Acta Protozool. (2006) 45: 65 - 75

ACTA
PROTOZOOLOGICA

The Moss Dwelling Testacean Fauna of the Strømness Bay (South Georgia)

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Summary. The study of 22 aquatic and 36 terrestrial moss samples of the Strømness Bay (South Georgia, sub-Antarctica) revealed 71 testate amoebae taxa (Protists) belonging to 21 genera. Twenty-eight taxa were reported for the first time, which resulted in a total of 87 testate amoebae taxa observed from South Georgia. A cluster and a correspondence analysis pointed out a clear difference between the aquatic and the terrestrial moss samples. Four assemblages of characteristic testate amoebae species with specific ecological preferences were distinguished. The moss dwelling testacean fauna of South Georgia was compared to other sub-Antarctic islands, such as Marion Island, Îles Kerguelen and Île de la Possession.

Key words: aquatic mosses, assemblages, biogeography, Île de la Possession, South Georgia, sub-Antarctica, terrestrial mosses, testate amoebae.

INTRODUCTION

Testate amoebae (Protists) are a group of free-living, heterotrophic protists with a world-wide distribution (Smith 1992). Recently a lot of attention has been given to the factors influencing the geographical distribution of these testate rhizopods. Most species are dispersed world-wide by wind and on the legs of birds or floating vegetation (Smith and Wilkinson 1986). An alternative hypothesis suggests the existence of geographical barriers for larger and heavier species. The lack of decent records however, may lead to hasty conclusions about the bio-geographical distribution of testate amoebae. Therefore, extensive research of testate amoebae habitats all over the world is necessary, especially on remote islands such as South Georgia.

The earliest records of testate amoebae on South Georgia were made by Richters (1908), who reported 5 taxa from moss samples of the Cumberland Bay and Royal Bay areas (Fig. 1). Sixteen years later, Sandon and Cutler (1924) observed 15 taxa in organic soil samples collected in the Grytviken area. Both studies should be considered as preliminary and reveal only a very small fraction of the real living testacean fauna of South Georgia. Not until late in the twentieth century,

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was the testate rhizopod fauna of the island more extensively studied by Smith (1982) and Beyens *et al.* (1995). These authors reported respectively 20 testate amoebae taxa from soils and peats (Smith 1982) and 46 taxa from freshwater habitats of the Strømness Bay (Beyens *et al.* 1995).

The moss dwelling testacean fauna of South Georgia remained unstudied however. Given the fact that mosses are the dominant vegetational life form in the whole Antarctic region (Putzke and Pereira 2001) and that testate amoebae are frequently observed from Antarctic mosses (e.g. Grospietsch 1971; Smith 1974, 1986; Vincke *et al.* 2004a), it is clear that the study of the moss habitats will complete the information about the testate amoebae fauna on South Georgia. Furthermore will the results of this study allow testing of some hypotheses regarding the biogeography of testate amoebae or the relationship between testacean diversity and latitude?

MATERIALS AND METHODS

Study site. The sub-Antarctic island of South Georgia is located in the Southern Ocean (54-55°S; 36-38°W), about 1300 km east-southeast of the Falkland Islands and 1930 km of Cape Horn (Chile, South America) (Fig. 1). The 3760 km^2 large island lies south of the Antarctic Convergence and belongs to the sub-Antarctic region of Holdgate (1964). The climate is cold, but a permanent maritime influence limits the variation of temperatures between +4.4 in January and - 1.5 in July (Smith 1978). Annual precipitation usually exceeds 1580 mm (Greene 1964) and prevailing wind directions are northwest and southeast (Smith 1978).

Much of the island is rugged and mountainous, with the highest point, Mount Paget, at 2915 m a.s.l. About 56% of the island is covered by glaciers that have been retreating during the last 17000 years, depositing millions of tons of moraine on the floor of the island's bays and surrounding ocean (Morley 2004). The vegetation of South Georgia consists mainly of grasses, mosses and lichens, while seabirds and seals dominate the animal life on the island.

Sampling. During the austral summer of 1992-1993, twenty-two aquatic moss and thirty aquatic sediment samples were taken in the region of the Strømness Bay on South Georgia. Results on testate amoebae in these aquatic habitats have already been published by Beyens *et al.* (1995). During the same period another 36 terrestrial moss samples were collected near the Strømness Bay, from which the diatom flora has been studied (Van de Vijver and Beyens 1997). To determine the moss-inhabiting testacean fauna of South Georgia, the 36 terrestrial moss samples of Van de Vijver and Beyens (1997) as well as the 22 aquatic moss samples of Beyens *et al.* (1995) were analysed. Eleven samples (out of 48) were withdrawn from further analysis, since they contained no or too little testate amoebae (less than 10 tests per slide).

The moisture content of the sampled mosses was determined with reference to the F-classification of Jung (1936): FI - submerged mosses; FII - free-floating mosses, partly submerged, partly floating; FIII - very wet-water drips from sample without pressure; FIV - wet-water drips after by slight pressure; FV - semi-wet-water drips after moderate pressure; FVI - moist-little water produced after high pressure); FVII - semi-dry-only a few drops of water can be squeezed out; FVIII - dry-no water (Meisterfeld 1977). Water pH was measured, when possible, with a Hanna water tester and the habitat type of the sampled mosses was determined as follows: S - stream, P - pool, L - lake and T - terrestrial environments. All moss material was fixated in 3% formaldehyde.

Identifications of moss species are based on Bell (1973, 1974, 1984), Clarke (1973), Frahm (1988), Greene (1968, 1973), Lightowlers (1985), Newton (1979, 1983), Ochyra (1998). An overview of the characteristics of the samples used in this study is given in Table 1.

Slide preparation and counting. Moss samples were thoroughly shaken and stirred for 5 min in an indefinite amount of distilled water. The suspension was passed through a sieve with a mesh diameter of 595 µm and concentrated by centrifugation (10 min at 2500 rpm). The colour Rose Bengal was added to the samples to distinguish dead from living tests (at the moment of sampling). Encysted testate amoebae were considered as being alive. In each moss sample 150 tests were counted using a Leitz Wetzlar® microscope. Morphological identifications of the testate amoebae are mainly based on works by Deflandre (1928, 1929, 1936), Grospietsch (1964), Decloître (1962, 1978, 1979, 1981), Ogden and Hedley (1980), Ogden (1983) and Hoogenraad and de Groot (1940).

Data analysis. For pairwise comparison of the testate amoebae fauna of South Georgia with other sub-Antarctic islands, the Community Coefficient of Sørensen (1948) was calculated. This index, based on the number of common taxa, has following formula: 2C/(A+B+2C), with A and B being the number of taxa exclusively observed in one place, whereas C is the number of taxa the 2 places have in common.

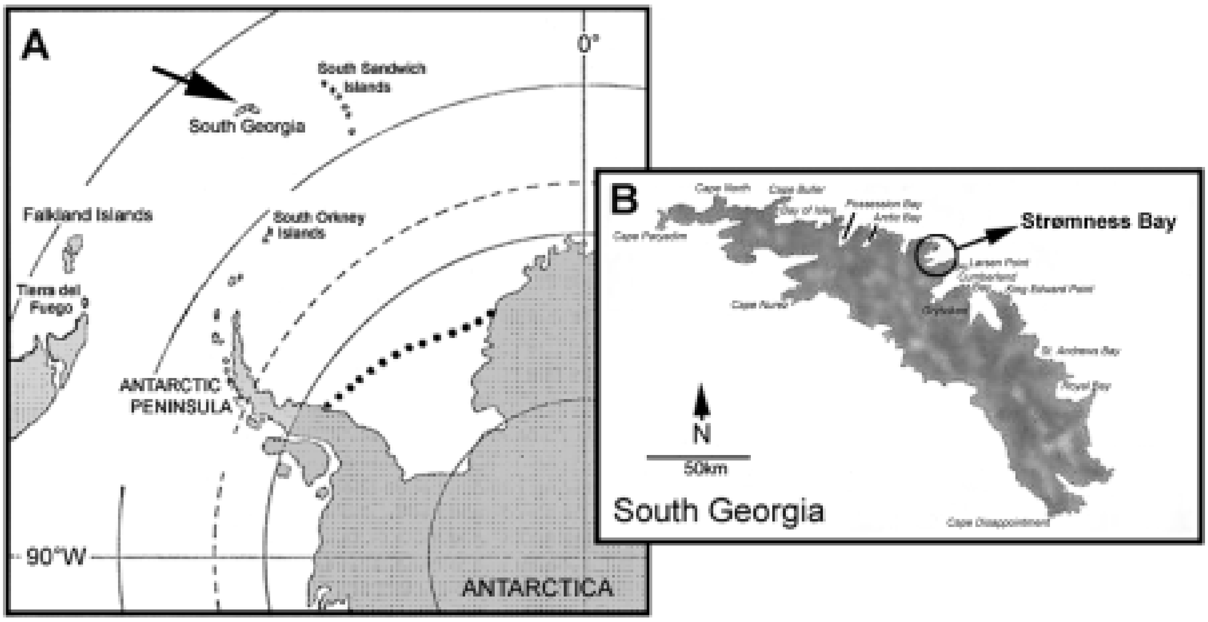
Diversity analysis [Shannon Wiener diversity index (log$_{10}$-based)] was performed using the Multivariate Statistical Package (MVSP) (Kovach Computing Services, 2002). The Gini evenness measure was calculated because of his independence of the number of taxa per sample and therefore allowing a better comparison between the samples (Nijssen *et al.* 1998).

A hierarchic-agglomerative cluster analysis, based on a minimum variance strategy with the Squared Euclidian Distance as a dissimilarity measure, was carried out to classify the species data (MVSP) (Kovach Computing Services, 2002). Species data were log(e) transformed.

A correspondence analysis (CA) was performed to explore possible relationships between the moss dwelling testate amoebae fauna and the measured environmental variables (F-value, pH and habitat-type) using the computer program CANOCO version 4.0 (Ter Braak and Smilauer 1998). Species data were square-root-transformed in order to downweight dominant taxa. The statistical techniques used are described in full detail by Jongman *et al.* (1987).

RESULTS

Species composition. The microscopic analysis of 37 samples revealed a total of 71 testate amoebae taxa (species, varieties and forms), belonging to 21 genera.



Figs 1A, B. A - Sketch map of the southern Atlantic Ocean with the position of South Georgia. **B** - Map of South Georgia, with indication of the Strømness Bay where samples have been collected.

An alphabetical list of all observed taxa with their relative abundance is given in Appendix 1. This list contains 13 testate amoebae taxa (4.4% of all counted tests) which could not be identified up to species level. Identification of these taxa, using Scanning Electron Microscopy (SEM), will be the subject of another paper. Twenty-eight testate amoebae taxa (39%) are reported here for the first time from South Georgia. These are indicated with an * in Appendix 1.

The most abundant testate rhizopod taxa in the mosses of South Georgia were *Trinema lineare* Penard (16.6%), *Microchlamys patella* (Claparede and Lachmann) Cockerell (15.8%), *Corythion dubium* Taranek (14.6%), *Nebela collaris* Ehrenberg (11.1%) and *Difflugia pulex* Penard (10.1%). Twenty-five testate amoebae taxa had relative frequencies <1%.

Figure 2 shows the number of taxa encountered per genus and the relative abundance of the genus. The genera *Centropyxis* and *Difflugia* showed the highest species diversity, respectively 12 and 11 taxa, while *Trinema* was the most abundant genus.

Thirty-one percent of the testate amoebae fauna was alive at the moment of sampling. This number corresponds to a dead-living ratio of 2.2. The proportion of cysts was very low (0.4%). Encysted organisms belonged mostly to the taxon *Nebela collaris* (0.3 %), but also to *Difflugia globulosa* Dujardin, *Euglypha strigosa* Leidy and *Trinema lineare*.

The diversity analysis revealed a mean Shannon-Wiener diversity index (H’) of 0.65 ± 0.05 and a Gini-evenness measure of 0.37 ± 0.01. The highest diversity was measured in sample M352 (H’=1.03), an FV moss sample (*Tortula robusta*) collected near a small brooklet at Tønsberg Point. The lowest diversity was observed in M332 (H’=0.02), a *Sphagnum fimbriatum* moss strongly dominated by *Nebela collaris*. The mean number of taxa per sample was 12 ± 1, with a maximum of 22 testate amoebae taxa in samples M352 and M326, and a minimum of 2 taxa in samples W395 and M332.

Community analysis. A hierarchic-agglomerative cluster analysis revealed 4 clusters, named after their most characteristic testate amoebae taxon (Fig. 3):

(1) *Nebela collaris* assemblage
(2) *Corythion dubium* assemblage
(3) *Microchlamys patella* assemblage
(4) *Difflugia bryophila* assemblage

Table 2 lists the most important characteristics of the 4 communities.

Samples of the *Nebela collaris* assemblage had very low diversity indices, due to the extreme dominance of *Nebela collaris* and *Euglypha strigosa*. Water pH-values were rather low (4.4 ± 0.1) compared to

Table 1. Overview of the characteristics of the samples used in the analysis.

Sample	Hab	F	pH[a]	Moss species
W365	S	II	8.2	*Brachytecium subplicatum* + *Orthotheciella varia*
W366	S	I	7.7	moss A
W367	P	II	6.1	*Warnstorfia sarmentosa* + *Warnstofia laculosa*
W370	P	I	5.6	*Warnstorfia laculosa*
W371	S	I	-	moss A
W383	S	II	7.6	moss A
W387	P	I	6.6	*W. sarmentosa* + *Sanionia uncinata* + *O. varia*
W388	L	I	5.7	*Warnstorfia laculosa*
W390	P	I	4.2	*Warnstorfia laculosa*
W395	P	II	4.3	*Warnstorfia laculosa*
W397	L	I	7.5	*Warnstorfia laculosa*
W399	P	I	4.6	*Warnstorfia laculosa*
W402	P	I	6.6	*Warnstorfia laculosa*
W407	P	I	8.1	*Sanionia uncinata* + *Warnstorfia laculosa*
W412	L	I	6.2	*Andreaea depressinervis* + *Warnstorfia laculosa*
M317	T	III	-	*Warnstorfia sarmentosa* + *Orthotheciella varia*
M318	T	III	7.3	Hepatic
M320	T	VI	-	*Tortula robusta*
M321	T	VII	-	*Tortula filaris*
M323	T	IV	-	*Warnstorfia sarmentosa*
M324	T	VIII	-	*Polytrichastrum alpinum*
M325	T	V	-	*Tortula robusta*
M326	T	IV	-	cfr. *Orthotheciella varia*
M329	T	VIII	-	*Tortula saxicola (?)* + *Polytrichum juniperinum*
M330	T	VII	-	*Conostomum pentastichum*
M331	T	VI	-	*Pohlia sp*
M332	T	IV	-	*Sphagnum fimbriatum*
M336	T	IV	4.4	*Campylium polygamum*
M337	T	III	6.2	*Brachytecium austrosalebrosum*
M338	T	III	6.6	*Sanionia uncinata*
M345	T	VII	4.6	*Campylium polygamum*
M347	T	VII	-	*Racomitrium striatipilum*
M348	T	VI	-	*Campylopus clavatus*
M349	T	V	6	*Warnstorfia sarmentosa*
M350	T	VII	-	*Camplylopus clavatus*
M351	T	VIII	-	*Racomitrium lanuginosum*
M352	T	V	-	*Tortula robusta*

Hab -habitat type: S - stream, P - pool, L - lake and T - terrestrial environments; F - classification of Jung (1936);[a] when measured.

neutral pH-values of the other assemblages. The terrestrial moss samples of the *Corythion dubium* assemblage had very low moisture contents (between FVI and FVII). These dry mosses were also characterised by taxa as *Assulina muscorum*, *A.* sp1 and *Euglypha compressa*. On the other hand, the *Microchlamys patella* assemblage grouped all aquatic mosses (FI and FII) from pools, lakes and streams. Next to *M. patella*, *Difflugia pulex* (and other *Difflugia* taxa), *Difflugiella crenulata* and *Euglypha tuberculata* typified this cluster. The three terrestrial moss samples appearing in this cluster (M317, M318, M337) were taken along fast flowing brooklets of meltwater. The very frequent washing over by the meltwater explains the FIII moisture values of these three moss samples and emphasises again the importance of humidity on the testacean species distribution. The terrestrial samples of the *Difflugia bryophila* assemblage had intermediate F-values and highest diversity indices. Testate amoebae taxa such as *Centropyxis aerophila* and *Nebela lageniformis* were characteristic for this assemblage.

Table 2. Characteristics of the 4 clusters. Means are provided with standard errors.

	CL 1 *Nebela collaris*	CL 2 *Corythion dubium*	CL 3 *Microchlamys patella*	CL 4 *Difflugia bryophila*
Number of samples	6	10	15	6
Number of species	20	39	47	39
Shannon-Wiener Diversity	0.37 ± 0.12	0.60 ± 0.07	0.69 ± 0.07	0.91 ± 0.04
Gini Evenness Measure	0.39 ± 0.04	0.34 ± 0.02	0.35 ± 0.02	0.40 ± 0.02
Mean Species Richness	6.5 ± 1.6	10.2 ± 1.1	12.7 ± 1.2	17 ± 2
Mean F-range	FIII - FIV	FVI - FVII	FI - FII	FIV - FV
Habitat type (number of samples):				
Stream	0	0	4	0
Pool	3	0	5	0
Lake	0	0	3	0
Terrestrial	3	10	3	6
*Frequency of occurrence in samples (%) * Relative abundance in these samples (%)*				
Assulina muscorum	0 * 0	90 * 7	7 * 1	0 * 0
Centropyxis aerophila	0 * 0	30 * 6	80 * 4	100 * 11
Corythion dubium	50 * 1	100 * 50	40 * 2	83 * 4
Difflugia bryophila	0 * 0	10 * 1	20 * 1	100 * 10
Difflugia pulex	33 * 4	40 * 17	87 * 21	50 * 7
genus *Difflugia*	5 * 3	12 * 7	33 * 8	36 * 4
Difflugiella crenulata	0 * 0	0 * 0	40 * 9	17 * 1
Edaphonobiotus campascoides	0 * 0	10 * 1	47 * 5	50 * 2
Euglypha compressa	0 * 0	50 * 3	0 * 0	0 * 0
Euglypha rotunda	33 * 1	60 * 3	40 * 3	67 * 2
Euglypha strigosa	50 * 31	30 * 2	0 * 0	0 * 0
Euglypha tuberculata	0 * 0	0 * 0	13 * 16	0 * 0
Microchlamys patella	83 * 7	30 * 1	100 * 34	83 * 6
Nebela collaris	100 * 66	10 * 9	7 * 1	17 * 7
Nebela lageniformis	17 * 1	10 * 3	7 * 2	100 * 6
Pseudodifflugia fulva	17 * 3	30 * 1	67 * 3	33 * 2
Trinema enchelys	17 * 9	10 * 3	67 * 3	67 * 9
Trinema lineare	67 * 8	100 * 16	87 * 18	100 * 33

A correspondence analysis confirmed the assemblages formed by the cluster analysis (Fig. 4a). The Eigen values ($l_1 = 0.60$ and $l_2 = 0.49$) of the first two CA-axes accounted for only 24.8% of the cumulative variance in the testate amoebae data. This low percentage is typical for noisy data sets containing may zero values. Most probably the first axis corresponds to the pH of the samples, while the second axis relates to the moisture content of the moss samples. A CA-species plot is also shown (Fig. 4b) and indicated the same characteristic taxa for each assemblage. Species in the centre of the ordination, such as *Trinema lineare* and *Euglypha rotunda* (abundant in all 4 assemblages), have little ecological preferences and appear under highly variable moist conditions.

DISCUSSION

Species composition and communities

The study of the moss dwelling testacean fauna of South Georgia revealed 71 taxa, which is the highest number of testate amoebae taxa recorded from the island so far. Twenty-eight taxa are reported for the first time and comparing the species list with Sandon and Cutler (1924), Smith (1982) and Beyens *et al.* (1995), brings the total to 87 testate amoebae taxa on South Georgia (17 unidentified species not taken into account).

The cluster and the correspondence analysis point out a clear difference between the aquatic and the terrestrial

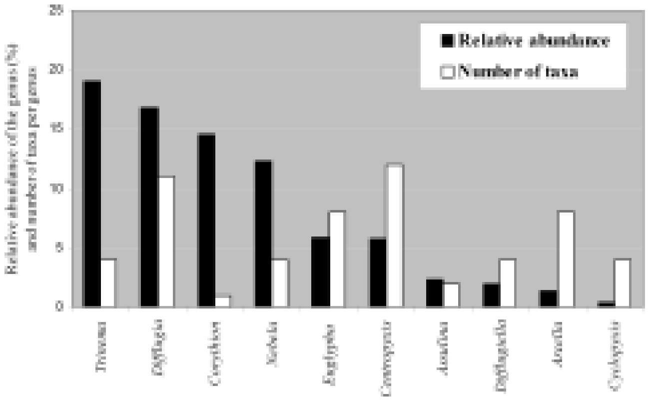


Fig. 2. Diagram showing the number of testate amoebae taxa per genus and the relative abundance (%) of the genus.

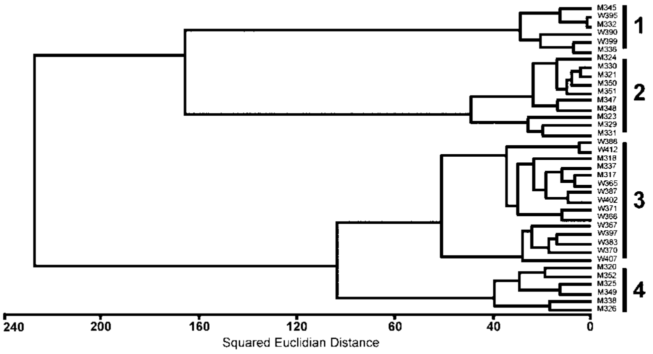
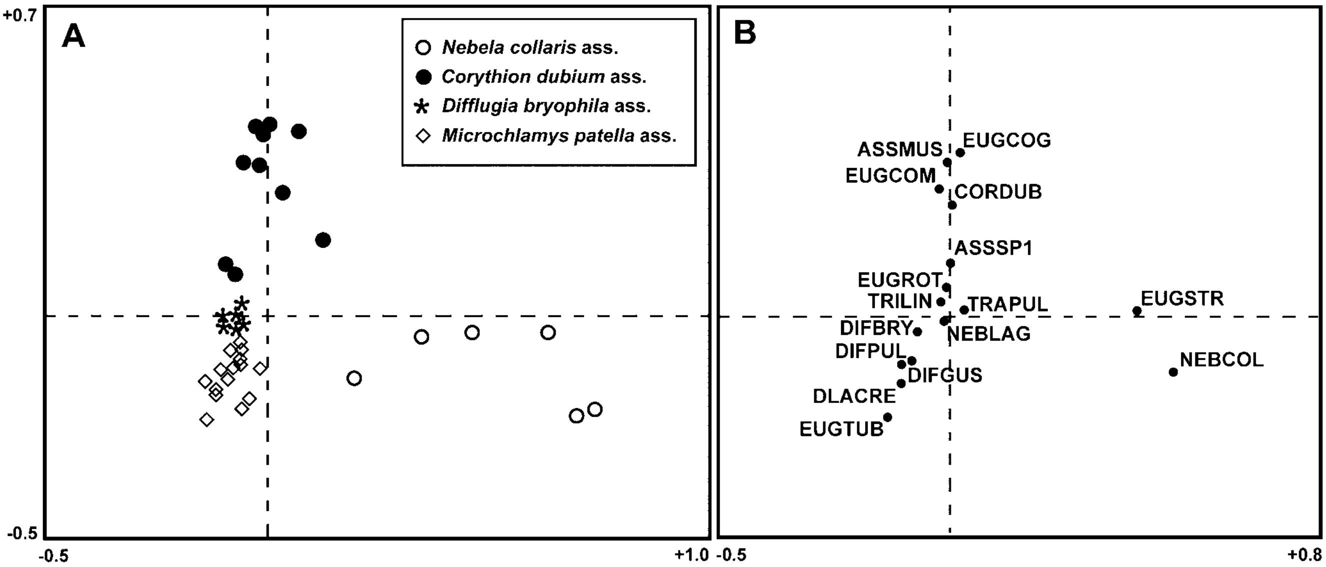


Fig. 3. A hierarchic-agglomerative cluster analysis showing the 4 clusters: (1) *Nebela collaris* cluster, (2) *Corythion dubium* cluster, (3) *Microchlamys patella* cluster and (4) *Difflugia bryophila* cluster



Figs 4A, B. A - CA ordination showing sample sites. Sites are labelled according to their correspondent cluster. **B** - CA species ordination. Taxon codes are explained in Appendix 1.

moss samples. The water surrounding the aquatic mosses has a significant influence on the testacean species distribution and therefore aquatic moss samples should be handled as aquatic samples rather than moss samples. The preference of *Microchlamys patella* for aquatic mosses (FI-FII), confirmed its ecological preference as observed on Île de la Possession (Vincke *et al.* 2004c). Similarly, *Difflugia*-taxa (especially *D. pulex*) were more abundant in aquatic habitats (Beyens *et al.* 1995; Vincke *et al.* 2004a,b), whereas *Nebela*-taxa were more bound to moist terrestrial mosses (e.g. *Nebela lageniformis* in the *Difflugia bryophila* assemblage). The species poor *Nebela collaris* assemblage was found in rather wet mosses (FIII - FIV) sampled from different localities in the Strømness Bay. The same assemblage was also described by Beyens *et al.* (1995),

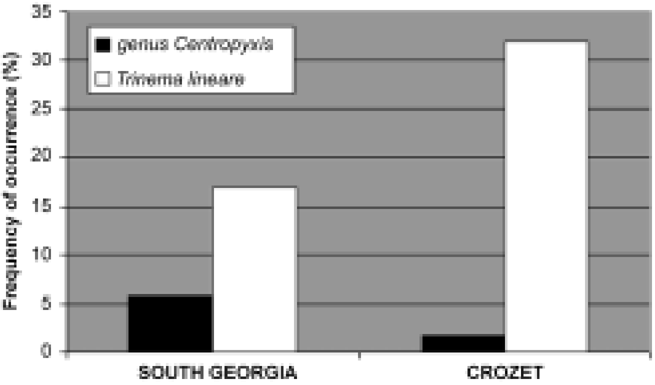


Fig. 5. Comparison of the relative abundance (%) of *Trinema lineare* (white bars) and individuals of the genus *Centropyxis* (black bars) on South Georgia and Crozet.

as characteristic for most acid waterbodies. Indeed, samples of this cluster had a mean pH of 4.4 ± 0.1 (SE) and were clearly distinctive from the neutral to slightly alkaline pH-values from the moss samples from the other assemblages.

Taxa such as *Corythion dubium*, *Assulina muscorum*, *Assulina* sp1 and *Euglypha compressa* were characteristic for the driest mosses sampled (FVI-FVII-FVIII). Moisture preferences of these taxa all correspond to the ones found on Île de la Possession (Vincke *et al.* 2004c). Smith (1982) found *A. muscorum* to be more characteristic of wet mosses, but results of this study clearly indicate *A. muscorum* to be associated to drier mosses (Table 2). This study confirmed the hygrophilous nature of *Centropyxis aerophila* found by Smith (1982). The highest abundances of this taxon were observed in the range from FIII to FV. *Difflugia bryophila*, typical for the third assemblage, had high frequencies in semi-wet moss samples (FIV-FV), confirming earlier records of Île de la Possession (Vincke *et al.* 2004c).

The observed dead-living ratio of 2.2 (31% living tests) of all observed tests may seem rather low compared to high ratios of the temperate regions (about 10), where empty tests dominate manifold above living and encysted tests (Balik 1994). Probably the penetration of water into empty tests, as suggested by Balik (1994), caused the destruction of empty tests in freeze-thaw cycles (as appear frequently on South Georgia).

Comparison with other sub-Antarctic islands

Smith (1982) compared the testate amoebae fauna of South Georgia with Marion Island (Grospietsch 1971: 53 taxa) and Kerguelen (Bonnet 1981: 50 taxa) and found at that time “a significantly greater species diversity on these wetter and less cold sub-Antarctic islands than on South Georgia”. Comparing the actually known rhizopod fauna of South Georgia (87 taxa) with the same data of these sub-Antarctic islands (no additional data yet), results are just the other way round and therefore Smith’s observed trend about pauperisation towards the South Pole seems to be overruled. However, this ostensible finding is more probably the result of insufficient research and lower sampling intensities on Kerguelen and Marion Island.

When the testacean fauna of South Georgia is compared to the one of sub-Antarctic Île de la Possession (Crozet Archipelago) (Smith 1975, Vincke *et al.* 2004a,b,c: 88 taxa + 34 unidentified taxa) however, both sub-Antarctic islands seem to have rather similar amounts of testate amoebae taxa. Taken into account the unidentified taxa on both islands (South Georgia: 87+17=104 taxa; Île de la Possession: 88+34=121 taxa), Smith’s theory (1982) about pauperisation towards the South Pole is reconfirmed.

Nevertheless it’s still possible that the number of testate amoebae taxa of South Georgia is higher than that of Île de la Possession. In contrast to the intensive sampling strategy on Île de la Possession (over 300 samples analysed from places all over the island by Richters 1907, Smith 1975 and Vincke *et al.* 2004a,b,c), the sampling on South Georgia was restricted (so far) to several bays along the north-east coast of the island (in total about 110 samples, Richters 1908, Sandon and Cutler 1924, Smith 1982, Beyens *et al.* 1995 and this study). Knowing that South Georgia (3760 km²) has about 24 times the surface of Île de la Possession (156 km²), it is most likely that the limited number of samples does not represent the total testacean diversity of the island. Moreover the diversity of microclimates, that influences the diversity of niches for different species, may be higher on South Georgia because of the lower exposure of the island compared to Île de la Possession. Even though these assumptions can’t be proven at this point in time, it remains possible that the testacean fauna of South Georgia, although located at higher latitude, is indeed more divers than that of Île de la Possession. Therefore the pauperisation phenomenon towards the South Pole should be considered as a general trend rather than a strict rule.

The Sørensen similarity index between South Georgia and Île de la Possession (0.42) indicates that the composition of the testate amoebae fauna on both islands is rather different. Both islands have 47 taxa in common, including 2 unidentified taxa, *Assulina* sp1 and *Difflugia* sp6, that are morphologically (genetic similarity unknown) identical on both places. *Trinema lineare* was the most dominating taxon on both islands, but its relative abundance differed significantly (17%: South Georgia; 32% Île de la Possession) (Fig. 5) (Vincke *et al.* 2004a,b,c). Another striking difference between the islands is the number of taxa of the genus *Centropyxis* (South Georgia: 17 taxa; Île de la Possession: 8 taxa) (Fig. 5) and the relative abundances of the *Centropyxis* taxa (moss samples South Georgia: 5.8% versus Île de la Possession: moss: 1.7% (Vincke *et al.* 2004c); aquatic: 1.3% (Vincke *et al.* 2004b), soils: 0.5% (Vincke *et al.* 2004a)). On Île de la Possession, *Trinema lineare* became more abundant when moisture was a limiting factor (24% aquatic habitats; 30% mosses; 41% soils) (Vincke *et al.* 2004a,b,c). It appears that samples of South Georgia were on average taken in wetter conditions than those of Île de la Possession and this would explain the higher relative abundance of the generally hygrophilous *Centropyxis*-taxa (de Graaf 1956) and lower relative abundance of *Trinema lineare*.

Despite the considerable geographical distance between the sub-Antarctic islands of South Georgia and Île de la Possession, and differences in their climatological and bryological characteristics, it is clear that similar habitats on both islands are colonised by rather similar testate amoebae faunas. The 42 rhizopod taxa both islands have in common (mostly cosmopolitan taxa) seem to have well-defined ecological preferences (especially for moisture) that are similar in different geographical locations. Besides this shared testate amoebae fraction, each island maintains a certain degree of uniqueness, expressed by a number of taxa occurring only on that specific island, when it comes to filling up the gaps in the ecological niches. The question remains if this uniqueness is due to the existence of biogeographical barriers that inhibit the distribution of certain species, or to the lack of specific environmental conditions and habitats required for the survival and development of population of these species. Therefore, every additional study on the diversity and ecology of testate amoebae, from places all over the world, will add indispensable information about the precise ecological optima and the biogeography of these free-living protists.

Acknowledgements. This survey was made possible by the British Antarctic Survey, Cambridge. The authors wish to thank Prof. Dr. David Walton and the staff of the Terrestrial and Freshwater Science Division for stimulating discussions and help. Funding was provided by the national Science Foundation, Belgium (NFWO). Bart van de Vijver is a Research Assistant at the NFWO.

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Received on 26th July, 2005; revised version on 12th September, 2005; accepted on 28th September, 2005

APPENDIX 1. List of all observed testate amoebae taxa, including abbreviations used in figures and relative abundancies of the taxa. Taxa reported for the first time on South Georgia are indicated with *. The habitat type in which each taxon was found is also indicated with S (stream), P (pool), L (lake) and T (terrestrial samples).

Abbreviation	Testate amoebae taxon	Rel. Abund. (%)	Habitat
ARCARE	*Arcella arenaria* Greeff	0.02	T
ARCBAT	* *A. bathystoma* Deflandre	0.02	T
ARCROT	*A. rotundata* Playfair	0.36	T/P/L
ARCRSU	* *A. rotundata* v. *stenostoma* f. *undulata* Deflandre	0.09	P
ARCSP1	*A.* sp1	0.07	T
ARCSP2	*A.* sp2	0.09	T
ARCSP3	*A.* sp3	0.47	T
ARCVUL	*A. vulgaris* Ehrenberg	0.29	T/S
ARCHS1	*Archerella* sp1	0.02	P
ASSMUS	*Assulina muscorum* Greeff	1.80	T/S
ASSSP1	*A.* sp1	0.56	T
CENACU	*Centropyxis aculeata* Stein	0.18	T/L
CENAER	*C. aerophila* Deflandre	3.53	T/P/S/L
CENAEM	*C. aerophila* v. *minuta* Chardez	0.05	T
CENASP	*C. aerophila* v. *sphagnicola* Deflandre	0.54	T/P/S/L
CENASY	* *C. aerophila* v. *sylvatica* Deflandre	1.06	T/S
CENCAS	* *C. cassis* Deflandre	0.04	T/S
CENELO	*C. elongata* (Penard) Thomas	0.02	P
CENGIB	* *C. gibba* Deflandre	0.02	P
CENMIN	* *C. minuta* Deflandre	0.02	S
CENORB	* *C. orbicularis* Deflandre	0.05	P/L
CENPLA	* *C. platystoma* Penard	0.22	T/PS/L
CENSP1	*C.* sp1	0.04	S
CORDUB	*Corythion dubium* Taranek	14.56	T/S/P
CYCARC	*Cyclopyxis arcelloides* (Penard) Deflandre	0.02	P
CYCARM	* *C. arcelloides* v. *minima* Van Oye	0.22	T
CYCEUR	* *C. eurystoma* Deflandre	0.09	T
CYCEUP	* *C. eurystoma* v. *parvula* Bonnet & Thomas	0.11	T/P
DIFBRY	* *Difflugia bryophila* (Penard) Jung	1.68	T/S/P
DIFGLA	*D. glans* Penard	0.45	T/S/P
DIFGSA	*D. globulosa* Dujardin	0.99	T/P/S/L
DIFGUS	*D. globulus* Hopkinson	0.86	T/S/P
DIFLUC	*D. lucida* Penard	0.11	T/P
DIFPAR	* *D. parva* (Thomas) Ogden	0.02	P
DIFPUL	*D. pulex* Penard	10.07	T/P/S/L
DIFSP1	*D.* sp1	1.23	T/PS/L
DIFSP2	*D.* sp2	0.02	T
DIFSP6	*D.* sp6	1.26	T/P/S/L
DIFTEN	* *D. tenuis* (Penard) Chardez	0.13	T/P
DLACRE	* *Difflugiella crenulata* Playfair	1.46	T/P/L
DLACRG	* *D. crenulata* v. *globosa* Playfair	0.02	P
DLAOVI	* *D. oviformis* (Penard) Bonnet & Thomas	0.27	T/P/S/L
DLAOVF	* *D. oviformis* v. *fusca* (Penard) Bonnet & Thomas	0.18	T/S/P
EDACAM	* *Edaphonobiotus campascoides* Schönborn, Foissner & Meisterfeld	1.14	T/S/P
EUGCIL	* *Euglypha ciliata* (Ehrenberg) Perty	0.04	T
EUGCOM	* *E. compressa* Carter	0.40	T
EUGCOG	* *E. compressa* v. *glabra* Cash	0.34	T
EUGPOL	* *E. polylepis* Bonnet	0.14	T
EUGROT	*E. rotunda* Wailes	1.35	T/S/P
EUGSTR	*E. strigosa* Leidy	2.67	T/P
EUGSTG	* *E. strigosa* v. *glabra* Wailes	0.07	T
EUGTUB	*E. tuberculata* Dujardin	0.85	P/L
HELSYL	* *Heleopera sylvatica* Penard	0.02	T
HYAMIN	* *Hyalosphenia minuta* Cash	0.02	P
HYASP1	*H.* sp1	0.04	T
HYASP2	*H.* sp2	0.16	T

Appedix 1.

MICPAT	*Microchlamys patella* (Claparede & Lachmann) Cockerell	15.80	T/P/S/L
MICSP1	*Microcorycia* sp1	0.11	P
NEBCAU	* *Nebela caudata* Leidy	0.02	T
NEBCOL	*N. collaris* (Ehrenberg) Leidy	11.14	T/L
NEBLAG	*N. lageniformis* Penard	1.08	T/S
NEBVAS	*N. vas* (Certes)	0.14	T
NEBWAI	*N. wailesi* Deflandre	0.07	T
PHRACR	*Phryganella acropodia* (Hertwig & Lesser) Hopkinson	0.22	T/S
PSEFUL	* *Pseudodifflugia fulva* Penard	1.06	T/P/S/L
TRAPUL	*Trachelocorythion pulchellum* (Penard) Bonnet	0.41	T/S/P
TGPSP1	*Trigonopyxis* sp1	0.38	T/S
TRIALO	*Trinema alofsi* Stepanek	0.20	T
TRICOM	*T. complanatum* Penard	0.22	T
TRIENC	*T. enchelys* Leidy	2.05	T/P/S/L
TRILIN	*T. lineare* Penard	16.59	T/P/S/L