

BLOOMS OF *Pyrodinium bahamense* var. *compressum* AND ROCK OYSTER TOXICITY IN COSTA CHICA, GUERRERO, MEXICO

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ABSTRACT. Blooms of *Pyrodinium bahamense* var. *compressum* were detected from July to December 2010 in Costa Chica, Guerrero. To estimate the cell abundance of this dinoflagellate, phytoplankton samples were collected from 7 July to 9 December 2010 at five sampling sites. Wild rock oysters and specimens from fishing cooperatives were only collected during November-December 2010. Abundance of *P. bahamense* var. *compressum* ranged from < 1000 to 194000 cells L⁻¹ in the first three samplings performed in July. Low densities (< 9000 cells L⁻¹) were observed at the end of November and December. Rock oyster toxicity from the fishing areas ranged from 46.24 to 788.85 µg STXeq 100 g⁻¹. Rock oyster samples collected in the fishing cooperatives had toxicity from 52.2 to 440.88 µg STXeq 100 g⁻¹. Although rock oysters were collected at the end of the blooms, their toxicity could be associated to this dinoflagellate both during this period and during previous blooms that occurred from on July-August in the study area.

Keywords: Algal bloom, *Pyrodinium bahamense* var. *compressum*, rock oyster, shellfish toxicity

Florecimientos de *Pyrodinium bahamense* var. *compressum* y toxicidad en ostión de roca en Costa Chica, Guerrero, México

RESUMEN. Se detectaron florecimientos de *Pyrodinium bahamense* var. *compressum* de julio a diciembre de 2010 en Costa Chica, Guerrero. Con el fin de calcular la abundancia de este dinoflagelado se recolectaron muestras de fitoplancton desde el 7 de Julio hasta el 9 de diciembre en cinco estaciones de muestreo. Asimismo, se recolectó ostión de roca en los sitios naturales de captura y en cooperativas pesqueras de la región de noviembre a diciembre. La abundancia de *P. bahamense* var. *compressum* alcanzó valores < 1000 y máximos 194000 céls L⁻¹ en los tres primeros muestreos realizados en julio; se observaron bajas densidades (< 9000 cells L⁻¹) a finales de noviembre y diciembre. La toxicidad del ostión de roca recolectado en los sitios de captura comercial varió entre 46.24 y 788.85 µg STXeq 100 g⁻¹. La toxicidad en las muestras de ostión recolectado en las cooperativas pesqueras varió entre 52.2 y 440.88 µg STXeq 100 g⁻¹. Aunque el ostión de roca fue recolectado al final de los florecimientos, su toxicidad puede asociarse a la presencia del dinoflagelado, tanto en estas fechas como por los florecimientos previos ocurridos entre julio-agosto en el área de estudio.

Palabras clave: Florecimiento algal, ostión de roca, *Pyrodinium bahamense* var. *compressum*, toxicidad en mariscos.

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INTRODUCTION

The frequency of occurrence of algal blooms appears to have increased in recent decades. Likewise, in Mexico, an important number of algal blooms have also been recorded for the last three decades. Microalgae blooms are frequent and periodic throughout the year along the Pacific coast of Mexico (Cortés-Altamirano *et al.*, 1995; Figueroa-Torres & Zepeda-Esquivel, 2001; Gárate-Lizárraga *et al.*, 2001; 2008; 2009; Cortés-Altamirano & Alonso-Rodríguez, 1997; Díaz-Ortiz *et al.*, 2010; Gárate-Lizárraga & González Armas, 2011; Quijano-Scheggia *et al.*, 2011). Most algae blooms are innocuous; however, some blooming-species can be harmful or toxic. Their toxicity reaches several levels

of the food chain killing fish and other marine life, thus affecting fishing activities. Besides, they cause illness to people who consume marine fish and shellfish affected by the toxic algae.

Harmful algae blooms are common events along the coasts of Guerrero (Licea-Durán *et al.*, 1999; Ramírez-Camarena *et al.*, 2004; Gárate-Lizárraga *et al.*, 2008; 2009; 2011; Díaz-Ortiz *et al.*, 2010), and since 1991, the Public Health Laboratory "Dr. Galo Soberón y Parra" has successfully monitored for species causing red tides and paralytic toxin-producing species along the central and southwestern Mexican coast, including toxicity in marine bivalves. The main toxic species responsible for red tides in

this area are the dinoflagellates *Cochlodinium polykrikoides*, *Gymnodinium catenatum*, and *Pyrodinium bahamense* var. *compressum*. Sometimes, these three species occur simultaneously along the coasts (Gárate-Lizárraga *et al.*, 2011). *P. bahamense* var. *compressum* is broadly distributed along the Mexican Pacific coastline, while *P. bahamense* var. *bahamense* has an uncertain distribution (Gárate-Lizárraga & González-Armas, 2011). *P. bahamense* var. *compressum* is the main species responsible causing important PSP outbreaks in this area (Saldate-Castañeda *et al.*, 1991; Orellana-Cepeda *et al.*, 1998; Gárate-Lizárraga *et al.*, 2011). Few red tide events and paralytic shellfish toxicity of this dinoflagellate have been reported elsewhere off Bahía de Acapulco (Cortés-Altamirano *et al.*, 1993; Orellana-Cepeda *et al.*, 1998; Ramírez-Camarena *et al.*, 2004). Recently, Gárate-Lizárraga *et al.* (2011; 2012) reported several PSP incidents in 2010 in Costa Grande (Zihuatanejo) on the northern part of Guerrero. Here, we report for the first time the presence of blooms of *P. bahamense* var. *compressum* and toxicity in the rock oyster (*Crassostrea iridescens* Hanley, 1854) in Costa Chica, Guerrero.

MATERIAL AND METHODS

The locality known as Costa Chica is an area along the south coast of the state of Guerrero, Mexico, extending from south of Acapulco to the Oaxaca border. As part of a continuing toxic microalgae monitoring program, phytoplankton samples were collected from 7 July to 9 December 2010 at several shellfish catching sites in Costa Chica (Sampling stations 1-9;

Fig. 1; Table 1). During the samplings done on 23 November and 8 December, around 100 g of rock oyster meat were collected to measure shellfish toxicity. Also, to measure the quality of products sold in commercial markets, oyster samples were obtained from five fishing cooperatives (Cooperativas pesqueras; sampling stations 6-10; Table 2).

Blooms samples were collected with a 1m-tube sampler and were fixed with Lugol solution. One mL of each phytoplankton sample was placed in a Sedgwick-Rafter chamber for cell counting under an inverted microscope (Olympus Axiovert 40 C) and scanned at 200× with a digital camera (Cannon Power Shot A64Q). SEM images were obtained with a JEOL JSM-5600 electron microscope operating at 10 kV and 8 mm working distance. Shellfish toxicity was determined by standard mouse bioassay (AOAC International, 1995). Preparation of an extract obtained from 100 g of whole shellfish tissue dissolved in boiling acid (0.1 N HCl, 100 mL) was injected (0.5 g tissue equivalent) into each 20 g mouse (Díaz-Ortiz *et al.*, 2010). Satellite data of sea surface temperature (SST) in a sampling at the study area were obtained by Moderate Resolution Imaging (MODIS-OCEAN) satellite database.

RESULTS AND DISCUSSION

Sea surface temperature ranged from 27.6 °C (February) to 30.5 °C (July) and showed a clear marked seasonal pattern (Fig. 2). Blooms of *P. bahamense* var. *compressum* occurred during the highest summer temperatures recorded in July (30.5 °C), indicating its subtropical and tropical nature. *Pyrodinium bahamense*



Figure 1. Location of sampling stations (1–10) in the southern part of the Costa Chica, Guerrero coastline surveyed from July 7 through December 15, 2010.

Table 1. Abundance (cells L⁻¹) of *Pyrodinium bahamense* var. *compressum* from red tides samples collected at 5 georeferenced sites in Costa Chica, Guerrero from July 7 to December 9, 2010.

Sampling station number	Sampling sites (geographical coordinates)	Sampling dates									
		July 7	July 9	July 14	July 21	July 27	August 4	November 23	December 2	December 9	
1	Casa de Piedra; Playa Ventura 16° 32' 04.3" 98° 53' 48.4"	83000	52000	25000	3000	4000	< 1000	2 000	< 1000	2 000	
2	Playa La Picuda 16° 32' 06.9" 98° 54' 45.2"	94000	62000	64000	4000	8000	< 1000	3 000	< 1000	9 000	
3	Las Salinas; Las Salinas 16° 32' 42.6" 98° 50' 45.9"	108000	16000	194000	8000	4000	< 1000	2 000	< 1000	1000	
4	Bahía El Faro; Punta Maldonado 16° 19' 56.4" 98° 34' 11.3"	135000	15000	< 1000	12000	1000	< 1000	< 1 000	< 1000	2 000	
5	El Pico de la Playa; Punta Maldonado 16° 19' 15.5" 98° 34' 01.0"	89000	21000	< 1000	22000	2000	< 1000	0	< 1000	1000	

var. *compressum* was the only toxic species found in the samples collected at five sites on 7 July to 9 December 2010 in Costa Chica, Guerrero (Table 1). This variety occurred as individual cells and two-cell and four-cell chains (Figs. 3–7). Cells are about 34–62 µm long and 40–54 µm wide ($n = 30$). Abundance of *P. bahamense* var. *compressum* ranged from 16000 to 194000 cells L⁻¹ in the first three samplings performed in July. Its densities diminished at the end of July and were not observed during September and October. Low cell densities were observed at the end of November and December (Table 1). Densities of *P. bahamense* var. *compressum* found in this study lie in the range reported by other authors (Díaz-Ortiz *et al.*, 2010; Gárate-

Lizárraga *et al.*, 2011, 2012; Meave del Castillo *et al.*, 2012). These authors reported densities from 1000 to 1,462,000 cells L⁻¹.

Wild oyster toxicity ranged from 96.24 to 573.3 µg STXeq 100 g⁻¹ on November 23. An increase of the oyster toxicity was observed on December 3, reaching the highest toxicity value (788.85 µg STXeq 100 g⁻¹). Two oyster samples showed toxicity values under the limit permissible (80 µg STXeq 100 g⁻¹) for human consumption (DOF, 2011) and five oyster samples had toxicities that were over 1-9 times the permitted limit (Table 2). Rock oyster samples collected in the fishing cooperatives exhibited toxic levels from 52.2 to 440.88 µg STXeq 100 g⁻¹. Four

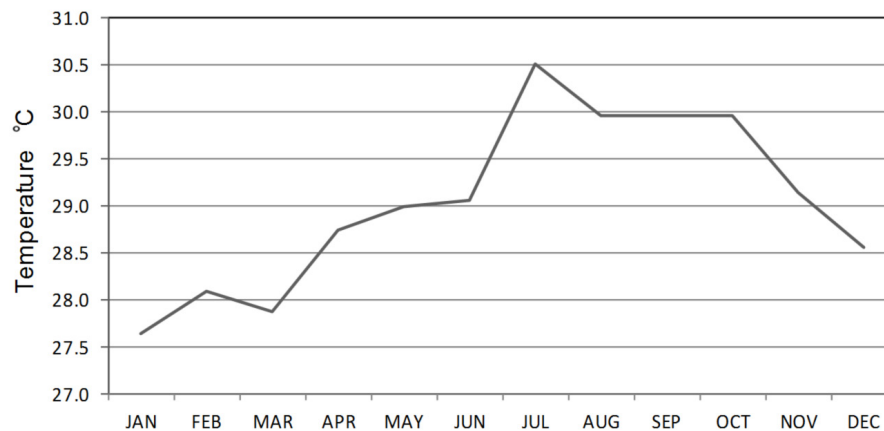
**Figure 2.** Annual variation of the average sea surface temperature during 2010 in Bahía de Acapulco,

Table 2. Oyster toxicity determined in 13 collection sites in Costa Chica, Guerrero from 23 November to 15 December 2010.

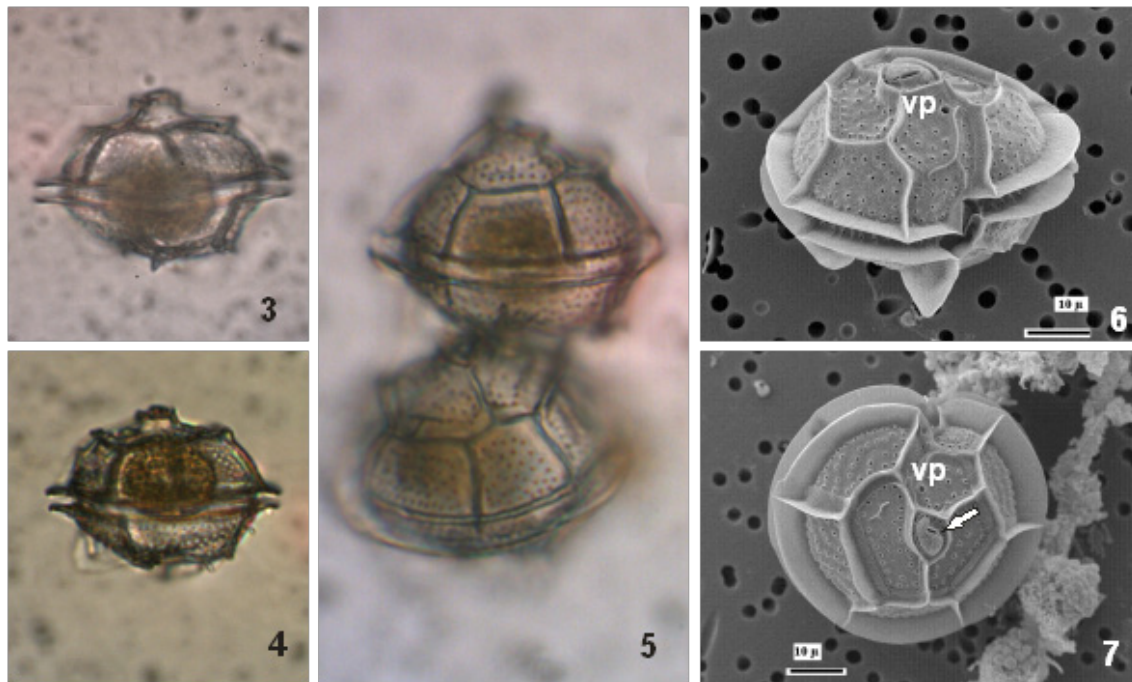
Sampling station number	Date	Sampling sites	Oyster toxicity ($\mu\text{g STX}_{\text{eq}} 100 \text{ g}^{-1}$)
1	Nov. 23	Casa de Piedra; Playa Ventura	573.3
3	Nov. 23	Las Salinas, Copala	403.2
4	Nov. 23	Punta Maldonado; Cuajinicuilapa	96.24
4	Dec. 03	Punta Maldonado; Cuajinicuilapa	28.86
1	Dec. 03	Casa de Piedra; Playa Ventura	703.8
3	Dec. 03	Ojo de Agua; Las Salinas	788.85
4	Dec. 08	Punta Maldonado; Cuajinicuilapa	46.8
6	Dec. 08	Copala	440.88
9	Dec. 08	Marquelia	200.4
7	Dec. 15	Cooperativa Pesquera "Salinas Hipozahualco"; Copala	52.2
8	Dec. 15	Cooperativa Pesquera "Baltazar R. Leyva Mancila"; Copala	329.4
10	Dec. 15	Cooperativa Pesquera Marquelia	320.4

samples were over 2.5-5.5 times the permitted limit for human consumption. Although rock oysters were collected at the end of the blooms of *P. bahamense* var. *compressum*, their toxic-

ity could be associated to this dinoflagellate not only for the presence of this species but due to the occurrence of previous blooms occurred on July-August in the study area. On the other hand, wild oysters could have accumulated paralytic toxins previously to the collection of phytoplankton samples, because they feed on *P. bahamense* var. *compressum*.

There were no human intoxications during this outbreak because the public health authorities in Acapulco responded rapidly. Nevertheless, along the Zihuatanejo coast in the northern coast of Guerrero, during December 2010, fourteen PSP incidents occurred from consuming raw clams ($2541 \mu\text{g STX}_{\text{eq}} 100 \text{ g}^{-1}$), victims required hospitalization (Gárate-Lizárraga *et al.*, 2011, 2012). High toxicity found in oysters from the Guerrero coast could result from the high content of STX and neoSTX, the two of the most potent analogues of all the PSP toxins analogues found in marine bivalves from this area (Nuñez-Vázquez *et al.*, 2007; Gárate-Lizárraga *et al.*, 2012).

Two dinoflagellate taxa are the main source of paralytic shellfish toxins along the coasts of Guerrero, *P. bahamense* var. *compressum* and *Gymnodinium catenatum* (Orellana *et al.*, 1998; Ramírez-Camarena *et al.*, 2004; Díaz-Ortiz *et al.*, 2010; Gárate-Lizárraga *et al.*, 2009, 2011, 2012; Meave del Castillo *et al.*, 2012). Because



Figures 3–7. Photomicrographs of *Pyrodinium bahamense* var. *compressum* found in Costa Chica, Guerrero, Mexico. Cells observed under light microscope (Figs. 3-5) and scanning electron microscope (Figs. 6-7); 6) ventral view of cell showing the sulcal area and ventral pore (vp), 7) apical view showing the epitheca arrangement, ventral pore (vp) in 4' plate and the apical plate complex which consists of a comma-shaped canopy and pores.

of the increasing frequency and impacts in the coasts of Guerrero due to blooms of these two species, research performed by the Laboratorio Estatal de Salud Pública "Dr. Galo Soberón y Parra" have been focused on avoiding risks to public health. However, few studies have been conducted to know the causes that can trigger the initiation or development of red tide blooms in this area. At present a more intense program of monitoring of PSP toxin-producing species and toxicity in several species of mollusks along the coasts of Guerrero state is ongoing.

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REFERENCES

- AOAC International. 1995. Paralytic shellfish poison: Biological method. Sec. 35.1.37, Method 959.08. 22–23, *In*: Cunniff, P.A. (Ed.) *Official Methods of Analysis of AOAC International*, 16th ed. AOAC International, Gaithersburg, MD.
- Cortés-Altamirano, R. & R. Alonso-Rodríguez. 1997. Mareas rojas durante 1997 en la bahía de Mazatlán, Sinaloa, México. *Ciencias del Mar UAS*, 15: 31–37.
- Cortés-Altamirano, R., L. Muñoz-Cabrera, & O. Sotomayor-Navarro. 1993. Envenenamiento paralítico por mariscos (PSP), causado por el dinoflagelado *Pyrodinium bahamense* var. *compressum* en la costa suroeste de México. *An. Inst. Cienc. del Mar y Limnol. Univ. Nat. Autón. México*, 20(1): 43–54.
- Cortés-Altamirano, R., D. U. Hernández-Beceril & R. Luna-Soria. 1995. Mareas rojas en México: una revisión. *Rev. Lat.-Amer. Microbiol.*, 37: 343–352.
- Díaz-Ortiz, J.A., B. Pérez-Cruz, R. Valdovinos-Sánchez, M.A. Alarcón-Romero, S. López-Silva, L. Chávez-Almazán & J.L. García-Barboza. 2010. Registro histórico de marea roja en la Bahía de Acapulco de 1992 a 2010. *Red Sanitaria*, 7: 1–4.
- DOF. 2011. Norma Oficial Mexicana-NOM-242-SSA1-2009. Productos y servicios. Productos de la pesca frescos, refrigerados, congelados y procesados. Especificaciones sanitarias y métodos de prueba. *Diario Oficial de la Federación*, 10 de febrero de 2011, México.
- Figueroa-Torres, M.G. & M.A. Zepeda-Esquivel. 2001. Mareas rojas del Puerto Interior, Colima, México. *Scientiae Naturae*, 3: 39–52.
- Gárate-Lizárraga, I., M. L. Hernández-Orozco, C. Band-Schmidt & G. Serrano-Casillas. 2001. Red tides along the coasts of Baja California Sur, México (1984 to 1999). *Oceánides*, 16(2): 127–134.
- Gárate-Lizárraga, I., J.A. Díaz-Ortiz, M. Alarcón-Tacuba, B. Pérez-Cruz, A. Torres-Jaramillo, M.A. Alarcón-Romero & S. López-Silva. 2007. Paralytic shellfish toxin in marine mollusks from the Southwestern region of the Mexican coasts (1992–2006), 50–51. *In*: 40th Annual Meeting of the Western Society of Malacologists, 25–28 July 2007. La Paz, Baja California Sur, Mexico.
- Gárate-Lizárraga, I., B. Pérez-Cruz, J.A. Díaz-Ortiz & C.J. Band-Schmidt. 2008. Microalgas y biotoxinas marinas en las costas mexicanas. *Conversus*, 9: 22–26.
- Gárate-Lizárraga, I., J. Díaz-Ortiz, B. Pérez-Cruz, M. Alarcón-Tacuba, A. Torres-Jaramillo, M.A. Alarcón-Romero & S. López-Silva. 2009. *Cochlodinium polykrikoides* and *Gymnodinium catenatum* in Bahía de Acapulco, Mexico (2005–2008). *Harmful Algae News*, 40: 8–9.
- Gárate-Lizárraga, I., J.A. Díaz-Ortiz, B. Pérez-Cruz, M.A. Alarcón-Romero, M.L. Chávez-Almazán & S. López-Silva. 2011. A multi-species dinoflagellate bloom and shellfish toxicity in Costa Grande, Guerrero, Mexico (December, 2010). *CICIMAR Oceánides*, 26: 67–71.
- Gárate-Lizárraga, I., & R. González-Armas. 2011. Occurrence of *Pyrodinium bahamense* var. *compressum* along the southern coast of the Baja California Peninsula. *Mar. Pollut. Bull.*, 62(3): 626–630.
- Gárate-Lizárraga, I., B. Pérez-Cruz, J. A. Díaz-Ortiz, M. Alarcón-Tacuba, L. A. Chávez-Almazán, M. A. Alarcón-Romero, S. López-Silva, J. J. Bustillos-Guzmán & S. Licea-Durán. 2012. Toxicity and paralytic toxin profile in *Pyrodinium bahamense* var. *com-*

- pressum* and violet oyster in Bahía de Acapulco. *Harmful Algae News*, 45: 2–3.
- Licea-Durán, S., S. Gómez-Aguirre, R. Cortés-Altamirano & S. Gómez. 1999. Notas sobre algunos florecimientos algales y la presencia de especies tóxicas en cinco localidades del Pacífico Mexicano (1996-1999). 335–337, *In*: Tresierra-Aguilar, A.E. & Z.G. Culquichicón-Malpica (Eds.). *VIII Congreso Latinoamericano sobre Ciencias del Mar*, 17-21 de octubre de 1999, Trujillo, Perú.
- Meave-del Castillo, M. E., M. E. Zamudio-Resendiz & M. Castillo-Rivera. Riqueza fitoplanctónica de la Bahía de Acapulco y zona costera aledaña, Guerrero, México. 2012. *Acta Bot. Mex.*, 100: 405–487.
- Nuñez-Vázquez, E. J., J.J. Bustillos-Guzmán, C. Ramírez-Camarena & F.E. Hernández-Sandoval. Perfiles cromatográficos de toxinas paralizantes en moluscos bivalvos asociados a *Pyrodinium bahamense* var. *compressum* en el Pacífico Sur Mexicano. Resúmenes del II Taller sobre Florecimientos Algales Nocivos, 21–23 Noviembre 2007. CICESE-CETMAR, Ensenada, B.C., México. p. 18.
- Orellana-Cepeda, E., E. Martínez-Romero, L. Muñoz-Cabrera, P. López-Ramírez, E. Cabrera-Mancilla & C. Ramírez-Camarena. 1998. Toxicity associated with blooms of *Pyrodinium bahamense* var. *compressum* in southwestern Mexico, 60, *In*: Reguera, B., J. Blanco, M.L. Fernández & T. Wyatt (Eds.) *Harmful Algae*. Proceedings of the 8th International Conference on Harmful Algae. Xunta de Galicia and Intergovernmental Oceanographic Commission of UNESCO, Vigo, Spain.
- Quijano-Scheggia S., A. Olivos-Ortiz, J.H. Gaviño-Rodríguez, F. Castro-Ochoa, M. Rivera-Vilarelle, M.A. Galicia-Pérez & M. Patiño-Barragán. 2011. The first report of *Pseudo-nitzschia brasiliana* and *P. micropora* (Bacillariophyceae) found in Cuyutlán Lagoon, Mexico. *Rev. Biol. Mar. Oceanogr.*, 46: 189-197.
- Ramírez-Camarena, C., A. Martínez-García, N. Juárez-Ruíz, R. Rojas-Crisóstomo & H. Ramírez-García. 2004. Impactos de *Pyrodinium bahamense* var. *compressum* durante el florecimiento algal nocivo 2001-2002, en la costa suroeste de México. Abstracts, XIII Reunión Nacional de la Sociedad Mexicana de Planctología, A.C. VI International Meeting of Planktology, abril 25-28. Nuevo Vallarta, Nayarit, México. p. 62.
- Saldade-Castañeda, O., J.L. Vázquez-Castellanos, J. Galván, A. Sánchez-Anguiano & A. Nazar. 1991. Poisoning from paralytic shellfish toxins in Oaxaca, México. *Sal. Pub. Méx.*, 33: 240–247.