers (cf. foot-note, p. 637). In May there is no trace of *Asterionella*, whilst *Melosira varians* is present in extreme abundance, large numbers of the chains of this Diatom always lying in the field of view under the microscope; *Fragilaria* is relatively far less abundant. The only other common species is *Synedra Ulna*, the green forms being just as rare as in March. This latter feature may in part be due to the strong current in the river on this occasion, owing to the heavy rains (cf. p. 631). Samples collected a month later (June 3, 1903) showed an increase in the green forms (species of *Pediastrum*, *Chlamydomonas Braunii*, *Closterium moniliferum*), whilst the relative number of individuals of Diatoms occurring is approximately the same as before, *Melosira varians* being by far the most abundant species. In the next month two species of *Synedra* (*S. Ulna* and *S. Acus*, as well as its var. *delicatissima*) develop to an extraordinary extent, *Melosira* being almost lost in contrast to the numerous needles of these species. Two months before we had a *Melosira*-Plankton; in July we have an excellent example of a *Synedra*-Plankton. The green forms are now rather abundant, and *Synura Volvox* is also frequently met with.

Stated briefly, the relative development of the Plankton of the Thames at different times of the year is thus as follows: In October, *Melosira*, *Fragilaria*, *Surirella*, &c., in almost

equal numbers, being accompanied by a development of *Asterionella gracillima* about the time of the New Year; in May a very abundant development of *Melosira varians*, succeeded in the summer months again by a great increase in species of *Synedra*; in the height of the summer and the autumn considerable prevalence of any particular form is not noticeable (according to last year's results, see Fritsch, '02). This periodicity in the course of a year may be summarized thus :—

mixed Plankton (with *Asterionella*-phase) → *Melosira* → *Synedra* → mixed Plankton.

Asterionella, it should be observed, cannot be said to individualize the Plankton to the extent that *Melosira* and *Synedra* do in later months. In the past season, at least, it merely formed a minor phase in the development of the river's Plankton, and the characteristic outward form of this species alone makes its occurrence so striking and readily noticeable; there are probably a number of such minor phases [1], which are not great enough to give a definite stamp to the Plankton, and most of which would be overlooked in the course of a single year's observations (cf. also p. 631).

If we compare the periodicity of the Plankton of the Thames with that of the Oder and Danube, which was mentioned above, it will at once be perceived that, although we have the same dominant forms, their distribution in the different seasons of the year is not at all identical. *Synedra*, which is a spring and autumn form in the two continental rivers, attains its maximum during the summer in the waters of the Thames; whilst *Asterionella*, which plays some part in the winter-Plankton of the latter, abounds in the Oder and Danube during the summer months, a time at which it is not at all or scarcely represented in the Thames. According to Brunnthaler, *Melosira* (but together with *Fragilaria*) abounds in the Danube in spring, that is to say, at the same time as it does in the Thames; apparently this Diatom does not occur

[1] The relative abundance of *Synedra Acus*, var. *delicatissima* in March may possibly turn out to be another such minor phase.

to such an extent as to characterize the Plankton of the Oder at any particular period. *Melosira*, being well provided with chloroplasts, would be likely to be able to assimilate freely before forms like *Synedra*, *Fragilaria*, &c., with far smaller chloroplasts, were capable of doing so, and its great development during the spring months may be explained on these grounds (cf. Zacharias, '99, p. 27). To some extent *Asterionella* and *Synedra* may be said to have exchanged places in the Thames Plankton with regard to that of the continental rivers. It remains to be seen whether other European rivers show the same periodicity as the Oder and Danube, and whether other British rivers will follow the lines of the Thames Plankton. Our present scanty knowledge of the conditions of life of the Plankton of rivers makes it impossible to account for this divergence; it may be that the difference of climate, already referred to above, has something to do with the matter. It does not seem likely that the height of the water at some times during this year will have had any effect on the general features of the periodicity of the Plankton, although the minor points may have been to some extent obscured. From what I have seen I do not consider it impossible that different portions of the river's course, sufficiently distant from one another, may show variations in the periodicity of the Plankton, a point which I hope to examine more carefully next year.

A few points regarding the Plankton of this part of the river still deserve mention. In addition to collecting samples from the main river, on several occasions some were also taken from a side-arm of the river between Tatham's Island and the Middlesex bank. Those taken from this arm in last October contained a number of individuals of *Bacillaria paradoxa*, Gmel., in a healthy condition, the concertina-like movement of the individuals of the colony taking place in rapid succession. This was not the only marine form observed here at the time, *Pleurosigma Fasciola* (Ehrb.), Sm. and *Navicula amphisbaena*, Bory being also represented in small numbers. The peculiar point about their occurrence here is that a diligent search did

not reveal them in the main river itself, although *Bacillaria* was found in samples taken from below the lock at Teddington. Possibly the salinity of the water in the shallow arm is greater than in the main river, although *Pleurosigma Fasciola* was observed in a sample taken from the latter at a later date. The first two of the above-named Diatoms have also been observed by Zacharias ('98, p. 44) in the Unter-Eider (near Rendsburg), the waters of which at this point are of a brackish nature. I have never met with *Bacillaria* before or after in the river. *Stephanodiscus Hantzschianus*, a common constituent of the Plankton in the warmer months and in the autumn, was frequently observed to be provided with numerous elongated needle-like processes at its margin; such have been already described and figured by Schröder ('97, p. 488 and Pl. XXV, Fig. 1), although in the cases observed by me they were relatively far more numerous than Schröder's figures indicate. They undoubtedly serve to heighten the floating capacity of the individual. The individuals of *Nitzschia sigmoidea*, which were very common in some samples, were frequently covered by large numbers of epiphytic specimens of *Amphora minutissima*, whose occurrence in the Plankton is thus due to its attachment to a larger form. Finally the occurrence of *Gonium pectorale* in the samples of June 30 is noticeable, it not having been observed in the river before this.

In the following portion of this paper I propose to give an account of the flora of some of the backwaters of the Thames between Chertsey and Teddington, of which on the whole there is a remarkably small number. I have already previously pointed out (Fritsch, '02, p. 578), that the Plankton such as we find it in the main stream, although capable of a certain amount of multiplication, must to a great extent be stocked from other places, namely from the backwaters and slow-flowing tributaries of the river's course. The presence of these backwaters is of immense importance from the point of view of the fisheries, for it is on the Plankton that the smaller fish, which furnish the food for the larger

ones, must rely for sustenance. Zimmer ('99, p. 7) remarks as follows on this important subject: 'Die verschwindende Planktonmenge eines Flusses kann als Fischnahrung ganz und gar nicht in Betracht kommen. Die Fische, die auf das Plankton des Gewässers als Nahrung angewiesen sind, also namentlich die junge Brut, würden in fliessendem Wasser einfach verhungern, sie müssen sich ihre Nahrung da suchen, wo sie zahlreicher vorhanden ist, d. h. einmal in den Stellen zwischen den Buhnen und dann in den Altwässern und den stromlosen Uferbuchten. Da aber zwischen den Buhnen das Plankton quantitativ immer noch ausserordentlich spärlich auftritt, so können diese Stellen die Altwässer durchaus nicht ersetzen.' This sufficiently indicates the value of the backwaters of a river in relation to the production of fish in the same, and the importance of leaving them undisturbed in their natural condition cannot be sufficiently emphasized. The quantity of individuals in the Plankton of a backwater is in most cases very much greater than that in the main stream, although the number of different species is often less (cf. also Fritsch, '02, p. 584).

(i) *Backwater just below Molesey Lock* (June 3, 1903).

	Head of backwater.	Mouth of backwater.	Main river just outside backwater.
Melosira moniliformis (Müll.), Ag.	rc.	rc.	rr.
„ *varians*, Ag.	c.	c.	a.
Campylodiscus noricus, Ehrb.	rr.	rr.	rr.
Surirella biseriata, Bréb.	rr.	rc.	rc.
„ *ovalis*, Bréb.	rc.	r.	r.
„ *splendida* (Ehrb.), Ktz.	rc.	rc.	rc.
Cymatopleura Solea (Bréb.), Sm.	—	r.	rr.
Amphora ovalis, Ktz.	—	—	rr.
Fragilaria virescens, Ralfs	—	—	rc.
Synedra Ulna, Ehrb.	—	rc.	c.
Nitzschia sigmoidea (Nitzsch), Sm.	rc.	rc.	rc.
Pleurosigma attenuatum (Ktz.), Sm.	—	rc.	rc.
Tabellaria fenestrata, Ktz.	r.	r.	r.
Scenedesmus acutus, Meyen.	rr.	rc.	—
Pediastrum Boryanum (Turp.), Men.	r.	r.	rc.
„ *pertusum*, Ktz.	rc.	rc.	rc.
Chlamydomonas Braunii, Gorosch.	rc.	rc.	rc.
Eudorina elegans, Ehrb.	rc.	rc.	rr.
Closterium acerosum (Schrank), Ehrb.	rc.	rc.	—
„ *moniliferum* (Bory), Ehrb.	r.	r.	rc.

This backwater has a winding course, and penetrates between 100–150 yards into the land up to Hampton Court railway station ; it is deep enough to admit of rowing along its entire length. The banks are fairly thickly wooded, pollard willows being especially common. This is the only case I have as yet observed, in which the Plankton of a backwater is relatively poor as compared with that of the main river[1], although the percentage of green forms present in the former is even here greater. To some extent also there is a difference in the constitution of the Plankton of the backwater and the main stream ; *Synedra Ulna*, which is common in the latter at this time of the year, is entirely wanting in the backwater, as is also the case with *Fragilaria virescens* and *Pleurosigma attenuatum*; on the other hand *Scenedesmus acutus* and *Closterium acerosum* were both only found in the backwater, whilst the other species of *Closterium* is far commoner in the main river. Animals are also considerably more abundant in the backwater. As far as I am aware, the River Mole is in some way connected with this backwater; and the Plankton of the former, except for the occurrence of a number of blue-green forms (*Microcystis marginata*, *Merismopedia glauca*), is quite identical with that of the backwater just discussed, being rich in green forms and poor in Diatoms relative to the main river.

(ii) *Backwater near Sunbury* (May 23, 1903).

This backwater, except in quantity of individuals, differs very slightly from the main river. It is very shallow, and communicates with the stream by means of a short arm about halfway along its length. At this time of the year there is little vegetation in it ; *Nymphaea* is just commencing to appear. It has a rich Diatom flora, green forms in correspondence with the time of the year being rare. Amongst the Diatoms *Pleurosigma Fasciola* and *Asterionella gracillima*

[1] Bacteria were rather abundant in some parts of this backwater, which seems to indicate that refuse of some kind has access to it. This may possibly account for the paucity of its Plankton.

were observed in very small numbers. On the same day a slow-flowing arm a little further down the river was examined; here the green forms were rather more abundant, and in correspondence with this animal life more frequent than in the main stream. *Asterionella gracillima* was again observed here, and even in rather greater quantity than in the backwater; it would thus appear as though some of the forms, which are already wanting in the main stream, manage to maintain their existence for a somewhat longer period in some of the backwaters and slow-flowing arms on the river's course (cf. also the small backwater at Walton, discussed below).

The two backwaters at Walton, except perhaps for the one at Shepperton, are the most typical of those examined this year. The first (the 'Sale') is a broad pond-like arm of the river just below the bridge at Walton; its connexion with the main river is about 5 to 6 yards in breadth, but a very little way inside it broadens out very considerably. It is deep enough to allow of easy rowing, and in part was filled with a growth of *Nymphaea*, &c. In no part of the river was such a diversity of green forms and Flagellates found as here, whilst blue-green forms, curiously enough, were entirely wanting. It is unnecessary to especially mention any of these forms, as they are sufficiently evident from a glance at the following table; the latter also shows how the large majority of them are wanting in the main river. In the case of a form like *Synura Volvox*, which is abundant in the backwater, the entire absence in the river itself is very noteworthy. On the other hand *Gonium pectorale*, which is occasionally met with in the river at this point, was not observed in the backwater. In this latter, however, the first member of Peridineae that I have as yet found in the Thames was observed, but even then only scanty in number of individuals. With regard to the Diatoms, *Melosira* and the two species of *Synedra* are represented in rather equal numbers, whereas the latter are the prevalent forms in the river outside. The almost entire absence of *Campylodiscus noricus* and the species of *Surirella*

in the backwater, as contrasted with their occurrence in the main river, is also of interest.

A little below Walton Bridge on the opposite (Middlesex) side of the river there is a short, very narrow backwater, which, perhaps owing to its origin in a small bay, formed

(iii) *Backwaters at Walton* (July 1, 1903).

	The 'Sale' at Walton Bridge; t = 23°C.	Backwater a little lower down; t = 21·5°C.	Main river at Walton; t = 21·5°C.
Stephanodiscus Hantzschianus, Grun. . . .	rc.	rc.	rc.
Melosira moniliformis (Müll.), Ag.	r.	—	r.
„ *varians*, Ag.	c.	a.	rc.
Campylodiscus noricus, Ehrb.	—	—	r.
Surirella biseriata, Bréb.	—	—	r.
„ *ovalis*, Bréb.	—	r.	rr.
„ *splendida*, Ehrb.	r.	—	rr.
Cymbella gastroides, Ktz.	r.	—	—
Fragilaria virescens, Ralfs	rc.	c.	rr.
Synedra Acus, Ktz.	rc.	rc.	c.
„ *Ulna*, Ehrb.	rc.	rc.	c.
Nitzschia sigmoidea (Nitzsch), Sm.	r.	—	—
Pleurosigma attenuatum (Ktz.), Sm. . . .	vr.	—	vr.
Pleurostaurum acutum (Sm.), Rabenh. . .	rc.	—	—
Scenedesmus quadricauda (Turp.), Bréb. . .	rr.	—	r.
„ *acutus*, Meyen.	r.	—	vr.
Pediastrum Boryanum (Turp.), Men. . . .	rr.	—	r.
„ *pertusum*, Ktz.	rc.	r.	rc.
„ *pertusum*, var. *clathratum*, Braun	rc.	r.	rc.
Eudorina elegans, Ehrb.	rc.	—	—
Gonium pectorale, Müll.	—	r.	r.
Pandorina morum, Ehrb.	rc.	r.	r.
Richteriella polychaete, Fritsch. n. sp.[1] . . .	r.	—	—
Closterium moniliferum (Bory), Ehrb. . .	r.	—	—
„ *Cornu*, Ehrb.	r.	r.	—
„ *acerosum* (Schranck), Ehrenbg. .	vr.	—	—
Staurastrum paradoxum, Meyen.	rr.	—	—
Ceratium cornutum, Clap. et Lachm. . . .	vr.	—	—
Synura Volvox, Ehrb.	c.	r.	—
Dinobryon sertularia, Ehrb.	rc.	—	—
Phacus longicaudus, Dujard.	r.	—	—

[1] This new species is very closely related to *Richteriella botryoides*, Lemm., the only well-marked difference lying in the occurrence of numerous hyaline processes on each cell of the colony; further investigation may show such differences to only warrant the establishment of a variety. Figures and full description will be given in a later publication.

by the river, and its consequent removal from the current, showed a well-marked Plankton of its own. This is chiefly interesting because of the abundance of *Melosira varians* present, which is quite the most prominent form; this backwater as it were is at present in the phase of Plankton-development, found in the main river about two months ago. The *Melosira* completely eclipses the species of *Synedra* in numbers, whilst it is accompanied by a relatively abundant development of *Fragilaria virescens*. Green forms are rare here, some of them not being even as common as in the main river. The main mass of the Plankton of this backwater is thus constituted by Diatoms.

(iv) *Backwater just above Shepperton* (June 6, 1903).

	Backwater; t = 18°C.	Main river; t = 18°C.
Stephanodiscus Hantzschianus, Grun. .	rc.	rc.
Melosira moniliformis (Müll.), Ag. . .	—	rc.
„ *varians*, Ag.	a.	c.
Campylodiscus noricus, Ehrb.	—	rr.
Surirella biseriata, Bréb.	—	r.
„ *ovalis*, Bréb.	—	r.
„ *splendida* (Ehrb.), Ktz. . . .	rr.	rc.
Cymatopleura Solea (Bréb.), Sm. . . .	rr.	r.
Cymbella gastroides, Ktz.	r.	—
Amphora ovalis, Ktz..	r.	r.
Fragilaria virescens, Ralfs	a.	c.
Synedra Acus, Ktz.	rr.	rc.
„ *Ulna*, Ehrb.	rr.	rr.
Nitzschia sigmoidea (Nitzsch), Sm. . .	c.	r.
Pleurosigma attenuatum (Ktz.), Sm. .	r.	rr.
Tabellaria flocculosa, Ktz.	rc.	—
„ *fenestrata*, Ktz.	r.	r.
Scenedesmus quadricauda (Turp.), Bréb.	r.	r.
„ *acutus*, Meyen.	r.	—
Pediastrum Boryanum (Turp.), Men. .	rr.	r.
„ *pertusum*, Ktz..	rc.	rc.
Eudorina elegans, Ehrb..	rc.	—
Pandorina morum, Ehrb.	rc.	—
Richteriella polychaete, Fritsch, n. sp. .	rr.	—
Closterium moniliferum (Bory), Ehrb. .	vr.	—
Synura Volvox, Ehrb.	rc.	—

This backwater is of no very great length, and is sufficiently deep to admit of rowing all along it. The flora shows well-

marked differences from the main river outside ; the Plankton in the first place is very much richer in number of individuals. The Diatom flora is mainly composed of *Melosira varians* and *Fragilaria virescens*, the latter species especially being far commoner here than in the main river. Further, the Plankton of the backwater is characterized by the occurrence of large numbers of splendid specimens of *Nitzschia sigmoidea* (frequently bearing *Amphora minutissima*), which are almost absent from the river itself at this point. Green forms were better represented in the backwater, whilst a number of them (notably *Pandorina morum* and *Eudorina elegans*) were entirely wanting in the Plankton of the river ; however, the relative abundance of the green forms with regard to the main river is not so noticeable in this as in some of the other backwaters. It is the Diatom-flora here, as in the case of the smaller backwater at Walton, that affords the characteristic feature. The Plankton of the Wey, which was cursorily examined on this occasion, does not differ noticeably from that of the Thames at this point, except for a rather frequent occurrence of *Closterium acerosum*.

The most important features of the backwaters are thus :—

(i) Relative abundance of the Plankton in individuals as compared with that of the main stream.

(ii) Relative greater development of green and blue-green Algae and of the fauna, compared with the river itself.

(iii) An often very noticeable difference in the entire specific constitution of the Plankton.

On the whole, though however much the Plankton of the backwaters examined may differ from that of the actual Thames, its nature is still very different from that of the Plankton of a pond, and, so to say, always bears the stamp of a river Plankton. As an example, the results of some dredging carried out on the Brentford Reservoir near Hendon towards the end of October of last year may be mentioned. The chief mass of the Plankton consisted of animals, whilst Diatoms were only represented by a species of *Stephanodiscus* and a few isolated individuals of *Surirella ovalis*. A con-

siderable number of other Algae are common, however, *Clathrocystis aeruginosa* being most abundant. The following other forms were observed:—*Pediastrum Boryanum*, *P. pertusum*, *Scenedesmus quadricauda*, *S. acutus* with vars. *obliquus* and *dimorphus*, *Chlamydomonas Braunii*, *Lemmermannia emarginata*, *Closterium gracile*, *C. striolatum*, *Staurastrum paradoxum*, *Gomphosphaeria aponina*, *Phacus longicauda*.—It seems probable, however, that longer backwaters may at their head show less of the character of a river Plankton than those discussed in the present paper; the backwater at Molesey (see table, p. 640) even showed a greater contrast from the river in the Plankton from its head as compared with that from its mouth.

The following are the main points brought out by the present paper:—

(i) The Thames has a well-marked living Plankton all the year round.

(ii) The periodicity of the Plankton (mixed Plankton—*Melosira*—*Synedra*—mixed Plankton) differs rather markedly from that observed in continental rivers; *Asterionella* forms a minor phase during the winter months.

(iii) The backwaters, although differing very markedly in quality and quantity of the Plankton from the river itself, always bear the stamp of a river Plankton.

It is hoped during the next year to make a more complete study of the periodicity and also of the Plankton of the backwaters of the higher parts of the river's course.

University College, London
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Literature cited.

Brunnthaler ('00): Plankton-Studien, I. Das Phytoplankton des Donaustromes bei Wien. Verhandl. d. k. k. zoolog.-botan. Gesellsch. in Wien, pp. 308–11.

Fritsch ('02): Algological Notes: III. Preliminary Report on the Phytoplankton of the Thames. Annals of Botany, vol. xvi, no. lxiii, Sept., 1902.

Schröder ('98): Planktologische Mitteilungen: Biolog. Centralbl., Bd. xviii, no. xiv, 1898, pp. 525–35.

——— ('99): Das pflanzliche Plankton der Oder: Plöner Forschungsberichte, Teil vii, 1899, pp. 16–24.

Zacharias ('98): Das Potamoplankton: Zoolog. Anzeiger, no. 550, 1898, pp. 42–8.

——— ('99): Ueber die Ursache der Verschiedenheit des Winterplanktons in grossen u. kleinen Seen: Zoolog. Anzeiger, Bd. xxii, nos. 577 and 578.

Zimmer ('99): Das tierische Plankton der Oder: Plöner Forschungsberichte, Teil vii, 1899, pp. 1–15.

Zykoff ('02): Das pflanzliche Plankton der Volga bei Saratow: Biol. Centralbl., Bd. xxii, no. 2, 1902.