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Occurrence of true branches in *Rhizoclonium* (Cladophorales, Ulvophyceae) and the reinstatement of *Rhizoclonium pachydermum* Kjellman

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Abstract

The phylogenetic position of the freshwater green alga *Rhizoclonium pachydermum* (Ulvophyceae: Cladophorales) was investigated using nuclear 18S rRNA gene and internal transcribed spacer 2 (ITS2) sequences. This alga has been referred to as *Cladophora pachyderma*. Based on its morphology, it was formerly classified in the section *Affines* in the genus *Cladophora*. However, this classification was not supported by the current phylogenetic analyses, where *Rhizoclonium pachydermum* formed a well-supported clade with other *Rhizoclonium* species. We consider that *Rhizoclonium* possesses real branches and the most important criteria that characterize the genus are: long unbranched filaments only with rhizoid branches, or only branched at the basal region of the thallus; and cylindrical cells with few or limited numbers of nuclei.

Key words: 18S rDNA, Cladophorales, ITS2, phylogeny, *Rhizoclonium pachydermum*, taxonomy

Introduction

Rhizoclonium pachydermum Kjellman (1877: 55) is a filamentous green alga (Chlorophyta: Cladophoraceae) that usually grows on the wet surfaces of rocks, the walls of wells, and the upper or lower sides of stones, being a fairly shade-loving species (van den Hoek 1963). This alga was established by Kjellman (1877) originally based on a sample he collected on the west coast of Novaya Zemlya. The alga has been recorded from Germany, Sweden, West Greenland, China, and other countries (Jao 1947, Kann 1947, van den Hoek 1963, Christensen 1991, Liu & Hu 1999). Brand (1909) transferred it to the genus *Cladophora* Kützing (1843: 262) because it had real branches and a disc-like holdfast. Since then, *R. pachydermum* Kjellman has been called *Cladophora pachyderma* (Kjellman) Brand (1908: 72) (Hoek 1963, Liu & Hu 1999).

The genus *Cladophora* is a rather heterogeneous assemblage of species, and one of the most species-rich genera among the green macroalgae (van den Hoek 1982, 1984, van den Hoek and Chihara 2000). Van den Hoek (1963) placed *C. pachyderma* in the first group of *Cladophora*: Section *Affines* Brand (1909:70). This section is often characterized as follows: i) long filaments, which grow via frequent intercalary cell divisions; ii) scattered branches, concentrated in the basal region of the plants, inserts laterally, often deflecting the axes over a wide angle; iii) attachment by a disc-like holdfast formed by the lower cell wall of the basal cell; and iv) cells relatively short, length/width ratio mostly 1–2 (van den Hoek 1963).

The two species in this group were *Cl. basiramosa* Schmidle in Wittrock, Nordsted & Lagerheim (1896: 13–14, fasc. 26, no. 1225) (Schmidle 1897) and *Cl. pachyderma*. Van den Hoek supplemented Kjellman's illustrations with some new drawings, which agreed with the taxonomic opinion of Brand. However, he also noted that both algae were very similar. In his opinion, the lack of moniliform chains of zooidangia and the very different ecology appeared to justify the perhaps provisional separation of *Cl. pachyderma* from *Cl. basiramosa* Schmidle. When Christensen (1991) re-examined Kjellman's type material, he found a thin *Oedogonium* and some diatoms that proved to be freshwater species, as well as representatives of the freshwater genera *Gomphonema* and *Eunotia*.

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TABLE 3 (continued)

Taxon	Locality	Voucher, culture	GenBank No. SSU	ITS2
Siphonocladus tropicus	-	UTEX LB 2369	Z35313	*
Valonia utricularis	-	VuF	Z35323	*
Cladophoropsis vaucheriiformis	Japan: Okinawa, Gushikawa	-	AB062719	*
Chamaedoris peniculum	-	CMP5	Z35417	*
Chaetomorpha moniligera	Japan:Hokkaido,Otaru	-	AB062703	*
Chaetomorpha antennina	Japan:Shizuoka,Shimoda	-	AB062700	*
Chaetomorpha crassa	Japan:Ishikawa,Shika	-	AB062701	*
Chaetomorpha ligustica	Japan	SAP:114369	AB807622	*
Chaetomorpha linum	Japan:Kochi	-	AB062702	*
Chaetomorpha sp.	-	WC	Z35420	*
Rhizoclonium sp.	USA	LB1523	*	AB259959
Rhizoclonium riparium	China	AST2010021	*	JN399202
Aegagropila linnaei	United Kingdom: Scotland, Loch Watten, Caithness	L0793543	*	GU325821
Pithophora sp.	Wuhan, Hubei, China	HB1204	*	KC898955
Pithophora sp.	Wuhan, Hubei, China	HB1201	*	KC898954
Cladophora vagabunda	Japan:Fukui, Mihama, Lake Kugushi	vag-1	*	AB665562
Cladophora laetevirens	Japan:Fukui, Mihama, Lake Hiruga	lae-1	*	AB665564
Cladophora fascicularis	China: Qingdao	AST2010014	*	JQ308255
Outgroup				
Ulothrix zonata	-	SAG 38.86	Z47999	*
Ulva fasciata	Japan: Kochi, Usa	#1	AB425964	*
Ulothrix zonata	Russia:Irkutsk	WELT:A032277	*	HE860526

"-" missing data.
"*"not used in the phylogenetic trees.

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