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ECOLOGY AND BIODIVERSITY CONSERVATION OF THE ROMANIAN SYNUROPHYCEAE

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Abstract: The golden-brown Synurophyceae (phylum Chromophyta) are exclusively silica-scaled, single-celled or colonial heterokont flagellates, with two families – Synuraceae and Mallomonadaceae. Both flagella are anteriorly inserted, with almost parallel bases, a longer pleuronematic flagellum, and a shorter smooth one, the latter often vestigial. The green pigments are chlorophylls *a* and c_1, the major carotenoid being fucoxanthin. Their survival stages are siliceous, endogenous stomatocysts. Synurophyceae are characterized by external cell armour consisting of bilaterally symmetrical silica scales and sometimes also bristles (*Mallomonas*).

Synurophyceae occur almost exclusively in freshwater plankton, being widely distributed all over the world. Not all the species are ubiquitous or cosmopolitan as formerly believed; on the contrary, some require well-defined environmental conditions (e.g. *Synura sphagnicola* and *Mallomonas paludosa* are low pH forms; *Synura uvella*, *S. petersenii*, *Mallomonas acaroides*, *M. elongata*, *M. alpina* are high pH forms; many others are circumneutral). Their preference towards temperature is also specific; most of them seem to be microthermal, occurring in spring and autumn, and others develop rich summer water blooms (*Synura petersenii*, *M. elongata*). Synurophyceae exhibit different distribution patterns; some are cosmopolitan, others are restricted to tropical regions, several have bipolar distribution, many are characteristic for the arctic-northern temperate zone, and some are considered endemic (*M. intermedia* var. *saliceaensis*). Silica-scaled chrysophyte populations occur mostly in spring and autumn, and belong to a given planktonic algal assemblage – "phytoplankton association" or "functional group" (cf. Reynolds). The structure of such Synurophyceae–containing phytoplankton association groups depends on the physico-chemical and biotic conditions of the habitat (temperature, light, pH, nutrients, macrophytes, zooplankton, etc.) and on the seasonal dynamics of the plankton. Therefore, it is evident that the maintenance of silica-scaled chrysophytes is possible only in self-regulating populations within natural biocoenoses, or within those less disturbed by human activities. The presence of such biocoenoses, lakes, ponds and bogs, including raised peat bogs, with outstanding Synurophyceae assemblages has been documented by the present authors in 'Mestecanişu de la Reci' (Covasna County) and near the village of Sălicea (Cluj County), as well as in the Eastern and Southern Carpathians.

Keywords: Synurophyceae, *Mallomonas*, *Synura*, ecology, biogeography, biodiversity conservation proposals

Introduction

Surveys of the Romanian Synurophyceae using transmission electron microscopy were initiated in the early 1960s, the first electron micrographs being published somewhat later, based on plankton samples collected in fishponds near the town of Salonta – Romanian Western Plain) [13-15]. Subsequently, the investigations were extended to cover various aquatic habitats (lakes, pools, bogs, raised peat bogs, etc.) located in Transylvania, in the Southern and Eastern Carpathians and the Romanian Western Mountains [8, 11, 18-24]. Unfortunately, no investigations were carried out in the territories outside the Carpathians, except a fishpond in the Danube Delta and a small eutrophic pond at Eşelnița (near the Danube, close to the 'Porțile de Fier' area [17, 25]. For the time being, the occurrences of 60 Synurophyceae taxa have been documented in Romania by means of electron microscopy.

The present paper aims to analyze the ecology, biogeography and phytosociology of Synurophyceae taxa documented in Romania during the last 50 years, and to discuss strategies for their possible conservation.

Taxonomy of Synurophyceae

The classes Chrysophyceae Pascher 1914 and Synurophyceae Andersen 1987, known as golden-brown algae or chrysophytes (Phylum Chrysophyta – the old joint name of these two classes), have recently been placed in the phylum Chromophyta. A commonly used term "silica-scaled chrysophytes" accommodates not only Synurophyceae, but also four of the Chrysophyceae genera, those with silica-scale investment (*Paraphysomonas, Chrysosphaerella, Spiniferomonas, Polylepidomonas*). The present paper deals with the Synurophyceae or silica-scaled chrysophytes – *sensu stricto,* and exclusively with the 60 taxa documented in Romania.

The members of these two classes, in spite of many common features, readily differ in several ultrastructural and biochemical characteristics [1, 5, 6]. The flagellar apparatus is of heterokont type in both classes; the long anterior flagellum is hairy or pleuronematic, and bears tripartite mastigonemes, distributed in two opposed rows. There are also some distinctive characters. The flagellar number of Synurophyceae is not a major taxonomic criterion; the second, short or smooth flagellum is often vestigial. The insertion of flagella is at a very narrow angle, almost parallel. Flagellar roots are cross-banded; additional microtubular roots and cytoskeletal microtubules have also been documented. The eyespot is absent in Synurophyceae, but a flagellar swelling on the smooth flagellum (photoreceptor) is present in both major genera (*Mallomonas* and *Synura*). Minute, organic annular or rod-shaped flagellar scales may also be present. Resting spores are endogenous siliceous stomatocysts with an organic plug. The chloroplasts are golden-brown (two or a large bilobed one), surrounded by four membranes (chloroplast envelope doubled by the chloroplast endoplasmic reticulum cisterna); girdle lamella present. Pigments: chlorophyll *a* and c_1, β- carotene, xanthophylls, especially fucoxanthin [1, 5].

The most striking feature of Synurophyceae is the cell envelope (armour) consisting of imbricate silica scales (*Synura*), or scales and movable silica bristles (*Mallomonas*) and their biogenesis. The scales are bilaterally symmetrical and together with the bristles are forming on the external chloroplast cover of the unicellular or colonial monads. The complex micro-morphology and fine structure of scales and bristles is species-specific. Therefore, the scales and bristles are the only reliable taxonomic markers of the Synurophyceae when their occurrence and distribution is documented [3-5, 7, 34].

The recent classification split Synurophyceae into Synuraceae Lemmermann 1899 and Mallomonadaceae Diesing 1866, the most important genera being *Synura* Ehrenberg 1833 and *Mallomonas* Perty 1852 [29].

Synurophyceae are widely distributed in the freshwater plankton of various habitat types (lakes, reservoirs, ponds, bogs, large rivers, etc.) in most parts of the Earth. However, it should be emphasized that the silica-scaled chrysophytes are neither ubiquitous nor cosmopolitan, as formerly believed. They prefer particular environmental conditions and each taxon has its own characteristic geographical distribution area [2-4, 9, 10, 25].

Ecology of Synurophyceae

Differences in the abundance and species diversity of Synurophyceae is mainly related to water quality, namely the physico-chemical and biotic conditions of particular water bodies. They tend to comprise a significant proportion of the phytoplankton of lakes, large rivers, oxbow lakes, ponds, pools, bogs, peat bogs, etc. These general statements are equally applicable for the Romanian silica-scaled chrysophytes [9, 10]. Their seasonal distribution is usually restricted mainly to early spring (March–April), at slightly acidic pH conditions (6–6.5) in mesotrophic bogs, when the water temperature does not exceeded 10–11° C. There were also documented

species-rich Synurophyceae communities in eutrophic conditions, with considerable organic loading (fishponds), at pH 7.5–8.0, in midsummer time when the temperature of the water surface reached over 28°C.

Seasonal distribution of Synurophyceae. Although most of the Romanian Synurophyceae taxa occur and develop their peaks of population densities mostly in spring (March–April), according to the course of weather, their distribution is not entirely restricted to the colder period of the year [9, 35]. According to their distribution behaviour the present authors distinguish the taxa growing and developing higher population densities mostly in:

(1) **late winter–early spring,** e.g. *Mallomonas insignis, M. heterospina, M. multiunca, M. teilingii, M. intermedia, M. leboimei, M. mangofera, M. transsylvanica* (Pl. I, fig. 5), *Synura lapponica* (Pl. I,fig.6), *S. splendida* (Pl. I, fig. 8);

(2) **late summer–early autumn**, e.g. *M. trummensis, M. portae-ferreae* (Pl. I, fig.3), *M. cyathellata, M. punctifera, M. tonsurata, M. elongata, Synura sphagnicola* (Pl. I, fig.4);

(3) **throughout the year** (season–indifferent), e.g. *Mallomonas caudata, M. crassisquama, M. acaroides, M. striata, M. akrokomos, Synura echinulata, S. uvella, S. petersenii*, etc. Taxa of the third category may achieve their abundance in the colder or, on the contrary, in the warmer period of the year, according to their own distributional pattern. The present scheme, based on the authors' own findings, is somewhat similar to previous ones [35, 37], but less sophisticated.

Synurophyceae and pH gradient. According to the many available records [35, 36], most silica-scaled chrysophytes are acidophilous and only few seem to be truly **acidobiontic** (pH below 6), like *Mallomonas paludosa, M. corcontica* and *Synura sphagnicola*, occurring in peat bogs. The **acidophilous** (mid-acid taxa) which usually form fairly abundant populations in slightly acidic habitats (pH 5.0-6.5), peat bogs, ponds and small lakes are *Mallomonas transsylvanica, M. heterospina, M. multiunca, M. strictopteris* (Pl. I, fig. 2), *M. striata, M. intermedia, M. leboimei, Synura multidentata, S. splendida, S. mollispina* and *S. lapponica.* Species with **circumneutral** preferences (pH around 7) are *Mallomonas akrokomos, M. caudata, M. crassisquama, M. punctifera, Synura spinosa* and others. They grow mostly in bogs, ponds, lakes, oxbow lakes, etc. The **alkaliphilic/alkalibiontic** (high pH group) Synurophyceae occur mostly in habitats with pH 7.5-8.5, such as *Mallomonas acaroides, M. corymbosa, M. alpina, M. tonsurata, M. elongata, M. portae-ferreae, M.areolata, M. costata, M. cyathellata, M. trummensis, Synura echinulata, S. petersenii* and *S. uvella.* They inhabit eutrophic lakes, fishponds, water reservoirs, etc., mostly during the hot summer periods, often occurring in high population densities or even producing heavy blooms (like *Mallomonas acaroides, Synura petersenii, S. echinulata etc.*). The blooms affect the aesthetic value of the water, producing unpleasant fishy odor and taste [12]. The present authors have detected such heavy blooms in fishponds near Salonta (western Romania) and in the Hortobágy (eastern Hungary) [16, 28]. It should also be emphasized that there is some overlap between the different categories. Some species exhibit wider pH tolerances, occurring at more then one pH level, but their centre of distribution falls into a particular category.

Synurophyceae and water temperature. Seemingly most Synurophyceae are **microthermal**, distributed in cold waters, sometimes under ice or immediately after it has melted, when the temperature remains below 10–11°C [9]. When temperature exceeds the critical level, the formation of stomatocysts take place and the population density falls drastically (end of the spring maximum). A second, but moderate, growth may be achieved in late autumn or the beginning of winter, when environmental conditions are appropriate. Typical coldwater forms are probably *Mallomonas insignis, M. heterospina, M. multiunca, M. transsylvanica, Synura lapponica*, and many others. This is a general statement, because a fair number of Synurophyceae taxa grow well at different temperature levels, developing variable population densities. These seem to be **temperature indifferent** forms, like *Mallomonas acaroides, M. caudata, M. akrokomos, M. crassisquama, Synura petersenii, S. spinosa, S. sphagnicola* and

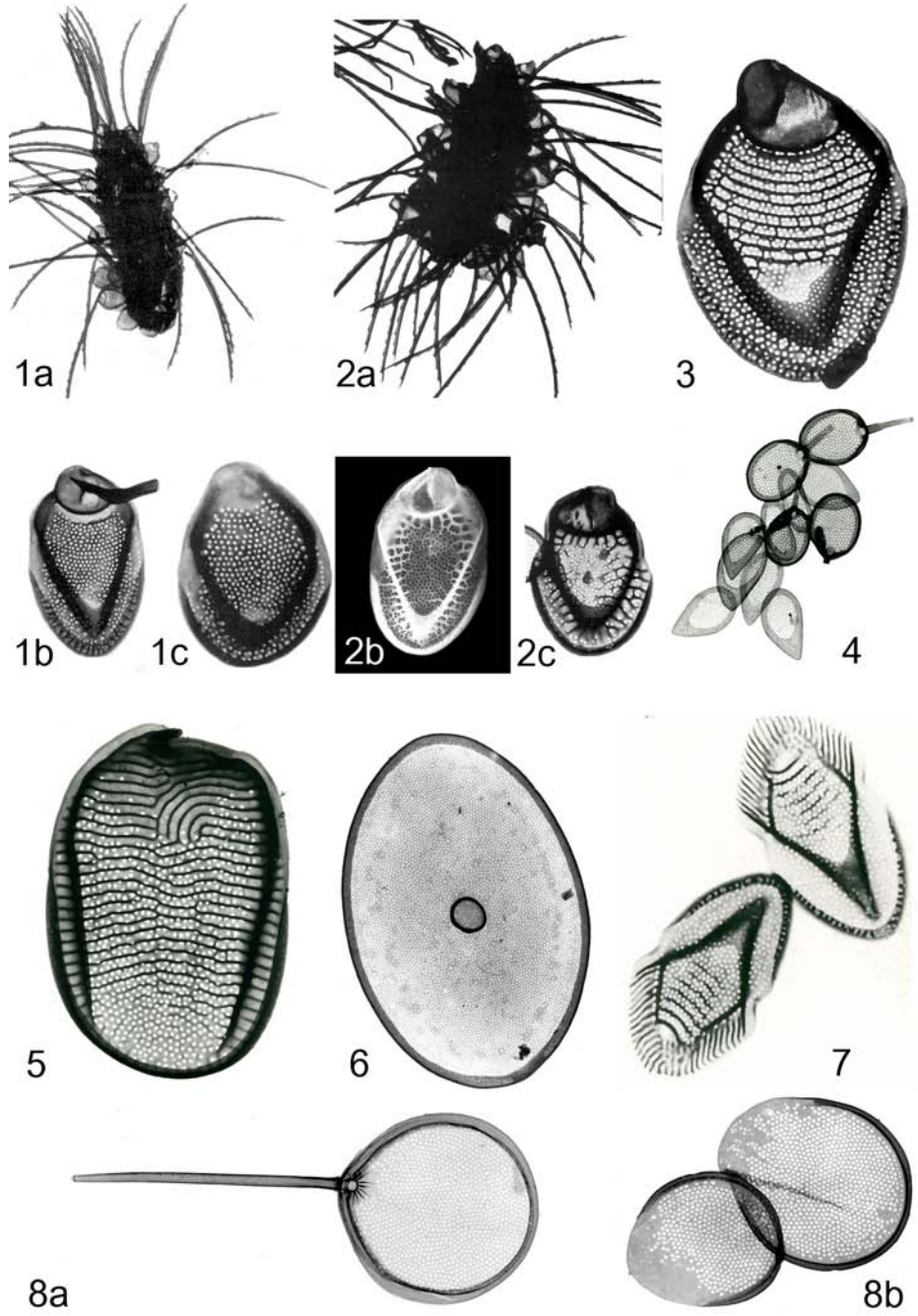

Plate I.: Direct electron micrographs (TEM) of some Romanian Synurophyceae. Fig. 1: ***Mallomonas intermedia*** var. ***saliceaensis*** Péterfi et Momeu – (a) whole cell armor [X 1,260], (b) anterior body scale [X 6,470], (c) rear body scale [X 9,300] . **Fig. 2:** ***M. strictopteris*** Péterfi et Momeu – (a) whole cell armor [X 1,260], (b) body scale, (c) collar scale [X 6,800]. **Fig. 3:** ***Mallomonas portae-ferreae*** Péterfi et Asmund – body scale [X 6,100]. **Fig. 4:** ***Synura sphagnicola*** Korshikov – anterior and posterior scales [X 3,760]. **Fig. 5:** ***Mallomonas transsylvanica*** Péterfi et Momeu – body scale [X 12,830]. **Fig. 6:** ***Synura lapponica*** Skuja – body scale [X 6,500]. **Fig. 7:** ***Mallomonas actinoloma*** var. ***maramuresensis*** Péterfi et Momeu – body scales [X 8,770]. **Fig. 8:** ***Synura splendida*** Korshikov – (a) anterior scale [X 4,470], (b) rear scales [X 4,000].

Synura echinulata. Some of them may develop highest population densities at water temperatures up to 20–25 (30)°C, producing genuine phytoplankton blooms (e.g. *Mallomonas paludosa, Synura petersenii, S. echinulata* and *S. sphagnicola).* In Romania, genuine warm water taxa – **thermophilic forms,** are *Mallomonas portae-ferreae* and *Mallomonas cyathellata* (with Sub-tropical/Mediterranean distribution centre) [17, 25]. Temperature should be considered a very important factor controlling the distribution of Synurophyceae taxa, but it is not the only one. Responsible for the occurrence of silica-scaled chrysophytes is a complex of various factors acting simultaneously and it is difficult to select the correct and most important.

Specific conductibility and Synurophyceae. It was postulated that the silica-scaled chrysophytes are tolerant of habitats with low specific conductance [33], but some of them may occur in water bodies high in salt content. Siver and Hamer [36], according to the tolerance of the Synurophyceae, distinguished three categories or groups of taxa: (1) low specific conductance group (e.g. *Mallomonas paludosa, M. actinoloma var. maramuresensis* (Pl. I, fig. 7), *M. corcontica, M. transsylvanica, M. multiunca, Synura sphagnicola, S. lapponica*), (2) moderate specific conductance group (*Mallomonas annulata, M. heterospina, M. punctifera, M. elongata, M. portae-ferreae, M. tonsurata, M. corymbosa* and others), and (3) high specific conductance group (possibly *Mallomonas acaroides* var. *acaroides, M. costata, M. cyathellata, M. caudata, M. areolata, Synura uvella, S. echinulata,* etc.). Further investigations are desirable.

Distribution of Synurophyceae and trophicity of waters. The silica-scaled chrysophytes according to their nutritional preferences are differentially distributed along the trophic gradient of waters. Most are important inhabitants of oligotrophic or mesotrophic water bodies, developing fairly rich populations, others prefer primarily eutrophic localities and may tolerate even hypertrophic conditions. *Synura sphagnicola, S. lapponica, Mallomonas paludosa, M. actinoloma* var. *maramuresensis* and *M. torquata* were found mostly in **oligotrophic** habitats, but they may equally be found in slightly mesotrophic ones (raised peat bogs or transitory peat bogs). Others are more often found in **mesotrophic** waters, such as *Mallomonas transsylvanica, M. lelymene, M. intermedia, M. leboimei, M. mangofera, Synura spinosa, S. multidentata, S. mollispina, S. splendida,* etc. The **eutrophic** waters (bogs, fishponds, oxbow lakes) are sometimes populated by rich Synurophyceae assemblages. Some of the taxa are preferentially eutrophic, such as *Mallomonas punctifera, M. costata, M. insignis, M. trummensis, M. tonsurata, M. acaroides* var. *acaroides, M. elongata, M. corymbosa, M. portae-ferreae, Synura uvella, S. petersenii* and *S. echinulata*; others are rather indifferent.

A fair number of Synurophyceae were observed equally in oligo-, meso- and even eutrophic conditions; they seem to tolerate a wide range of trophic levels, but their centre of distribution is in habitats with one particular trophic level, in which they may produce rather high population densities. Both *Mallomonas* and *Synura* are represented by a diversity of seemingly **indifferent** taxa; for example *Mallomonas crassisquama, M. caudata, M. akrokomos, M. annulata, M. oviformis, M. teilingii* and *Synura spinosa.*

Geographical distribution of Synurophyceae

The silica-scaled chrysophytes inhabit an exciting variety of aquatic habitat types and are widely distributed in all continents, mainly due to their various and efficient dispersal strategies. Based on the available worldwide records, Kristiansen [2-4] established several distributional types: cosmopolitan and widely distributed, northern temperate-subarctic-arctic, bipolar, tropical, disjunct or scattered, and finely endemic. All these categories are represented in Romania; the examples are given based on the present authors' previous records. The majority of the taxa documented in Romania are **cosmopolitan**, found in all six continents, such as *Mallomonas akrokomos, M. mangofera, M. tonsurata, M. annulata, M. matvienkoae, M. papillosa, Synura spinosa* and *S. petersenii,* or widely **distributed,** not yet found in one or two continents, for

example *M. acaroides, M. areolata, M. caudata, M. corymbosa, M. costata, M. crassisquama, M. heterospina, M. lychenensis* and *M. punctifera*. The Romanian Synurophyceae with **disjunct or scattered** distribution are less numerous (*Mallomonas insignis, Synura mollispina, S. splendida*, etc.), as well as those with **northern temperate-subarctic-arctic** distribution pattern (*M. teilingii, S. lapponica*). Very interesting are the species with bipolar distribution – *Mallomonas transsylvanica* and *M. paludosa.* Two of the taxa recorded in Romania, *Mallomonas portae-ferreae* and *M. cyathellata*, are distributed mainly in the **tropical and subtropical** zones of the Earth. They seemingly have their northernmost distribution limit in Romania (Danube Delta) and Eastern Hungary (Hortobágy) [28]. The extension of their distribution area towards the northern temperate territories of Europe is possibly due to recent climatic changes (global warming) and to their dispersal mechanism by migratory waterfowl [25]. For the time being the only **endemic** taxon in Romania is *Mallomonas intermedia* var. s*aliceaensis* (Pl. I, fig. 1)[3].

Phytosociology of Synurophyceae

The Synurophyceae are distributed in the plankton according to their ecological preferences, inhabiting various water bodies – lakes, reservoirs, pools, fishponds, bogs, peat bogs, glacial lakes, etc. Their growth is mostly restricted to a relatively short period – days or weeks, in particular periods of the year, mostly in early spring, but also in summer or fall – in accordance with their preferences for light, temperature, pH, nutrients (especially silica), etc., as already discussed. The development of populations is limited by nutrient deficiency, changes in water temperature and radiation, competition, grazing by zooplankton, etc. Seemingly, the raising of temperature over a certain level triggers the construction of endogenous resting cysts (stomatocysts), which means the end of the normal life cycle and fall in the population.

The various silica-scaled chrysophyte populations alone or mostly together with other algal populations of similar ecological preferences may associate to constitute short-term assemblages. Such temporary aggregates of planktonic algae have been identified by Reynolds and called “phytoplankton associations” or “functional groups” [30-32]. The functional groups or plankton associations were named by the same author according to 1–2 dominant genera, and coded with capital letters of the alphabet (A to Z), and characterize a particular habitat type, in a particular and usually short period of the year (season). For instance, the phytoplankton association **“E”**, characterized by *Dinobryon* and *Chrysosphaerella*, prefers mesotrophic water bodies and occurs in summer; **“E_2”**, dominated by *Synura* and *Gymnodinium*, prefers organically rich ponds; **“M”**, dominated by *Microcystis*, prefer warm, well-insolated, eutrophic habitats. This association was identified in Romania, in fishponds near Salonta, in August, the phytoplankton being dominated by *Microcystis* ssp.; *Mallomonas elongata, M. caudata, Synura echinulata, S. spinosa*, and *S. uvella* joined the phytoplankton assemblage.

There are characteristic functional groups with Synurophyceae in oligotrophic, dystrophic, mesotrophic, eutrophic and even hypertrophic habitats, but possibly not yet described and named. Further detailed investigations are necessary.

The spring functional groups exhibit the richest species diversity and are most frequently dominated by various silica-scaled chrysophytes. Such phytoplankton associations appear in early spring, just after the ice has melted (towards the end of February–beginning of March), when silica is available; the formation of stomatocysts starts at the beginning of April, and the populations disappear afterwards (end of April).

The summer functional groups are usually dominated by different algal groups (dinophytes, greens, blue-greens, etc.), but often some *Mallomonas* or *Synura* species join the association, and may develop high population densities – even heavy Synurophyceae blooms may occur (*Mallomonas acaroides, M. crassisquama, M. caudata, M. elongata, Synura petersenii, S. echinulata, S. uvella* etc.). The summer Synurophyceae in lakes are usually large single-celled or colonial forms, provided with heavy silica armour of scales with spines or/and

bearing long bristles. They are readily rejected by the grazing zooplankton, tolerate higher temperature and light intensity, slightly alkaline pH, higher nutrient level and organic loading, and are able to maintain their populations in the plankton for a relatively longer time. In addition their taste and odor are not agreed by the grazing zooplankters.

The spring functional groups may reappear during autumn, or somewhat similar associations may arise, when climate and habitat conditions are suitable.

Important Synurophyceae areas of diversity and their conservation

The occurrence of Synurophyceae is more related to water quality than to geographical area or altitude. It has been documented that aquatic localities supporting the richest Synurophyceae floras are those with slightly acidic or neutral waters, with low nutrient content, conductance and alkalinity, and moderate in dissolved humic substances [33-37].

Unfortunately the southern and eastern districts of Romania (Oltenia, Muntenia, Dobrudja and Moldavia) have not yet been investigated for their silica-scaled chrysophytes, except a fishpond in the Danube Delta, and a small artificial pond near the Danube River at the town of Orşova.

For the time being, the highest Synurophyceae diversities have been documented in Transylvania and the surrounding mountainous regions (Romanian Western Mountains and Eastern Carpathians), as well as in the wetlands of the Romanian Western Plain.

Especially important Synurophyceae habitats – mesotrophic and eutrophic bogs and oxbow lakes – are located south-west of the city of Cluj-Napoca, near Sălicea, and those situated in Covasna County, in the 'Mestecănişul de la Reci' and 'Mestecănişul de la Sântionlunca' areas.

The Synurophyceae-rich habitats near Sălicea are small eutrophic and mesotrophic bogs, in various stages of silting, some with peat deposits and living peat moss layers. In spring they are flooded by water mainly resulting from the melting snow of the surrounding slopes. The small marginal depressions at the end of March and beginning of April shelter very interesting and diverse chrysophyte communities, consisting of *Dinobryon sertularia, Chrysosphaerella, brevispina, Synura splendida, S. lapponica, Mallomonas akrokomos, M. intermedia, M. lelymene, M. heterospina, M. multiunca, M. clavus, M. doignonii, M. allorgei, M. insignis, M. paxillata, M. calceolus*, etc. [11, 15, 18]. At least 20 different Synurophyceae have been recorded. In one of the mesotrophic bogs, known as 'Tău cu Mesteceni', with thick peat deposits and living *Sphagnum* patches, was found and described the endemic *Mallomonas intermedia* var. *saliceaensis* forming rather dense populations. Eighty years ago 'Tău cu Mesteceni' was a genuine transitory peat bog covered by a living *Sphagnum* layer and a dense population of *Eriophorum vaginatum*. The whole area, including the bogs, has been overgrazed by water buffalo and recently by sheep, and altered by the native population and tourists. The surrounding forest was cleared 60 years ago. Today the bogs are endangered by the extension of the village and tourist cottages. Some of the most interesting bogs, at least Tău cu Mesteceni, should locally be protected and allowed to recover.

'Mestecănişul de la Reci' and 'Mestecănişul de la Sântionlunca' are interesting areas adjacent to the villages Ozun and Reci, in Covasna County (between Sf. Gheorghe city and Covasna town). Mestecănişul de la Reci is a remnant of an extended aeolian sand-dune district of diluvial origin in the south-east of Transylvania. Its genesis started during the last Quaternary interglacial (Riss-Würm) by the formation of an ancient lake in the 'Trei Scaune' depression. When the lake was emptied by the Râu Negru (Black River), the generation of sand-dunes could begin, as well as the formation of hundreds of small pools and bogs among them, mainly due to the rising ground water (Holocene). Belts of alder lined the bogs, and the sand-dunes were overgrown by populations of birch. The landscape was little changed from pre-Boreal times. Changes started at the end of the 19th century when a pine belt was planted to reduce the effect of the 'Nemira' wind, and the birch, willow and alder populations have been periodically cleared

and utilized by the native population. Mestecănişul de la Reci is called the "Country of a Hundred Pools", sheltering rare plants and animals (recently some of them could not be found). It was declared a nature reserve in 1962, but probably too late. Mestecănişul de la Reci has been profoundly altered; forestry staff and local authorities do not always understand the meaning of nature conservation. The last 20 years of 'privatization' has triggered the invasion of the area by holiday cottages, tourist houses and restaurants. Hundreds of years of traditional farming produced less destruction than the contemporary 'civilization'. The eutrophic and mesotrophic bogs, some with living peat moss layers, are the habitats of a variety of unique silica-scaled associations. In Mestecănişul de la Reci is located a bog with a centrally floating *Sphagnum* islet – the type locality of *Mallomonas transsylvanica* [19]. From another bog was collected and described the holotype of *Mallomonas strictopteris* [21]. During the last 40 years, 34 Synurophyceae (26 *Mallomonas* and 8 *Synura*) have been documented, some of them rare or otherwise interesting: *Mallomonas actinoloma* var. *maramuresensis, M. costata, M. insignis, M. mangofera, Synura lapponica, S. multidentata* and *S. sphagnicola* [27].

The oxbow lakes of the neighbouring area – 'Mestecănişul de la Sântionlunca' – are inhabited by typical eutrophic phytoplankton assemblages with interesting Synurophyceae populations: *Mallomonas costata* (recorded by means of TEM by the present authors as *Mallomonas = Mallomonopsis robusta*; therefore one of the oxbow lakes of the area is its type locality) and *M. trummensis* [24]. These oxbow lakes seemingly are not yet endangered by farming or urbanization. The anthropogenic factor consists of agricultural intensification of the surrounding land, which might produce increased nutrient input and further eutrophication of their waters.

The fishponds of the Romanian Western Plain (continuation of the Pannonian Plain in Romania), are inhabited by eutrophic phytoplankton assemblages. During the hot summer periods some Synurophycean taxa may produce very high population densities, such as *Mallomonas caudata, M. elongata, Synura spinosa, S. echinulata, S. petersenii* and *S. uvella*. These associations are very close to type "M" of Reynolds, dominated by blue-greens (*Microcystis aeruginosa, M. flos-aquae*), chlorococcaleans (various *Ankistrodesmus, Crucigenia, Chodatella, Coelastrum, Pediastrum, Scenedesmus* and *Tetraëdron* species), desmids (especially small forms of *Cosmarium*), and euglenoid flagellates [16].

Samples collected in a fishpond of the Danube Delta revealed the presence of *Mallomonas portae-ferreae* and *M. cyathellata*, the latter with a relatively high population density. Both are thermophilic forms, distributed mostly in warmer and tropical regions. Their future dispersal is not yet endangered; the Danube Delta is part of the main routes used by migratory waterfowl [25].

The low-pH Synurophyceae are mostly distributed in the genuine raised peat bogs located in the Romanian Western Mountains (Munții Bihorului) and Eastern Carpathians (Munții Maramureşului, Munții Bodocului, Munții Bârgăului). A summer population of *Synura sphagnicola* was documented in bog pools of the 'Mohoş' Peat bog (Munții Bodocului). *Mallomonas paludosa* was found developing dense summer population in a polyhumic bog pool of the 'Poiana Stampei' raised peat bog (in Munții Bârgăului). In the central bog pool of a genuine raised peat bog of the Munții Maramureşului – known as 'Tăul lui Dumitru' was detected *Mallomonas corcontica* [20]. In the small acidic, alpine bog 'Vinderele' (Rodna Mountains) was discovered and described *Mallomonas actinoloma* var. *maramuresensis* [8].

Although the Romanian Carpathians exhibit a great many glacial lakes, the only one sheltering a dense early autumn population of *Mallomonas acaroides* was 'Câlcescu Lake' (Parâng Mountains, Southern Carpathians) [26], similar to one in Bulgaria. Urgent investigations are needed to reveal the real richness of these subalpine and alpine lakes, before anthropogenic factors affect their water quality.

Conclusions and perspectives

Synurophyceae form various percentages of phytoplankton assemblages (associations), which are characteristic for different aquatic habitats, according to their physical, chemical and biotic requirements.

In oligotrophic or moderately mesotrophic water bodies, the Synurophyceae are more important in the phytoplankton than in eutrophic bodies. The Romanian Synurophyceae taxa seemingly produce the highest richness and population densities in small mesotrophic bogs and pools, with slightly acidic waters and low specific conductance, in spring at water temperatures up to 10–11^{0}C. The stenotopic, acidobiontic Synurophyceae usually occur and produce higher population densities or blooms in the bog pools of raised peat bogs, during the summer months.

Some of the preferentially eutrophic species tolerate higher pH and alkalinity, high organic load, and may develop high population densities in oxbow lakes and fishponds; some often produce summer blooms or are sub-dominants.

The acidophilous Synurophyceae assemblages of small bogs and transitory peat bogs are endangered by many anthropogenic factors: urbanization, agricultural intensification, forest clearing, overgrazing, etc. The raised peat bogs and transitory bogs with peat deposits are also endangered by peat extraction, which produces irreversible changes in their biocoenoses.

In some cases just the maintenance of traditional agricultural techniques is sufficient. The authors wish to emphasize that the most endangered are the phytoplankton associations of raised peat bogs; any anthropogenic factor including tourism may profoundly harm the ecological equilibrium and alter their biocoenoses. The same is true for the glacial lakes in the subalpine and alpine zones of the Carpathians.

Less vulnerable for the time being are eutrophic associations in which the Synurophyceae tend to comprise a relatively significant proportion, inhabiting oxbow lakes or fishponds. Even the thermophilic *M. portae-ferreae* and *M. cyathellata*, subtropical/tropical species that inhabit the fishponds of the Danube Delta, are not endangered, their dispersal being possibly assured by migratory waterfowl.

Synurophyceae diversity conservation is guaranteed when all the environmental factors of their habitats are maintained within reasonable tolerance ranges. Therefore, educational programmes should be initiated with local and district authorities to explain and clarify the importance and necessity of preservation of particular habitats or habitat complexes, and to include them within the national system of protected areas.

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ECOLOGIA ŞI CONSERVAREA BIODIVERSITĂŢII SPECIILOR DE SYNUROPHYCEAE DIN ROMÂNIA

(Rezumat)

Clasa Synurophyceae, crizofite cu scvame silicioase care are două familii mai importante – Synuraceae şi Mallomonadaceae, aparţine încrengăturii algelor brune-aurii – Chromophyta. Ele sunt flagelate heteroconte, solitare sau coloniale, caracterizate prin doi flageli inegali, inseraţi apical, unul mai lung, pleuronematic şi altul mai scurt şi neted, care dese ori poate fi redus sau vestigial. Pe lângă pigmenţii clorofilieni specifici – clorofila *a* şi c_1, apar o serie de pigmenţi carotenoidici, dominant fiind fucoxantina. Stomatocistii silicioşi endogeni reprezintă formele de rezistenţă ale taxonilor. Sinuroficeele sunt caracterizate printr-un înveliş celular extern format din scvame silicioase, cu simetrie bilaterală (*Synura*), la care se ataşează uneori şi sete (*Mallomonas*).

Sinuroficeele sunt planctonice, întâlnite de cele mai multe ori în habitate cu apă dulce, fiind răspândite pe întreg mapamond. Cu toate acestea, nu toate speciile sunt ubicviste sau cosmopolite, aşa cum se credea anterior, ci din contră, unele necesită condiţii foarte bine definite de mediu (*Synura sphagnicola, Mallomonas paludosa* – acidofile; *Synura uvella, S. echinulata, S. petersenii, Mallomonas caudata, M. elongata, M. tonsurata* – alcalifile). Algele din acest grup prezintă, de asemenea, preferinţe specifice faţă de temperatură, cele mai multe fiind microterme, răspândite primăvara şi toamna, altele din contră, dezvoltându-se exploziv vara (*Synura petersenii, Mallomonas elongata*). Prezintă diverse tipuri de distribuţie: unele sunt cu adevărat cosmopolite (*Synura petersenii*), altele sunt întâlnite doar în regiunile tropicale, câteva au distribuţie bipolară, în timp ce numeroase specii sunt caracteristice pentru zona temperată arctică; unele sunt considerate a fi endemice (*Mallomonas intermedia* var. *saliceaensis*). Populaţiile de crizofite cu scvame silicioase se dezvoltă în special primăvara şi toamna şi aparţin comunităţilor planctonice (“asociaţii” sau grupuri funcţionale, cf. Reynolds). Structura unor astfel de grupuri funcţionale ce conţin sinuroficee depinde de caracteristicile habitatului (prezenţa macrofitelor, condiţii fizico-chimice, zooplancton etc.) şi de dinamica sezonieră a planctonului. De aceea, este evident că menţinerea crizofitelor cu scvame silicioase stenotope este posibilă doar în populaţii cu auto-susţinere din cadrul biocenozelor naturale, sau în cadrul acelora puţin afectate de activităţile umane. Prezenţa unor astfel de biocenoze: iazuri şi mlaştini, inclusiv mlaştini de turbă, în diferite stadii de colmatare, a fost documentată de autorii prezentei lucrări în “Mestecanişu de la Reci” (judeţul Covasna) şi lângă satul Sălicea (judeţul Cluj), ca şi în Carpaţii Româneşti.

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