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FRESHWATER HELIOZOA (PROTISTA, HELIOZOA) FROM INDIANA

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ABSTRACT. Six taxa of siliceous scale-bearing heliozoa belonging to the genera *Acanthocystis*, *Pinaciophora*, *Pterocystis*, *Raphidocystis* and *Raphidiophrys* were observed from various northern Indiana freshwater sites. All are new records for Indiana.

Keywords: Protista, Heliozoa

Previous surveys of Indiana's freshwater protists which utilized electron microscopy (EM) have reported a diverse flora on the group of organisms known as the silica-scaled chrysophytes (Wujek & Swinehart 1995; Wujek & Bechtel 1997). While the taxonomy of silica-scale bearing algae of the golden-brown algae (Chrysophyceae and Synurophyceae) has been affirmed on the structure of siliceous scales as determined with the electron microscope (Takahashi 1978; Asmund & Kristiansen 1986; Siver 1989; Kristiansen 2002), "the use of similar criteria in scale-bearing protozoa has been slow to develop" (Nicholls 1983a).

Petersen and Hansen (1960) were the first to describe new species of a group of protistans known as heliozoa based on the electron microscopy of their scales. Since 1960 contributions to the literature on this topic has been sporadic. Only the studies of Dürrschmidt in Chile, New Zealand and Sri Lanka (1985, 1987a, b); Nicholls and co-workers in Canada (Nicholls 1983a, b; Nicholls & Lynn 1984; Nicholls & Dürrschmidt 1985); Croome and co-workers in Australia (Croome 1986, 1987a, b, c; Croome et al. 1987); Siemensma & Roijackers in The Netherlands (Siemensma 1981; Siemensma & Roijackers 1988a, b); and Mikrjukov in Russia (Mikrjukov 1993a, b, 1994a, b, c, 1995, 1996a, b, 1999, 2000a, b) have demonstrated that scale structure in heliozoa possessing siliceous scales is the single most reliable taxonomic criterion for this group. Previously much of the taxonomy was based on light microscopy of variable cell features (e.g., color, size, vacuolation, etc.), or of scales, the structure of which cannot be discerned clearly by light microscopy.

The purpose of this paper is to give a taxonomic account of Indiana freshwater heliozoa observed during EM surveys for silica-scaled chrysophytes (Wujek & Swinehart 1995; Wujek & Bechtel 1997) from two northern counties and Lake Monroe in Monroe County. The only other reports of scaled protists from the United States using EM other than silica-scaled chrysophytes are those of Wee & Millie (1983), Wujek et al. (1999, 2002), and Wujek (2003a, b).

METHODS

Lugol-fixed plankton samples from a wide variety of northern Indiana fresh waters were examined using transmission and scanning electron microscopy as previously described in Wujek & Swinehart (1995) and Wujek & Bechtel (1997). Observations were made on samples collected at various times in 1993 and 1994: in 1993 from nine sites in Noble County (Fig. 1) and one site in Whitney County (Wujek & Swinehart 1995); and in 1994, 14 samples from Lake Monroe (Wujek & Bechtel 1997) (Table 1).

OBSERVATIONS AND DISCUSSION

Six species belonging to the heliozoan genera *Acanthocystis*, *Pinaciophora*, *Pterocystis*, *Raphidocystis*, and *Raphidiophrys* were observed from various northen Indiana freshwater sites (Table 1, Figs. 2–7). The heliozoan classification that follows conforms to criteria established by Page & Siemensma (1991).

Cristidiscoid Heliozoa

Numerous, but variable round, biconvex, perforated, and overlapping scales cover the

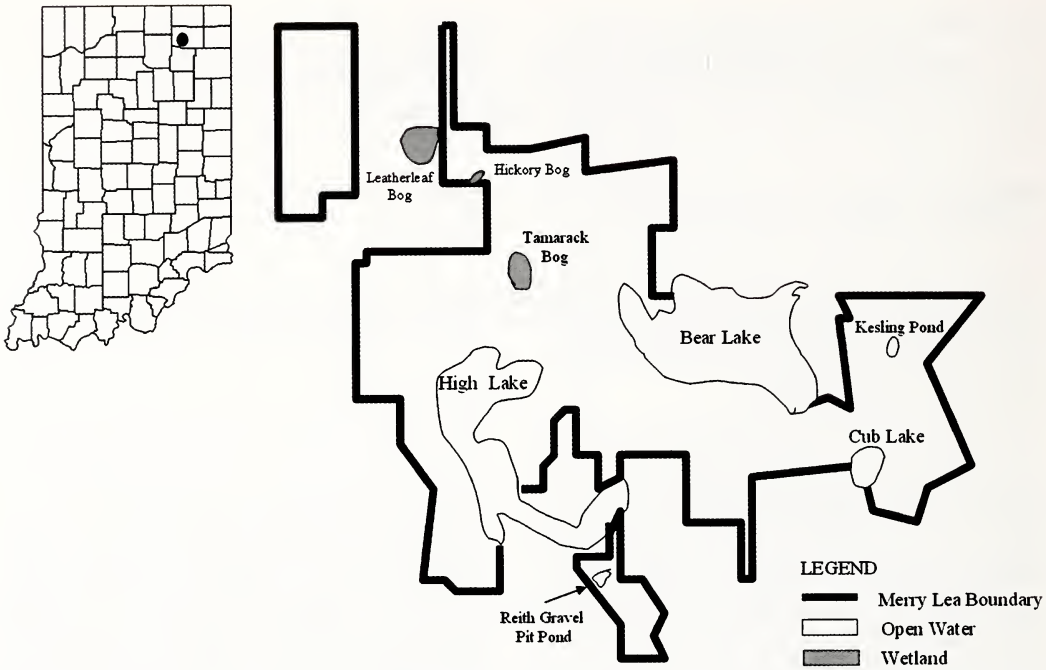


Figure 1.—Map of the Merry Lea Environmental Center, showing the location of the sampling sites in Noble County, Indiana.

cells in the genus *Pinaciophora*. Like all filose amoeba, this genus lacks the axonemes and extrusomes observed in the centrohelid heliozoa.

***Pinaciophora fluviatilis* Greeff.**—(Fig. 2). First reports of this organism for the U.S., under the name of *Potamodiscus kalbei* Gerloff, were from Mississippi and Ohio (Gaardner et al. 1976) and Alaska (Manton & Sutherland 1979). Gaardner et al. (1976) showed this species was incorrectly described as a centric diatom. It has since been reported from the U.S. Great Lakes (Wee & Millie 1983) and New York (Smol 1987). I observed it from only one site (Table 1). Other EM reports of this species include both marine and freshwater habitats in Europe (Thomsen 1978; Belcher & Swale 1978), Canada (Nicholls 1983b), Antarctica (Takahashi 1981), and The Netherlands (Roijackers & Siemensma 1988).

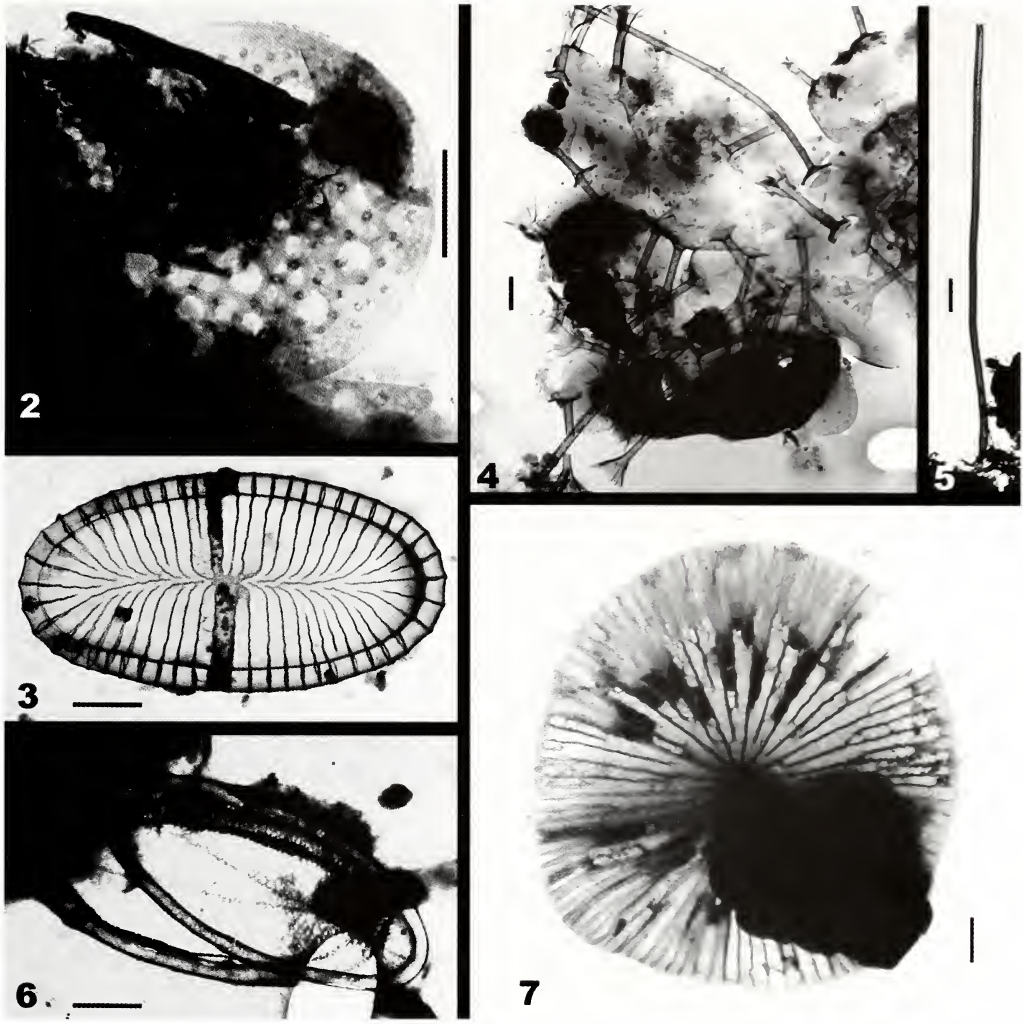
***Raphidiophrys intermedia* Penard.**—(Fig. 3). The cells of the genus *Raphidiophrys* are coated with curved, spindle-shaped scales. Eighteen species are recognized (Mikrjukov 1994c). The only EM reports of this species are from Canada (Ontario), Chile, New Zealand and Malaysia (Nicholls & Dürrschmidt 1985), Australia (Croome 1987) and The Netherlands and Sweden (Roijackers & Siemensma 1988). I observed it only once during my observations (Table 1).

Centrohelid Heliozoa

The genus *Acanthocystis* contains more species than any of the other Centrohelida. The genus, erected by Carter (1863), is wide spread with members occurring in both freshwater and marine habitats. Cells tend to be round and covered by siliceous spine scales with a layer of overlapping body scales.

***Acanthocystis polymorpha* Dürrschmidt.**—(Fig. 4). Although scales of this organism were originally illustrated by Takahashi (1959) as occurring in Japan, it was not until 1985 that Dürrschmidt (1985) formally described it as a taxon from Chile. Its occurrence in Indiana (Table 1) represents the second report for this species in the U.S.

***Pterocystis fortesca* (Nicholls) Siemensma & Roijackers.**—(Fig. 5). Members of the genus *Pterocystis* (Siemensma & Roijackers 1988a), as in the genus *Choanocystis*, possess tangential plate scales and radial spine scales. However, the spine scales are bilaterally sym-



Figures 2–7.—Transmission electron micrographs of siliceous scales of Indiana heliozoans. 2. *Pinaciophora fluviatilis*, plate scale; 3. *Raphidiophrys intermedia*, lamellate plate scale; 4. *Acanthocystis polymorpha*, cell with plate and spine scales; 5. *Pterocystis fortesca*, spine scale; 6. *Raphidocystis tubifera*, plate scale, two large plate scales; 7. *Raphidocystis flabellata*, circular plate scale. Scale bars = 1 μm.

Table 1.—Indiana locations containing heliozoa. See Wujek & Swinehart (1995) and Wujek & Bechtel (1997) for physiochemical data.

Taxon	Date	Location
Acanthocystis polymorpha	4 May 1994	Lake Monroe (Monroe County)
Pinaciophora fluviatilis	28 June 1994	Lake Monroe (Monroe County)
Pterocystis fortesca	29 June 1993	Crooked Lake (Whitley County); Kesling Pond, High Lake & Reith Gravel Pit (Noble County)
	8 June 1994	Lake Monroe (Monroe County)
Raphidocystis flabellata	2 July 1993	Leatherleaf Bog (Noble County)
Raphidocystis tubifera	29 June 1993	Reith Gravel Pit & Tamarack Bog
	2 July 1993	Leatherleaf Bog (all Noble County)
Raphidiophrys intermedia	2 July 1993	Leatherleaf Bog (Noble County)

metrical, with a cylindrical shaft and membranous base which merge into two lateral membranous wings that extend for some distance along the shaft.

Originally described from Canada as *Acanthocystis fortesca* Nicholls (1983a), Siemensma & Roijackers (1988a) transferred it to the genus *Pterocystis* and also placed it in synonymy with the taxon *Acanthocystis pantopodecoides* Nicholls (1983a). It has since been reported from Australia (Croome 1986). This species was the most widely observed in this study (Table 1).

***Raphidocystis flabellata* (Dürrschmidt) Page & Siemensma.**—(Fig. 7). Species in the genus *Raphidocystis* tend to have cells that are round and covered with cup-shaped scales in addition to many radiate tubular scales. Previously reported from Chile, New Zealand, Germany, and Canada (Dürrschmidt 1987), it has been recently reported from the Gulf Coast of the U.S. (Wujek 2003b). I observed it only from the Leatherleaf bog sample (Table 1).

***Raphidocystis tubifera* Penard.**—(Fig. 6). Since its original description from France (Penard 1904), electron microscopic reports of this species include: Rees et al. (1980) from England and Canada; Nicholls & Dürrschmidt (1985) from Canada, Chile, New Zealand, Malaysia and Sri Lanka; Croome (1986) from Australia; Finlay et al. (1988) from England; and Wujek (2003b) from the United States based on studies using EM. I observed it in collections from three sites (Table 1).

Unidentified Scales

The short species list given above is not exhaustive. I observed a number of other scales, but I was unable to identify them because in most cases either the plate or spine scales were not present and both are usually needed to confirm identifications.

What is significant is the paucity of taxa observed when considering that 24 different sampling sites were sampled. Collections and observations representing other seasons and from other regions will undoubtedly yield additional species.

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