

INTRODUCTION TO SURVEYS OF NON-MARINE ALGAE

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ABSTRACT

Early algal investigations in the west of Ireland are reviewed and special mention is given to the important role played by the William West and his son, George West. William West carried out the first survey of the freshwater algae of Clare Island in May 1910 and 1911. The background to his visit and new information based on recently discovered correspondence to William West from Robert Lloyd Praeger are presented. In William West's account of the algae, few collecting sites are mentioned: it may be that West's ill health and the inclement weather at the time of his visits prevented sampling from some important freshwater sites. The current state of his spirit-preserved material in the Natural History Museum, London, is assessed. West records 548 species of freshwater algae from Clare Island, of which three species, eleven varieties and three forms were considered new to science. The current status of these taxa is discussed, but all are regarded as doubtful. Seven field visits have been made to the island during the New Survey of Clare Island, beginning in June 1990.

Introduction

George Stephen West and William West wrote in 1902 that

compared with Great Britain, little is known concerning the Freshwater Algae of Ireland, a country which, in its richness of lakes, bogs and other suitable collecting grounds for these plants, far surpasses all other parts of the British Isles.

The quote is taken from a paper the Wests, father and son, presented in January 1902 at a meeting of the Royal Irish Academy (West and West 1902). It reported the findings of a survey of the freshwater algae of Lough Neagh, Lough Beg and the Upper River Bann that had been supported by a grant from the Fauna and Flora Committee of the Royal Irish Academy. They recorded over 610 species, and a similar number had been found by William West (Pl. I) more than ten years earlier, when he surveyed 'small lakes and moor-pools' in two separate districts in the west of Ireland, the counties of Galway and Mayo in the north-west

and Kerry and Cork in the south-west (West 1892). Despite recording similar numbers, the Wests (West and West 1902) mention that 'the northern counties of Ireland are by no means so rich in Algae as the western and south-western districts'. No doubt these comments were also based on still earlier accounts of Irish algae by O'Meara (1875) and others.

A second grant from the Royal Irish Academy enabled the Wests to collect phytoplankton in some of the more important loughs in the west and south-west of Ireland during May, August and September 1904. These findings were presented to the Academy in February 1906 and were published in its transactions later in the same year (West and West 1906). The Wests mention collecting algae in August 1904 from Lough Keel and Lough Acorrymore on Achill, an island lying about 5km north-north-east of Clare Island and connected by a bridge to the mainland. Two years earlier the Wests published



William West's collection of Clare Island algal samples in the Natural History Museum, London.



Pl. I William West (1848–1914).

the first of a series of five monographs entitled *British Desmidiaceae* (1904–1923; see Williamson, this volume, p. 27). Those volumes published before the Clare Island Survey contained records of desmids from the nearby coastal district of County Mayo (including Westport, Castlebar and Achill Island). All earlier studies of Irish algae were reviewed by Adams (1908) in his *A synopsis of Irish Algae, Freshwater and Marine*. No mention is made by Adams of any records from Clare Island, and William West comments in his 1912 paper (p. 2) that ‘from Clare Island itself and the Louisburgh district I do not know of any previous records.’

The Clare Island Survey

The Wests were the obvious choice of the Clare Island Committee of the Royal Irish Academy when deciding which experts to invite to carry out the survey of freshwater algae. Not only were the Wests the foremost authorities at the time on Irish freshwater algae, but they had also gained international recognition for their work on the desmids of the West Indies, United States, Madagascar and south-east Asia. It is somewhat surprising that William West joined the Clare Island Survey rather than his son, since on his first visit to the island in May 1909 he was

aged 61 and ‘still active but in failing health’ (see Collins 1999, 20).

Some of the correspondence between William West and Robert Lloyd Praeger, the principal organiser and one of the instigator of the Clare Island Survey, have been discovered in the Botany Department at the Natural History Museum in London. In a letter to William West (P. II) Praeger writes that he was ‘Delighted to hear positively that you will help our island work though I am sorry you cannot join the Easter part’. Much of the letter gives details of the planned visits by members of the survey team. It mentions a ‘Miss West’ who is to accompany William West. In his letter Praeger asks

Why would not Miss West go to the island with you? It is a charming place, and if she would sketch the cliff scenery her sketches might be very useful to us. In any case I can get her the reduced fares on which our party will travel in Ireland. I shall remember to collect you some slimy stuff at Easter.

William West did not join the Clare Island Survey team in 1909 and withdrew at a very late stage, to judge from remarks made in a letter sent by Praeger to him on 25 May 1909. In it Praeger writes

I have not got out of the difficulty about May 27; so you need not rush off on that date, but can start on morning of May 28, as you suggest. I presume you will spend that evening in Dublin and start by the mail train at 7 a.m. on the 29th.

There is no question that Praeger expected him to be joining the survey team within the next few days.

According to Praeger’s narrative of the Clare Island Survey (1915, p. 6),

The Fresh-water algae were worked on May 12–22 [1910] by the late William West, who also made valuable collections of Lichens and Bryophytes.

There is no further mention of the aforementioned ‘Miss West’, and a letter sent on 31 May 1910 suggests that West was never accompanied by Praeger on his visit to the island. Praeger writes

I was much interested to have your account of your doings on Clare Island. But extremely sorry to hear that you were not well, and did the work under difficulties. I trust you will not be the worse for your wetting—I know well the long tramp home from the west end, with the rain soaking through one’s back and legs. When your material comes to be

worked out I trust you will be rewarded with some interesting things.

The Clare Island Survey included not just the island but adjoining islands and neighbouring parts of County Mayo. William West therefore not only visited Clare Island but collected (West 1912, 1) 'over the whole of the district, from Achill Island round by Curraun and Westport to Louisburgh and Mweelrea; inland as far as Castlebar'. As mentioned earlier, he spent nine days on Clare Island in May 1910 and had been in ill health during his stay. This is apparent from remarks Praeger made in a letter sent on 31 May 1910 (see above) and in another dated 2 June 1910 in which he writes 'I hope you are feeling all right again now. It was too bad that you were off colour during your trip.' A further ten days were spent on Clare Island in the following May, when his visit coincided with that of three other members of the survey team, W.F. Johnson (insects), N. Arber (geology) and C.J. Patten (birds).

West mentions that during the Clare Island Survey 'hundreds of gatherings' of algae were made from 'as varied habitats as possible' (West 1912, 1) and using information gathered during earlier visits to County Mayo. Besides his own collections he mentions examining samples from others associated with the survey, including Lancelot Bayly, A.D. Cotton, J.W.H. Johnson, R.L. Praeger, L.B. Smyth and G.H. Wailes.

A list of marine diatoms was prepared by William West from samples collected by Arthur Disbrowe Cotton, later to become Director of Kew Gardens in London, who surveyed the marine algae. West was not aware at first that the Clare Island Committee expected him to deal with marine diatoms and therefore mentions in his 1912 paper having collected none 'for the purpose of this Survey' (1912, 1). Diatom preparation and identification is very time-consuming, and no doubt he was dismayed at the thought of all the extra work involved. By the time of his second visit West had agreed to examine the marine diatoms. Praeger mentions in a letter dated 8 December 1910 that

I am very glad to hear that you can do the marine Diatoms for us. I shall send you shortly what material has been collected and we shall arrange later as to the collection of further stuff.

West makes a point of mentioning that 'considerably more than a thousand hours' was spent in the microscopical examination of the samples (1912, 3).

Another group of freshwater algae, the stoneworts or charophytes (Chlorophyta, Order Charales), were collected by Praeger and sent to brothers Henry and James Groves, who were the main authorities on the stoneworts.

Information given in William West's 1912 paper is too imprecise to relocate his collecting sites (Table 1), with the exception of Creggan Lough. It seems very probable that most of his samples were collected from pools and small ponds (see below), the most common and widespread freshwater habitat types on the island. West comments that

At first I made lists from the different divisions of Clare Island; but as I found they were increasing in similarity as work proceeded, I thought it best to merge them into one (West 1912, 3).

The 'divisions' referred to were shown on a map given to all members of the Survey. For further discussion of the reasons for West's failure to give more precise information on his collecting sites, see Williamson's account in this volume.

During the time of the first Survey there were four loughs on Clare Island. West describes an algal 'association' from Lough Avullin, whereas he listed Creggan Lough only as a site under the entries for the desmids *Haplotaenium rectum* var. *rectissimum* and *Cosmarium cucumis*¹. Otherwise no other mention was made of any areas of standing water such as the moorland loughs of Leinapollbauty and Merrignagh, a large pool close to the harbour, or of ponds on Toormore and Loughanaphuca, which at that time was a series of ponds: these were dry in July 1911 (Stelfox 1912). It is difficult to know why West failed to make any mention of these important aquatic sites. Perhaps ill health and inclement weather prevented him visiting as much of the island as he might have wished. It is just conceivable that a few of the sites mentioned (e.g. the top of Croaghmore, Creggan Lough) were sampled on his behalf by other members of the survey team. William West made it very clear that he had little interest in ecology, despite

Table 1
Sampling sites on Clare Island mentioned by West (1912)

Lough Avullin
'pool near the light-house'
'ditch near the chapel'
'fairly aerated water near the hotel'
'small pool on the top of Croaghmore'
'Creggan Lough'

describing several 'loose associations' of algae, which he rather dismissively stated to be 'of some interest in these days of ecology-worship' (1912, 2). These associations take the form of long lists of algae from particular sites (e.g. 'small pool on the top of Croaghmore') growing with an aquatic angiosperm (e.g. *Ultricularia intermedia*) or from a 'gathering' of a filamentous green alga such as *Mougeotia*.

All that survives of William West's spirit-preserved algal samples are 150 variously sized medicine bottles and tubes that are housed in the Department of Botany at the Natural History Museum in London (Frontispiece, p. xi). The collection was discovered at the University of Birmingham in 1957 by the late Robert Ross, then Keeper of Botany, who arranged for them to be transferred to the Natural History Museum. The labels on 98 of the bottles give localities on the neighbouring mainland (all dated 19/10/1911), and only 55 bottles are from Clare Island itself. Of the Clare Island samples, thirty-six are dated 1910 in William West's hand, ten are undated, two are dated '19.4.11' and '4.5.11' with 'Wailles' as the collector, three are dated 22, 23 and 26 February 1911, and five are dated '4.08', without a collector mentioned. 'Wailles' is probably G.H. Wailles, who collected testate amoebae (Rhizopoda) in April and May 1911. Unfortunately, the spirit-preserved samples were not accompanied by any documentation (such as field notebooks), and the labels give little information on the collecting site. The labels are difficult to decipher, but the words 'pool near light-house' and 'sent to George' (a reference to his son, George West) can be made out on a few.



Pl. II Letter sent to West by Praeger on 8 March 1909.

The spirit used to preserve the samples had evaporated by the time West's tubes and bottles were sent in 1957 to the Natural History Museum. In 1959, staff added 5% formalin to the dried samples (P. Sims, pers. comm.), although the original preservative was unknown. The Wests used several preservatives but considered 2% or 3% formalin to be the best (West and West 1909). Only ten bottles contained any liquid preservative when examined for the New Survey of Clare Island. The remainder were dry, with the samples coated in a white deposit. Those containing formalin were examined, and these contained a wide range of algae that could still be identified (e.g. desmids, chlorococcalean algae and diatoms). No attempt was made to revive the dried samples, although these would certainly contain diatoms that could be identified after suitable cleaning. Unfortunately, the digestion of material required for the examination of the silica frustules of diatoms would inevitably result in the destruction of most of the other algae present.

The freshwater algal flora of Clare Island and the neighbouring mainland is very diverse. In his paper West (1912) lists 769 species (230 varieties, 40 forms) of which 57 were new to Ireland and nineteen new to Britain and Ireland. Six species, twenty-seven varieties and seven forms were described as new to science. Of the species mentioned, almost two-thirds are from Clare Island (550 species), and of these three species, eleven varieties and three forms were described as new (Table 2). The last section of his paper lists 118 species of marine diatoms and includes 24 varieties and six forms.

William West's relationship with the editor of the *Proceedings of the Royal Irish Academy* was not always cordial, to judge from a note (partly written in William West's own hand) accompanying an offprint of his 1912 paper in the reprint collection in the Botany Department at the Natural History Museum. He writes (dated July 1912) that proofs for the redrawn plates 'were not submitted [to him] or they would have been rejected.'

William West died in 1914, just three years after his last visit to the island, and was therefore one of several members of the Clare Island Survey who never lived to see publication of the full report in 1915. His son, George West, is known to have suffered from ill health and

Table 2
New species and subspecies described by West in 1912 based on material from Clare Island and two mainland localities. See comments on pp 87, 88, 154, 158 and 162 concerning the current status of some of these taxa

Phylum Chlorophyta	Phylum Bacillariophyta
Order Chlorococcales	Order Pennales
<i>Pediastrum boryanum</i> var. <i>productum</i>	<i>Stauroneis anceps</i> var. <i>lata</i>
'Var. processibus cellularum externarum perlongis, multe longioribus quam latitudo cellulae et non capitatis.'	'Var. cellulis diametro 3-plo longioribus, 60 × 20µ. A marked variety, as the type is 4½ times as long as broad.'
<i>Reinschiella curvata</i>	<i>Stauroneis phoenicenteron</i> f. <i>producta</i>
'R. cellulis solitariis, libere natantibus, late lunatis, margine interiori concavo, apicibus acutis, spina brevi extrorsum curvata praeditis, long. Sine spin. 38µ, lat. 2µ, long, spin. 5–6µ.'	'F. cellulis minoribus et apicibus distincte productis, 81 × 18.2µ average size, some only 73 × 15µ.'
Order Zygnematales	<i>Navicula peregrina</i> var. <i>producta</i>
<i>Closterium toxon</i> var. <i>validum</i>	'Var. polis distincte productis, cellulis latioribus quam in forma typical. Formae majores 118–119 × 37.5µ formae minores 71 × 29µ.'
'Var. cellulis duplo crassioribus quam in forma typica, 250–260 × 17.5–20µ.'	Phylum Cyanobacteria
<i>Closterium pronum</i> f. <i>brevius</i>	Order Oscillatoriales
'Cellulis semper distincte brevioribus, 222–250 × 8.4–9µ.'	<i>Lyngbya cliarensis</i>
<i>Cosmarium anceps</i> var. <i>tatricoides</i>	'L. filis singulis libere natantibus, rectis vel subrectis, 11.5–12.0µ lat., rigidis, vaginis hyalinis et crassis, 1.7µ crassitudine, trichomatibus coeruleo-aerugineis, contentu granulis sparsis, 6–6.7µ lat. articulis valde inequalibus, diametro semper longioribus, 9–24µ long.'
'Var. cellulis relative latioribus, cum isthmo ancipitis sed forma tatrici, cytodermate glabra. C[Clare Island], 33 × 21µ.'	Order Nostocales
<i>Cosmarium depressum</i> var. <i>minor</i>	<i>Anabaena flos-aquae</i> var. <i>minor</i>
'Var. cellulis minoribus, long. 25µ, lat. 26µ, also 24.1 × 25µ. Cr[near Castlebar]; C[Clare Island], a wider form 23.3µ long, 31µ wide.'	'Var. ut in forma typica sed latitudine cellularum 2.5–3µ, heterocystis 3.5–4.5µ.'
<i>Cosmarium subtumidum</i> var. <i>minor</i>	Order Chroococcales
'Var. cellulis minoribus quam in forma typica, 26 × 20µ.'	<i>Synechococcus aeruginosus</i> f. <i>angustior</i>
<i>Netrium oblongum</i>	'F. cellulis relative angustioribus, circiter 25 × 10µ.'
var. <i>angustatum</i>	<i>Microcystis minutissima</i>
'Var. cellulis distincte angustioribus quam in forma typica, 123 × 23µ',	'M. cellulis oblongis et confertis, aerugineis, post divisionem subrotundatis, 0.8–1µ latitudine (interdum 1.2µ), 1.1–1.5 longitudine (interdum 2µ); familiis irregularibus in margine, circiter 40–140µ (interdum majoribus), tegumento hyalino. Hab.-in locis paludosis libere natans. C[Clare Island], SL [Sraheens Lough, Achill Island], VL[Valley Lough, Achill Island].'
var. <i>brevius</i>	
'Var. cellulis diametro 3½-plo longioribus. C[Clare Island], 86 × 35µ, also 86 × 25µ in another locality.	
<i>Staurastrum polymorphum</i> var. <i>pusillum</i>	
'Var. multe parvior, processibus gracilioribus et subinflexis, forma corporis ut in forma typica. C[Clare Island], 18–18.5µ long.'	

that might be a reason why his father joined the Clare Island Survey rather than himself. One of the reasons why the final volume of the *British Desmidiaceae* (West *et al.* 1923) was not published in the lifetime of the Wests was because George West was unable to complete the illustrations due to a 'nervous illness'. The mediocre quality of the illustrations in William West's 1912 paper might be because he had to draw the algae himself rather than rely on his son. George West

only survived his father by five years, succumbing to the influenza epidemic of 1919.

The New Survey of Clare Island

The New Survey of Clare Island's freshwater algae survey began almost 80 years after William West's last visit to the island. On the first visit in 1990 (21–26 June 1990) the freshwater algae were sampled at thirty-six sites selected to be representative of the full range of freshwater habitats

present on the island. As indicated earlier, information on sampling sites given by West in 1912 was too vague and imprecise for a detailed sampling programme to be planned in advance of the field visit.

The first report on the freshwater algae of Clare Island since West's time was submitted to the Royal Irish Academy in 1990 (John *et al.* 1990). About 250 species of freshwater algae are listed in the report: of these 74 species are new records for the island (33 are diatoms and 41 belong to other groups). On that occasion diatoms were the most diverse group sampled (115 species) and

were closely followed by the green algae (106 species).

Six further visits have been made to Clare Island since the formal launch of the New Survey of Clare Island in 1991 (Table 3). On each occasion many of the sites visited in June 1990 were revisited, together with many new sites. Due to heavy rainfall in May 2002 it was impossible to resample many stream and river sites since these flowing waters were in flood. One pond site sampled in September 2001 (Site 34) had been in-filled by the following year. During surveys carried out in 2001 and 2002,

21–26 June 1990	D.M. John, P.A. Sims, J.E. Bryant, M.D. Guiry
16–21 September 2001	D.M. John, P.A. Sims, J.E. Bryant, M.D. Guiry, F. Rindi
21–24 May 2002	D.M. John, P.A. Sims, F. Rindi
10 September 2002	F. Rindi
19–20 March 2003	F. Rindi
21–25 July 2004	B.A. Whitton, F. Rindi
26–27 September 2005	D.M. John, F. Rindi

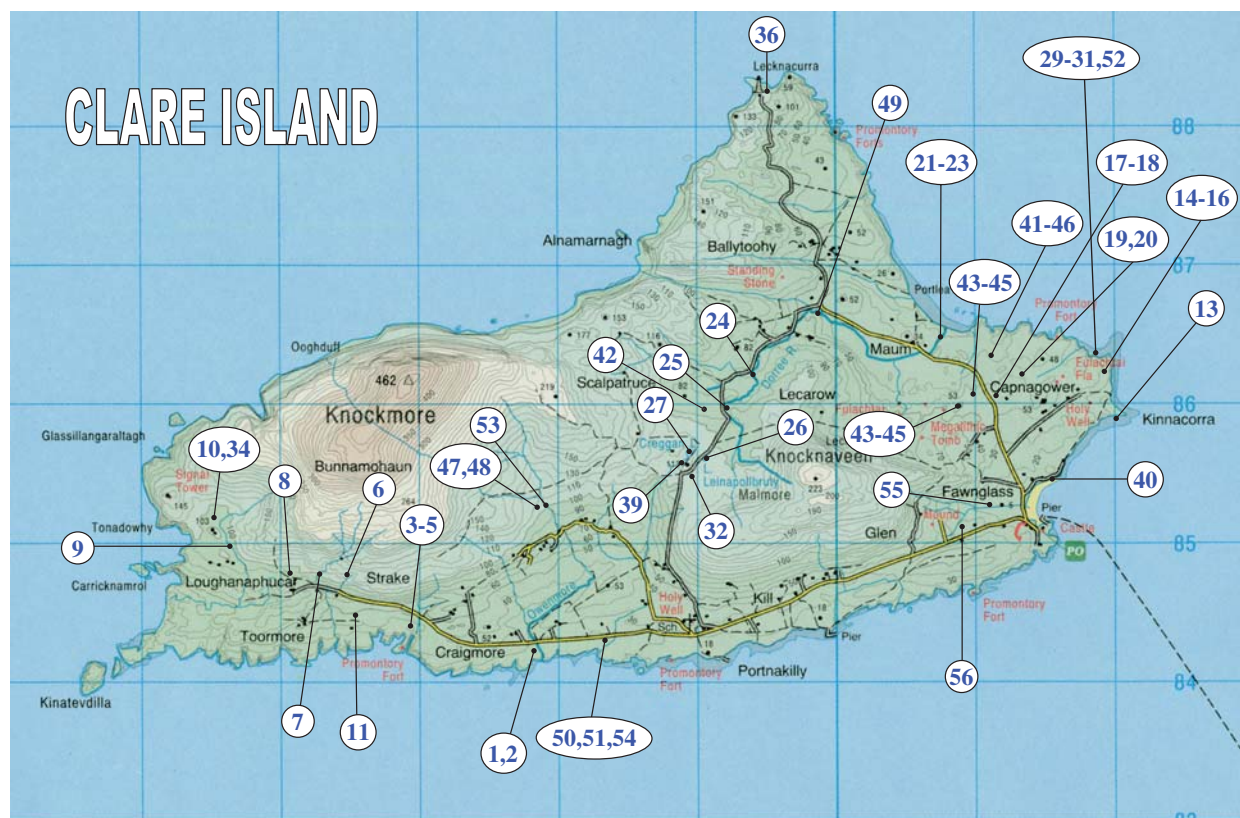


Fig. 1 Map of Clare Island showing the principal sampling sites. See Table 4 for details of individual sites and Whitton (this volume, table 2, p. 145) for information on sites sampled by him in June 2004.

Table 4

The majority of sites sampled on Clare Island from June 1990 to July 2004. Additional sites are listed by Whitton (this volume, table 2, p. 145) and most of those mentioned by Rindi and Guiry (this volume, pp 180–181) are sites for subaerial algae. All sites sampled in 1990 (Sites 40–54) and the main sites first sampled in 2001/2002 are shown in Fig. 1.

Site No.	Latitude ¹	Longitude ¹	Locality	pH ²	Remarks
1	53° 47.505N	09° 59.868W	Owenmore River	7.8, 7.6, 7.56*	50m downstream of road
2	53° 47.470N	09° 59.943W	Owenmore River	8.2, 7.6, 7.56*	Area of pools and waterfalls
3	53° 47.487N	10° 00.363W	Unnamed stream	8.2, 7.5	20m downstream, waterfalls present
4	53° 47.457N	10° 00.335W	Unnamed stream	8.2, 7.5	60m downstream of bridge
5	53° 47.429N	10° 00.331W	Unnamed stream	8.2, 7.6	250m downstream of bridge
6	53° 47.667N	10° 01.670W	Small stream	8.2, 7.6	Uphill side of road, includes waterfall
7	53° 47.693N	10° 01.820W	Small stream	8.2, 7.6, 8.0*	Uphill side of road, includes waterfall
8	53° 47.737N	10° 01.990W	Small stream and peaty bank	4	<i>Sphagnum</i> along bank
9	53° 47.882N	10° 02.427W	'Western' stream	7.2	About 3m wide, <0.5m deep
10	53° 47.864N	10° 02.392W	Peat bog, boggy pool	7.5, 6	<i>Sphagnum</i> -dominated
11	53° 47.484N	10° 01.022W	Shallow, peaty pools	7.5, 6.9	<i>Isoetes</i> -lined pools
12	53° 47.584N	09° 59.098W	Ditch beside road		<i>Rorripa</i> , masses of green filaments
13	53° 48.448N	09° 56.627W	Pool behind storm beach	7.4, 6.4	Probably brackish
14	53° 48.598N	09° 56.656W	Cliff seepage area		Brownish-green filamentous masses
15	53° 48.586N	09° 56.653W	Cliff seepage area		Brownish hemispherical colonies, etc
16	53° 40.574N	09° 86.657W	Cliff seepage area	7.5	Green filamentous masses
17	53° 40.558N	09° 57.465W	Boggy pool, abandoned turf cutting	8.3, 7.1	<i>Chara virgata</i> , <i>Scirpus</i> , etc.
18	53° 48.562N	09° 57.403W	Seepage area	5.1	Area lined by <i>Sphagnum</i>
19	53° 48.630N	09° 57.385W	Moorland pool, abandoned turf cutting	6.4	Green filamentous masses
20	53° 40.663N	09° 57.385W	Moorland pool, abandoned turf cutting	5.8	<i>Sphagnum</i> -dominated
21	53° 48.661N	09° 57.826W	River Dorree	6.6, 6.6	Rocky bed
22	53° 40.723N	09° 57.761W	River Dorree	6.6, 6.6	Boulder-dominated wider reach
23	53° 48.748N	09° 57.750W	River Dorree	6.6, 6.6, 7.55*	Waterfall and boulder stretch
24	53° 48.723N	09° 58.740W	River Dorree, bridge	6.5, 6.9	Sill covered by green filamentous algae
25	53° 48.633N	09° 58.970W	River Dorree	7, 7.1	Narrow bed, surrounded by moorland
25A	53° 48.400N	09° 59.184W	River Dorree	7, 7.1	Swift-flowing, <i>Nitella flexilis</i>
26	53° 48.216N	09° 52.286W	Lough Leinapollbauty	7.5, 7.1, 7.3*	<i>Scirpus</i> - and <i>Potamogeton</i> -dominated
27	53° 48.251N	09° 59.420W	Creggan Lough	6.3, 7.2, 7.1*, 7.3*	<i>Menyanthes</i> - and <i>Potamogeton</i> -dominated

(continued)

Table 4 (continued)

Site No.	Latitude ¹	Longitude ¹	Locality	pH ²	Remarks
28	53° 48.231N	09° 59.437W	Boggy pool,	4.2, 4.6	<i>Sphagnum</i> -dominated
29	53° 48.653N	09° 56.701W	Pool, point from Lacknacram-Inahastalla	9.2, 8.1	Shallow and brackish
30	53° 48.621N	09° 56.721W	Cliff seepage area	8.2	Green filamentous masses
31	53° 48.646N	09° 56.694W	Cliff seepage area, shaded		Upper seepage area
32	53° 48.229N	09° 59.362W	Boggy <i>Sphagnum</i> -dominated pool	4.9, 4.71*	On hill between the two loughs
33	53° 47.789N	10° 02.341W	Seepage area by side of road		
34	53° 47.906N	10° 02.450W	Small pool with aquatic macrophytes		
35	53° 49.344N	09° 58.923W	Bank of small stream		Beside road, c. 0.5km from lighthouse
36	53° 49.599N	09° 50.091W	Small pool filled with emergent aquatics		Beside lighthouse
37	53° 49.433N	09° 59.952W	Seepage area in ditch		Ditch beside road to lighthouse
38	53° 48.610N	09° 57.692W	Turf cutting pools		Beside road, seemingly polluted by sheep
39	53° 48.577N	09° 57.430W	Turf cutting pool		Close to Creggan Lough
40			Seepage area influenced by spray		Close to 'Bay View' hotel
41, 42, 46			Bog pools dominated by moss	4.1–6.9	
44, 45			Bog pools dominated by emergent aquatics	6–8.3	
47, 48			River Owenmore	7.2–8.4	Near source and upper middle stretch
49			River Dorree	6.5	Middle stretch, not sampled in February 2001
43			Unnamed stream	7.7	Not sampled in February 2001
50			Pool in hoof print	7.7	Not sampled in February 2001
51			Water-filled trough, fed by field drainage.	8	Not sampled in February 2001
52–54			Subaerial, not influenced by sea spray		
55	53° 48.073N	09° 57.217W	Small stream, brackish	7.1	Diatom samples
56	53° 48.009N	09° 57.400W	Small pond	7.8	Flocculent surface masses; diatom samples

¹ Coordinates were measured using GPS in 2001 and 2002.

² pH was measured during visits in 1990, 2001 and 2004; electrical conductivity was measured in 2004 (this volume, table 1, p. 144, table 2, p. 145).

* measurements taken during visits in 1990, 2001 and 2004.

over 130 samples were collected and a total of 41 sites visited. All freshwater sites sampled during these surveys are shown in Fig. 1, and further details are given in Table 4. Some of these sites were revisited in July 2004 by

Brian Whitton and again in September 2005 by Fabio Rindi and the author. Details of the one hundred samples collected by Brian Whitton are given in Whitton (this volume, table 2, p. 145).

NOTE

1. For nomenclatural authorities, see individual chapters.

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