Silica-scaled Chrysophyceae and Synurophyceae from Nigeria. III. Chrysophytes from rivers of Edo State

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Abstract: A total of 18 species of silica–scaled chrysophytes (Chrysophyceae: one species each in *Chrysosphaerella*, *Spiniferomonas*, and *Paraphysomonas*; Synurophyceae: 11 *Mallomonas* spp. and four *Synura* spp.) was recorded from river samples collected in Edo State, Benin, Nigeria, from both dry and rainy seasons in 2003. Identifications were based on transmission electron microscopy. Five are new records for Nigeria, including four being newly reported for Africa. Two further species could not be identified.

Key words: Africa, Chrysophyceae, silica-scaled chrysophytes, Synurophyceae

Introduction

The Chrysophyceae and Synurophyceae, characterized by an exogenous siliceous envelope composed of scales and/or bristles have long been recognized as important indicators of environmental conditions. Light microscopy–based identifications are of limited value as electron microscopy (EM) usually is necessary to distinguish sufficient structure for species identification in the scaled chrysophytes (KRISTIANSEN 1979).

The Nigerian freshwater algal flora, and silica-scaled chrysophytes in particular (classes Chrysophyceae and Synurophyceae), is poorly documented. Compared to the electron microscopic (EM) studies elsewhere in Africa (Chad Republic, Kenya, Madagascar, Botswana, and Zimbabwe - see WUJEK et al. (2003/2004) for review), only two EM investigations of the chrysophyte flora of Nigeria have been published (WUJEK & OGUNDIPE 2003; WUJEK et al. 2003/2004). African chrysophyte studies in general have lagged behind those for the Americas, Europe, and Asia (KADIRI 1992, 2004; JANATKOVÁ & Němecová 2009). Cronberg (1988, 1989, 1996) summarizes the literature on the tropics and more recent literature citations may be found in

HANSEN (1996a), WUJEK & MOGHADAN (2001) and KRISTIANSEN (2002).

In this study, the silica–scaled algal flora from samples collected in both dry and wet seasons in 2003 from ten river locations, Edo State, Nigeria, were examined using transmission (TEM) and scanning (SEM) electron microscopy. Of all the sampling sites, only Ikpoba Reservoir, dammed from the Ikpoba River, has a published phytoplankton record. This includes desmids (KADIRI 1988, 1993a, b, 1996; KADIRI & OPUTE 1989), euglenids (KADIRI & OPUTE 2000) and diatoms (KADIRI 2003; KADIRI & OPUTE 2003).

Material and methods

Phytoplankton samples collected with a 20 µm plankton net were made from ten different river locations, Edo State, Nigeria (Fig. 1, Table 1: Ovia, Nikorogha, Orionmwon, Okomu, Gelegele, Ikpoba, Ogba, Ugonoba, Ogbese, and Okokhou Rivers; the latter eight were collected twice, both in the dry season, February, and rainy season, September, 2003 while the first two were sampled only in the dry season). Preparations and observations were as previously described (WUJEK & OGUNDIPE 2003). All identifications were based on TEM. None of the measured ecological parameters correlated significantly with individual taxa or taxa number.

Fig. 1. 2003 river sampling sites, Edo State, Nigeria.

Results and discussion

Eighteen species of silica–scaled chrysophytes were found during this investigation. The list of taxa (Table 2) includes 11 *Mallomonas* taxa, four *Synura* taxa, and one species each of *Chrysosphaerella*, *Spiniferomonas*, and *Paraphysomonas*. The seven taxa newly reported for Nigeria are illustrated (Figs 2–6, 8–9), including two unidentified *Mallomonas* taxa (Figs 5, 6). The scales of taxa not illustrated fell within the morphologies of those illustrated in the literature.

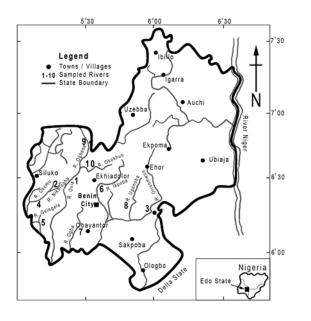
Species richness ranged from one to ten species (Table 2), the highest being in the Gelegele River dry season sample. Low richness corresponds to other studies from lotic habitats. Four samples from two dates, all from the rainy season (5R, 7R, 8R, 10R), did not yield any scaled chrysophytes. Four sampling date's yielded only one taxon each (Table 2: 3R, 4R, 6D, 9D). In our study, 83% of the samples contained at least one scaled chrysophyte, much different than CRONBERG'S (1996) study of nearly 350 plankton samples of which only 20% contained scaled chrysophytes. She did, however, observe 24 taxa in contrast to our 18. In our study as in the CRONBERG (1996) study, Mallomonas, followed by Synura, were the most common genera. Unlike the more extensive African studies of CRONBERG (1996) and HANSEN (1996a, 1996b), our study did not find the single species representing the genus Chrysodidymus.

Sampling sites contained at least one taxon, either during the dry or rainy season (Table 1). Examination of greater than 100 published papers describing silica-scaled floras around the world, all except one from Florida, U.S.A. WUJEK & SIVER (1997), report lotic habitats as not being very diverse. The Gelegele River Dry Season sample had ten taxa. All our other samples each had four or less taxa (Tables 1, 2). Indeed, most of the taxa were observed from the dry season samples (Tables 1, 2). The dry season species richness may be due to generally higher turbidities, lower flow rates and pH and elevated conductivities. The rivers were mildly acidic to acidic (pH 6.8-5.1) and low in nutrients with conductivities ranging from 12–82 µS.cm⁻¹ (Table 3).

The most frequently observed taxa were Paraphysomonas vestita and Synura echinulata. Ten of the taxa were observed only once (Table 2). Six taxa, including two unidentified Mallomonas taxa, are newly reported for Africa: Mallomonas doignonii var. doignonii, M. parvula, M. paxillata, Mallomonas sp. 3, Mallomonas sp. 4, and Synura leptorrhabda (Figs 2-6, 8); in addition, Spiniferomonas septispina is newly reported for Nigeria (Fig. 9). The single scale identified as Mallomonas sp. 3 (Fig. 5) closely resembles the body scale of *M. inornata* Nicholls, a taxon reported only from North East America. The only scale of Mallomonas sp. 4 (Fig. 6) does not appear to resemble any described Mallomonas taxon. Two of the species observed by WUJEK & OGUNDIPE (2003) were not observed in this study, all Mallomonas species (M. portae-ferreae, M. stellata). Another Mallomonas taxon observed, M. matvienkoae var. matvienkoae, is the most widely reported African silica-scaled chrysophyte. It was our second most observed taxon with Synura echinulata being the most widely distributed (Table 2).

We report the third occurrence for Africa and the second for Nigeria of *Mallomonas lemuriocellata* (Fig. 7) originally described by Hansen (in HANSEN & KRISTIANSEN 1995) from Madagascar. It was reported previously from Nigeria from Lekki Lake (WUJEK et al. 2003/2004).

It is not possible from this short list of species to make any comprehensive claims about the distribution of Nigerian scaled chrysophytes. More collections are needed from other Nigerian sites and from different seasons of the year to allow compiling a more complete list of the



Locality	Coordinates		Date of sampling	Species richness Dry/Rainy
1. Ovia River	6° 34′10′′ E; 5° 31	′ 52′′N	13.2.	4
2. Nikorogha River	6° 14′ 45′′ E; 5°	21′ 46′′ N	14.2.	2
3. Orionmwon River	6° 13′ 05′′ E; 5°	56′ 10′′ N	13.2.; 19.9.	4/1
4. Okomu River	6° 15′ 36′′ E; 5°	06′ 10′′ N	07.2.; 19.9.	3/1
5. Gelegele River	6° 09′ 15′′ E; 5°	21′00′′ N	13.2.; 20.9.	10/0
6. Ikpoba River	6° 21′ 25′′ E; 5°	38′ 20′′ N	06.2.; 19.9.	1/3
7. Ogba River	6° 17′ 05′′ E; 5°	35′ 10′′ N	06.2.; 19.9.	2/0
8. Ugonoba River	6° 19′ 05′′ E; 5°	50′ 10′′ N	06.2.; 19.9.	3/0
9. Ogbese River	6° 45′ 00′′ E; 5°	33′ 15′′ N	13.2.; 19.9.	1/3
10. Okokhuo River	6° 34′ 15′′ E; 5°	36′ 10′′ N	17.2.; 19.9.	2/0

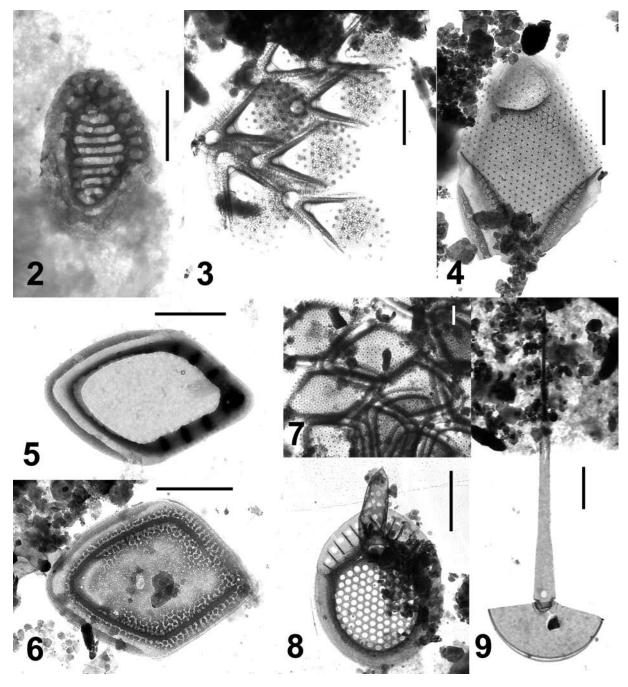
Table 1. Benin Region, Edo State, Nigeria, silica-scaled chrysophyte sampling sites in 2003.

Table 2. Benin Region, Edo State, Nigeria, silica–scaled chrysophytes [(*) new record for Africa; (**) new for Nigeria; (D) dry season, (R) rainy season; localities see Table 1].

Taxon	Locality
Chrysophyceae	
<i>Chrysosphaerella annulata</i> Kristiansen et D. Tong	5D
**Spiniferomonas septispina K.H. Nicholls	6R
Paraphysomonas vestita (STOKES) de SAEdeleer	1D, 3R, 4D, 4R, 5D, 6D, 7D, 8D, 9D, 10D
Synurophyceae	
Mallomonas cyathellata var. kenyana Wujek et Asmund	3D, 5D
*M. doignonii var. doignonii Bourrelly em. Asmund et Cronberg	1D
<i>M. lemuriocellata</i> P. Hansen	5D, 10D
<i>M. matvienkoae</i> var. <i>matvienkoae</i> (MATVIENKO)	
Asmund et Kristiansen	1D, 2D, 5D
<i>M. multisetigera</i> Dürrschmidt	2D, 5D
* <i>M. parvula</i> Dürrschmidt	4D
*M. paxillata (D.E. BRADLEY) L.S. PÉTERFI et MOMEU	9R
M. peronoides (K. Harris) L.S. Péterfi et Momeu	1D, 5D, 6R
M. rasilis Dürrschmidt	9R
*Mallomonas sp. 3	3D
*Mallomonas sp. 4	5D

Synura curtispina (J.B. PETERSEN et J.B. HANSEN) ASMUND	3D, 5D
S. echinulata Korshikov	3R, 4D, 6R, 7D, 8D, 9R
*S. leptorrhabda (ASMUND) K.H. NICHOLLS in K.H. NICHOLLS et	
Gerrath	8D
S. spinosa Korshikov	5D

Table 2 Cont.



Figs 2–9. (2) *Mallomonas doignonii* var. *doignonii*: body scale; (3) *M. parvula*: body scales; (4) *M. paxillata*: body scale; (5) *Mallomonas* sp. 3: scale; (6) *Mallomonas* sp. 4: scale; (7) *M. lemuriocellata*: body scales; (8) *Synura leptorrhabda*: body scale; (9) *Spiniferomonas septispina*: spine scale. Scale bar 1 µm.

Locality	d	рН	Condu	ctivity	Total D	Fotal Dissolved	Total A	Fotal Alkalinity	PC	PO_{4} -P	N- [•] ON	Z	S(D_4
			(μS.c	cm^{-1}	Solids	Solids (mg.l ⁻¹)	(m)	(mg.l ⁻¹)	(mg.l	5.1 ⁻¹)	(mg	(mg.l ⁻¹)	(mg	(mg.l ⁻¹)
	D	R	D	К	D	R	D	R	D	Я	D	R	D	Ч
1. Ovia River	6.7		32		15		11.0		0.4		0.034		0.002	
2. Nikorogha River	6.7		25		12.0		8.5		0.27		0.045		0.009	
3. Orionmwon River	6.6	5.1	27	15	13.0	7.0	11.0	2.0	0.19	0.82	0.018	0.005	0.003	0.01
4. Okomu River	6.1	6.3	12	19	6.0	9.0	5.0	11.0	0.65	0.31	0.025	0.015	0.001	0.019
5. Gelegele River	6.8	6.6	25	60	12.0	28.0	7.0	0	0.30	0.56	0.015	0.019	0.0033	0.007
6. Ikpoba River	6.3	6.3	14	17	7.0	8.0	10.0	12.0	0.41	0.21	0.08	0.012	0.003	0.002
7. Ogba River	5.8	6.0	19	27	9.0	13.0	17.0	11.0	1.01		0.018		0.026	0.001
8. Ugonoba River	6.3	6.5	13	14	6.0	6.0	15.0	10.0	0.34		0.021		0.003	0.007
9. Ogbese River	6.7	5.1	82	16	41.0	7.0	26.0	29.0	0.79	0.60	0.036	0.012	0.002	0.001
10. Okokhuo Rover	6.6	5.4	15	1	7.0	7.0	2.0	0.0	0.22	0.50	0.024	0.057	0.004	0.003

silica–scaled chrysophyte flora. Three EM silica– scaled chrysophyte studies of Nigerian samples have been conducted to date resulting in 31 observed taxa. These 31 species include only two, *M. lemuriocellata* and *P. nigeriensis*, which have not also been reported from temperate regions (see CRONBERG 1989; KRISTIANSEN 2001; WUJEK et al. 2003/2004). As HANSEN (1996a) stated "many unsolved questions remain regarding biogeography and ecology of the silica–scaled Chrysophyceae and Synurophyceae in the tropics."

Acknowledgements

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