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First record of *Synedropsis roundii* (Bacillariophyta, Fragilariaceae) in the Mediterranean region

Saúl BLANCO[1], Susana ROMO[2], Ana GARCÍA-MURCIA[2]

[1] Diatom Laboratory, IMARENABIO, La Serna, 58 – 24007 León, Spain

[2] Departamento de Ecología, Facultad Biología, Universitat València, 46100-Burjasot, Valencia, Spain

Corresponding author: sblal@unileon.es

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Abstract

Populations of the fragilarioid diatom *Synedropsis roundii* from the phytoplankton of the Albufera of Valencia, a large and shallow eutrophic lagoon on the Spanish Mediterranean coast, are described. The collected specimens are described and illustrated using light and scanning electron microscopy. This is the first documented record of this species since its description, and the first illustrated record of the genus in the Mediterranean region. The Albufera lagoon and the type locality of the species (Imboassica Lagoon, SE Brazil) are similar in some ecological features. The ecological and biogeographical implications of this finding are briefly discussed.

Keywords: Albufera of Valencia; diatoms; biogeography; lagoon; phytoplankton; taxonomy.

Introduction

Synedropsis Hasle et al. is a genus of pennate, araphid diatoms that preferentially inhabits marine Arctic and Antarctic waters. It was proposed that the genus encompassed *Fragilaria* Lyngb./*Synedra* Ehr. Taxa, characterised by apical field pores arranged in slits that are not recessed below the valve surface, and by a single rimoportula per valve located close to the apex (Hasle *et al.,* 1994; Fernandes *et al.,* 2007; Medlin & Desdevies, 2016). The genus is relatively recent, with no reports in pre-Holocene deposits (Stachura-Suchoples *et al.*, 2016, but see Srivastav, 2003). Current phylogenetic studies show that it is clearly paraphyletic (Karsten *et al.,* 2006), forming a well-supported clade along with other closely related taxa such as *Tabularia*, *Ulnaria*, *Grammonema*, as well as some species of *Fragilaria* (Belando *et al.*, 2018; Medlin *et al.,* 2008).

Current taxonomic databases (Guiry & Guiry, 2018) consider 11 validly published *Synedropsis* species, together with some fossil species (Srivastav, 2003). *Synedropsis* was believed to be exclusively a marine genus with polar distribution, but in 2003 a bloom in a tropical brackish coastal lagoon in southeastern Brazil (Melo *et al.,* 2003) was ascribed to a new species of *Synedropsis*, *S. roundii* Torgan *et al.* (Melo *et al.,* 2003). A similar taxon, *S. karsteteri* Prasad, was later reported in Perdido Bay (Florida), a shallow brackish estuarine bay located in the northeastern Gulf of Mexico (Prasad & Livingston, 2005). This paper describes a *S. roundii* population that is growing in a Mediterranean coastal lake in the east of Spain, which constitutes the unique record of this species outside the type locality, as well as the first confirmed record of a *Synedropsis* taxon in the Mediterranean region.

Materials and Methods

Study site

The Albufera in Valencia is a shallow, oligohaline lagoon (salinity 1-2) that is situated on the Mediterranean coast of Spain (39°20’N, 0°21’W). It is located in the Albufera Natural Park (210 km^2), a wetland protected by the Ramsar Convention and the European Habitat list NATURA 2000. It is the largest Spanish coastal lagoon with a surface area of 23.2 km^2 and an average depth of 1.2 m. Since the last century, the lake functions as a reservoir for the demands of the surrounding rice cultivation. The water level of the lake is regulated by sluice gates that are situated on its three outlet channels which flow into the Mediterranean Sea (Romo *et al*., 2013). Since the 1960s, eutrophication rapidly shifted the Albufera lagoon to a turbid, algal dominated state that eliminated submerged macrophytes and reduced general biodiversity (Romo *et al*., 2005, 2008).

Methodology

Phytoplankton samples were taken fortnightly between February 2016 and January 2017 at 30 cm depth and fixed with Lugol's solution. Clean diatom frustule suspensions were obtained as oxidising organic matter with heated hydrogen peroxide 30% v/v. Carbonate inclusions were removed by adding a few drops of hydrochloric acid. Permanent microscopic slides were mounted using a refractive resin (Naphrax®). Diatoms were identified at 1000× magnification using a Leica® DM-RB light microscope (LM) equipped with Differential Interference Contrast (Nomarski) optics. LM photographs were taken with an OPTIKA® camera. For scanning electron microscopy (SEM), a drop of the cleaned suspension was placed on a metal structure and allowed to dry at room temperature; then it was coated with a 10 nm thick gold layer using a High Vacuum Modular Metallisation System (QUORUM Q150T ES). Images were obtained with a MERLIN (Carl Zeiss) microscope, operating at 20 kV. Both LM and SEM photographs were adjusted for brightness and contrast using GIMP (GNU Image Manipulation Program v.2.8). Morphological terminology follows Hasle *et al.* (1994) and Melo *et al.* (2003).

Results

LM observations. Valves narrowly linear-lanceolate, somewhat broader in midvalve, with subcapitate to capitate apices (Fig. 1). Length 33-46 µm, width 1.3-2.1 µm, ratio 25-30. Sternum rather wide, linear throughout. Transapical striae inconspicuous under LM, opposite throughout, 22-25 in 10 µm, not becoming denser towards apices, interrupted in midvalve forming a hyaline central area. Marginal spines absent.

SEM observations. Striae formed by only two roundish areolae throughout, one of them in the mantle (Fig. 2E). Areolae occluded by delicate hymenes (Fig. 2C). Rimoportula at one of both poles only, internally bilobate, almost circular, lying oblique in subpolar position, extended to *ca.* one half of the valve breadth and opened to the exterior through a pore (Fig. 2D). At each apex of the valve there is a slit field that is composed of 3 slits internally (Fig 2D) and viewed externally as circular pores (Fig. 2C). Apices with no outgrowths or apical spines. The central area is delimited by ghost striae (Fig. 2B). The mantle interstriae are internally raised (Fig. 2D). The valve/mantle transition is abrupt, forming right angles (Fig. 2E). The valvocopulae lack apparent perforations (Fig. 2F).

Discussion

Synedropsis roundii differs from other *Synedropsis* taxa by the valve outline and the presence of a single chloroplast per cell (in contrast to the generitype *S. hyperborea*) (Melo *et al*., 2003). The individuals depicted here fit well with the diagnostic criteria that are defined for this species, in terms of both frustule morphometry and ultrastructural characteristics. The most closely related species is *S. karsteteri*, with shorter valves, denser striae, and two plastids per cell. In a noticeable manner, the latter species shares not only morphological but also ecological features with *S. roundii*, which suggests a recent speciation episode. These two taxa, which contrary to other *Synedropsis* do not form colonies, may constitute a separate clade from strictly marine *Synedropsis*/*Grammonema* (Medlin *et al*., 2008; Stachura-Suchoples *et al*., 2016) with more euryhaline ecological profiles.

Synedropsis species have probably been recorded as either *Fragilaria* or *Synedra* spp. or overlooked (Cefarelli *et al*., 2015). To our knowledge, to date, *S. roundii* has only been re-

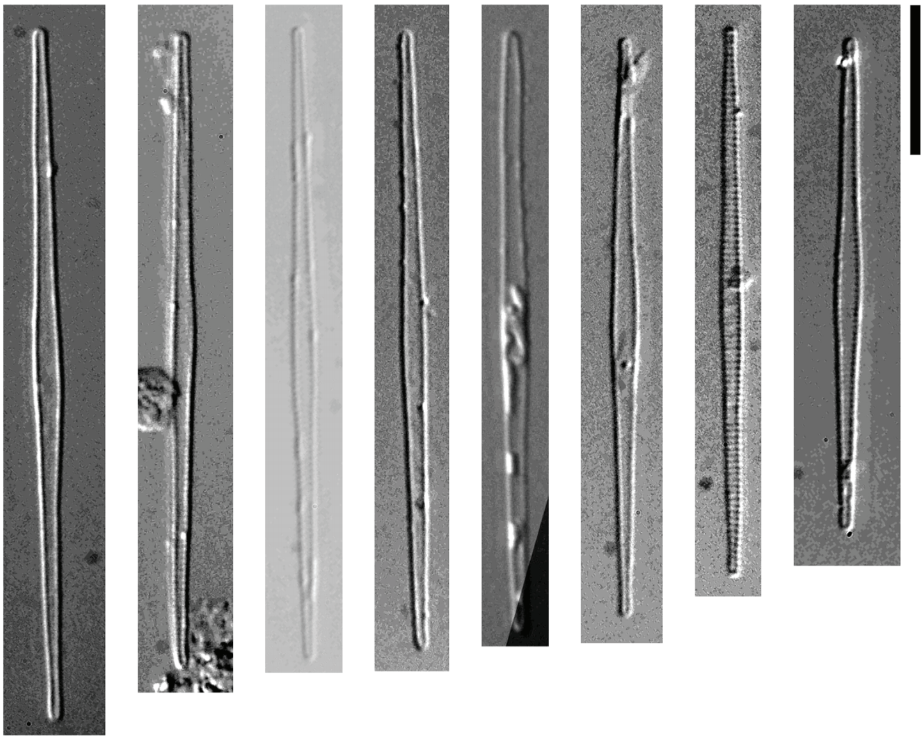

Fig. 1: *Synedropsis roundii* in Albufera Lake in Valencia (E Spain). LM images captured at different foci and illumination angles.

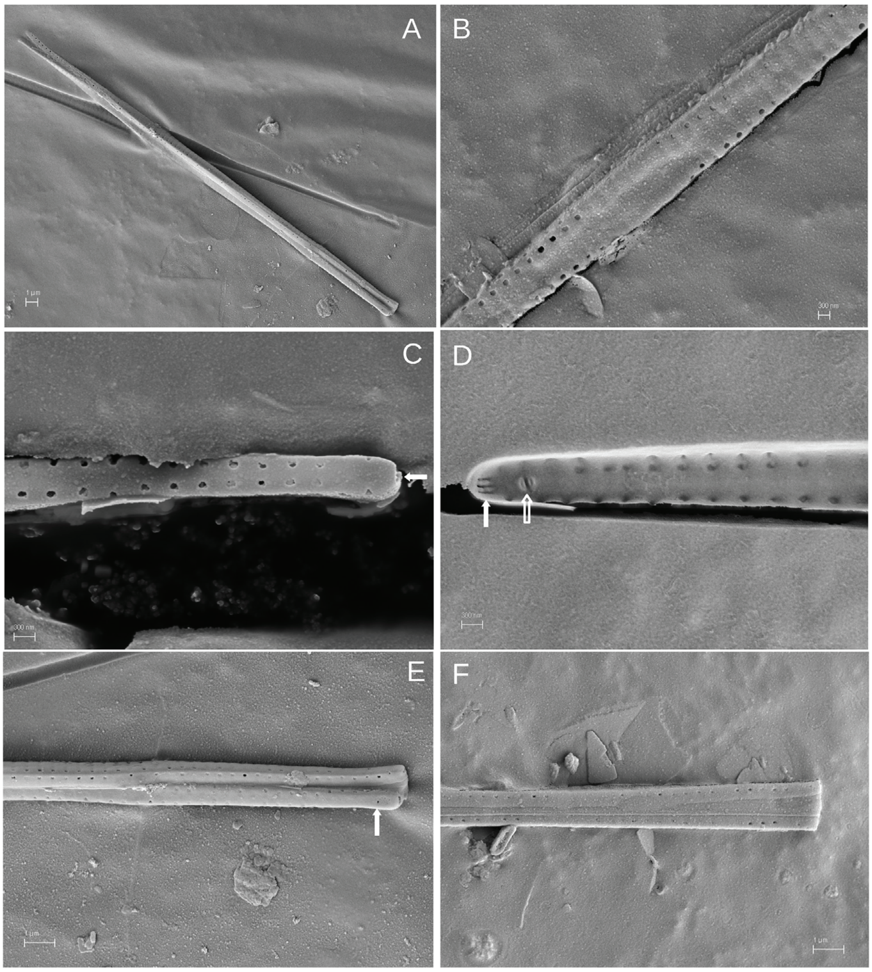

Fig. 2: *Synedropsis roundii*. SEM. (A) A whole frustule in oblique view. (B) Central area in valve view showing the central area and the ghost striae. (C) Valve apex lacking rimoportula pore. Note the uniseriated striae formed by a single areola and the final lateral pores that constitute reduced striae. (D) Valve apex in internal valve view. Note the apical slit-field, typical of the genus (filled arrow), the rimoportula (empty arrow) and the internally raised virgae of the mantle. (E) A detail of image A showing the external rimoportula pore (arrow). (F) Frustule apex in girdle view. Note the mantle striae formed by a single areola, the absence of spines and the unperforated valvocopula.

ported in the type locality. Previous studies may have misidentified this taxon as *Fragilaria famelica* (Kützing) Lange-Bert., in some temporary dune waters of the Albufera Natural Park (Antón-Garrido *et al*., 2013). An earlier, but non-illustrated, record of *Synedropsis hyperborea* (Grunow) Hasle on the south coast of Murcia, Spain (Bouza & Aboal, 2008) might also correspond to this taxon. In the Albufera lagoon, *S. roundii* forms extensive planktonic populations all year round, with the exception of summer when seawater inflows to the system reach a minimum.

Both sites with confirmed occurrences of *S. roundii* (Imboassica Lagoon in Brazil and Albufera Lake in Spain) are characterized by the presence of hypertrophic waters. It is well-known that needle-shaped Fragilariaceae are especially common in spring and autumn (King *et al.,* 2006), and may rise in a facultative manner into the plankton during periods of strong mixing (Barker *et al*., 2001; Marvan *et al*., 1975), where they can outcompete cyanobacteria due to their ability to exploit phosphorus pulses (Grover, 1988; Horn, 2003; Sommer, 1986).

This is the first confirmed record of *S. roundii* outside its type locality. Notwithstanding, the present study broadens the known distribution of the genus beyond marine polar waters by documenting and illustrating, for the first time, a *Synedropsis roundii* population in the Mediterranean region. Thus, this paper confirms that the species of *Synedropsis* are not restricted to polar sea ice and the water column nearby and shows that *S. roundii* is not endemic to SE Brazil, as previously hypothesised (Prasad & Livingston, 2005). The occurrence of S. *roundii* in Imboassica Lagoon was restricted to the oligohaline water periods (Melo *et al*., 2003) and since this species is able to grow under fluctuating salinities, its tolerance to brackish water is more likely to be the result of genetic changes rather than a gradual acclimatisation to less saline waters (Prasad & Livingston, 2005).

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