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Studies on Silica-Scaled Chrysophytes from Iowa. II. Common *Synura* Species

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Synura (Synuraceae, Chrysophyceae) includes some of the more common and conspicuous planktonic algal forms in Iowa. This genus, with its covering of characteristic overlapping siliceous scales is representative of the Synuraceae. Since 1955 published identifications of species in this family by specialists have not been considered accurate unless they are based on electron microscopy of scales. However, little effort has been made to correlate light microscopy with electron microscopy. In this paper scales are illustrated with transmission and scanning electron micrographs as well as light micrographs. Four of the most common *Synura* species are discussed. Three of them, *S. uvella* Ehrenberg, *S. echinulata* Korshikov, and *S. spinosa* Korshikov have not previously been identified from Iowa material on the basis of electron microscopy. The fourth species, *S. petersenii* Korshikov, has been reported once previously.

INDEX DESCRIPTORS: Iowa algae, scaled chrysophytes, *Synura,* Chrysophyceae, Synuraceae

This is the second paper of a series on the silica-scaled chrysophytes (Synuraceae, Chrysophyceae) of Iowa. The first (Wee, et. al., 1976) established the presence of this algal group in Iowa. In this family, species identifications are based upon the morphology of the siliceous scales and bristles, if present, which surround the cell. Since 1955, specialists have not considered identifications valid unless they are based upon electron microscopy of the scales. Most of these studies have used transmission electron microscopy (TEM), even though in the last decade the use of scanning electron microscopy (SEM) has become a common tool for phycologists.

There are few published accounts of scaled chrysophytes exhibiting the three dimensional image obtained with SEM (e.g. Cronberg, 1972, 1975; Wee, 1976). Interpretation of specimens examined with SEM when almost the entire literature uses TEM can be very confusing to the inexperienced observer. Using primarily Korshikov (1929) and Huber-Pestalozzi (1941) as sources, some specialists have gained knowledge of light microscope identification of this group. However, since the electron microscope has come into common use little of this information has been published by itself or in correlation with SEM or TEM. In this paper I demonstrate SEM, TEM and phase-contrast light microscopy (PCM) of the scales of four species of *Synura* common to Iowa. Two of these species have not been reported from the state previously.

MATERIALS AND METHODS

Plankton tow samples were collected using a 10μm or 37μm mesh size plankton net or as a one liter whole water grab sample. The whole water samples were concentrated using centrifugation or fixation with Lugol-Rodhe solution (Willén, 1962), subsequently settled and decanted. Samples were washed 3-5 times to remove most of the dissolved salts. To prepare a sample for washing, 2-10 ml of sample were placed in a 15 ml centrifuge tube, which was then filled with distilled water and centrifuged at 1000-2000 rpm for 5-10 minutes. The supernatant was poured off, up to 15 ml of distilled water was added, and the process repeated. For light microscopy, an appropriate amount of washed material was placed on a clean coverslip, allowed to dry, then incinerated in a muffle furnace at 550°C. Permanent slides were prepared using Hyrax as the mountant (IR = 1.71). Slides were examined at 1000× with a phase-contrast microscope. For SEM examination the washed sample was air dried on a SEM stub and coated with approximately 300Å of gold in a Polaron E5100 sputter coater. These samples were observed with a JEOL JSM-25 or JEOL JSM-35 scanning microscope at 15 or 20 KV. Preparations for TEM were made by drawing a small portion of washed sample into a capillary pipette and placing the sample on a Formvar coated 200 mesh grid. Examinations were made at 50 KV with an Hitachi H-11C transmission electron microscope.

OBSERVATIONS

Synura cells are united radially to form spherical to oblong colonies. Taxonomy within the genus is based upon the morphology of siliceous scales which surround the cell membrane. Cell shape does vary due to crowding of cells in the colony, or whether the cells are in the process of forming statocysts. The cells generally are oblong, tapering to a slender stalk-like shape at the point of attachment to the colony. The scales located on the more globose, apical part of the cell are usually more circular and are termed apical scales. The scales attached on the stalk-like portion of the cell are more elongate and are variously termed posterior, stalk, or caudal scales by different authors. Petersen and Hansen (1956, 1958) published the first comprehensive study on the genus using TEM. The literature reports which follow are all based upon electron microscope examination of these scales except where stated otherwise.

Synura petersenii Korshikov

This taxon has been reported from Iowa once previously (Wee et. al., 1976). Here it was at 10 additional sites (Table 1). It is the most frequently encountered species of the genus in Iowa. In this country it has been reported from Michigan (Wujek and Hamilton, 1972), Washington (Munch, 1972, 1980), Arkansas (Andersen and Meyer, 1977), Arizona (Gretz et. al., 1979), and Alaska (Asmund, 1968). Figure 1 represents the longer, narrower, posterior scales and the shorter apical scales as viewed by SEM. Figure 2 shows both scale types as seen by TEM and Fig. 3 (arrows) with PCM. Although this taxon is relatively distinct, another species, *S. glabra* Korshikov, does closely resemble it. Kristiansen (1979) described the transition of scale forms between these two taxa, stating that several workers question the validity of *S. glabra* as a separate species. If after further study these two taxa prove to be distinct species, distinguishing them with the light microscope will probably be impossible. The scales of *S. petersenii* are easy to differentiate from the other taxa reported here using PCM. The PCM micrographs correlate well with the TEM and SEM micrographs.

Synura uvella Ehrenberg em. Stein

Reports of this species from Iowa based upon light microscopy of colony and cell morphology have been presented by Spencer (1917), Starret and Patrick (1952), and Smith (1962). Asmund (1968), Wujek et. al., (1975), and Andersen and Meyer (1977) reported it from Alaska, Michigan, and Arkansas respectively. I report it from 6 sites in Iowa (Table 1). One of these, Dead Man's Lake, is the same as that of Smith (1962). Spined apical scales and spineless posterior scales are shown in Fig. 4 (SEM), Fig 5 (TEM), and Fig. 3 (PCM). Only apical scales are shown in Fig. 6 (PCM). The scales of this species are distinct and present no problems of identification eigher at the light or electron microscope level.

Table 1. *Collection data for* Synura *species collected in Iowa*

Site	Location	Date Collected	***Synura* taxa observed** S. petersenii	*S. uvella*	*S. echinalata*	*S. spinosa mollispina*
Big Wall Lake	Wright County	27 Sept 74	X	X		
	T-90N	8 Oct 76	X			
	R-24W	27 Jan 75	X			
	Sec. 11 and 12	15 Mar 75	X	X		
		6 Apr 80	X	X		
		6 May 78		X		
"HW9 Pond"	Dickinson County	16 July 78	X	X		
	T-100N	6 Oct 79		X		X
	R36W	20 Oct 79	X	X		X
	Sec. 6					
Jemmerson Slough	Dickinson County	20 Oct 79		X		
	T-100N	19 Nov 79	X	X		
	R-36W					
	Sec. 3					
Christopherson's Slough	Dickinson County	27 Aug 79	X	X		
	T-100N	7 Oct 79	X	X		
	R-35W					
	Sec. 14					
"Thorpe Park Marsh'	Winnebago County	5 Apr 80	X			
	T-98N, R25W					
	Sec. 36					
Miniwashta	Dickinson County	8 Apr 78	X			
	T-99N, R-36W					
	Sec. 29					
"3-Corner Pond"	Dickinson County	15 June 78	X			
	T-99N, R-37W					
	Sec. 35					
Beck's Canal	Dickinson County	4 July 75	X			
	T-99W, R-37W					
	Sec. 25					
Springbrook Lake	Guthrie County	19 Oct 78	X			
	T-80N, R-31W					
	Sec. 4					
"Upper Beaver Pond"	Dickinson County	19 June 78		X		
	T-99N. R-37W					
	Sec. 23					
Kettle Hole Fredda Hafner Preserve	Dickinson County	9 July 78			X	X
	T-99N, R-37W					
	Sec. 33					
Mark Sand Prairie	Black Hawk County	9 Nov 79			X	X
	T-90N, R-14W					
	Sec. 19					
Deadman's Lake	Hancock County	27 Oct 79	X	X	X	X
	T-97N, R-23W					
	Sec. 4					

Synura echinulata Korshikov

I report this species for the first time from Iowa, from 3 sites (Table 1). Relative to other lentic waters in Iowa, these sites are considered acidic habitats. Most of my pH measurements in these localities were between 5.5 and 7.0, occasionally reaching pH 7.5. Since most Iowa lakes vary between 7.5 and 9.5 this species may prove to be relatively acidophilic for the pH range in Iowa and thus rather rare. Other American reports have been from Michigan (Wujek and Hamilton, 1973), Washington (Munch, 1980) and Alaska (Asmund, 1968). SEM micrographs of apical and posterior scales are shown in Fig. 8. A TEM micrograph with apical scales and a long posterior scale is observed in Fig. 9. Both scale types as observed with PCM are shown in Fig. 10, while only apical scales are in Fig. 7. These scales could be confused with *S. uvella* and *S. spinosa* when observed with PCM. However,

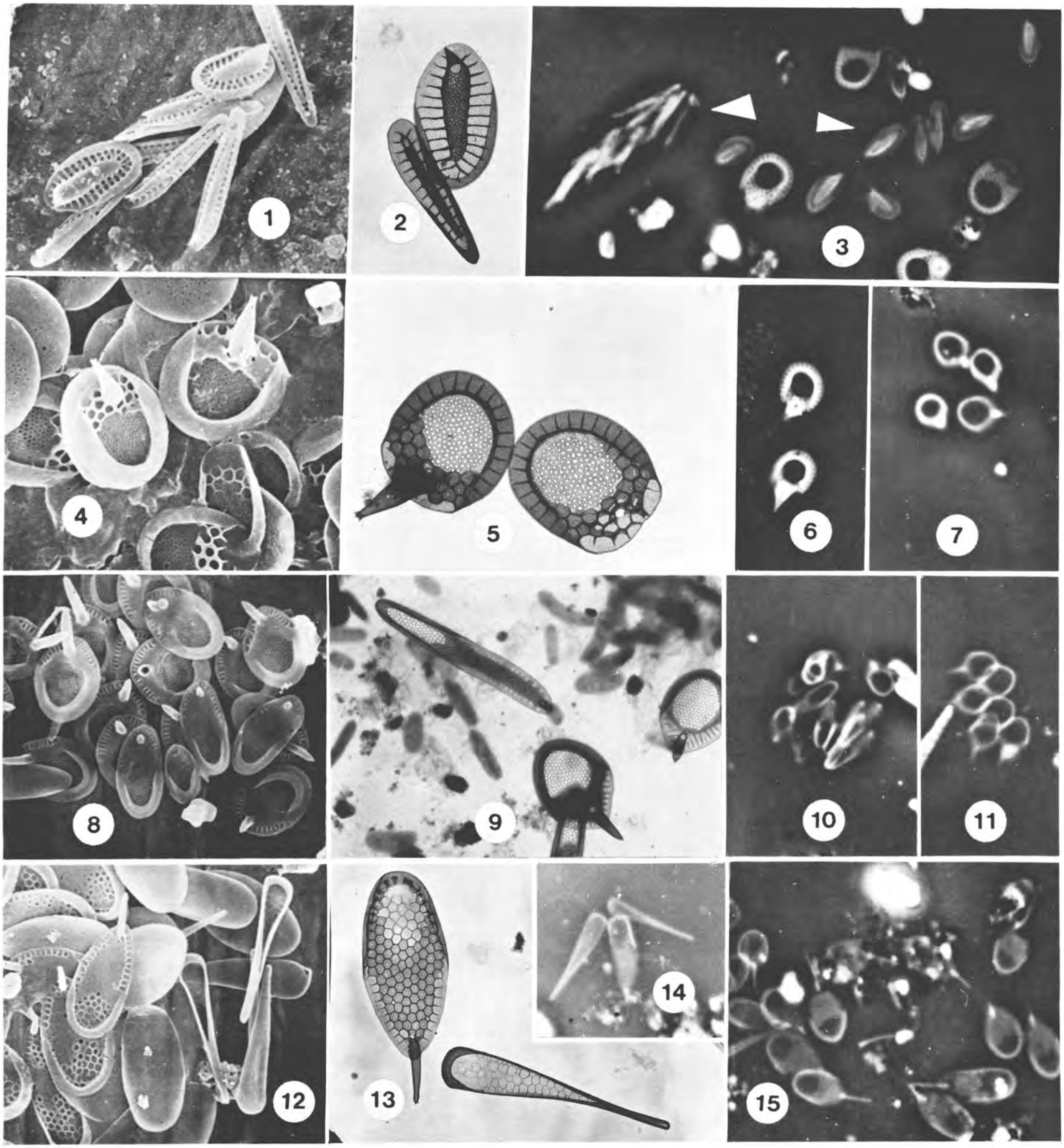

Fig. 1-15. *Micrographs of* Synura *scales collected in Iowa*. Fig. 1. S. petersenii. *SEM 4800×*. Fig. 2. S. petersenii *TEM 5000×* Fig. 3. S. petersenii *and* S. uvella. *PCM. 2000×*. Fig. 4. S. uvella. *SEM. 4800×*. Fig. 5. S. uvella. *TEM. 5000×*. Fig. 6. S. uvella. *PCM. 2000×*. Fig. 7. S. echinulata. *PCM. 2000×*. Fig. 8. S. echinulata. *SEM. 4800×*. Fig. 9. S. echinulata. *TEM. 5000×*. Fig. 10. S. echinulata. *PCM. 2000×*. Fig. 11. Synura *sp. PCM. 2000×*. Fig. 12. S. spinosa *forma* mollispina. *SEM. 4800×*. Fig. 13. S. spinosa *forma* mollispina. *TEM. 5000×*. Fig. 14. S. spinosa *forma* mollispina. *PCM. 2000×*. Fig. 15. S. spinosa *forma* mollispina. *PCM. 2000×*.

close examination of apical scales show those of *S. echinulata* to be smaller, less ornamented and with a less conspicuous spine. The posterior scales are distinctly long and narrow, quite different from those of *S. uvella*. Anterior scales with relatively long spines have a somewhat rounded appearance when observed with TEM or SEM (Fig. 8, 9). However, because the ribbed portion of the scale is not resolvable with PCM, the spined end of the scale appears "Y" or "T" shaped (Fig. 11). The PCM micrographs of the narrow posterior scales and short spined median body scales (Fig. 10) compare favorably with the SEM and TEM micrographs (Fig. 8 & 9).

Synura spinosa Korshikov forma *mollispina* Petersen and Hansen

This report from 4 sites in Iowa (Table 1) is also a state record. It was collected with *S. echinulata* in 3 localities which I described above as acidic. However, the pH of the "Highway 9 pond" is more typical of Iowa usually approximately 8. Additionally, *S. spinosa* was collected from the "Highway 9 pond" on dates 2 weeks apart when it was present in large numbers. *Synura spinosa* Korshikov forma *spinosa* with its less expansive honeycomb layer was not observed in any of my samples. It has been reported from Alaska (Asmund, 1968), Washington (Munch, 1972, 1980), and Michigan (Wujek and Hamilton, 1972). Because most *Synura* species are quite cosmopolitan it seems likely that it will eventually be collected from Iowa. Figures 12, 13 are SEM and TEM micrographs of apical and posterior scales. They correlate well with each other as well as with the PCM micrographs, except that the honeycombed layer near the spined part of the scale (Fig. 13) is not observed with the SEM (Fig. 12), and is obviously covered by an external covering of silica. This area of the scale is represented by only a gray shadow when viewed with PCM (Fig. 15). Both scale types of this taxon are larger than those of the other taxa discussed which adds to the recognizability of *S. spinosa* with PCM. A variety of scale types are shown in Fig. 14, 15 (PCM).

DISCUSSION AND SUMMARY

Since Korshikov (1929), species identifications in Synura have been considered accurate by specialists in Europe only when based upon scale morphology. However, American phycologists have traditionally continued to rely heavily on the use of cell and colony morphology for taxonomic characteristics. This practice should be avoided. Additionally, identifications since 1955 have not been considered valid unless based upon electron microscopy of scales. Kristiansen (1979) has discussed the special taxonomic problems in this group created by light and electron microscope observations which are not correlated. My studies on these four taxa indicate that both SEM and PCM can be used to distinguish them. However, it must be stressed that caution must be exercised when PCM is the only tool for observation. Whenever possible, light microscope observations should be substantiated by electron microscopy. Studies in Arizona (Gretz et. al., 1979), Michigan (Wujek et. al., 1972, 1973, 1975), Washington (Munch, 1972, 1980) and Arkansas (Andersen and Meyer, 1977) have reported at least 4 other species in the continental USA. The danger of misidentification is apparent when it is realized that most species of *Synura* are quite cosmopolitan. For example, I am unsure whether the taxon in Fig. 11 is *S. echinulata* or an additional species. However, for the observer who does not have routine use of an EM or who must process large numbers of samples, e.g. for ecological work, identifications using PCM of scales should prove more precise than using cell and colony morphology as taxonomic criteria.

My sampling indicates *S. petersenii* and *S. uvella* are ubiquitous throughout Iowa, occurring in a variety of habitats, temperature regimes and pH ranges. My findings also demonstrate at this time, that *S. echinulata* occurs in Iowa only in acid waters (pH 5.5-7.0). However Kristiansen (1975) and Takahashi (1978) describe this species as occurring in habitats with a wide range of pH (4-9, 7-9, respectively). Consequently a more complete study should be completed to determine if *S. echinulata* is a truly acidophilic taxon in Iowa. *Synura spinosa* forma *mollispina*, while seemingly more common in a pH range of 5.5-7.0 did occur in large numbers in one locality with a somewhat higher pH of 7.5-8.0.

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