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The unusual occurrence of *Chaetomorpha antennina* (Bory) Kützing, 1847 (Chlorophyta Cladophoraceae) in a sublittoral rocky reef of the Mexican tropical Pacific marine ecoregion: significant expansion of their ecogeographic range

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ABSTRACT This is the first record of *Chaetomorpha antennina* (Bory) Kützing, 1847 (Chlorophyta Cladophoraceae) from a deep rocky reef of the Mexican tropical Pacific marine ecoregion, a chlorophyte which had been reported only from intertidal and shallow subtidal zones. *C. antennina* of Sacramento reef in Zihuatanejo, Mexico, is smaller than had been previously reported. Extension of variation intervals of this species collected 18–20 m depth suggests that other factors such as hydrodynamic forces and light reduction in deep environments may have a relevant role in its morphological plasticity.

KEY WORDS *Chaetomorpha antennina*; subtidal algae; deep rocky reef; Eastern tropical Pacific; Zihuatanejo.

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INTRODUCTION

The phycofloristic knowledge of the Mexican tropical Pacific marine ecoregion (Spalding et al., 2007) has increased notably since the 1980s and currently there is a clear picture of the presence and distribution of the majority of the reported species (González-González, 1992; Pedroche & Sentíes, 2003). Such is the case for the chlorophyte *Chaetomorpha antennina* (Bory) Kützing 1847 (Phylum Chlorophyta, Order Cladophorales), which has a thallus with a simple uniseriate level of filamentous organization, forming upright bushes constituted by aggregations of numerous filaments [see photographs in Guiry (2022)]. It is an epilithic species with a pantropical distribution; it is one of the most prominent species in the Mexican tropical Pacific and it is well known ecologically. It has been reported in numerous locations at all points along the 1,200 kilometers of the coast (Pedroche et al., 2005; León-Álvarez, 2016) in different rocky habitats and in a wide range of microenvironmental conditions (González-González, 1993; Candelaria et al., 2006; Norris, 2010). This species is commonly found from the high intertidal zone to the low intertidal zone (Norris 2010; Leliaert et al., 2011a) and very rarely in the subtidal shallows to a depth of 2 meters (Mendoza-González et al., 2018). It can be found on more or less vertical cliff walls, rocky points, rocky blocks or breakwaters. It is generally directly exposed to the swell, lateral dragging, splash or intense spray. It is exposed to conditions of direct illumination, with more or less prolonged periods of sunshine.

Although it is true that there is already an extensive information base regarding the phycoflora of the Mexican tropical Pacific, there is a notable bias toward intertidal algae and comparatively little is known regarding sublittoral algal biodiversity. As part of a project focused on the algae of the rocky reefs in the Zihuatanejo area, in the state of Guerrero, we collected *C. antennina* at a depth of 18–20 meters. Given that this finding is very significant in terms of the ecogeographical distribution of this species, the objective of this study is to provide the first report of *C. antennina* in an unusual habitat in the marine ecoregion of the Mexican tropical Pacific.

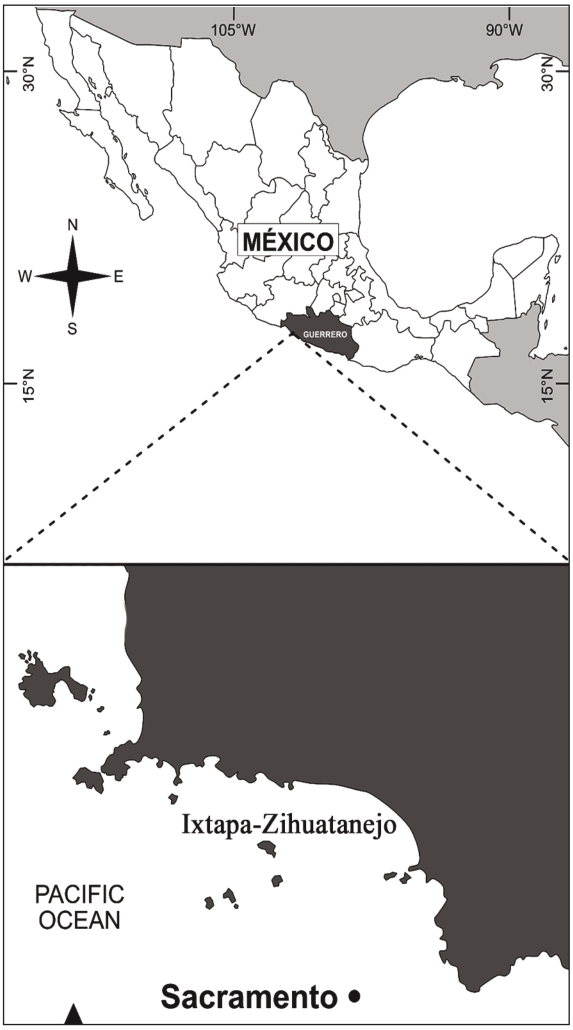


Figure 1. Location of the state of Guerrero, southern Mexico (upper) and Sacramento rocky reef in the Ixtapa-Zihuatanejo region (lower).

MATERIAL AND METHODS

We carried out a survey sampling in the Sacramento rocky reef (17°38'02"N, 101°36'39"W), at southern Ixtapa-Zihuatanejo (Fig. 1). This site descends to a depth of 30 m and is composed of overlapping, irregularly shaped rocky blocks 1–5 m long, among which there are deposits of sand, gravel and boulders, which are exposed to strong internal currents that produce laminar or turbulent flows of water. *Chaetomorpha antennina* is attached to rocks and balanus shells.

The samples were collected randomly by SCUBA diving on 23 October 2012 between 18 and 20 m depth. All the algal specimens were collected by hand using hammer and chisel and preserved in 4% formalin in seawater for morphological analysis. The specimens were deposited in Sección de Algas, Herbario de la Facultad de Ciencias (FCME), Universidad Nacional Autónoma de México.

The morphological characteristics were examined following taxonomic descriptions of *C. antennina* from the Mexican tropical Pacific (Setchell & Gardner, 1924; Taylor, 1945; Abbott & Hollenberg, 1979; Candelaria, 1985; López, 1993; Norris, 2010; Leliaert et al., 2011a). Diagnostic characters used were: habit, thallus length, basal cell features (shape, length, upper diameter, presence of annular constrictions and type of holdfast), suprabasal cell length, and intermediate cells features (shape, length and diameter). Morphometric analyses were carried out with an Olympus SZ2ILST stereo microscope and an Olympus BX51TF microscope. Photographs were taken with an Olympus SC100 digital camera mounted on an Olympus SZX10 stereomicroscope and Olympus cellSens Standard software.

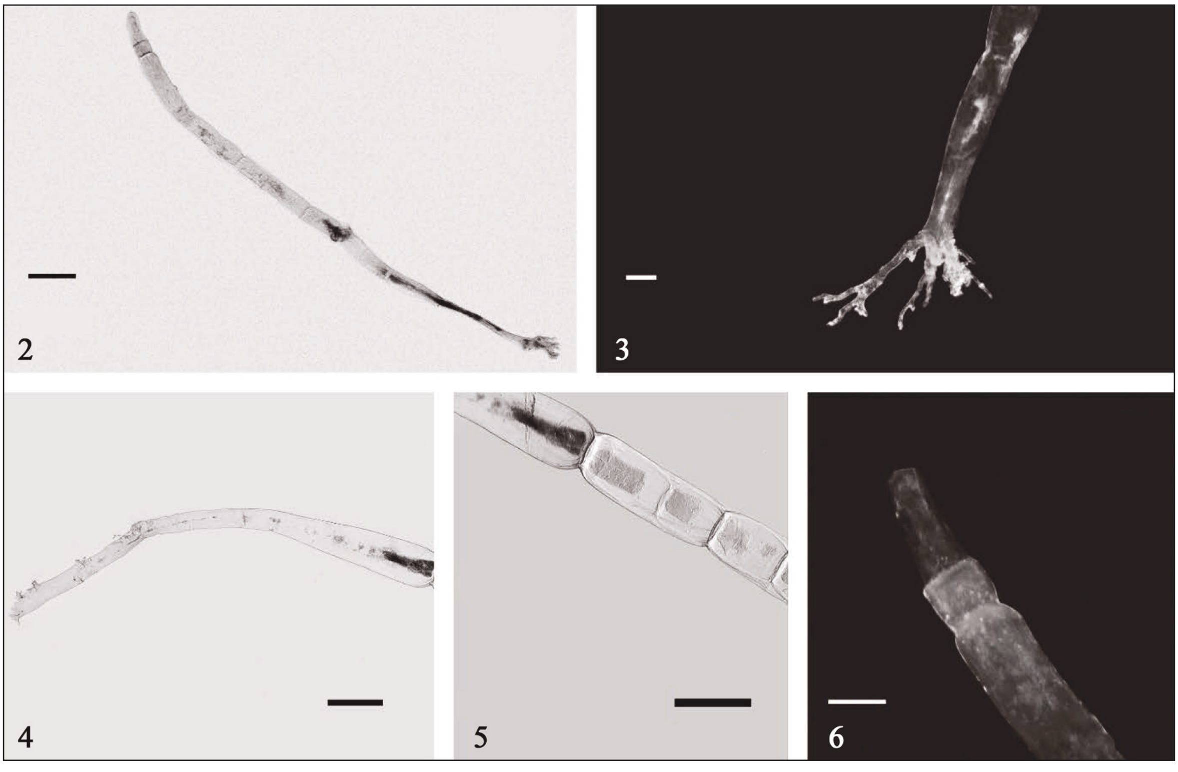
RESULTS

The recognition of *Chaetomorpha* species is currently based on a few morphological features such as growth form, cell shape and dimensions, and shape of basal attachment cell (Leliaert et al. 2011a, 2011b). The collected specimens form tufts of scarce fine green filaments, 0.6–1.2 cm high (Fig. 2). The elongated, thick-walled basal cells are club-shaped, 600–3600 µm long and 180–570 µm in diameter at the distal end; with tenuous annular constrictions near the base; proximal pole bearing branched rhizoids (Fig. 3). The suprabasal cells are 185–720 µm long (Fig. 4). Other cells are sub cylindrical (Fig. 5) towards the basal area of the filaments, 510–900 µm long and 360–840 µm in diameter, gradually becoming broader and barrel-shaped upward (Fig. 6). Reproductive cells were not observed.

Sacramento specimens are in accordance with *C. antennina* descriptions from the Mexican tropical Pacific in habit and length of thallus; form, length and diameter of basal cell; presence of annular constrictions; presence of branched rhizoids; suprabasal cell length; and shape, length and diameter of intermediate cells. However, other features, specifically measurements, extend down the recorded variation intervals, e.g. thallus length (our specimens 0.6–1.2 cm vs. 1–16 cm from previous reports); basal cell length (600–3600 µm vs. 1800–15000 µm); suprabasal cell length (185–720 µm vs. 360–3700 µm) (Table 1). Also, the scarcity of filaments in tufts in our material was notable, in contrast to the dense bush described by numerous authors from many Mexican tropical Pacific localities. Furthermore, the presence of annular constrictions is barely distinguishable.

DISCUSSION

Chaetomorpha antennina has been recognized as a species that is "clearly circumscribed and shows a fairly constant morphology throughout its ecological and geographical range" (Leliart et al., 2011a) and it is easily identifiable from other species in the genus essentially from its habit, a long claviform basal cell, branched rhizoids that develop on the proximal extreme of the basal cell, and the presence of annular constrictions. In turn, Abbott and Huisman (2004) mention that "*the identification of* C. antennina *is confirmed by the presence of a conspicuously long basal cell*", just as occurs in our specimens. Considering the morphologic definition of this species, there is no doubt about the identity of *C. antennina* from Sacramento reef, however the habit formed by sparse filaments



Figures 2-6. *Chaetomorpha antennina* from Sacramento Reef. Fig. 2: a fine filament. Fig. 3: branched rhizoids. Fig. 4: suprabasal cell. Fig. 5: intermediate cells. Fig. 6: apical cell showing upper end. Scale bars: Figs. 2, 5 = 500 µm; Fig. 3, 6 = 200 µm; Fig. 4 = 450 µm.

and the smaller thallus length were noteworthy. This aspect represents a pattern of size reduction similar to that observed in many subtidal turf-forming species from Zihuatanejo (López et al., 2004). Also noteworthy, is the barely distinguishable presence of annular constrictions on the basal cell. Several authors indicate that this characteristic is commonly (Taylor, 1945), frequently (Abbott & Hollenberg, 1979), or usually (Norris, 2010) present; however, Leliart et al. (2011a) mention that in culture conditions, the annular constrictions do not appear, which could be associated with a morphogenetic development in conditions of lower hydrodynamics in the sublittoral or the non-existent movement in cultures, when compared with the prevailing conditions in the intertidal zone.

The impact that abiotic factors have on deep habitat organisms is considerably different from that which occurs on organisms of intertidal habitats (Coleman, 2002; Araújo et al., 2005; Benedetti-Cecchi & Trussell, 2014) or subtidal shallow rocky habitats (Garrabou et al., 2002; Balata & Piazzi, 2008). The tides, swell, desiccation, light, temperature, and nutrient availability, are among the most extreme and dynamic factors that *C. antennina* is exposed to in the intertidal zone. The differences found in *C. antennina* from the Sacramento reef could be interpreted as a plastic response to the environmental gradients that are relatively more constant in deep habitats, such as the low incidence of light, lower temperatures, and lower intensity turbulence from water currents, similar to the conditions observed in deep rocky reefs in the Mediterranean (Garrabou et al., 2002; Balata & Piazzi, 2008), but it is necessary to evaluate this correlation at Sacramento and at other rocky reefs in the Mexican tropical Pacific. The ecological conditions in the rocky habitats of the intertidal and sub-

Features	**Previously reported features**	**Our description**
Habit	Erect brushlike tufts	Tufts of very fine green scarcity filaments
Length of thallus	1-16 cm	0.6-1.2 cm
Basal cell form	Club-shaped	Club-shaped
Basal cell length	1800-15000 μm	600-3600 μm
Basal cell diameter	180-900 μm	180-570 μm
Annular constrictions	Conspicuous annular constrictions generally	Tenuous annular constrictions
Presence of branched rhizoids	Proximal end bearing branched rhizoids	Proximal end bearing branched rhizoids
Suprabasal cell length	360-3700 μm	185-720 μm
Intermediate cell form	Subcylindrical towards the basal area of the filaments, gradually becoming broader and barrel-shaped upward	Subcylindrical towards the basal area of the filaments, gradually becoming broader and barrel-shaped upward
Intermediate cell length	330-2000 μm	510-900 μm
Intermediate cell diameter	225-1000 μm	360-840 μm

Table 1. Features of *Chaetomorpha antennina* from the Sacramento rocky reef and those previously reported.

tidal shallows where *C. antennina* has been previously reported and those which we are reporting at the deep rocky reef of Sacramento, suggest that this species has an adaptive capacity greater than was previously known in this ecoregion and expands its condition as an eurytopic species (Lincoln et al., 2001), exhibiting a tolerance for an ample variety of habitats, from the upper intertidal zone to the subtidal depths (18–20 m), and therefore its ecological range is extended as has been shown in this work.

This report is a contribution to morphological and ecogeographical knowledge of *Chaetomorpha antennina* in the Mexican tropical Pacific, and highlights the need to carry out more detailed studies of distribution patterns, habitat characterization, and morphological descriptions of subtidal flora, which constitute the baseline of rocky reefs biodiversity of this ecoregion, as was pointed out by Rincón-Díaz et al. (2020) for the Panama Bight ecoregion at the Eastern Tropical Pacific.

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