

Scale bearing planktonic chrysophytes from North Tyrol, Austria

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Introduction

Central Europe belongs to regions with long tradition of chrysophyte research and its flora is in general very well studied. Nevertheless, even here large areas remain practically unexplored. For example, strikingly very few chrysophyte records have been published from waterbodies within the Alps, European highest mountains (Asmund et al. 1982, Cronberg 2010, Fott 1962) and no extensive floristic study has been published from this region so far. In this study we aimed at the silica-scaled chrysophytes of the Austrian province North Tyrol situated in the northern part of the Alps. During our survey, samples were taken from 23 lakes and pools in various altitude. In addition, we measured a whole range of environmental parameters in order to reveal relationships between species composition and ecological conditions.



Sampling sites

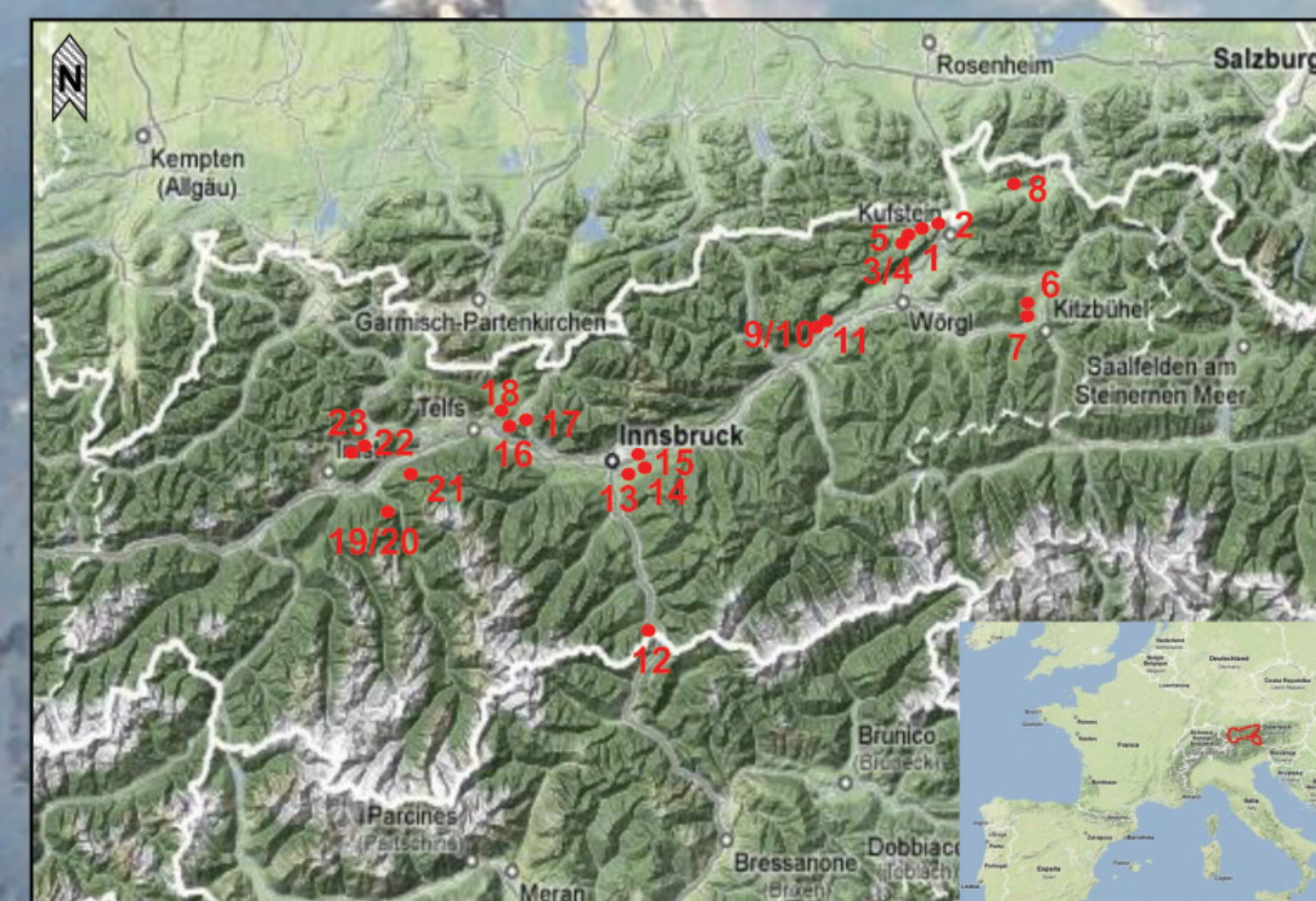


Fig. 1 Map of the investigated localities and pictures of selected sampling sites



Methods

The samples of plankton and upper sediment layer were taken in April 2012. Conductivity, pH and water temperature were measured *in situ* and additional samples of water were taken for subsequent laboratory analyses of water chemistry. For species identification, samples were dried on formvar-coated copper grids, washed in a series of water droplets and examined in a TEM JEOL 1011 electron microscope. Statistical analyses were performed in R (version 2.14.0).

Results and discussion

To our knowledge, this is the first study of chrysophyte silica scales from the region of North Tyrol based on electron-microscopic observations. The investigated localities varied considerably both in their chrysophyte flora and physico-chemical characteristics. For example, pH ranged from 5.6 to 8.5 and conductivity from 16 to 673 μScm^{-1} . Altogether, more than 40 taxa were identified, belonging to five different genera – *Chrysophaerella*, *Mallomonas*, *Paraphysomonas*, *Spiniferomonas* and *Synura*. The most abundant species were *P. vestita*, *C. brevispina*, *M. alpina* and *M. striata*. On the other hand, *M. hexagonis*, *M. paludosa*, *M. cf. pumilio*, *M. punctifera*, *M. schwemmlei* and some of the *Paraphysomonas* and *Spiniferomonas* species were found only in one single sampling site. Most of the identified species belong to cosmopolitan, alkaliphilic or pH indifferent species (Kristiansen & Preisig 2008, chrysophytes.eu) and our present findings are mostly in agreement with the generally accepted autecology of the individual chrysophyte species. Some rare species and other interesting findings are discussed and TEM images are presented (scale bar = 1 μm):

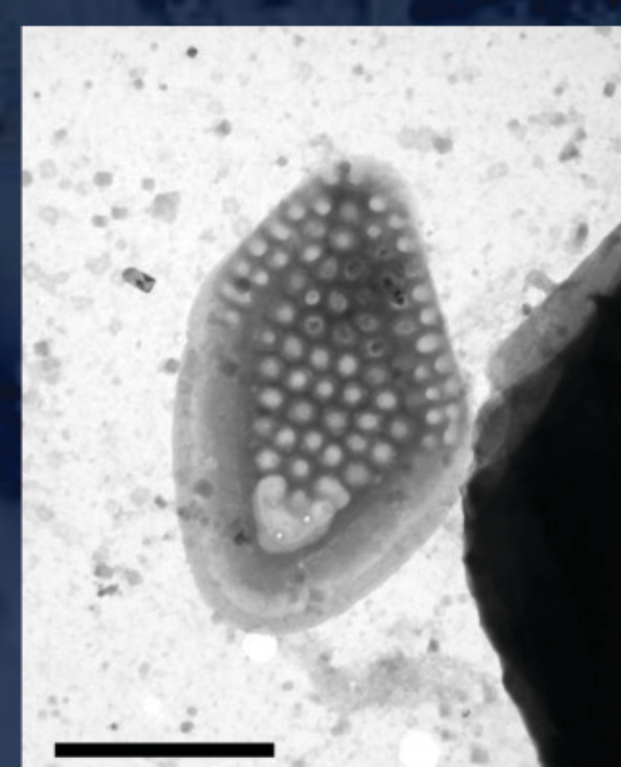
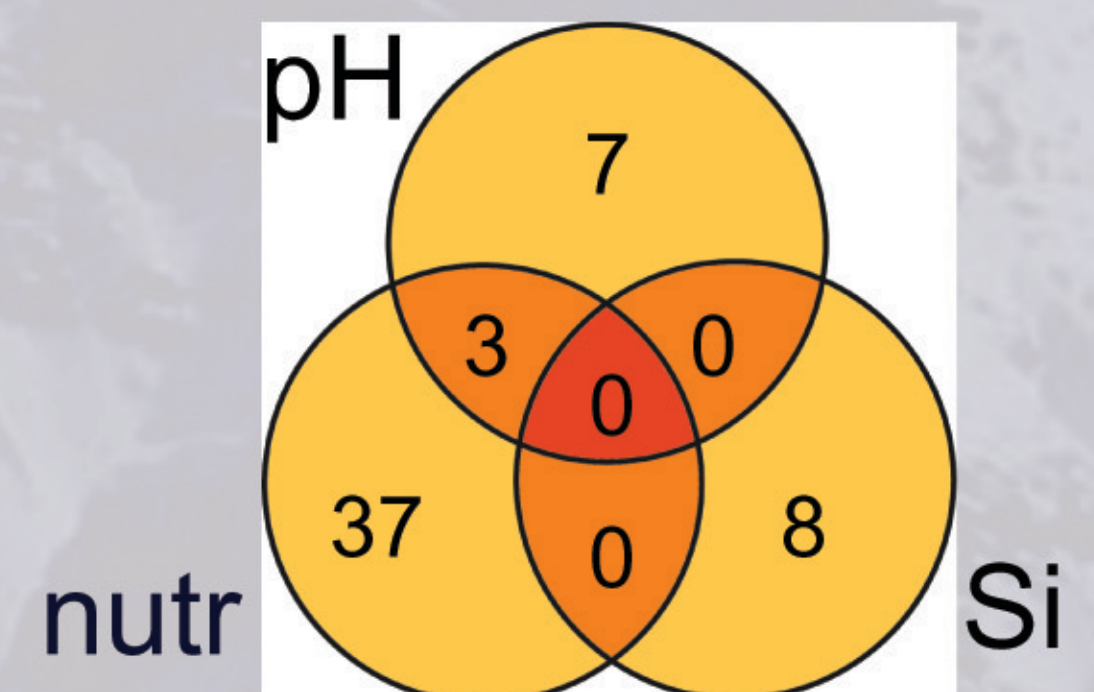
Statistical analyses

The relationship between the species composition and various measured parameters was tested using the ADONIS analysis. It turned out that geographical parameters represented by altitude and geographic distance of the localities did not significantly affect the species composition. On the other hand, various measured environmental parameters explained significant proportion of the overall variation (e.g. pH, conductivity, dissolved reactive silicon (DRSi), nutrients). The variation explained by conductivity comprises also the effect of various dissolved ions (e.g. Mg^{2+} , Ca^{2+} , SO_4^{2-} , Cl^- ,...). Their measured values strongly correlated with conductivity and therefore they were omitted in consequent statistical analyses.

variable	total effect		pure effect	
	%	p	%	p
pH	10.198	0.001	7.274	0.058
cond	11.566	0.001	9.465	0.006
N	21.886	0.011	18.613	0.048
P	15.565	0.002	8.68	0.528
DRSi	8.193	0.016	8.73	0.013

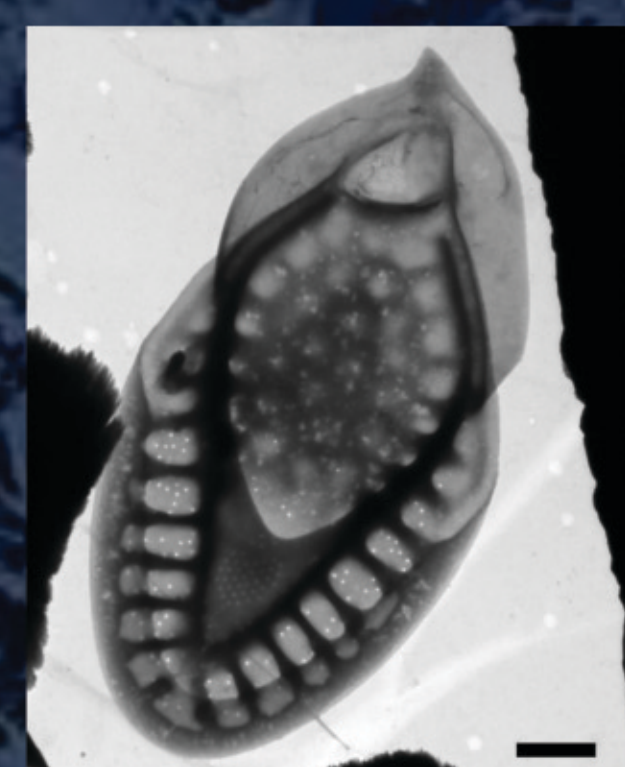
Tab. 1 Results of the ADONIS analysis of selected environmental parameters. Total effect of each parameter is shown as well as its pure, uncorrelated effect. "N" combines the effect of various measured forms of nitrogen (NO_3^- , NH_4^+ , dissolved nitrogen and "P" of phosphorus (total P and dissolved P)

Fig. 2 Diagram showing percentage of explained variation divided among three parameters: pH, nutrients (all measured nutrients and conductivity were combined in this variable) and DRSi. DRSi was treated separately from other nutrients, because its measured values were not correlated with any other parameter. Values in %.



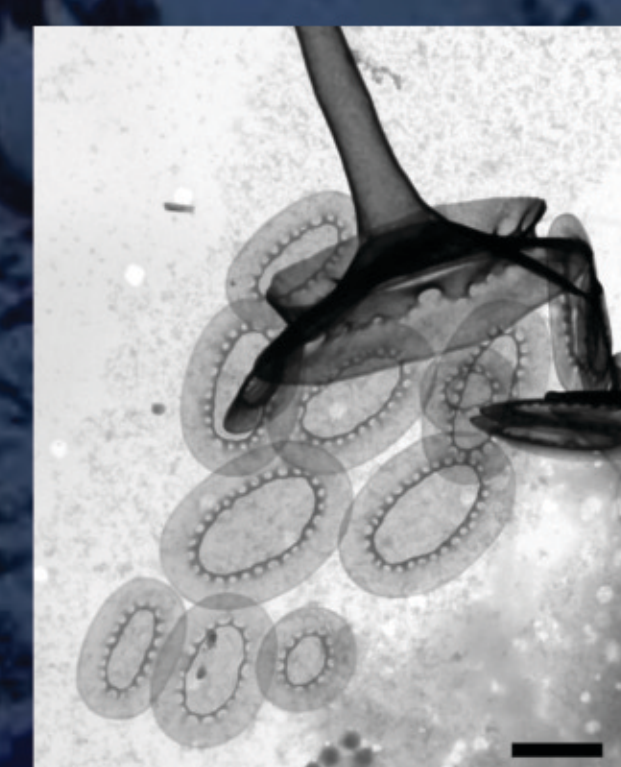
Mallomonas hexagonis

A very rare species, so far published only from North America and Russia (Kristiansen & Preisig 2007), nevertheless it has been already found also in the Czech Republic (Němcová, unpublished). Its autecology is still unknown. We found only single scale in site 7 (Schwarzsee near Kitzbühel), in pH 7.7 and conductivity 247 μScm^{-1} .



Mallomonas pseudocoronata

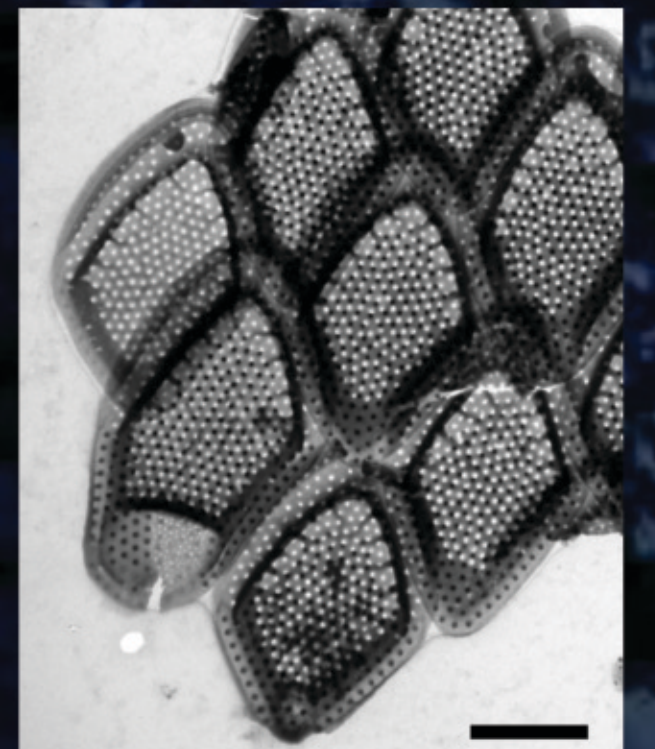
This alkaliphilic (Siver 1995) species used to be considered endemic to North America, where it belongs to common species. However, its enigmatic recent dispersion in Sweden and Austria was already discussed by Cronberg (2010). During our survey we found four other Austrian localities containing this species: 11 - Reintaler See, 14 - Herzsee, 15 - Baggersee and 23 - Kropfsee, with pH range 8.2 – 8.5.



Chrysophaerella coronacircumspina

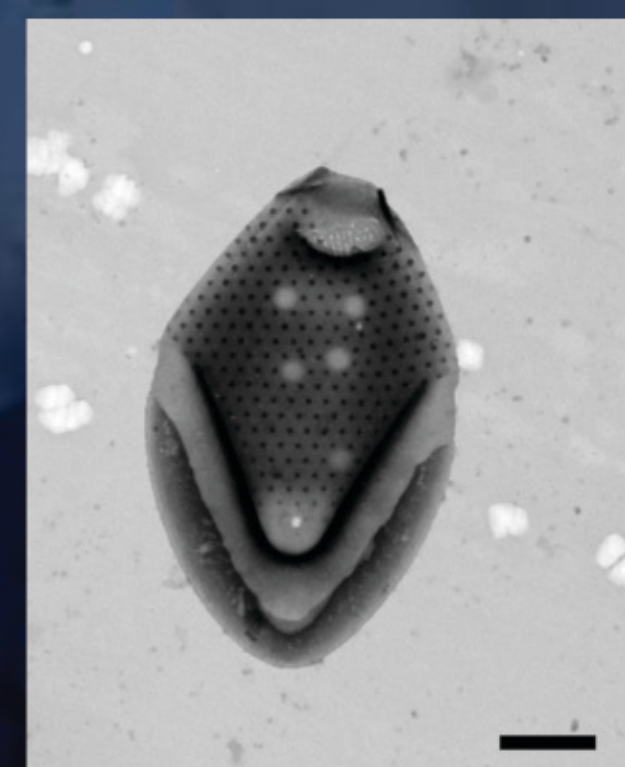
According to the chrysophyte database (chrysophytes.eu) this species is characterised by an interesting distribution pattern in Europe being found along the western coast from Portugal to Russia and therefore it seems to be an atlantic element. Interestingly, the only record so far from inland regions is from Ameisensee in southern Germany (Hartman & Steinberg 1989), not far away from our sampling sites. It prefers low conductivity levels under 100 μScm^{-1} (chrysophytes.eu). However, we found it in 7 sites with conductivity ranging between 102-673 μScm^{-1} .

M. annulata



Mallomonas multisetigera

A cosmopolitan species (Kristiansen & Preisig 2007), but not very common in Europe (chrysophytes.eu). It is considered to be acidophilic (chrysophytes.eu), but we found it in two sites (6 - Gieringer Weiher and 15 - Baggersee) in pH 7.6 and 8.2, respectively.



Mallomonas guttata

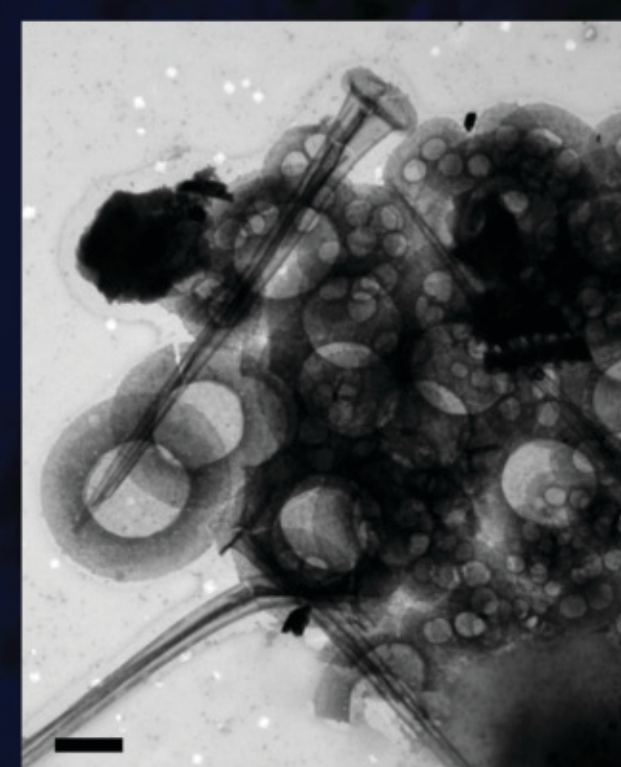
A rare species with unknown autecology. Widely distributed except Europe (Kristiansen 2002), however some records already exist from Aquitaine, France (Němcová 2012, in press). We found this species in four localities where pH ranged from 7.6 to 8.5 and conductivity from 102 to 461 μScm^{-1} . However, the observed scales differed slightly from the species description in having lower number (3-7) of circular pits on the shield, instead of 9-15 (Kristiansen 2002).



Mallomonas schwemmlei

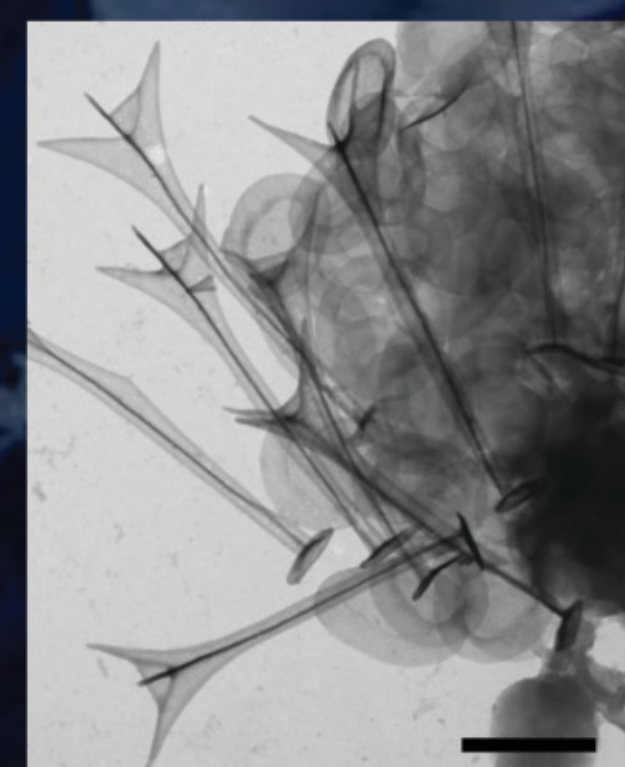
A species with northern temperate distribution including the Arctic (Kristiansen & Preisig 2007) with unknown autecology. We found it only in site No.18 (Lottensee), in pH 8 and conductivity 238 μScm^{-1} .

M. pillula f. valdiviana



Spiniferomonas bilacunosa

This species is in Europe restricted to the Northern regions, being common even in the Arctic. This is the first record south of Denmark so far. We observed it in three sites (2 - Egelsee, 3 - Pfirillsee, 6 - Gieringer Weiher). Such pattern of distribution might suggest its preference for cold climate, however the localities mentioned did not belong to those with the highest altitude (565-785m).



Spiniferomonas alata

This is quite a rare species, in Europe it has been recorded only from Finland (chrysophytes.eu). Its autecology is unknown, we observed only in site 6 (Gieringer Weiher), in pH 7.6 and conductivity 102 μScm^{-1} .



Mallomonas paludosa

A species with bipolar distribution (Kristiansen 2002), considered as acidophilic to acidobiontic (chrysophytes.eu), often recorded from pH lower than 5 (chrysophytes.eu). We found it in only one sampling site, No. 21 (Amberger See) characterised by the lowest pH level (5.9) from all the sampling sites, which is well congruent with above mentioned species autecology.

Synura glabra



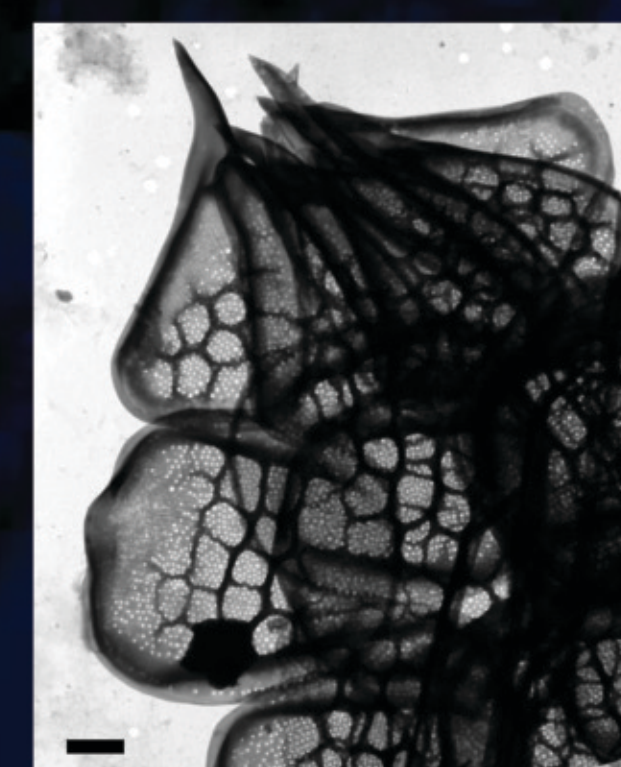
Mallomonas cratis

A widely distributed species (Kristiansen & Preisig 2007), alkaliphilic to pH indifferent (chrysophytes.eu). In the present study we observed it in two sites (14 - Herzsee, 16 - Möserer See). In addition, it has also been recorded from Brennersee (No. 12) in 2008 (Rott, unpublished).



Mallomonas striata

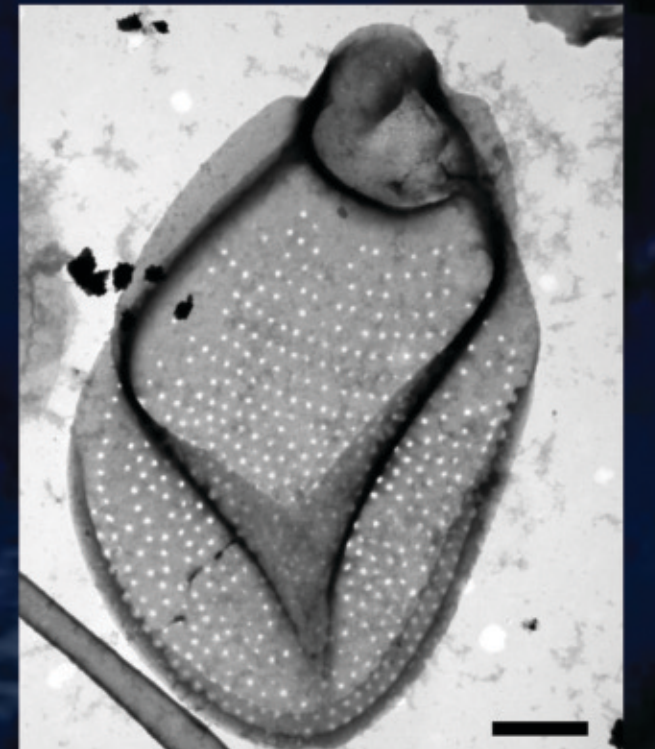
This species was one of the most frequent in our study. Two varieties based on bristle morphology have been described (var. *striata* and var. *serrata*), both being alkaliphilic and widely distributed. In this study we observed both of them: *M. striata* var. *striata* was more common whereas *M. striata* var. *serrata* was found only in site 6, Gieringer Weiher.



Mallomonas punctifera

A species with northern temperate distribution including the Arctic (Kristiansen 2002), alkaliphilic to pH indifferent (chrysophytes.eu). We found it only in site No.6 (Gieringer Weiher), in pH 7.6 and conductivity 102 μScm^{-1} .

M. elongata



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