

12. Bipolarity in the distribution of silica-scaled chrysophytes

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Key words: silica-scaled chrysophytes, biogeography, bipolar distributions, Tierra del Fuego

Abstract

An investigation of the chrysophyte flora of Tierra del Fuego (Argentina), 54–55 °S., has shown a high degree of similarity with the flora of climatically comparable regions on the northern hemisphere. All the Fuegian species (except two endemic to South America) also occur on the northern hemisphere – some are more or less cosmopolitan, others have pronounced bipolar distributions. Species in common with other Antarctic regions such as Tasmania are all cosmopolitan, and none of the interesting species originally described from Tasmania occur in Tierra del Fuego. Thus the Fuegian flora appears to be mainly climatically determined and a special Antarctic chrysophyte flora does not exist.

Introduction

The idea behind this study originated during an investigation of the silica-scaled chrysophytes in Tierra del Fuego, Argentina. The southern part of this island, with most of the suitable localities, along the Beagle Canal and around the capital Ushuaia, is situated at a southern latitude of 54–55 °, almost corresponding to the northern latitude of the position of Denmark. Accordingly, our main working hypothesis was the question whether this latitudinal similarity would be reflected in the chrysophyte flora – or if we would meet an Antarctic flora more related to e.g. the Tasmanian. Investigations on the higher plants have shown that several species have Antarctic distributions, and the same is true of many animals (Moore, 1993; compare also Seberg, 1991).

The aim of the investigation was in the first hand to collect material for a chrysophyte volume of the 'Flora Criptogámica de Tierra del Fuego', edited by S. A. Guarrera et al., of which several fascicles already have been published, but so far only two on algae, viz. on Chroococcales and on Chlorococcales (Guarrera, 1986; Tell & Mosto, 1982). The field work took

place during a stay in November 1992. Some of the results have already been published or are under publication (Kristiansen & Vigna, 1994; Vigna & Kristiansen, 1995a; Vigna & Kristiansen, 1995b; Vigna & Kristiansen, 1996; Kristiansen & Vigna, 1996).

Previous studies of chrysophytes in Tierra del Fuego include records by Thomasson (1955, 1963) and Vigna (1986, 1988, 1993).

Climate and vegetation of Tierra del Fuego

The southern part of Tierra del Fuego belongs to the antiboreal zone, 52–56 °S (Tuhkanen, 1992). The climate is extremely oceanic, especially in the western parts, with heavy precipitation (400–1000 (–4000) mm per year, around Ushuaia around 500), mild winters and cool summers. The region is mountaneous; the lower regions are covered with dense *Nothofagus* forests and extended *Sphagnum* moors.

Corresponding climates in southern and northern temperate regions have been discussed in detail by Tuhkanen (1992). On the southern hemisphere, there are only few regions with corresponding climate, viz.

small subantarctic islands such as Islas Malvinias (Falkland Islands), Marion Island, Crozet Islands, Kerguelen, Macquarie Island, Campbell Island, etc. Some of these have been investigated for chrysophytes (Croome & Tyler, 1988), but with negative results, at least partly because of lack of suitable habitats. Thus any southern hemisphere comparison of distribution must also include Tasmania and New Zealand, although these islands have different climates, except in some areas in the mountains.

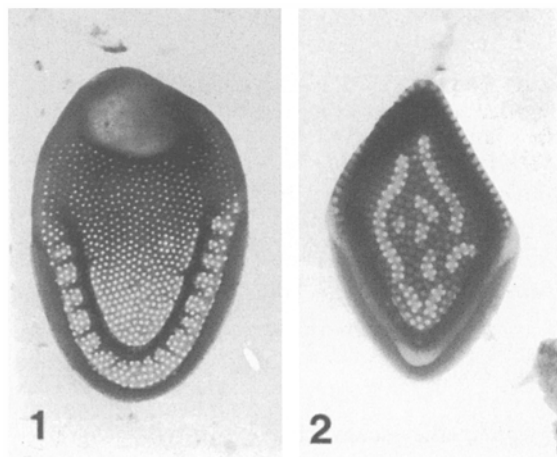
Because of the prevailing distribution of the land masses to the north, the northern hemisphere presents considerably larger areas with climate corresponding to the Fuegian, although they are found at somewhat higher latitudes. In Europe, corresponding climate is found along the Norwegian coast, from c. 62 to 71 °; on the Shetland Islands, Faroe Islands, Iceland, and the southernmost tip of Greenland this climate is found from 60 to 66 °. *Nothofagus* has been transplanted from Tierra del Fuego to the treeless Faroe Islands and proves to grow well, also to southernmost Greenland (Odum, 1991). In N. America, the climate corresponding to the Fuegian is found along the Alaskan south coast, extending out into the Aleutian Islands (54–60 °). Thus the possibilities for relevant comparisons are better, although also here further large areas, both in N. America, Greenland, and Scandinavia must be included, in order to secure enough chrysophyte material for comparisons.

Hypotheses:

(1) The Fuegian chrysophyte flora is historically derived, it is an Antarctic flora, related to the Australian-Tasmanian-New Zealand flora, corresponding to the distribution of the *Nothofagus* forests and of the marsupial animals. Compare the Gondwanaland theory and other geological theories about continental connections in the circum-pacific area (Seberg, 1991).

(2) The Fuegian chrysophyte flora is primarily determined by the climate, and thus related to the corresponding northern temperate floras, or it may be more or less cosmopolitan.

(3) The Fuegian chrysophyte flora is mainly endemic in its composition.



Figures 1, 2. Silica scales of Fuegian chrysophytes endemic to southernmost South America. Figure 1: *Mallomonas americana*. – Figure 2: *M. fuegiana*. EM, 10 000 ×.

Discussion

This discussion of the Fuegian chrysophyte flora will include the genera *Synura*, *Chrysodidymus*, *Mallomonas*, and *Chrysosphaerella*. The distribution records have been based on Asmund & Kristiansen (1986) for *Mallomonas* and on special papers for the other genera, e.g. Kristiansen & Tong (1989) and Wujek & Bicudo (1993); especially for *Synura curtipina* see Kristiansen & Lind (1995). The species of the genera *Spiniferomonas* and *Paraphysomonas* are still so inadequately investigated as regards their distribution, because of their small size and the special methods required to obtain representative material, that it is premature to include them in any biogeographical speculations.

The composition of the Fuegian flora and its biogeographic characteristics is seen from Table 1. A closer description of the species new to the flora of Tierra del Fuego and their biogeography is given by Vigna & Kristiansen (1996).

In the Fuegian flora there are only two chrysophytes endemic for southern S. America: *Mallomonas americana* Dürschm. (Figure 1) and *M. fuegiana* Vigna & Kristiansen (Figure 2; Vigna & Kristiansen, 1995a; Vigna & Kristiansen, 1995b). In this connection some remarks are necessary about the many species described by Dürschmidt (1980, 1981, 1982a, 1982b, 1983) from southern Chile, which at first were thought to be endemic; but most of these have later been found in northern temperate regions also, some of these in

Table 1. Table 1. Distribution types of silica-scaled chrysophytes from Tierra del Fuego. Explanations: *Endemic*: Known distribution restricted to southern South America. *Bipolar*: Only in northern and southern regions, not in the tropics. *Cosmopolitan or widely distributed*: Occurrence also including the tropics. *Tasmania*: Occurrence in Tasmania.

	End. Bipolar	Cosm. or widely distrib.	Tasman.
<i>Chrysodidymus</i>			
<i>synuroideus</i>		+	+
<i>Chrysosphaerella</i>			
<i>brevispina</i>		+	+
<i>coronacircumspina</i>		+	+
<i>Mallomonas</i>			
<i>matvienkoae</i> f. <i>matvienk.</i>		+	+
<i>parvula</i>	+	+	+
<i>multisetigera</i>		+	+
<i>calceolus</i>		+	+
<i>papillosa</i>		+	+
<i>paxillata</i>	+		
<i>rasiliis</i>		+	
<i>guttata</i>		+	+
<i>transsylvanica</i>	+		
<i>americana</i>	+		
<i>heterospina</i>		+	+
<i>akrokomos</i>		+	+
<i>striata</i>		+	+
<i>flora</i>		+	
<i>cristata</i>	+		
<i>areolata</i>		+	+
<i>cyathellata</i> v. <i>chilensis</i>		+	+
<i>pillula</i> f. <i>valdiviana</i>	+		
<i>annulata</i>		+	+
<i>fuegiana</i>	+		
<i>pumilio</i>	+		
<i>alata</i>	+		
<i>mangofera</i> f. <i>foveata</i>		+	
<i>mangofera</i> f. <i>gracilis</i>		+	
<i>alveolata</i>	+		
<i>Synura</i>			
<i>curtispina</i>		+	+
<i>echinulata</i>		+	+
<i>petersenii</i>		+	+
<i>sphagnicola</i>		+	
<i>spinosa</i>		+	+

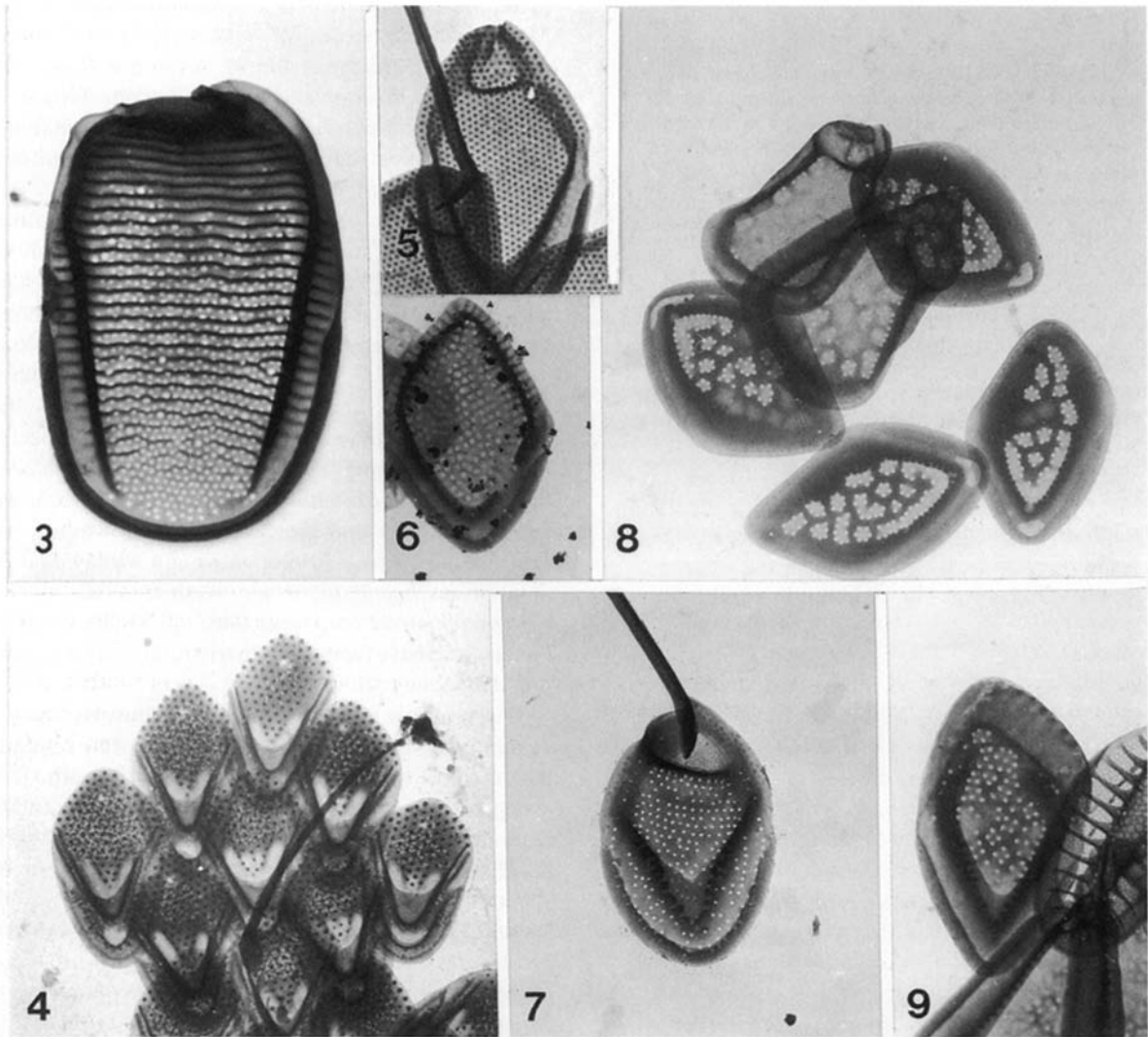
addition to a more or less cosmopolitan distribution: *M. parvula* Dürschm., *M. multisetigera* Dürschm., *M. cristata* Dürschm., and *M. alveolata* Dürschm. *M. rasilis* Dürschm and *M. cyathellata* Wujek & Asmund var. *chilensis* Dürschm. have later been found mainly in tropical regions. Only a few species have still only been found in S. America, as *M. americana*.

Cosmopolitan species, or nearly cosmopolitan species, include most of the species found. All of these have, in addition to their temperate occurrence, also been found in the tropics. Most frequent among these were *M. heterospina* Lund, *M. akrokomos* Ruttner in Pascher, *M. striata* Asmund, *Synura petersenii* Korsh., *S. echinulata* Korsh., *S. spinosa* Korsh. – and there are several others less frequently recorded species with more scattered distributions, such as *M. calceolus* Bradley and *M. guttata* Wujek. However, the distinction between this group and the following is not clear, because many cosmopolitan and widely distributed species, e.g. *M. akrokomos* Ruttner in Pascher and *Chrysosphaerella coronacircumspina* Wujek & Kristiansen, still have their main distribution – so far known – in temperate regions.

Fuegian species with bipolar distributions, occurring in both southern and northern temperate regions, but not in the tropics or subtropics (with few exceptions), are the following: *Mallomonas parvula* Dürschm. (Figure 4), *M. paxillata* (Bradley) Péterfi & Moméu (Figure 5), *M. transsylvanica* Péterfi & Asmund (Figure 3), *M. cristata* Dürschm. (Figure 7), *M. pillula* Harris f. *valdiviana* Dürschm. (Figure 10), *M. pumilio* Harris & Bradley (Figure 8), *M. alveolata* Dürschm. (Figure 6), and *M. alata* Asmund et al. (Figure 9).

In summary: All the species found in Tierra del Fuego, except the endemic species *M. americana* and *M. fuegiana*, have also been found in northern temperate regions.

Comparisons with Iceland and Southern Greenland where chrysophyte investigations have been made confirm these considerations (Bradley, 1964; Nygaard, 1978; Kristiansen, 1994; Kristiansen, 1995). Out of the 28 species recorded during these investigations, 16 have been found in Tierra del Fuego, further two in Patagonia (Argentina, Thomasson, 1963), and one in Chile (*M. scalaris* Dürschm., also showing a bipolar distribution). The remaining 9 species are restricted to northern temperate-subarctic areas, a few of them (*M. variabilis* Cronberg and *M. duerrschmidtiae* Siver) with rather restricted occurrences.



Figures 3–9. Silica scales of Fuegian chrysophytes with bipolar distributions. Figure 3: *Mallomonas transsylvanica*. – Figure 4: *M. parvula*. – Figure 5: *M. axillata*. – Figure 6: *M. alveolata*. Figure 7: *M. cristata*. – Figure 8: *M. pumilio*. – Figure 9: *M. alata*. EM, 10000 ×. Figure 5 is from Danish material (Asmund & Kristiansen, 1986).

Tasmanian, Australian and New Zealand species: None of the species originally described from Tasmania or described from Australia or New Zealand and occurring in Tasmania have been found in Tierra del Fuego: *M. grossa* Dürschm., *M. morrisoensis* Croome & Tyler, *M. perpusilla* Dürschm., *M. plumosa* Croome & Tyler, *M. sabulosa* Croome & Tyler, *M. splendens* (West) Playfair, *M. tasmanica* (Croome & Tyler) Asmund & Krist. (Compare Croome & Tyler, 1985). Thus there are no species found only in Tasmania etc. and in Tierra del Fuego. Species which these regions have in common are all cosmopolitan

(except the bipolar *M. parvula* Dürschm.) And three of the species indicated as cosmopolitan/ widely distributed in Table 1 have not been found in Tasmania/Australia.

There are many species characteristic for the Tropics which occur in tropical and sub-tropical parts of S. America, but do not extend so far south as Tierra del Fuego: e.g. *Synura australiensis* Playfair, *M. matvienkoae* (Matv.) Asmund & Krist. f. *grandis* Dürschm. & Cronberg, *M. fenestrata* Cronberg & Hickel, *M. bronchartiana* Compère, *M. portae-ferreae*

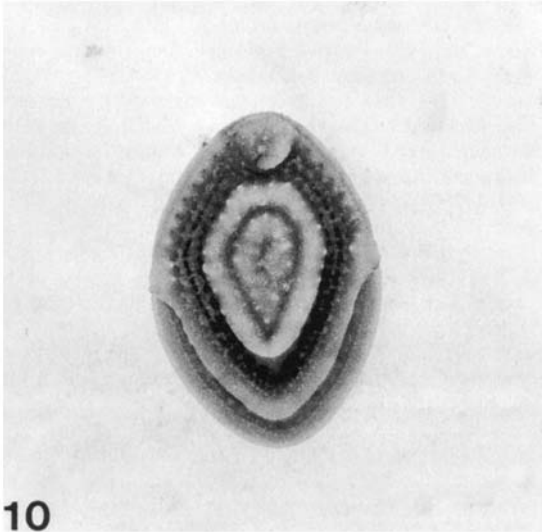


Figure 10. Silica scale of a Fuegian chrysophyte with bipolar distribution: *Mallomonas pillula* f. *valdiviana*. EM, 20 000 \times .

(Péterfi & Asmund), *M. rhombica* Cronberg (Cronberg, 1989; Vigna, 1990; Wujek & Bicudo, 1993).

It must also be mentioned that a considerable number of species have been found in northern regions, but not in Tierra del Fuego. *M. caudata* Ivanov em. Krieger, *M. acaroides* Perty em. Ivanov, and *M. multiunca* Asmund are widespread on the northern hemisphere. *M. teilingii* Conrad is mainly found in northern Europe. *M. crassisquama* (Asmund) Fott and *M. alpina* Ruttner in Pascher, which are among the most common species in the northern hemisphere, and almost cosmopolitan, have – though not found in Tierra del Fuego – been recorded from Nahuel Huapi in Argentina (Thomasson, 1963).

It is interesting to compare the distribution of desmids (Lenzenweger, 1993), which shows the same tendency: similarity between the Fuegian flora and the Austrian mountain flora. Also the freshwater algal flora (mainly cyanophytes and chlorophytes) of the Antarctic islands Kerguelen and Crozet is very similar to that of Arctic islands (Therezien & Couté, 1977).

Concluding remarks

It is obvious from the above discussion that the Fuegian chrysophyte flora is very similar to the northern temperate flora. Apart from two endemic species all the Fuegian species also occur in the temperate regions of

the northern hemisphere. Most of them are cosmopolitan or widely distributed, several of these with main occurrence in northern temperate areas, and a few are decidedly bipolar, showing only a northern and southern almost exclusively temperate occurrence.

There is little similarity with other southern temperate regions such as Tasmania. Apart from the cosmopolitan species, the regions have no species in common. None of the Fuegian bipolar species occur in Tasmania, and none of the several species characteristic of Tasmania (and described from there or from Australia or New Zealand) have been found in Tierra del Fuego. There are no species with a circumpolar Antarctic distribution, and thus there is no special Antarctic chrysophyte flora.

Then the question remains of the origin of the Fuegian chrysophyte flora. The chrysophytes may have spread from lake to lake southwards along the Andean Range, following the retreat of glaciers after the last, pleistocene glaciation. At that time there were suitable climatic conditions in larger parts of South America than now for these species.

Long distance transport by birds is another, additional possibility to be discussed. There are no migrating routes circumnavigating the southern hemisphere, except for albatrosses and petrels, which cannot be expected to spread freshwater algae. However, there are several north-south routes. Most interesting are the migrations between Alaska and Tierra del Fuego, performed by some species of sandpipers (*Calidris*). And South Polar Skua and Arctic Tern are known to migrate between Antarctic and Arctic islands (Schlichting et al., 1978). There is, however, no evidence of the ability of any of these to act as vectors of chrysophytes, but an investigation of this problem should be highly desired.

Acknowledgments

Lisbeth Haukrogh and Lene Christiansen, Dept. of Phycology, have helped in electron microscopy and in photographic work.

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