FIRST RECORD OF A CERAMIACEOUS RED ALGAL SPECIES, *CERAMIUM STICHIDIOSUM*, FROM MAGELLANIC REGION, CHILE

PRIMER REGISTRO DEL ALGA ROJA *CERAMIUM STICHIDIOSUM* EN LA REGION DE MAGALLANES, CHILE

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ABSTRACT

A ceramiaceous red alga, *Ceramium stichidiosum* J. Agardh was found for the first time in waters of Magellanic Strait, Chile. Thalli are usually epiphytic on other macroalgae such as *Mazzaella laminarioides* (Bory) Fredericq and *Sarcothalia crispata* (Bory) Leister. They have fully corticated axes with alternate to dichotomous branches, straight tips and six periaxial cells per each axial cell. This report extends the distribution limit of *C. stichidiosum* from the X Región de los Lagos (42° 58'S; 74° 19'W) to the XII Región de Magallanes (53°37'S; 70°59'W).

KEYWORDS: *Ceramium*, *Ceramium stichidiosum*, Chile, geographical distribution, Rhodophyta, taxonomy.

RESUMEN

La alga roja *Ceramium stichidiosum* fue encontrada por primera vez en aguas del Estrecho de Magallanes, Chile. Los talos son frecuentemente encontrados epifitando otras macroalgas como *Mazzaella laminarioides* (Bory) Fredericq y *Sarcothalia crispata* (Bory) Leister. Se caracteriza por presentar ejes completamente corticados y ramificaciones alternadas a dicótomas, ápices rectos y seis células periaxiales por cada célula central. Este reporte extiende el límite de distribución sur de *C. stichidiosum* desde la X Región de los Lagos (42° 58'S; 74° 19'W) hasta la XII Región de Magallanes (53°37'S; 70°59'W).

PALABRAS CLAVES: *Ceramium*, *Ceramium stichidiosum*, Chile, distribución geográfica, Rhodophyta, taxonomía.

INTRODUCTION

Ceramium Roth (Ceramiaceae, Rhodophyta) is a cosmopolitan genus that commonly occurs in both hemispheres, on the tropical as well as on polar coasts (Boo & Lee 1994). The genus is characterized by great specific diversity with more than 191 species described all over the world (Boo & Lee 1994, Barreto & Yoneshigue-Valentin 2001, Fujii *et al.* 2001, Cho *et al.* 2003). Furthermore, the genus presents a great morphological variability and

taxonomic instability in red algae (Womersley 1978, Boo & Lee 1994, Maggs & Hommersand 1993, Fujii *et al.* 2001). The most prominent taxonomical characteristics of the genus are the nodal cortication patterns from periaxial cells at upper ends of axial cells forming partial or complete investment; the number and formation pattern of the periaxial cells and their derivatives, apex form, and tetrasporangial patterns (Nakamura 1965, Itono 1972, Boo 1993, Maggs & Hommersand 1993, Boo & Lee 1994, Athanasiadis 1996).

On temperate South American coast, 14 species of *Ceramium* have been reported. Of these, 13 species occur on the Chilean coast (Ramírez & Santelices 1991), and eight of the species are distributed in the Magellan and Antarctic regions of Chile or are endemic to this region: *C. circinnatum* (Kützinger) J. Agardh, *C. diaphanum* (Lightfoot) Roth, *C. dozei* Hariot, *C. involutum* Kützinger, *C. rubrum* (Hudson) J. Agardh, *C. strictum* Greville & Harvey, *C. unguatum* (Kützinger) Hariot, and one unidentified taxon (Ramírez & Santelices 1991).

Ceramium stichidiosum J. Agardh was at first recognized based on collections from Chatham Islands, New Zealand and Tasmania, Australia (J. Agardh 1876). The species is characterized by dichotomously branched thalli with fully corticated axes and tetrasporangial branches referred to stichidia (J. Agardh 1876). *Ceramium stichidiosum* is mostly found in the sectors of Las Cruces, Pelancura and Los Molles (central Chile) and also occurs in Chiloé and Puerto Montt (southern Chile) (Santelices & Abbott 1978, Ramírez & Santelices 1991, Hoffmann & Santelices 1997). In this paper, we proposed to extend the range of distribution of *Ceramium stichidiosum* in the Chilean territory by reporting its occurrence in the Magellan

Region (53°37'S; 70°59'O). Here, we report detailed morphology of the species such as cortication pattern, the number and distribution of the periaxial cells, its acropetal and basipetal distribution and the tetrasporangial structures.

MATERIALS AND METHODS

The studied plants were collected in the intertidal zone of the San Juan sector, Magellan Strait, Chile and were immediately fixed in 4% formalin/seawater. Longitudinal and cross sections were made with a stainless steel razor blade under a stereoscopic dissection microscope, and stained with 0.5% aqueous aniline blue solution, acidified with 1% diluted HCl. Photomicrographs were taken with an Olympus BH-2 microscope. Drawings were made with the aid of a Zeiss camera lucida.

All voucher specimens of *Ceramium stichidiosum* were deposited in the Herbarium of the Institute of Botany in Sao Paulo, Brasil (SP365 652) and in the collection of marine algae in the Faculty of Sciences of the Universidad de Magallanes in Punta Arenas, Chile.

FIGURE 1. Collection site of *Ceramium stichidiosum*.

FIGURA 1. Sitio de recolección de *Ceramium stichidiosum*.

STUDY AREA

San Juan sector, where material was collected, is situated in the region of the Magellan Strait (53°37'S; 70°59'W), approximately 70 km of the city of Punta Arenas, Chile (Fig. 1). The sampling area is characterized by rocky substrates, with stones and boulders. Furthermore, the area is characterized by strong hydro-energetic activity all year round. According to the classification by Köppen, the climate corresponds to the trans-Andean type with degeneration to steppe *Dfk'*c. The category *Df* is defined by a uniform distribution of precipitation, with mean annual rainfall between 400 and 620 mm. In this type of climate, precipitation mainly occurs as snow. The mean temperature is around 5.8°C (Pisano 1977). The region is also characterized by a great variation in the amount of daily temperature throughout the year. During winter, less than eight hours of sunshine are registered whereas about 16 hours of sunlight in the summer.

RESULTS

Ceramium stichidiosum J. Agardh, 1876: p. 105

REFERENCE: Agardh, J.G. (1876). *Species genera et ordines algarum. Volumen tertium. Part 1.* pp. vii + 724 Lipsiae [Leipzig].

HABIT: Thalli are purplish to dark red color, up to 4 cm high, forming tufts on rocky substrate or epiphytic on *Mazzaella laminarioides* (Bory) Fredericq and *Sarcothalia crispata* (Bory) Leister. The thalli consist of uniaxial filamentous branches, showing alternate to dichotomous patterns. All branches are fully corticated by cortical cells. Apices are straight to slightly incurved (Fig. 2).

In surface view, cortical cells of vegetative structures are continuous throughout the thalli. Cells in the nodes are regular to elongate of 15-25 µm in diameter and 20 µm of length, decreasing in size to acropetal and basipetal directions (Fig. 3). In a nodal cross section, a central cell produces five to six periaxial cells (Fig. 4). The cortex in nodes is formed from the periaxial cells. Each periaxial cell gives rise up to four, primary cortical cells, two acropetal and two basipetal cells. Each primary cortical cells produces two to three small cortical cells; similar pattern is produced by acropetal and basipetal

secondary cortical cells. Adventitious branches are sometimes produced from periaxial cells. Rhizoids are disc-shaped and originated from periaxial cells. Reproductive structures: Tetrasporangia are mostly localized in apical regions of terminal branches, appearing stichidial branches. They are produced from periaxial cells in the nodes (Fig. 5, 6). Tetrasporangia are tetrahedrally divided, measuring 31-46 µm in diameter and completely covered by cortical cells. Male and female thalli were not found in our collections.

GEOGRAPHICAL DISTRIBUTION

In central Chile, *Ceramium stichidiosum* has been reported in Las Cruces, Pelancura and Los Molles (33°30'S; 71°65'W; Hoffmann & Santelices 1997), and in Chiloé (42°58'S; 74°19'W), and Puerto Montt (41°28'S; 73°00'W) by Santelices & Abbott, 1978 and Ramírez & Santelices 1991. The species is restricted to Subantarctic coasts as Southern Pacific South America, New Zealand, and Tasmania (Australia, Fig. 7).

DISCUSSION

This is the first report of the occurrence of *C. stichidiosum* in the extreme south of Chile. Our recent collections of *Ceramium stichidiosum* from Magellanic region of Chile correspond in their habit and structure of vegetative thalli and tetrasporangial stichidium to the description of J. Agardh (1867). Ramírez and Santelices (1991) listed up seven species of *Ceramium* in the Magellan region plus an unidentified taxon, which has been found by Avila *et al.* (1982) and also by Mansilla and Navarro (2003). Among the seven reported species, only *C. dozei*, *C. involutum*, *C. rubrum*, and *C. stichidiosum* are fully corticated on axes. *Ceramium dozei* is similar with our species, but is characterized by short adventitious branches on axes (Hariot 1889) and *Ceramium involutum* and *C. rubrum*, do not have stichidial branches (Maggs & Hommers 1993, Stegenga *et al.* 1997).

However, thalli bearing cystocarps or spermatangial clusters were not collected and it is not known whether the sexual thalli occur in other seasons. Considering the occurrence of female thalli bearing cystocarps and males having

spermatangia in central Chile (Hoffmann & Santelices 1997), the absence of sexual reproduction of the species in Magellanic region could be regarded a phenomenon due to a short summer for producing sexual reproductive organs. A limited collection could skip to find female and male thalli on intertidal areas because they could occur only in the subtidal zone. Asexual reproduction may be a strategy for maintaining marginal populations in areas where predominate very cold weather conditions. Culture studies for the tetrasporangial thalli of *C. stichidiosum* may give answers to above considerations.

The diagnostic characters of *Ceramium stichidiosum* are straight apices and stichidial tetrasporangia (J. Agardh 1867). However, most of fully corticated *Ceramium* species tend to have straight apices in tetrasporangial thalli, while female and male thalli often have incurved apices (Boo, pers. comm.). Stichidium with tetrasporangia is the most distinguished character for recognizing *C. stichidiosum*, the character sounding the name of specific epithet (J. Agardh 1867). However, the identity of *C. stichidiosum* appears not clear because the species is not listed up in marine flora of both New Zealand (Adams 1994) and Australia

FIGURE 2-6. Fig. 2. Vegetative thalli of *Ceramium stichidiosum*. Bar = 500 µm; Fig. 3. Surface view of vegetative thalli showing disposition of cortical cells in nodes and internodes. Bar = 50 µm; Fig. 4. Transversal section of thalli showing six periaxial cells originated from the central cell. Bar = 100 µm; Fig. 5. Transversal section of thalli showing formation of tetrasporangia. Bar = 50 µm; Fig. 6. Stichidial branch showing tetrasporangia around nodes. Bar = 50 µm.

FIGURA 2-6. Fig. 2. Talo vegetativo de *Ceramium stichidiosum*. Barra= 500 µm; Fig. 3. Vista superficial de talo vegetativo mostrando la disposición de las células corticales en los nudos e internudos. Barra = 50 µm; Fig. 4. Sección transversal de un talo mostrando seis células periaxiales originadas desde la célula central. Barra = 100 µm; Fig. 5. Sección transversal de un talo mostrando la formación de tetrasporangios. Barra= 50 µm; Fig. 6. Estiquidio mostrando tetrasporangios alrededor de los nudos. Barra = 50 µm.

FIGURE 7. Distribution of *Ceramium stichidiosum* (black circle) in the world.

FIGURA 7. Distribución de *Ceramium stichidiosum* (círculos negros) en el mundo.

(Womersley 1998). Instead, Adams (1994) mentioned, in a remark of *C. apiculatum*, that there might be considerable confusion concerning the corticated species of *Ceramium* that have variously been identified as *C. apiculatum*, *C. stichidiosum*, and *C. planum* Kützinger. In addition, *C. stichidiosum* var. *smithii* Laing from Auckland Islands appears to be referable to *C. vestitum* Harvey (Adams 1994). *Ceramium stichidiosum* is distributed to Campbell Island in Antarctic region (Papenfuss 1964), Chatham Islands and Snares Islands in New Zealand (J. Agardh 1867), and Tasmania in Australia (J. Agardh 1867). Since Papenfuss (1964), there are no reports of the species in the sub-Antarctic region except this study.

In Chile, Levring (1960) first reported the occurrence of *Ceramium stichidiosum* based on samples collected in Ancud Bay and Reloncavi fjord and marsh. The Chilean distribution ranges from Valparaíso in the north (Santelices & Abbott 1978) to Chiloé Island in the south (Levring 1960).

There have been many floral works in the Falkland, Kerguelen, and South Georgia Islands as well as islands in the extreme south of Chile, like Cape Horn and Diego Ramírez. Species may be not found due to sampling in different seasons, tiny size, its habitat in sub-tidal zones, and the challenge of isolating species that lives as epiphytes or parasites. However, it is surprising that the species has not been reported in the Magellan region because *Ceramium stichidiosum* was found as an epiphyte on algae of the genera *Mazzaella* and *Sarcothalia*, which had been collected extensively

over the years without previously reporting the existence of *Ceramium stichidiosum*.

We suggest that *C. stichidiosum* has been recently introduced to the Magellan region with the agent of marine transportation. The species possibly entered from the north of Chile or from sub-Antarctic islands by way of currents. The most plausible route of its dispersal is from the north of Chile, given the common traffic of boats from Puerto Montt. If *C. stichidiosum* were to be found to the south of the Strait of Magellan, such as South Georgia, Diego Ramírez, Falklands or Cape Horn, it is possible that our report is due to natural colonization. However, the species has not been found in the Diego Ramírez Islands (Mansilla & Navarro 2003), South Georgia Islands, and the Falkland Islands (Pedrini 1992, John *et al.* 1994). Two invasive species have been reported in Chile to date: *Codium fragile* spp. *Tomentosoides* (van Goor) P.C. Silva (González & Santelices 2004) and *Polysiphonia morrowii* Harvey (Kim *et al.* 2004). Given the development of inter-ocean transport, algae from coastal ecosystems now are threatened by invasive species (Carlton & Geller 1992, McIvor *et al.* 2002).

Our report shows the need of an extensive revision for the ceramiceous red algae in the Chilean sub-Antarctic region, not only for morphologically similar species, but also for possible exotic species. Recently frequent marine traffics make many marine organisms including algae to be introduced from other sea to Magellanic region (Kim *et al.* 2004).

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