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Schmidingerothrix extraordinaria nov. gen., nov. spec., a secondarily oligomerized hypotrich (Ciliophora, Hypotricha, Schmidingerotrichidae nov. fam.) from hypersaline soils of Africa

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Abstract

Schmidingerothrix extraordinaria nov. gen., nov. spec. was discovered in hypersaline soils from Namibia and Egypt. Its morphology and ontogenesis were studied with standard methods. *Schmidingerothrix extraordinaria* is a highly flexible, slender hypotrich with an average size of 90 × 15 μm. Likely, it prefers a salinity around 100‰ and feeds mainly on bacteria. *Schmidingerothrix* is extraordinary in having a frayed buccal lip, three-rowed adoral membranelles, only one frontal cirrus, a distinct gap between frontal and ventral adoral membranelles, and a miniaturized first frontal membranelle, while a paroral membrane, dorsal bristle rows, and buccal, transverse, and caudal cirri are absent. The ontogenesis is simple: the opisthe oral apparatus and frontoventral ciliature originate de novo, while parental structures are involved in the development of the ciliature of the proter. This special organization is used to define a new family, the Schmidingerotrichidae, which is likely related to the Cladotrichidae. *Schmidingerothrix extraordinaria* is very likely a secondarily oligomerized hypotrich, and the reduction occurred possibly very long ago because no traces of the ancestral ciliature remained in the ontogenetic processes. Possibly, the simple ciliature is an adaptation to highly saline habitats, where competition is low and bacterial food abundant.

Keywords: Biodiversity; Loss of dorsal bristle rows; Loss of paroral membrane; Ontogenesis; Reduction

Introduction

Studies of the past decades have shown a fascinating diversity of undescribed hypotrich ciliates (for reviews, see Berger 1999, 2006, 2008, 2011), supporting the notion of Foissner et al. (2008) that as much as 80% of ciliate diversity is still undescribed. Few features of the hypotrichs are so stable that they are possibly not affected by evolution, for instance, the dorsal bristles, i.e., rows of dikinetids having only the anterior basal body ciliated. Thus, I was fascinated to discover a hypotrich without dorsal bristles in highly saline soils of Africa. Other very stable features of the hypotrichs include two undulating membranes (paroral and endoral) and adoral membranelles composed of four ciliary rows. The new ciliate from Africa lost the paroral and the middle ciliary row of the adoral membranelles. These and other peculiarities, e.g., lip fringes and the loss of buccal, transverse, and caudal cirri show the extraordinary vegetative morphology of the new ciliate, while its ontogenesis is comparatively simple, unfortunately telling us nothing about the ancestral cirral pattern.

Many curious hypotrichs live in saline inland habitats, e.g., *Cladotricha* Gaievskaia, 1925; *Erniella* Foissner, 1987; *Afrothrix* Foissner, 1999; *Etoschothrix* Foissner et al., 2002;

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and *Schmidingerothrix*, the new genus described here, suggesting that these are major drivers of evolution. However, few detailed studies of ciliates from saline inland biotopes are available although the above mentioned and some other studies (e.g., Borror 1972; Foissner et al. 2002; Kahl 1933; Ruinen 1938; Wilbert 1986, 1995; Wilbert and Kahan 1981, 1986) show a high number of undescribed ciliate species living there.

I shall describe *Schmidingerothrix* in great detail, not only because of its unusual morphology but also because it is likely related to the Cladotrichidae, a poorly known group of hypotrichs (Berger 2011). Unfortunately, attempts to obtain molecular sequences were unsuccessful.

Material and Methods

Material and cultivation

Schmidingerothrix extraordinaria was discovered in three hypersaline soil samples from Africa, using the non-flooded Petri dish method, as described in Foissner and Xu (2007). Briefly, this simple method involves placing 50–500 g air-dried terrestrial material (soil, leaf litter, roots, etc.) in a Petri dish (13–18 cm wide and 2–3 cm high) and saturating, but not flooding it, with distilled water. Such cultures are analysed for ciliates by inspecting about 2 ml of the run-off on days 2, 7, 14, 21 and 28. For highly saline samples (>30‰), the method usually needs to be modified. First, an ordinary, non-flooded Petri dish culture is set up with the material available. If no or very few ciliate species appear and look unhealthy after three days, the culture is flooded 5–10 times with distilled water to reduce salinity. Then, the sample is wetted as before, that is, not flooded and again inspected for ciliates after three days. If no ciliates appear, the procedure is repeated several times, i.e., until ciliates begin to grow.

Raw cultures were set up in Petri dishes, using artificial sea water with the same salinity as the soil water in the non-flooded Petri dish culture. Then, some crushed wheat or rice grains and 2 ml of soil percolate, which contained a variety of protists, were added. Usually, such "raw cultures" grow well and are sufficient for taxonomic purposes. Frequently, the target ciliates become very abundant also in the non-flooded Petri dish culture.

I first discovered *S. extraordinaria* in a soil and litter sample from the margin of Fischer's Pan in the Etosha National Park, Namibia (sample designation: Namibian site 4/2001). The sample, which was collected in January 2001 and investigated in June 2001, was composed of dark humus mixed with litter and cyanobacterial crusts. Salinity (measured with a refractometer) in the non-flooded Petri dish soil percolate was 90‰, pH 7. *Schmidingerothrix extraordinaria* appeared when the soil had been washed several times to reach a salinity of 80‰.

The second population occurred also in Namibia, viz., in the Skeletal Coast National Park near the village of Terrace Bay. The sample, which was collected in January 2001 and investigated in May 2001, was taken from the margin of a pool surrounded by small sand hills formed by sedge bushes. These hills were full of sedge roots and decomposing litter, which was collected with sand in a ratio of about 1:1. The sample had a salinity of 180‰ and pH 7.2. Ciliates appeared when the sample was washed to a salinity of 130‰.

The third population is from an island in the Nile River some kilometers south of the town of Luxor. The sample, which was collected in June 2007 and investigated in June 2008, consisted mainly of sand and had a salinity of 120‰. Ciliates appeared when it was washed to a salinity of 90‰.

Morphological methods

Living cells were studied using a high-power oil immersion objective and differential interference contrast microscopy. Protargol impregnation and scanning electron microscopy (SEM) were performed as described by Foissner and Xu (2007). Some drops of osmium acid (2%) were added to Stieve's solution to obtain well-fixed cells; in spite of this, cells became inflated (width) and shrunk (length) by about 20%.

Counts and measurements of silvered specimens were performed at a magnification of 1.000×. In vivo measurements were conducted at magnifications of 40–1.000×. Drawings of live specimens were based on free-hand sketches and micrographs; those of impregnated cells were made with a drawing device. In the ontogenetic stages, parental structures are shown by contour, while newly formed structures are shaded black. Each of the stages depicted has been seen in at least two specimens.

Terminology

For general and specific terms see Lynn (2008) and Berger (2011). Details of the oral apparatus are according to Foissner and Al-Rasheid (2006).

Results

Schmidingerotrichidae nov. fam.

Diagnosis: Amphisiellids (?) with a single short frontoventral cirral row, one frontal cirrus, one right and one left marginal row, an adoral zone of membranelles, and an endoral membrane. Paroral membrane and dorsal bristles absent. Frontoventral and oral ciliature develop independently in proter and opisthe, while marginal cirral rows and nuclear apparatus divide as usual. Frontoventral ciliature developing de novo in the opisthe, while parental ciliature is involved in the proter.

Type genus: *Schmidingerothrix* nov. gen.