THE PROTOZOA OF SOME EAST GREENLAND SOILS

By A. DIXON

From the Department of General Microbiology, Rothamsted Experimental Station

1. Introduction

A series of soil samples illustrating stages of plant colonization was collected by Dr and Mrs H. G. Wager on the British East Greenland Expedition (**2**) in the summer of 1936 from Kangerdlugssuak, Lat. 68° 30′ N.

Previous work on the Protozoa of Greenland soils was done by Sandon (**3**) who examined nine samples collected by Dr Morten Porsild at Disko in the neighbourhood of the Danish Arctic Station. His samples were a variety of types, including among them two black peaty soils. On the whole, these samples were rather poor in Protozoa, and in some respects their distribution was unexpected, e.g. one heath soil yielded 15 species of Protozoa—more than soils which were supporting a more luxuriant vegetation.

Sandon's findings show that the climatic conditions do not make the soils of this region unsuitable for the development of Protozoa, since, among these samples, a garden soil enriched every year with poultry manure yielded 46 species, this being the highest number in any of the samples from his world's survey. This garden sample was very rich in Ciliates and Flagellates, but the high numbers were not made up by the testaceous Rhizopoda, as is the case in the soils described here.

The British East Greenland Expedition's samples were taken to a depth of 4 in. and placed in sterile jars which were subsequently sent to Rothamsted for an examination of the protozoan fauna. The observations made were only qualitative, since the time taken in transport precluded any useful quantitative work.

Four media were used for cultivating the Protozoa: peptone agar, soil extract agar, soil extract and hay infusion, and the cultures were kept under observation for four weeks (**1**).

2. Description of samples

The soils are listed according to the stage of plant colonization. With two exceptions, all of them were collected in the region of Kangerdlugssuak, the base of the expedition. The remaining two samples were peaty soils collected

from Angmagssalik about 200 miles farther south. The numbers of species of Protozoa found in each sample are shown in Table 1.

Table 1. *Number of species of Protozoa occurring in each sample*

No. of sample	Rhizopoda		Flagellata	Ciliata	Total Protozoa
	Nuda	Testacea			
6	2	0	3	0	5
4	1	3	5	2	11
9	5	4	8	1	18
1	2	5	9	3	19
8	3	3	8	0	14
2	7	15	9	10	41
5	6	15	6	5	32
7	5	13	7	7	32
3	9	12	10	11	42
10	10	12	13	7	42
1A	4	8	7	3	22
2A	8	16	10	3	37

Sample 6, 10 August. A dry moraine soil near Miki Fjord, *p*H 7·0, stony and grey in colour and showing the first stages of plant colonization. The soil was damp below 1·5 in., though the surface was dry. A few adult plants were scattered about it at wide intervals, also many seedlings which never matured. The following plants were commonly found: *Luzula spicata*, *L. arcuata*, *Trisetum spicatum*, *Oxyria digyna*, *Saxifraga cernua*, and *S. caespitosa*. Only five species.

Sample 4, 11 July. A deposited glacial silt near Miki Fjord, *p*H 6·8, which came from a platform of rock at the base of the moraine mentioned above and forms another early stage in plant colonization. The locality was very wet and the vegetation consisted of *Salix glauca*, *S. herbacea*, *Saxifraga cernua*, *S. oppositifolia* and moss. Eleven species.

Sample 10, 17 August. Soil from just below the largest ruined house of the Skaergaard Peninsula Eskimo settlement, inhabited 150 years ago, *p*H 5·2. This was a dry warm position with a fairly typical vegetation: *Saxifraga cernua*, *Oxyria digyna*, *Draba alpina*, *Erigeron uniflorus*, *Cerastium alpinum*, *Trisetum spicatum*, *Poa glauca*, etc. Forty-one species.

Sample 9, 14 August. Soil consisting of river sand and plant remains, *p*H 5·6, taken from a small, damp plateau, where the soil was frozen from September to the end of May and was boggy in between. The flora on this site included *Salix herbacea* and *Ranunculus glacialis* in great profusion, and *Oxyria digyna*. Eighteen species.

Sample 1, 7 June; *Sample* 8, 11 August. A dark brown soil from red gabbro rock with vegetable remains, *p*H 5·8. In the spring, when sample 1 was taken, the snow had just melted and the soil was wet and the nearby rocks were green with algae. When sample 8 was taken, however, after two months of hot weather, the soil was dry; the flora here was composed mainly of *Salix glauca*, *Erigeron uniflorus*, *Luzula spicata*, mosses and lichens. Nineteen species in sample 1 and thirteen in sample 8.

Sample 2, 12 June; *Sample* 5, 19 July; *Sample* 7, 11 August. A rich vegetation on Thermometer Hill, *p*H 6·2. This position was 180 ft. above sea-level, facing south, and was under a deep snowdrift all the winter. When sample 2 was taken the soil had been exposed for about ten days but was very damp; on the two later dates it had dried. The vegetation was dense, consisting of a mat of *Salix glauca*, *Empetrum nigrum* and *Vaccinium uliginosum* var. *microphyllum*. In sample 2, 40 species and 30 in each of samples 5 and 7.

Sample 3, 10 July. A very rich vegetation site on the lower banks of Miki Fjord, *p*H 5·6. The soil had dried after the melting of the snow and was completely covered with rich vegetation. Among the numerous plant types found were: *Alchemilla alpina*, *A. glomerulans*, *Erigeron uniflorus*, *Cerastium alpinum*, *Veronica fruticans*, *Bartsia alpina*, *Gentiana nivalis* and *Tofieldia palustris*, with patches of *Salix glauca*. There were 43 species.

The soils from Kangerdlugssuak and Miki Fjord showed a transition from moraine to a type of soil composed chiefly of plant remains, which had a peat-like appearance. The only true peats were collected at Angmagssalik on 21 August:

Sample 1A, *p*H 4·8, from the bank of the main river. The vegetation was plentiful (consisting of *Campanula rotundifolia*, *Luzula spicata*, grasses, sedges and *Chamaenerium* spp., etc.) and was a typical herb field of the district. The Protozoa, 22 species in all, were characteristic of peat.

Sample 2A, in the same region, from a peat bog of a depth of at least 4–5 ft., *p*H 4·8. The vegetation was characteristic, mainly *Carex rigida*, *Eriophorum Scheuchzeri*, also *Sphagnum* and other mosses. The sample was taken from the top of a peat hag. This site would always be damp, except when it was actually frozen, as the water table was probably 5–6 in. below the level at which the sample was taken. The protozoan fauna was very rich: 39 species.

3. Protozoa present in the soils

The species of Protozoa found in each soil are recorded in Table 2.

All the amoebae found have been previously recorded from soil; it is perhaps worthy of note that *Hartmanella hyalina* and *Naegleria gruberi*, both very common soil forms, were less widely distributed in these samples than previous work would have led one to expect. The dominant species were *Amoeba actinophora*, *Amoeba* α, which was common in seven of the soils, and *Amoeba radiosa*. The last is probably not a true species and is usually regarded as being a stage in the life history of more than one species of amoeba.

The testaceous Rhizopoda were absent from or scanty in the five soils where the vegetation was sparse, but in samples 2, 3, 5 and 7 where the vegetation was rich they were abundant. They also occurred freely in sample 10; this soil, however, is not strictly comparable with the others since there was an increased nitrogen content at this site owing to the previous presence of men and animals.

Table 2.

Soil Protozoa	Samples 1	2	3	4	5	6	7	8	9	10	1A	2A
Rhizopoda nuda												
Amoeba a Sandon	+	+	+	.	+	.	.	.	+	.	+	+
A. verrucosa Ehrbg.	.	.	+	.	+	.	.	.	.	.	.	.
A. diploidea Hartmann & Nägler	.	.	.	.	.	.	+	+	.	+	.	.
A. striata Penard	.	.	+	.	.	+	.	.	.	.	+	+
A. actinophora Auerb.	.	+	+	.	+	+	+	+	+	+	+	+
A. alveolata Mereschk.	.	.	.	.	.	.	.	+	.	+	.	+
A. annulata Penard	.	+	+	.	.	.	.	.	.	+	.	.
A. albida Nägler	.	.	+	.	.	.	.	.	.	.	.	.
A. fluida Gruber	.	+	.	.	.	.	.	.	.	+	.	+
A. radiosa Ehrbg.	.	+	+	.	+	.	+	.	+	+	.	+
A. vespertilio Penard	.	.	.	.	+	.	.	.	.	.	.	.
Naegleria gruberi (Schardinger) Wilson	+	.	.	.	.	.	.	.	.	+	.	+
Hartmanella hyalina (Dang.) Alex.	.	+	.	.	+	.	+	.	.	+	+	.
Biomyxa vagans Leidy	.	+	+	.	.	.	.	.	.	+	.	.
Nuclearia simplex Cienk.	.	.	.	+	.	.	.	.	+	.	.	.
Acanthocystis aculeata Hertw. & Less.	.	.	+	.	.	.	+	.	+	.	.	+
Actinophrys sol Ehrbg.	.	.	.	.	.	.	.	.	.	+	.	.
Rhizopoda testaceous												
Arcella vulgaris Ehrbg.	.	.	.	.	.	.	.	.	.	.	.	+
Pseudochlamys patella Clap. & Lachm.	.	.	.	.	.	.	.	.	.	+	.	.
Difflugia oblonga Ehrbg.	.	.	.	.	+	.	.	.	.	.	.	.
D. globula Ehrbg.	+	+	+	.	+	.	+	.	.	+	+	+
D. constricta (Ehrbg.) Leidy	+	+	+	.	+	.	+	.	+	+	+	+
Cryptodifflugia eboracensis Wailes	.	.	.	.	+	.	+	.	.	.	+	+
Nebela collaris (Ehrbg.) Leidy	.	.	.	.	.	.	.	.	.	.	.	+
N. dentistoma Penard	.	+	.	.	.	.	.	.	.	.	.	.
Hyalosphenia minuta Cash.	.	.	.	.	+	.	.	.	.	.	.	.
Heleopera sp. Leidy	.	.	.	.	.	.	.	.	.	.	.	+
Cochliopodium bilimbosum Auerb.	.	+	+	.	+	.	+	.	.	+	.	+
Euglypha tuberculata Duj.	.	+	+	.	+	.	+	+	.	+	+	+
E. rotunda Wailes	.	+		.	+	.	+	.	.	.	.	.
E. laevis Ehrbg.	.	+	+	.	+	.	+	.	.	+	+	+
Assulina seminulum (Ehrbg.) Leidy	.	+	.	.	+	.	+	.	+	.	.	.
Trinema enchelys (Ehrbg.) Leidy	+	+	+	+	.	.	+	+	.	+	.	+
T. lineare Penard	+	+	+	.	+	.	+	+	+	+	+	+
T. complanatum Penard	.	+	+	.	+	.	+	.	.	+	.	.
Corythion dubium Paranek	+	+	+	.	.	.	.	.	+	+	+	+
C. pulchellum Penard	.	+	+	.	.	.	.	.	.	.	.	+
Sphenoderia lenta Schlumb.	.	+	+	.	+	.	+	.	.	+	.	+
Lecythidium hyalinum Ehrbg.	.	.	+	+	.	.	+	.	.	+	.	.
Pseudodifflugia fulva (Archer) Penard	.	+	.	.	.	.	.	.	.	.	.	.
P. gracile Schlumb.	.	.	.	+	+	.	.	.	.	.	+	+
Microgromia levipes Penard	.	.	.	.	+	.	.	.	.	.	.	+
Mastigophora												
Cercomonas crassicauda Alex.	+	+	+	+	+	+	+	+	+	+	+	+
C. longicauda Stein	+	.	.	+	.	.	+	.	+	.	.	+
Cercobodo agilis Moroff	+	.	+	.	.	.	.	.	+	.	.	.
Helkesimastix faecicola Woodc. & Lap.	.	+	.	.	.	.	.	.	+	.	.	.
Mastigamoeba sp. F. E. Schultze	.	.	.	.	.	.	.	.	.	+	.	.
Monosiga ovata Kent	.	.	.	.	.	.	.	.	.	.	.	+
Phalansterium solitarium Sandon	.	.	.	.	.	.	.	.	.	+	.	.
Bodo celer Klebs.	.	+	.	.	.	+	.	+	.	+	.	.
B. edax Klebs.	+	.	+	.	+	.	+	.	.	.	+	+
B. saltans Ehrbg.	.	.	.	.	.	.	+	.	.	.	+	+
Heteromita globosa Stein	+	+	+	+	+	+	+	+	+	+	+	+
Spiromonas angusta (Duj.)	.	.	+	.	.	.	.	.	.	.	.	.
Sainouron mikroteron Sandon	+	+	+	+	+	+	+	+	+	+	+	+
Allantion tachyploon Sandon	.	+	.	+	.	.	.	+	.	+	+	+
Proleptomonas faecicola Woodcock	.	.	.	.	.	.	.	.	.	+	.	.
Tetramitus spiralis Goodey	+	+	.	.	.	.	.	.	.	+	.	+

Table 2 (*continued*)

Soil Protozoa	Samples 1	2	3	4	5	6	7	8	9	10	1A	2A
Mastigophora (*cont.*)												
Oikomonas termo Ehrbg.	+	+	+	+	+	+	+	+	+	+	+	+
Scytomonas pusilla Stein	.	.	+	.	.	.	.	.	.	.	.	.
Anisonema minus Sandon	.	.	+	.	.	.	.	.	.	.	.	.
Entosiphon sulcatus (Duj.) Stein	+	+	+	.	+	.	.	+	+	+	.	.
Astasia sp. Duj.	.	.	.	.	.	.	.	.	.	+	.	.
Hexamitus inflatus Duj.	.	.	.	.	.	.	.	.	.	+	.	.
Ciliata												
Holophrya ovum Ehrbg.	.	.	.	.	.	.	.	.	.	+	.	.
Enchelys farcimen Ehrbg.	.	.	+	.	.	.	+	.	.	.	.	.
Lionotus lamella Ehrbg.	.	+	+	.	.	.	.	.	.	.	.	.
Colpoda cucullus O.F.M.	.	.	.	.	+	.	.	.	.	.	.	.
C. steinii Maupas	.	+	+	+	.	.	+	.	.	.	+	.
Microthorax sulcatus Englm.	.	+	.	.	.	.	.	.	.	.	+	+
Cinetochilum margaritaceum Py.	.	+	.	.	+	.	+	.	.	+	.	+
Pleuronema chrysalis Ehrbg.	+	+	.	.	.	.	.	.	+	.	.	.
Balantiophorus elongatus Schew.	.	.	+	+	+	.	+	.	.	+	.	.
B. minutus Schew.	+	+	+	.	+	.	+	.	.	+	+	.
Blepharisma sp., Py.	.	+	+	.	.	.	.	.	.	.	.	.
Strombidium gyrens Stokes	+	.	.	.	.	.	.	.	.	.	.	.
Uroleptus musculus Ehrbg.	.	.	+	.	.	.	.	.	.	.	.	.
U. mobilis Englm.	.	+	.	.	.	.	+	.	.	+	.	.
Gonostomum affine Stein	.	.	+	.	.	.	.	.	.	.	.	.
Oxytricha pellionella O.F.M.	.	.	.	.	.	.	.	.	.	+	.	.
Pleurotricha lanceolata Ehrbg.	.	+	+	.	+	.	.	.	.	+	.	.
Stichotricha secunda Py.	.	.	.	.	.	.	+	.	.	.	.	+
Vorticella microstoma Ehrbg.	.	+	+	.	.	.	.	.	.	.	.	.
V. striata Duj.	.	.	+	.	.	.	.	.	.	.	.	.

Of the two peat soils, sample 2A showed a large population of testaceous Rhizopods, while sample 1A yielded lower numbers; these results suggest that the amount of organic matter in the soil, rather than the *p*H value, was the factor controlling the distribution of the Protozoa of this group.

The Flagellates obtained from these soils were species common to most soils, as for example, *Cercomonas crassicauda*, *Heteromita globosa*, *Oikomonas termo*, *Sainouron mikroteron* and *Allantion tachyploon*. These were recorded for almost every sample. *Entosiphon sulcatus*, though only occasionally found in soils, appear to be more common in these Greenland samples, as it was found in seven of them. *Bodo edax* occurred in six samples and *B. celer* in four. The other Flagellates recorded were only found in one or two samples (see Table 2).

In the case of the Ciliates no particular species can be described as typical of these soils. The ones found most commonly were *Balantiophorus minutus*, *B. elongatus*, *Colpoda steinii*, *Cinetochilum margaritaceum*, *Pleurotricha lanceolata* and *Uroleptus mobilis*, which are all usual soil types. *Colpoda cucullus*, one of the commonest of soil Ciliates, was only found in one soil.

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5. Summary

1. Soil samples from Kangerdlugssuak in East Greenland were examined.

2. The highest number of species of Protozoa occurred in soils producing the richest vegetation.

3. An unusually large number of species of testaceous Rhizopods occurred in non-peaty soils.

4. A large protozoan population was present in soils frozen for nine months of the year.

References

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