

FIRST RECORD OF THE DINOFLAGELLATE *Prorocentrum panamense* (PROROCENTRALES, DINOPHYCEAE) IN THE MEXICAN PACIFIC FROM THE ARCHIPIÉLAGO DE REVILLAGIGEDO

Primer registro del dinoflagelado *Prorocentrum panamense* (Prorocentrales, Dinophyceae) en el Pacífico Mexicano recolectado en el Archipiélago de Revillagigedo

RESUMEN. Se reporta por primera vez el dinoflagelado *Prorocentrum panamense* en la costa del Pacífico de México. Diez células de *P. panamense* se encontraron en muestras de red procedentes de aguas superficiales en tres islas del Archipiélago de Revillagigedo donde se recolectaron muestras en marzo de 2017. Los sitios de muestreo tenían una profundidad aproximada de 60-70 m y la temperatura superficial del agua estaba entre 21 y 23 °C.

Gárate-Lizárraga, Ismael* & Rogelio González-Armas. Instituto Politécnico Nacional, Centro Interdisciplinario de Ciencias Marinas, Departamento de Plancton y Ecología Marina, Apartado postal 592, La Paz, Baja California Sur, 23000, México. *Correspondence author: igarate@ipn.mx

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The epiphytic dinoflagellates began to receive attention when *Gambierdiscus* Adachi & Fukuyo was identified as responsible for ciguatera fish poisoning, the principal cause of non-bacterial illness associated with the consumption of fish in tropical areas (Fukuyo, 1981). The dinoflagellate genus *Prorocentrum* Ehrenb. comprises planktonic and benthic, epiphytic and sand-dwelling species. Some epiphytic species such as *Prorocentrum lima* (Ehrenb.) F. Stein are known as producers of okadaic acid and other toxins (Faust *et al.*, 1999; Faust & Gulledge, 2002). Osorio-Tafall (1942) described several species of *Prorocentrum* in the coastal waters of Mexico. One of these species, *P. mexicanum* Osorio-Tafall (1942) has gained much attention as a widespread toxic species (Gómez *et al.*, 2017). Currently, 27 species of *Prorocentrum* have been reported in the Mexican Pacific (Osorio-Tafall, 1942; Hernández-Becerril *et al.*, 2000; Okolodkov & Gárate-Lizárraga, 2006; Gárate-Lizárraga & Muñetón-Gómez, 2008; Muciño-Márquez *et al.*, 2015; Gárate-Lizárraga *et al.*, 2016; Morquecho-Escamilla *et al.*, 2016; this study).

In molecular phylogenies, species of *Prorocentrum* are divided into three clades: one clade mostly composed of planktonic species such as *P. micans* Ehrenberg and the tychoplanktonic species *P. mexicanum*; another clade mostly composed of epiphytic species such as *P. lima*; and a third clade including the epiphytic species *Prorocentrum panamense* Grzebyk, Y. Sako & B. Berland (Grzebyk *et al.*, 1998). This species was first described from Contadora Island, Pacific coast of Panama, and the Mururoa atoll, French Polynesia (Grzebyk *et al.*, 1998), and was further

reported from tropical waters of the Indian Ocean, from the Caribbean Sea (Hansen *et al.*, 2001; Hoppenrath *et al.*, 2014), and from Chinese waters (Luo *et al.*, 2017). Toxicity of this species has been tested for Chinese strains, and they do not produce a detectable level of okadaic acid (Luo *et al.*, 2017).

Many planktonic species are bloom-forming, and many benthic species are toxic and may reach high cell concentrations. Around 80 species of *Prorocentrum* have been described, out of which 29 are benthic dwellers (Hoppenrath *et al.*, 2014). Along the Pacific coast of Mexico 27 species of *Prorocentrum* have been reported (see above references). Of these, only *Prorocentrum belizeanum* M.A. Faust, *P. concavum* Y. Fukuyo, *P. emarginatum* Y. Fukuyo, *P. lima*, *P. maculosum* M.A. Faust, and *P. rhythimum* are considered benthic or tychoplanktonic (tycho planktonic) because they have been identified in phytoplankton samples. The goal of this paper is to report the first record of *Prorocentrum panamense* in the central Pacific coast of Mexico from Archipiélago de Revillagigedo.

The Archipiélago de Revillagigedo is located in the eastern Pacific Ocean, 386 km southwest of the southernmost tip of the Baja California Peninsula and 720 to 970 km west of the Mexican mainland (Fig. 1). The Archipiélago de Revillagigedo is a serial nomination made up of four remote islands and their surrounding waters: San Benedicto, Socorro, Roca Partida and Clarión (<http://whc.unesco.org/en/list/1510>). The islands have been part of Manzanillo municipality of the Mexican state of Colima. As part of a multidisciplinary study, several surveys were performed approximately 50-100 m off three of the islands of the Archipiélago de Revillagigedo (San Benedicto, Socorro, and Roca Partida Islands) from December 2016 to April 2017. Geographical coordinates and depths of the three sampling sites are shown in Table 1. Surface tows were made for 5 min. with a 20 µm mesh plankton net. The plankton concentrate was fixed with Lugol's solution and later preserved in 4% formalin. Sea surface temperature was measured with a bucket thermometer (Brannan, U.K.). Observations were made using a Carl Zeiss® phase-contrast microscope. A digital Konus® camera (8.1 MP) was used to record the images.

A total of ten cells of *P. panamense* were identified from 5 phytoplankton net samples (Figs. 2-6). This species was found in samples from Benedicto, Socorro and Roca Partida Islands (Table 1). Eight other planktonic species were also recorded; *Prorocentrum balticum* (Lohmann) Loeblich, *P. compressum* (Bailey) T.H. Abé ex J.D. Dodge, *P. dentatum* F. Stein, *P. gracile* F. Schütt, *P. kooreanum* M.S. Han, S.Y. Cho & P. Wang, *P. rostratum* F. Stein, *P. sigmoides* Böhm, and *P. triestinum* J. Schiller. Seawater temperatures recorded at the same time as the collections ranged from 21 to 23°C (Table 1).

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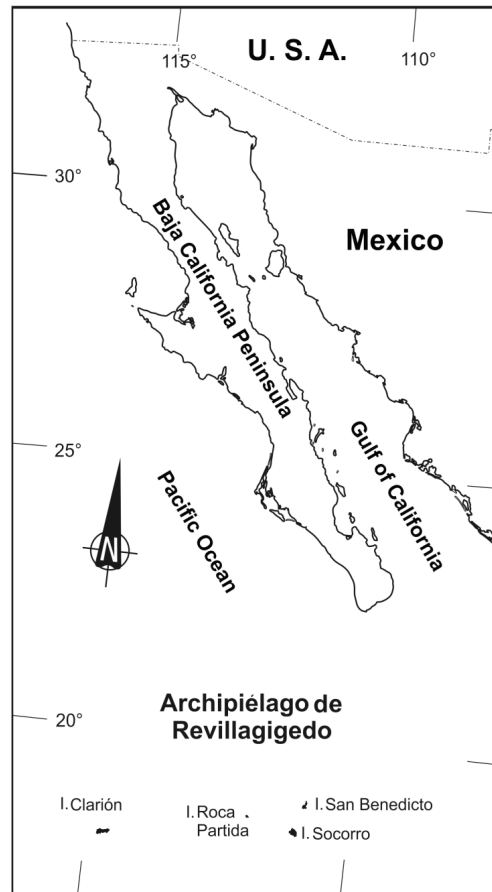


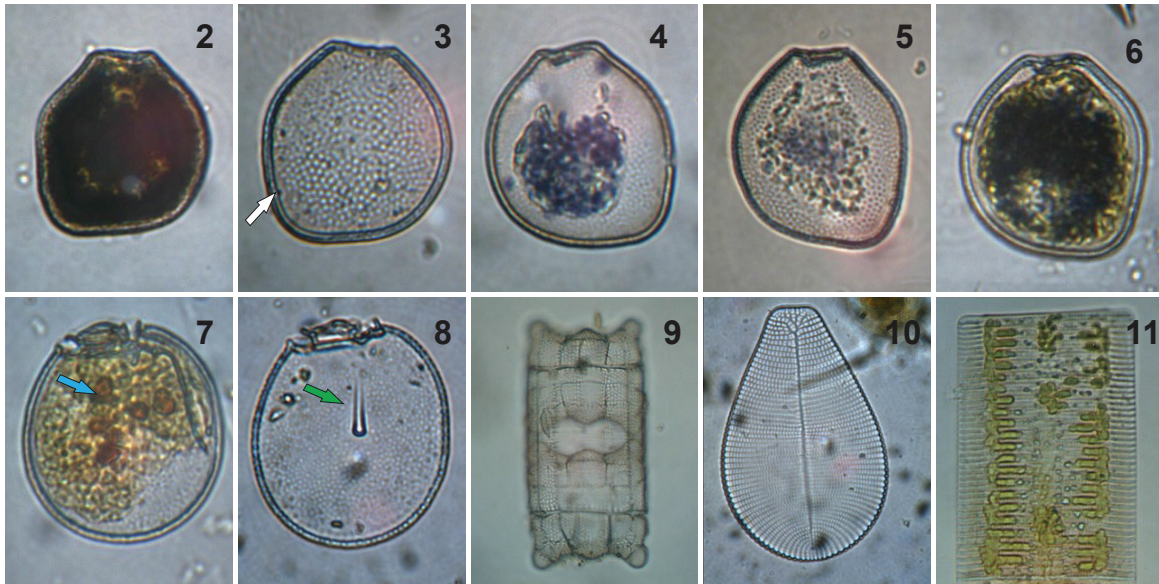
Figure 1. Sampling area located in the Archipiélago de Revillagigedo in the Mexican Pacific.

Description: Cells of *P. panamense* are broadly heart-shaped with a rounded posterior margin; valves are asymmetrical. Cells ranged in size from 46–48 μm in length and 40–43 μm in width ($n=5$). The periflagellar area is located anteriorly off-center in a shallow raised depression. The identification was based on the cell shape (Figs. 2–6), and the distribution of the pores was examined to confirm the

identity (Figs. 3–5). This taxon is characterized by strong depressions with pores inside. The sieve-like depression is observed on the edge of the right valve (white arrow; Fig. 3). The shape of *Proocentrum panamense* is very distinctive, similar only to the planktonic species *P. nanum* J. Schiller that is significantly smaller. *P. panamense* also differs from *P. pseudopanamense* Chomérat & Nézan,

Table 1. Geographical coordinates for each station, water column depth, sampling date, number of cells of *P. panamense* and surface seawater temperature recorded in 5 field sampling sites at the Archipiélago de Revillagigedo.

Sampling sites	Date	Geographical coordinates	Water column depth (meters)	Type of bottom	Surface seawater temperature ($^{\circ}\text{C}$)	Number of cells in samples
Isla San Benedicto (El Boiler)	03/03/2017	19°19'51.816''N, 110°48'48.6''W	30–40	Rocky	23	4
Isla Socorro (Punta Tosca)	03/03/2017	18°46'10.3''N, 111°02'15.616''W	30–40	Mainly sandy	23	1
Isla Socorro (Dedos de Lava)	28/03/2017	19°17'48.336''N, 110°48'9.72''W	30–40	Rocky and sandy	22	1
Isla Socorro (Cabo Pierce)	28/03/2017	18°46'41.088''N, 110°54'22.68''W	30–40	Rocky and sandy	23	2
Isla Roca Partida	30/03/2017	18°59'30.12''N, 112°4'58.583''W	70–80	Rocky	21	2



Figs. 2–11. Microalgae observed in the Archipiélago de Revillagigedo during March 2017. Five different specimens of *Prorocentrum panamense* collected in the Archipiélago de Revillagigedo in left-valve view (Figs. 2 and 3) and in right-valve view (Figs. 4, 5 and 6). Fig. 3. Left thecal view showing numerous depressions and a large sieve-like structure (white arrow). Two cells of *Sinophysia canaliculata*; blue arrow indicates some cyanobacteria-like cells (Fig. 7), and green arrow indicates a narrow thecal slit located in the proximal part of the left hypothecal plate (Fig. 8). *Biddulphia biddulphiana* (Fig. 9), *Podocystis spathulata* (Fig. 10), and *Rhabdonema adriaticum* (Fig. 11).

which is not heart-shaped. The species *P. panamense* has been previously reported from coral reef, sandy and turf algae habitats (Grzebyk *et al.*, 1998; Hansen *et al.*, 2001). In the present study, this species was collected from the surface waters in sampling stations located at a distance of 50–100 m from the islands (Table 1). The cells of *P. panamense* appeared in a plankton assemblage composed of the epiphytic dinoflagellate *Cabra matta* S. Murray & D.J. Patterson (not illustrated) and *Sinophysia canaliculata* Quod, Ten-Hage, Turquet, Mascarell & Couté (Figs. 7–8), that later has been previously reported for the Gulf of California and the Gulf of Tehuantepec, Mexico (Okolodkov & Gárate-Lizárraga, 2006), as well as the epibenthic diatoms *Biddulphia biddulphiana* (W. Sm.) Boyer (Fig. 9), *Podocystis spathulata* (Shadbolt) Van Heurck (Fig. 10), and *Rhabdonema adriaticum* Kütz (Fig. 11). This suggests that *P. panamense* is a common species in benthic habitat around the islands of the Revillagigedo Archipelago. Confirmation from samples collected in benthic habitats is needed.

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