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ABSTRACT

An initial study of scaled chrysophytes from Arkansas is presented. Species include: *Synura Petersenii* f. *Petersenii*, *S. spinosa* f. *spinosa*, *S. curtispina* f. *curtispina*, *S. curtispina* f. *reticulata*, *S. uvella*, *Mallomonas striata* var. *striata*, *M. pumilio* var. *pumilio*, and *Chrysosphaerella brevispina*. Transmission electron micrographs of their siliceous scales are included.

INTRODUCTION

This paper is intended to be the initial paper of a series concerning the scaled chrysophytes of Arkansas. Members of the Synuraceae previously have been reported in floristic studies of Arkansas algae (Meyer, 1969; Meyer, et al., 1970), but this is the first report based on electron microscopical observations. These are more frequent and abundant in Arkansas waters during the winter months, although these and other chrysophytes have been collected throughout the year in cooler bodies of water. All collections were from small ponds, seeps, streams, or impounded lakes located in Northwest Arkansas.

The sampling sites included in this study are Sequoyah Pond near Elkins; various backwater channels and isolated, ephemeral pools of Lake Sequoyah, an impoundment on the Middle Fork of the White River; West Fork of the White River near West Fork; Savoy Mill Pond on Clear Creek near Savoy; various unnamed seeps and farm ponds in the Boston Mountains (all in Washington County); the Buffalo River near Ponca (Newton County); and Lake Fort Smith and Lake Shepard Springs, impoundments on the Frog Bayou (Crawford County).

METHODS

All samples were collected with a plankton net, and the bottles were kept in ice water during transport to the laboratory. The samples were maintained in culture chambers until they were examined.

Preparation of samples for electron microscopy was conducted by two methods. In the first and most commonly used method, living organisms were selected from sample material using a dissecting microscope and a finely drawn out glass micropipette. All pipettes used were new, i.e., they had never been used before for any purpose, and they were always used only once. The organisms were cleansed by successive pipetting through small Syracuse watch glasses containing sterile, isotonic culture medium. Finally, one or more organisms were deposited on formvar-covered grids, distilled water was added to facilitate the rupturing of cells and scattering of scales, and these were allowed to air dry. The second method employed was similar to the preparation of diatom frustules. The organisms were gently heated in concentrated nitric or sulfuric acid and then rinsed by several changes of distilled water. A small amount of the material was deposited on a formvar-coated grid and allowed to air dry. This method separated the scales much better, but diatoms and inorganic particles from the sample were often excessive. All scales were examined without any further preparation such as shadowcasting or carbon replication. All samples were viewed with a Siemens Elmiskop transmission electron microscope operated at 75 KV.

RESULTS

Genus *Synura* Ehrenberg, 1838 emend. Korshikov, 1929

Several species of this genus have been described and electron micrographs of the siliceous scales of many of these species have been published by other investigators [see Petersen and Hansen (1956; 1958), Fott and Ludvik (1957), Takahashi (1967), Asmund (1968), and Kristiansen (1975a)]. The genus has been divided into two sections based upon the morphology of the siliceous scales. Petersen and Hansen (1956, p. 6) designated the Section *Petersenianae* to include those members with an elevated, strut-supported hollow cylinder along the longitudinal axis of each scale and the Section *Spinosae* to include those members without such a structure but possessing a more or less well developed anterior spine on all the scales except those near the base of the cell. But when they listed their species under these two sections, they used Section *Uvellae* (p. 13) in place of Section *Spinosae*. However, according to the International Code of Botanical Nomenclature, Article 22, the section including the type species of the genus must bear the unaltered generic name (Stafleu et al., 1972). Thus, by Article 66, the section names *Spinosae* and *Uvellae* are illegitimate, and, by Article 22, the valid section name must be *Synura*. We, therefore, include Sections *Spinosae* and *Uvellae* as synonyms of Section *Synura*.

We have not found *Synura lapponica* Skuja 1956 in our samples; however, it should be mentioned this species does not fit into either section. The scales of *S. lapponica* have neither a hollow cylinder nor an apical spine but rather large oval scales with a small exterior rim, reticulate base plate pattern and a central papillum (Skuja, 1956; Petersen and Hansen, 1958; Kristiansen, 1976). Petersen and Hansen (1958) suggest this organism may belong in another genus such as *Synuropsis*. There exists some difficulty in the distinction of the genera *Synuropsis*, *Syncrypta*, *Synochromonas*, *Volvochrysis*, *Pseudosynura*, *Pseudosyncrypta* and others (see Bourrelly, 1957, 1968; Starmach, 1968). Since *Synura lapponica* has definite and distinct scales and other features which fit the emended description of the well-known genus *Synura* (Korshikov, 1929), it seems better to maintain this species within the genus and erect a third section to include it.

Section *Synura*

syn. *Spinosae* Petersen et Hansen 1956, p. 6
Uvellae Petersen et Hansen 1956, p. 13

Synura curtispina (Petersen et Hansen 1956) Asmund 1968, p. 506 forma *curtispina*
Synura spinosa Korshikov 1929 forma *curtispina* Petersen et Hansen 1956, pp. 22, 26.

Plate I, Figures 1, 2, 4, 5.

This organism has been the most common *Synura* species found in the Fayetteville area in the past two years. We have collected it from Sequoyah Pond, Buffalo River at Ponca, several backwater pools of Lake Sequoyah, and several small farm ponds in the Boston Mountains. In addition, light microscopic examination of scales from Lake Fort Smith and Lake Shepard Springs have revealed scales which seem to belong to this taxon. *S. curtispina* was elevated from a form of *S. spinosa* to the species level based on the morphology of the anterior spined scales (Asmund, 1968). The basal scales are also typically more slender than those of *S. spinosa* f. *spinosa*. The rim of *S. curtispina* f. *curtispina* basal cells are folded in such a way as to produce a diamond-shaped pattern (Fig. 4) as opposed to the rim of *S. spinosa* f. *spinosa* which is folded equidistantly and forms a pattern similar to the outer margin of the scale (Fig. 7). Both Petersen and Hansen (1956) and Asmund (1968) have reported the basal scales to be without perforations. However, we have found scattered perforations to be present (Fig. 4) and Kristiansen's (1975b) micrograph,

Figure 27. appears to have one or two perforations on two of the body scales. Another feature which seems to distinguish the body scales of these two organisms is the complete rim of *S. spinosa* f. *spinosa* and the incomplete rim on the tapered end of *S. curtispina* f. *curtispina*.

Synura curtispina (Petersen et Hansen 1956) Asmund 1968, forma *reticulata* Asmund 1968, p. 508

Plate I, Figure 3.

Scales which best fit Asmund's (1968) description were found in an

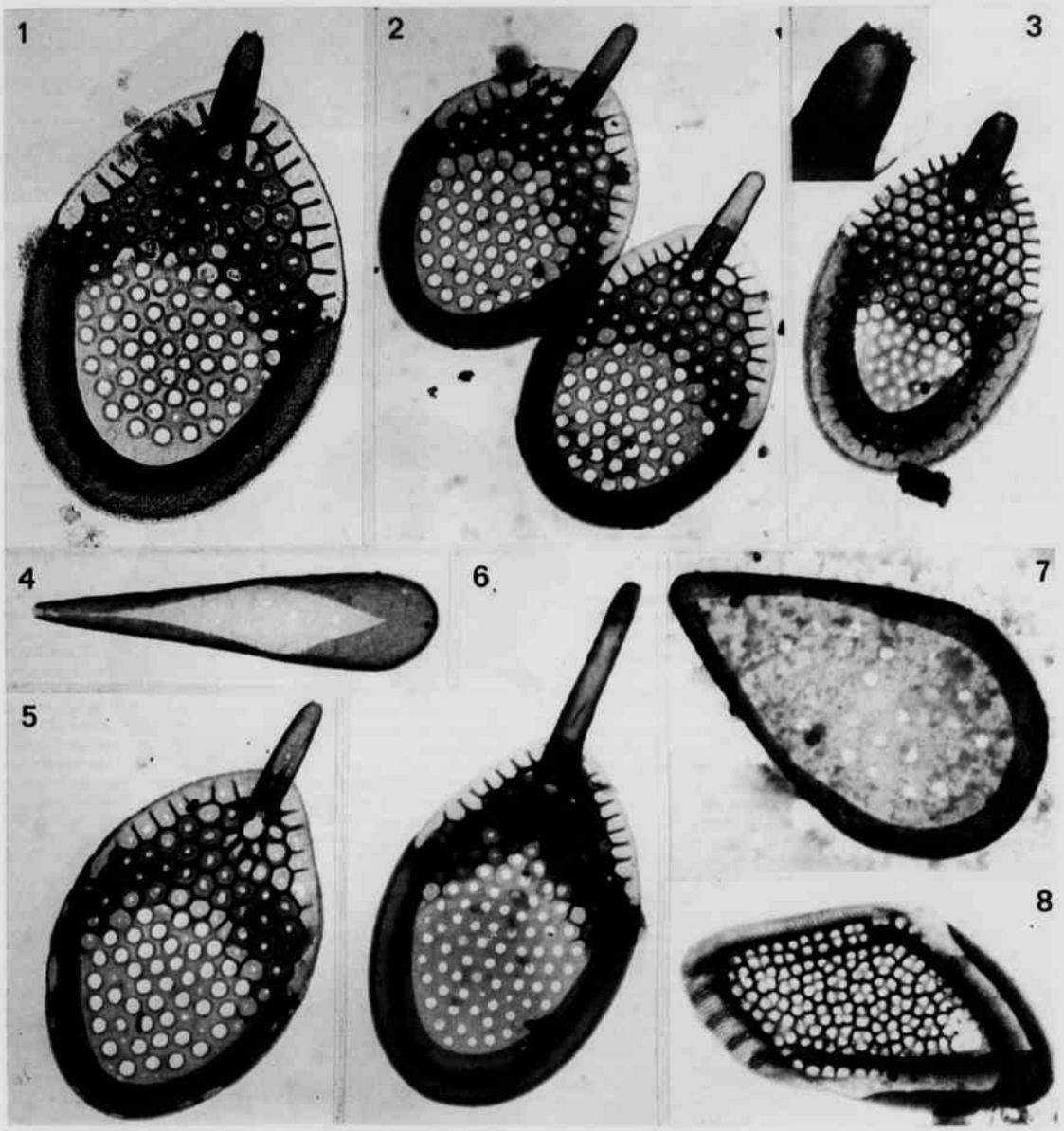

Plate I

Fig. 1. *Synura curtispina* f. *curtispina*, acid cleaned. 19,500X. Fig. 2. *S. curtispina* f. *curtispina*. 15,600X. Fig. 3. *S. curtispina* f. *reticulata*, acid cleaned. 13,000X. Inset of spine tip illustrating teeth, 30,500X. Fig. 4. *S. curtispina* f. *curtispina* basal scale. 26,000X. Fig. 5. *S. curtispina* f. *curtispina*. 18,200X. Fig. 6. *S. spinosa* f. *spinosa*. 15,600X. Fig. 7. *S. spinosa* f. *spinosa*, basal scale. 26,000X. Fig. 8. *Mallomonas pumilio* var. *pumilio*, acid cleaned. 20,800X.

acid-cleaned sample from a small pool near Lake Sequoyah on December 30, 1975. The honeycomb pattern covers the entire scale although it is very weak in the midsection of the posterior half of the scale. The scale in Figure 3 is 4.4 μm by 2.9 μm and has a short spine of 1.4 μm length with seven very minute teeth on the apex (Fig. 3, inset). Asmund (1968) shows only three teeth in her micrograph (Fig. 9), but this character is not included in her description and may be variable. Spined scales appear to cover about three-fourths of the cell based upon light microscopic examination of about 20 preserved colonies, with the remainder covered with spineless

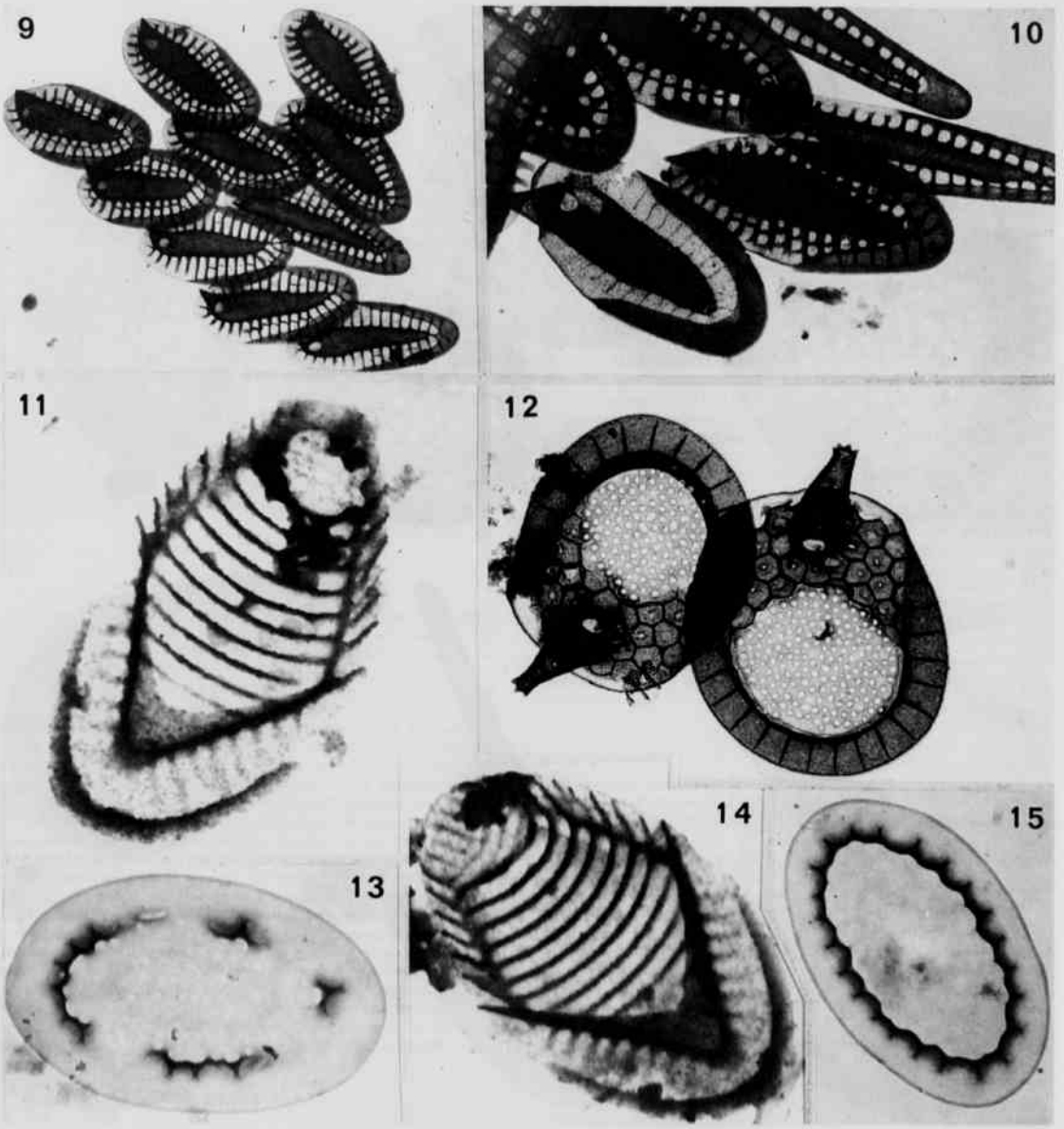

Plate II

Fig. 9. *Synura Petersenii* f. *Petersenii*. 5,400X. Fig. 10. *S. Petersenii* f. *Petersenii* incl. *S. glabra*-type scale, lower left. 10,400X. Fig. 11. *Mallomonas striata* var. *striata*, acid cleaned. 20,800X. Fig. 12. *S. uvella*, acid cleaned. 10,400X. Fig. 13. *Chrysosphaerella brevispina*, incompletely silicified scale, acid cleaned. 20,800X. Fig. 14. *M. striata* var. *striata* acid cleaned. 19,500X. Fig. 15. *C. brevispina* scale, acid cleaned. 20,800X.

scales. One slipper type basal scale was observed by light microscopy, and it appeared to be similar to those of the nomenclatural type. This organism has apparently been found previously only from Alaska (Asmund, 1968). *Mallomonas striata* var. *striata*, *M. pumilio* var. *pumilio*, and *Chrysosphaerella brevispina* were also present in the sample, but no other *Synura* colonies or scales were observed. The ephemeral pool has remained without water since the collection.

Synura spinosa Korshikov 1929 forma *spinosa*

Plate I, Figures 6-7.

Specimens of this taxon were collected February 20, 1976, from a pool of the West Fork of the White River near West Fork and a small seep (1 m diameter) in the Boston Mountains southeast of Winslow. The scales are comparable to Petersen and Hansen's (1956) description and the findings of other investigators.

Synura uvella Ehrenberg 1838 emend. Korshikov 1929, p. 279
Synura uvella Stein 1878

Plate II, Figure 12.

This organism was abundant in Sequoyah Pond during November and December, 1976, but has not been found there since. However, this pond was dry during most of 1976. We have also found this species in a shallow (<0.5 m), temporary pool near Lake Sequoyah during March, 1977.

Section *Petersenianae* Petersen et Hansen 1956, p. 6

Synura Petersenii Korshikov 1929 forma *Petersenii*
Synura uvella Ehrenberg 1838 in Petersen 1918, p. 345
Synura caroliniana Whitford 1943, p. 159

Plate II, Figures 9-10.

The history of this taxon has been discussed in detail by Petersen and Hansen (1956, 1958). This taxon is common in the Fayetteville area, and we have found it in samples from Sequoyah Pond, Savoy Mill Pond, Buffalo River near Ponca, and various backwater pools of Lake Sequoyah. The scales were typical of those reported by other authors, but we found a single instance of a *Synura glabra*-type scale in a cluster of typical *S. Petersenii* f. *Petersenii* scales (Plate II, Fig. 10). The colony was carefully rinsed before deposition onto the grid, and no other scales of the *S. glabra*-type were found on other grids of the sample or by light microscopy. The origin of silica has been shown to be from Golgi vesicles and is deposited around an elaborate template formed by the endoplasmic reticulum surrounding the chloroplast (Schnepf and Deichgraber, 1969; our unpublished results). The mechanism controlling the initiation and termination of silicification is still unknown but perhaps an interruption of this mechanism prior to completion results in the formation of *S. glabra*-type scales. The amount of silica present in the water apparently is not a factor since both *S. Petersenii* and *S. glabra* are sometimes found together (Kristiansen, 1975a; Wujek and van Der Veer, 1976). The preparation of our grid involved the disruption of the cell, and it is possible this *S. glabra*-like scale was within the cell and was in the process of being formed at the time of disruption. Yet, the rather natural placement of the scale within the cluster suggests the possibility that *S. glabra*-type scales may not be a valid species character, and this condition is worthy of further investigation.

Genus *Mallomonas* Perty, 1851

This rather large genus contains many species whose scales have been observed by electron microscopy. For more comprehensive studies, see Asmund (1959) and Harris and Bradley (1960). The taxonomy of this group is based largely on the structure of the scales, and Harris and Bradley (1960) have proposed an expanded scheme of series and groups within the genus based upon the gross structure of the scales. The series and group names which include the type species of the genus are not required to bear the generic name, unlike section names (see I.C.B.N., Art. 22, Stafleu et al., 1972). However, certain taxa of the expanded scheme of Harris and Bradley (1960) must include a Latin description of diagnosis before they can be considered valid because they are new names published after January 1, 1958 (I.C.B.N., Art. 36, Stafleu et al., 1972).

Series I. *Tripartiae* Harris 1953 emend. Harris et Bradley 1960, p. 752

Striata group Harris et Bradley 1960, p. 752

Mallomonas striata Asmund 1959, p. 38 var. *striata*

Plate II, Figures 11, 14.

We have found organisms which fit the description of *M. striata* using the light microscope but only three scales were observed with the electron microscope. These scales were from an acid-cleaned sample collected from a small, ephemeral woodland pool near Lake Sequoyah on December 30, 1975.

Series IV. *Torquatae* Harris et Bradley 1960, p. 752

Mallomonas pumilio Harris et Bradley 1957, p. 45 var. *pumilio*

Plate I, Figure 8.

Scales of this organism were observed in the same sample which contained *M. striata*. Scattered scales like the one in Figure 8 were found but anterior and posterior scales as published by Harris and Bradley (1957, Plate III, Fig. 3-4; 1960, Plate 7, Fig. 60) and Harris (1970, Plate I, Fig. 1-4) were not observed using the electron microscope.

Chrysosphaerella Lauterborn 1896 s. ampl. 1899

Chrysosphaerella brevispina Korshikov 1942 emend. Harris et Bradley 1958, p. 75
Chrysosphaerella Rohdei Skuja 1948, p. 276-278
Chrysosphaerella Conradii Bourrelly 1957, p. 214

Plate II, Figures 13, 15.

There appears to be some question concerning the scales of the type species, *C. longispina*, and subsequent species (Harris and Bradley, 1958; Kristiansen, 1969; 1975b; 1976; Wujek and Hamilton, 1972; Asmund, 1973). Asmund (1973, p. 133) states Harris and Bradley (1958) examined *C. brevispina* and found it to be identical with Lauterborn's (1896, 1899) species, but we find no comment of this in Harris and Bradley's paper and therefore presume Asmund was referring to Korshikov's species instead of Lauterborn's. The organisms, scales, and bristles we observed are consistent with the description of *C. brevispina* and the electron micrographs published by other authors (Harris and Bradley, 1958; Wujek and Hamilton, 1972 - Figs. 11, 14, 15; Asmund, 1973; Kristiansen, 1975b, 1976). We have no electron micrographs of the bristles but those observed by light microscopy were identical to those of this species. One scale (Plate II, Fig. 13) was incompletely silicified. Whether this scale was internal and in the process of formation at the time of sample preparation or simply was incompletely formed and located outside the cell membrane is not known. The scale was from an acid-cleaned sample but this process does not seem to be a factor since the complete scale shown in Figure 15 was also from the same sample. We have found *C. brevispina* in samples from Sequoyah Pond and a small woodland pool near Lake Sequoyah.

DISCUSSION

The scaled chrysophytes presented here are by no means a complete inventory of the Arkansas flora. We have observed with the light microscope many species of *Mallomonas* and organisms which

appear to be *Synura sphagnicola* and *S. echinulata*. The limited precipitation during 1976 hampered this investigation since many ponds known to contain chrysophytes were dry. It is our intent to continue this survey plus contribute knowledge concerning the habitat and environment of Arkansas scaled chrysophytes.

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