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PROLIFERATION OF *Levanderina fissa* AND *Polykrikos hartmannii* (DINOPHYCEAE: GYMNODINIALES) IN BAHÍA DE LA PAZ, GULF OF CALIFORNIA, MÉXICO

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ABSTRACT. On 19–20 August 2014, a moderate proliferation of dinoflagellates was detected in the southwestern part of Bahía de La Paz. The phytoplankton community within this red tide was composed of 60 microalgae taxa and was characterized by the presence of unarmored dinoflagellates such as *Levanderina fissa* and *Polykrikos hartmannii*. The proliferation occurred during low tide after a period of windy and rainy days. Densities of *L. fissa* varied from 163 to 265 **× 10**^{3} cells L^{-1} and for *P. hartmannii* varied from 16 to 33 × 10^{3} cells L^{-1}. Low densities were estimated on September and October samplings. Both species showed a great variation both in size and form. As part of the phytoplankton species composition during this proliferation, two taxa of dinoflagellates are new records for *the Pacific coast of Mexico (Ankistrodinium semilunatum* and *Sclerodinium calyptroglyphe*), one in the Gulf of California (*Pronoctiluca acuta*), and one in the Bahía de La Paz (*Prorocentrum robustum*). Cyanobacteria were an important group observed during this proliferation. The symbiotic association between a cyanobacterium *Synechococcus* sp., the stramenopile protist *Solenicola setigera*, and the diatom *Leptocylindrus mediterraneus* was observed for the first time in this bay.

Keywords: Dinoflagellate proliferation, *Levanderina fissa*, *Polykrikos hartmannii*, consortium *Solenicola–Leptocylindrus–Synechococcus*, new records, picoplankton.

Proliferación de *Levanderina fissa* y *Polykrikos hartmannii* (Dinophyceae: Gymnodiniales) en Bahía de La Paz, Golfo de California, México

RESUMEN. Se detectó una proliferación moderada de dinoflagelados en la porción suroeste de la Bahía de La Paz del 19 al 20 de agosto de 2014. La comunidad del fitoplancton dentro de este florecimiento estuvo compuesta de 60 taxa y se caracterizó por la dominancia de *Levanderina fissa* y *Polykrikos hartmannii*. La proliferación ocurrió durante la marea baja y después de días lluviosos. La abundancia de *L. fissa* varió de 163 a 265 **× 10**^{3} céls L^{-1} y *P. hartmannii* varió de 16 a 33 × 10^{3} céls L^{-1}. Densidades bajas fueron estimadas durante los muestreos de septiembre y octubre. Ambas especies mostraron una gran variación en su forma y su tamaño celular. Como resultado de la composición especifica del fitoplancton encontrado durante esta proliferación, dos taxa de dinoflagelados fueron nuevos registros para la costa Pacífica de México (*Ankistrodinium semilunatum* y *Sclerodinium calyptroglyphe*), un taxón para el Golfo de California (*Pronoctiluca acuta*) y un taxón para la Bahía de La Paz (*Prorocentrum robustum*). Las cianobacterias fueron un grupo importante durante esta proliferación. La asociación simbiótica entre una cianobacteria *Synechococcus* sp., el protista stramenopiles *Solenicola setigera* y la diatomea *Leptocylindrus mediterraneus* se observó por primera vez en la bahía.

Palabras clave: Proliferación de dinoflagleados, *Levanderina fissa*, *Polykrikos hartmannii*, consorcio *Solenicola–Leptocylindrus–Synechococcus*, nuevos registros, picoplancton.

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INTRODUCTION

Microalgae proliferations are frequent and periodic throughout the year in Bahía de La Paz in the southwestern part of the Gulf of California (Gárate-Lizárraga *et al*., 2001; 2006). Most red tides along both coastal zones of the gulf have been produced by dinoflagellate species (Gárate-Lizárraga *et al*., 2001; 2006; Cortés-Altamirano, 2002) wherein proliferations of naked dinoflagellates are common (Cortés-Altamirano, 2002; Gárate-Lizárraga *et al*., 2004). The most common blooming species recorded in Bahía de La Paz are *Noctiluca scintillans* Kofoid & Swezy 1921, *Gymnodinium catenatum* Graham 1943, *Cochlodinium polykrikoides* Margalef 1961, *C. fulvescens* M.Iwataki, H.Kawami & K.Matsuoka 2007, *Katodinium glaucum* (Lebour) Loeblich III 1965, *Levanderina fissa* (Levander) Ø.Moestrup, P.Hakanen, G.Hansen, N.Daugbjerg and M.Ellegaard 2014, and *Amphidinium carterae* Hulburt 1957 (Gárate-Lizárraga, 2012, 2013; Gárate-Lizárraga *et al*., 2001; 2004; 2006; 2009). Main unarmored dinoflagellate orders reported in Bahía de La Paz are: Actiniscales, Amphilothales, Brachidiniales, Gymnodiniales, and Noctilucales.

Most studies of Gymnodiniales have been focused on the species responsible for harmful algal blooms, which are abundant in coastal waters of the Gulf of California (Gárate-Lizárraga *et al*., 2001; 2009; Cortés-Altamirano, 2002; Gárate-Lizárraga, 2012; 2014). This report describes a moderate proliferation of *Levanderina fissa* and *Polykrikos hartmannii* Zimmermann 1930 in Bahía de La Paz. Composition of the phytoplankton during this proliferation and symbioses between phytoplankton species are described.

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MATERIAL AND METHODS

Bahía de La Paz is the largest bay on the east side of the Baja California peninsula. The bay constantly exchanges water with the Gulf of California through wide northern and southern openings (Gómez-Valdés *et al*., 2003). The main northern channel is wide and up to 300 m deep, while the southern mouth is shallow and associated with a shallow basin about 10 m deep. A shallow coastal lagoon, the Ensenada of La Paz, is connected to the bay by a narrow inlet (1.2 km wide) with an average depth of 7 m.

As part of a continuing toxic or noxious microalgae monitoring program, phytoplankton bottle samples were collected monthly at one fixed sampling station in the bay (Fig. 1; station 1; 24°21′N, 110°31′W). Samples were collected on 19–20 August 2014, on 29-30 September and 22-23 October 2014. Phytoplankton samples were collected using plastic flasks, fixed with Lugol's solution, and later preserved with 4% formalin. Identification and cell counts were made in 5 ml settling chambers, and the cells were studied under an inverted Carl Zeiss phase-contrast microscope (Utermöhl, 1958). Also, both surface and vertical tows at 15 m in depth were made with a 20 µm mesh phytoplankton net. A portion of each sample was immediately fixed with Lugol's acid solution and later preserved in 4% formalin. Live phytoplankton samples were used to properly identify some uncommon species also found in the bottle samples. Sea surface temperature was measured with a bucket thermometer. Salinity was measured with a refractometer. An Olympus CH2 compound microscope was used to measure cells. A digital Konus camera (8.1 MP) was used to record images.

RESULTS AND DISCUSSION

The phytoplankton proliferation occurred during low tide (Fig. 1) and was observed after windy and rainy days. Seawater temperature was 29.5 to 31*°C* and salinity was 34.4-34.82. This proliferation did not show any seawater discoloration. The phytoplankton community within this proliferation was composed of 60 taxa, including 31 species of dinophytes, 23 bacillariophytes, 2 cyanobacteria, 2 ebridians, 1 raphidophyte, and 1 silicoflagellate. Species richness was 55 taxa during the first day and 50 taxa during the second day of the proliferation. The microalgae and cyanobacteria species list and their abundances are summarized in Table 1. Total phytoplankton abundance in samples varied from 277 to 441 × 10^3 cells L^{-1}. Micro-phytoplankton was numerically the most important (avg. = 292 × 10^3 cells L^{-1}) vs. nanophytoplankton (avg. = 58 × 10^3 cells L^{-1}). Nanophytoplankton was mainly composed by small flagellates. Picoplankton was composed by unidentified symbiotic cyanobacteria with densities from 8 to10 × 10^3 cells L^{-1}.

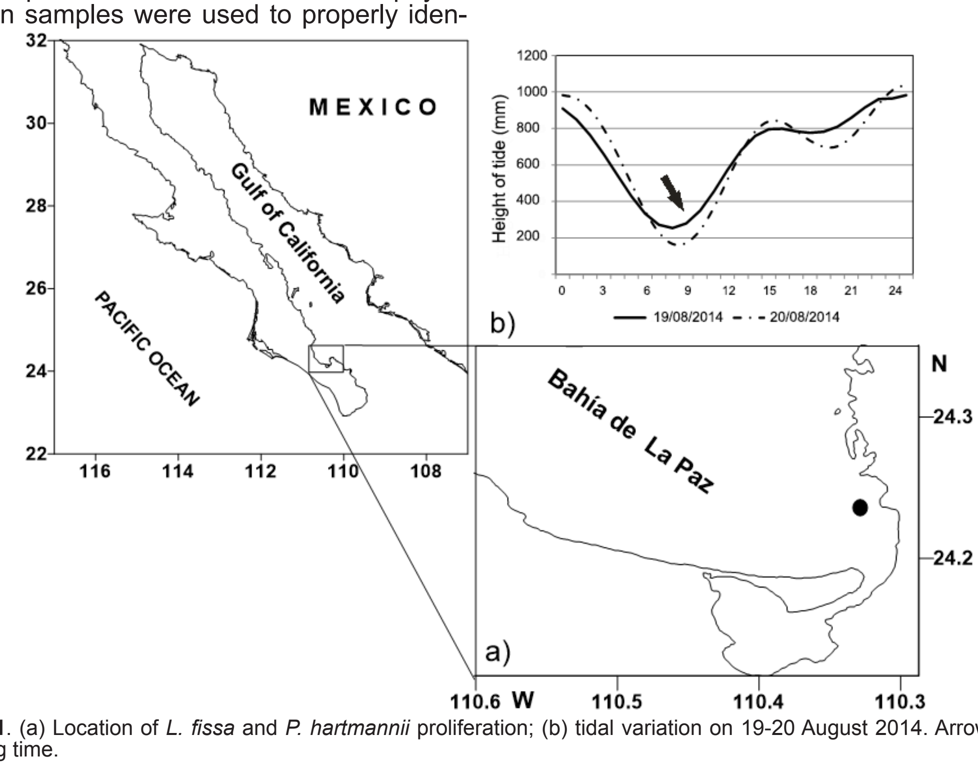


Figure 1. (a) Location of *L. fissa* and *P. hartmannii* proliferation; (b) tidal variation on 19-20 August 2014. Arrow indicates sampling time.

Table 1. Abundance of microalgae and cyanobacteria species recorded for Bahía de La Paz, Gulf of California during proliferation of *Levanderina fissa* and *Polykrikos hartmannii* in August 2014.

Microalgae and cyanobacteria species	**19/08/2014 cells L−1**	**20/08/2014 cells L−1**
Dinoflagellates		
Akashiwo sanguinea (K.Hirasaka) G.Hansen & Ø.Moestrup in N.Daugbjerg, G.Hansen, J.Larsen, & Ø.Moestrup, 2000	4200	1400
Ankistrodinium semilunatum (Herdman) Hoppenrath, Shauna Murray, Sparmann & Leander, 2012	400	200
Balechina coerulea (Dogiel) F.J.R.Taylor, 1976	200	200
Cochlodinium polykrikoides Margalef, 1961	1200	1800
Erythropsidinium agile (Hertwig) P.C. Silva, 1960	200	
Dinophysis caudata Saville-Kent, 1881	800	400
Gonyaulax polygramma (Pouchet) Kofoid, 1911	4200	2800
Gymnodinium gracile Bergh, 1881	200	200
Gymnodinium sp.	1200	2200
Gyrodinium lachryma (Meunier) Kofoid & Swezy, 1921	200	
Heterodinium milneri (Murray & Whitting) Kofoid, 1906	200	200
Katodinium glaucum (Lebour) Loeblich III, 1965	600	
Levanderina fissa (Levander) Ø. Moestrup, P. Hakanen, G. Hansen, N. Daugbjerg & M. Ellegaard, 2014	163600	265800
Lingulodinium polyedrum (F.Stein) J.D.Dodge, 1989	800	200
Oxytoxum sphaeroideum Stein, 1883	200	
Polykrikos hartmannii Zimmerman, 1930	16000	33600
Pronoctiluca acuta (Lohmann) Schiller, 1933	1200	2200
Prorocentrum gracile Schütt, 1895		200
Prorocentrum mexicanum Osorio-Tafall, 1942	200	
Prorocentrum micans Ehrenberg, 1833	200	400
Prorocentrum sigmoides Böhm, 1933	400	1200
Prorocentrum robustum Osorio-Tafall, 1942	400	1200
Protoperidinium conicum (Gran) Balech, 1974	200	200
Protoperidinium venustum (Matzenauer) Balech, 1974	200	600
Pyrocystis fusiformis C.W.Thomson in J.Murray, 1876	400	
Pyrocystis noctiluca Murray *ex* Haeckel, 1890	200	200
Sclerodinium calyptroglyphe (Lebour) J.D.Dodge, 1981	400	600
Tripos furca (Ehrenberg) F. Gómez, 2013	200	600
Tripos fusus (Ehrenberg) F. Gómez, 2013	200	400
Tripos lineatus (Ehrenberg) F. Gómez, 2013	200	
Total abundance of dinoflagellates	198600	316800
Diatoms		
Asteromphalus flabellatus (Brébisson) Greville, 1859	400	200
Asteromphalus heptactis (Brébisson) Ralfs, 1861		200
Carinasigma sp.	600	800
Cerataulina dentata Hasle *in* Hasle & Syvertsen, 1980	400	400
Cerataulina pelagica (Cleve) Hendey, 1937	1400	2800
Ceratoneis closterium Ehrenberg, 1839	400	1200
Chaetoceros curvisetus Cleve, 1889	6400	5200
Chaetoceros spp.	3200	1800
Climacodium frauenfeldianum Grunow, 1868	1000	600
Guinardia flaccida (Castracane) H.Peragallo, 1892		600
Hemiaulus membranaceus Cleve,1873	3800	5200
Leptocylindrus mediterraneus (H.Peragallo) Hasle 1975	1200	1600
Lithodesmium undulatum Ehrenberg, 1839	600	800
Mastogloia rostrata (Wallich) Hustedt, 1933		200
Meuniera membranacea (Cleve) P.C.Silva in Hasle & Syvertsen, 1996	1200	
Nitzschia longissima var. *reversa* Grunow, 1880	400	400
Paralia fenestrata Sawai and Nagumo, 2005	1200	400
Planktoniella muriformis (Loeblich. Wight & Darley) Round, 1972	200	
Planktoniella sol (C.G.Wallich) Schütt, 1892	200	200
Proboscia alata f. *gracillima* (Cleve) Gran	400	600
Pseudosolenia calcar-avis (Schultze) Sundström, 1986	1000	400
Rhizosolenia clevei Ostenfeld, 1902	1000	1600
Thalassionema nitzschioides (Grunow) Mereschkowsky, 1902	1200	600
Total abundance of diatoms	26200	25800

Table 1. Continued.

Microalgae and cyanobacteria species	19/08/2014 cells L−1	20/08/2014 cells L−1
Cyanobacteria		
Richelia intracellularis J.Schmidt in Ostenfeld & J.Schmidt, 1901	7000	8400
Synechococcus-like	1600	1800
Ebriids		
Ebria tripartita (J.Schumann) Lemmermann, 1899	200	400
Hermesinum adriaticum O. Zacharias, 1906	400	800
Raphidophyceae		
Chattonella marina (Subrahmanyan) Hara & Chihara, 1982	6800	8200
Silicoflagellates		
Dictyocha californica Schrader & Murray, 1982	600	400
Total abundance of Raphidophyceae, ebriids and silicoflagellates	8000	9800
Microphytoplankton	232800	352400
Nanophytoplankton	36000	68800
Abundance of cyanobacteria (picoplankton)	8600	10200
Total phytoplankton abundance	277400	441200

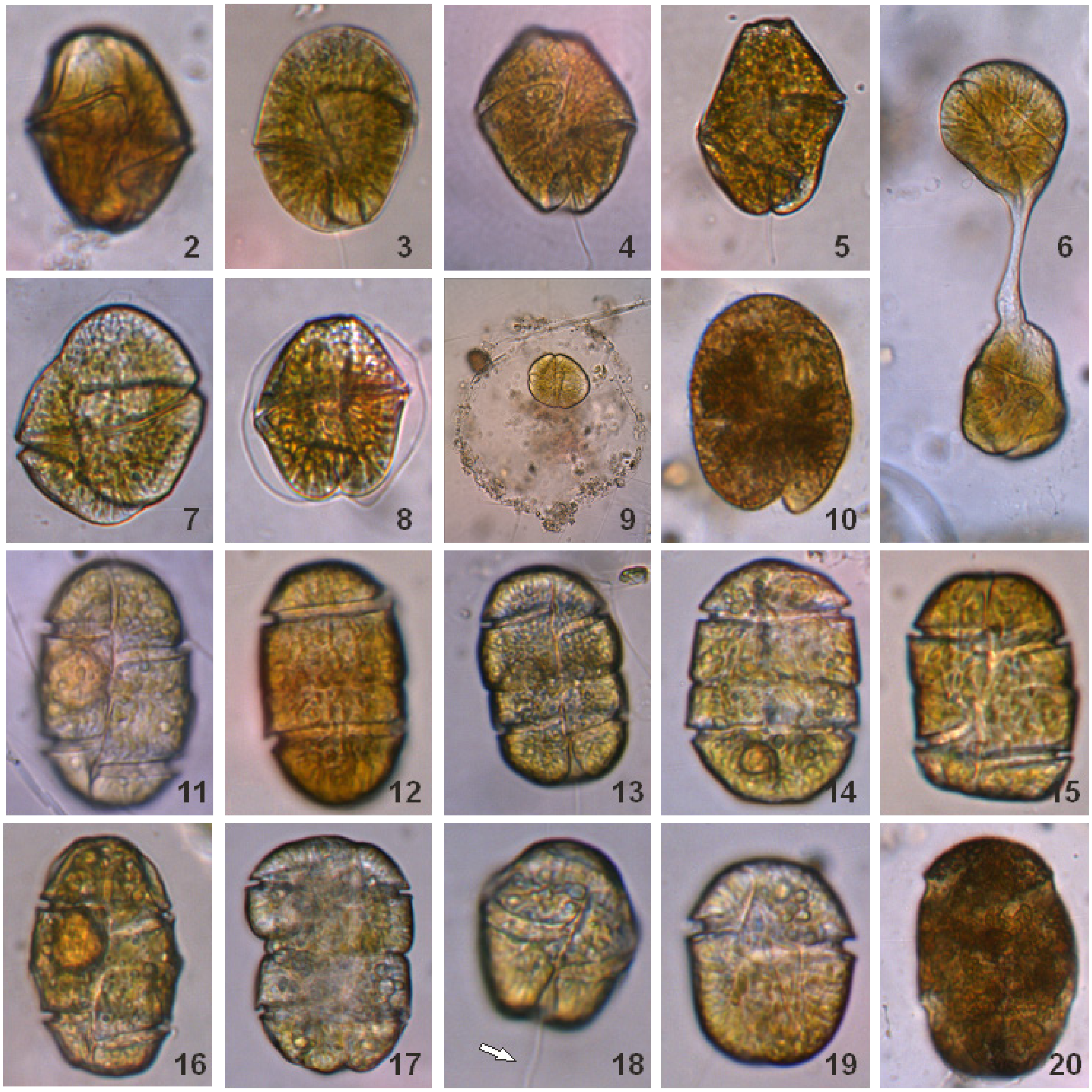
On the basis of abundance and the number of species, dinoflagellates were the most important group, followed by diatoms. *Levanderina fissa* (Levander) Ø. Moestrup, P. Hakanen, G. Hansen, N. Daugbjerg & M. Ellegaard, 2014 and *Polykrikos hartmannii* Zimmerman, 1930 were the main dominant species. *L. fissa* cells showed great cell size and shape variation (Figs. 2-10). Due to this *L. fissa* has been described as *Gyrodinium fissum* (Levander) Kofoid & Swezy 1921, *Gyrodinium instriatum* Freudenthal & J.J.Lee 1963, *Gyrodinium uncatenum* Hulburt 1957, and *Gymnodinium pavillardii* Biecheler 1952 (Moestrup *et al*., 2014). Cells of *L. fissa* ranged from 34 to 57 µm in length and 22 to 35µm in width (n=30); dividing cells (Figs. 6 and 7), hyaline cysts or pellicles (Fig. 8) and cells surrounded by a thick mucus sheath (Fig. 9) were observed during the examination of live samples. Specimens of *L. fissa* were altered by the Lugol´s solution, not allowing a proper identification (Fig. 10). Moderate densities of *L. fissa* were estimated during this event (163×10^3 to 265×10^3 cells L^{-1}) contributing with 59–60% to the total abundance. Low abundances of *L. fissa* were estimated in the samplings done on 29–30 September (6 to 17 $\times 10^3$ cells L^{-1}) and on 22–23 October 2014 (3 to 23×10^3 cells L^{-1}).

Cells of *P. hartmannii* also showed great cell size and shape variation (Fig. 11–20); most specimens observed were two-celled chains and few were solitary cells (Fig. 18-19). Chained cells ranged from 58 to 70 µm in length and 40 to 46 µm in width. Single cells were 64-72 *µm in length* and 42-46 in width (n=30). Dividing cells of *P. hartmannii* were observed (Fig. 17). Specimens of *P. hartmannii* were altered by the Lugol´s solution, not allowing a proper identification (Fig. 20). Moderate densities of *P. hartmannii* estimated during this event were 16 to 33×10^3 cells L^{-1} contributing with 6 to 8% of the total abundance. Low densities of *P. hartmannii* were estimated in the samplings done on 29–30 September (2 to 11 $\times 10^3$ cells L^{-1}) and 22–23 October 2014 (2 to 5×10^3 cells L^{-1}).

Both *L. fissa* and *P. hartmannii* are common bloom-forming dinoflagellates reported from different geographical regions. Both species are common in temperate and tropical waters (Steidinger & Tangen, 1997). Proliferations of *L. fissa* and *P. hartmannii* in Bahía de La Paz have occurred in a 24–31 °C temperature range, coinciding with those found by Gárate-Lizárraga *et al*. (2011, and 2013), Badylak & Phlips (2004) and Tang *et al*. (2013). Blooms of *L. fissa* are common along Japanese coasts (Toriumi, 1990), in the Gulf of Guayaquil in Ecuador (Jiménez, 1993), and along the east coast of the United States and estuaries leading into the Gulf of Mexico (Tomas *et al*., 2004; Badylak & Phlips, 2004). Blooms of *P. hartmannii* occur in waters off Japan (Matsuoka & Fukuyo, 1986), China (Huang & Dong, 2001), and Forge River, New York, USA (Tang *et al*., 2013). These species have been seen along the Pacific coast of Mexico (Gárate-Lizárraga *et al*., 2009; 2013; Mejía-Maya *et al*., 2011).

Densities of *L. fissa* found in this study are lower than those reported by Gárate-Lizárraga *et al*. (2009) (702–3680 $\times 10^3$ cells L^{-1}) in Bahía de La Paz, Mejía-Maya *et al*. (2011) (1973×10^3 cells L^{-1}) in Bahía de Maruata, Michoacán, and Gárate-Lizárraga *et al*. (2013) (796–2120 $\times 10^3$ cells L^{-1}) in Bahía de Acapulco. *P. hartmannii* densities (16-33 $\times 10^3$ cells L^{-1}) found now in this study are in the range reported by Gárate-Lizárraga *et al*. (2009) (1–35 $\times 10^3$ cells L^{-1}) in Bahía de La Paz and lower if compared with Gárate-Lizárraga *et al*. (2011) (5263×10^3 cells L^{-1}) in Bahía de Acapulco.

Blooms of *L. fissa* have been reported to be noxious (Jiménez, 1993; Tomas *et al*., 2004),



Figures 2-20. Light microphotographs of the unarmored dinoflagellates *Levanderina fissa* (2-10) and *Polykrikos hartmannii* (11-20) showing form variation; (6 and 7) two dividing mature specimens of *L. fissa*; (8) hyaline cyst of *L. fissa*; (9) cell of *L. fissa* enclosed in a mucus sheath with detritus; (10) Specimen of *L. fissa* fixed in Lugol´s solution; (11-16) different chains of *P. hartmannii*; (17) two-celled chains dividing specimen of *P. hartmannii*; (18-19) single cells of *P. hartmannii*, arrow shows the longitudinal flagellum; (20) specimen of *P. hartmannii* fixed with Lugol´s solution.

and it is thus considered a harmful species (Nagasoe *et al*., 2006). However, Kelly (2009) found that *L. fissa* produces hemolysins which are unlikely to reach substantial toxicity and suggested that fish mortality that occurred during blooming of this species was due to oxygen depletion. Blooms of *L. fissa* in the Pacific coast of Mexico were harmless (Gárate-Lizárraga *et al*., 2009, 2013, in this study). On the other hand, toxicity experiments of *P. hartmannii* conducted by Tang *et al*. (2013) showed that this species exhibited an acute ichthyotoxicity in juveniles of sheephead minnows (*Cyprinodon variegates* Lacepède, 1803) and aeration did not mitigate this effect, suggesting that *P. hartmannii* is an ichthyotoxic, harmful microalgae. These authors found that *P. hartmannii* release icthyotoxins that cause fish mortality. Therefore, massive blooms of this species represent a potential risk for fish and shrimp farms found in Bahía de La Paz.

Other important taxa during this proliferation were cyanobacteria, composed by symbiotic *Richelia intracellurais* and *Synechococcus* sp. The former were found associated to *Hemiaulus membranaceus* (Fig. 52) and *Rhizosolenia clevei* (Fig. 60). The *Synechococcus*-like form was observed inside the ebridian flagellate *Hermesinum adriaticum* (Fig. 63). Diatoms with symbiotic N_2-fixing cyanobacteria are often abundant in the oligotrophic open ocean gyres (Villareal *et al*., 2012) and coastal lagoons (Gárate-Lizárraga & Muñetón-Gómez, 2009). Other symbiotic associations were observed for the first time, between the stramenopile protist *Solenicola setigera*, the cyanobacterium *Synechococcus*-like form, and *Leptocylindrus mediterraneus* (Figs. 49a, b). The *Solenicola–Leptocylindrus–Synechococcus* consortium has been worldwide recorded (Buck & Bentham, 1998; Gómez, 2007, 2010; Lyn *et al*., 2012; Padmakumar *et al*., 2012). Buck & Bentham (1998) considered this association as mutually beneficial.

Finally, a relationship between *Planktoniella sol* with an unknown epibiont was observed (Fig. 55). The latter has not been previously recorded in literature. The analysis of live phytoplankton samples allowed us to identify many naked dinoflagellates as well these symbiotic associations. Based on my findings, the ecological importance of these groups or this kind of symbiotic associations have been underestimated because the fixative solutions used to preserve the samples destroy important morphological characteristics of the cells.

NEW RECORDS

During this proliferation, two taxa of dinoflagellates are new records for the Pacific coast of Mexico, one for the Gulf of California, and one for Bahía de La Paz.

Ankistrodinium semilunatum (Herdman) Hoppenrath, Murray, Sparmann & Leander (Fig. 22)

Basionym: *Amphidinium semilunatum* Herdman

References: Hallegraeff *et al*. 2010, p. 149, figs. 5.4F–I.; Hoppenrath *et al*. 2012, p. 149, figs. 5.4F–I.; Omura *et al*. 2012, p. 71, figs. a-e *Ankistrodinium semilunatum*

Dimensions: cells were 34–52 µm long and 14–20 µm wide.

Regional distribution: first record for the Pacific coast of Mexico. This species is worldwide distributed in marine sandy sediments from temperate to tropical regions (see Hoppenrath *et al*., 2012). Its presence in surface waters from Bahía de La Paz could be related to a resuspension of sediments due to winds previous to this proliferation.

Sclerodinium calyptroglyphe (Lebour) J.D. Dodge (Figs. 34–35)

Basionym: *Gyrodinium calyptroglyphe* Lebour

References: Lebour 1925, pl VII, figs. 3a-3b; Wood 1968, p. 69, Fig 191; Elbrächter 1979, p. 12, figs. 31–34; J.D. Dodge 1981: p. 276, figs 3, 4, 7; Hoppenrath *et al*. 2009, p. 129, figs. 54 n–p.

Dimensions: cells are 24-34 µm long and 16-22 µm wide.

Regional distribution: first record for the Pacific coast of Mexico and East Pacific Ocean. This species has been mainly reported in the North Sea in the North Atlantic (Dodge, 1981; Hoppenrath *et al*., 2009). It is also a common species in the northwestern African upwelling region (Elbrächter, 1979) and in waters off the Canary Islands (Ojeda, 2001).

Pronoctiluca acuta (Lohmann) Schiller, 1933 (Figs. 30–31)

References: Schiller 1933, p. 271, Fig. 260a; Wood 1968, p.120, fig. 369; Steidinger & Tangen 1997, p. 465, pl. 23.

Basionym: *Rhynchomonas acuta* Lohmann

Dimensions: cells are 34–38 µm long and 24–28 µm wide.

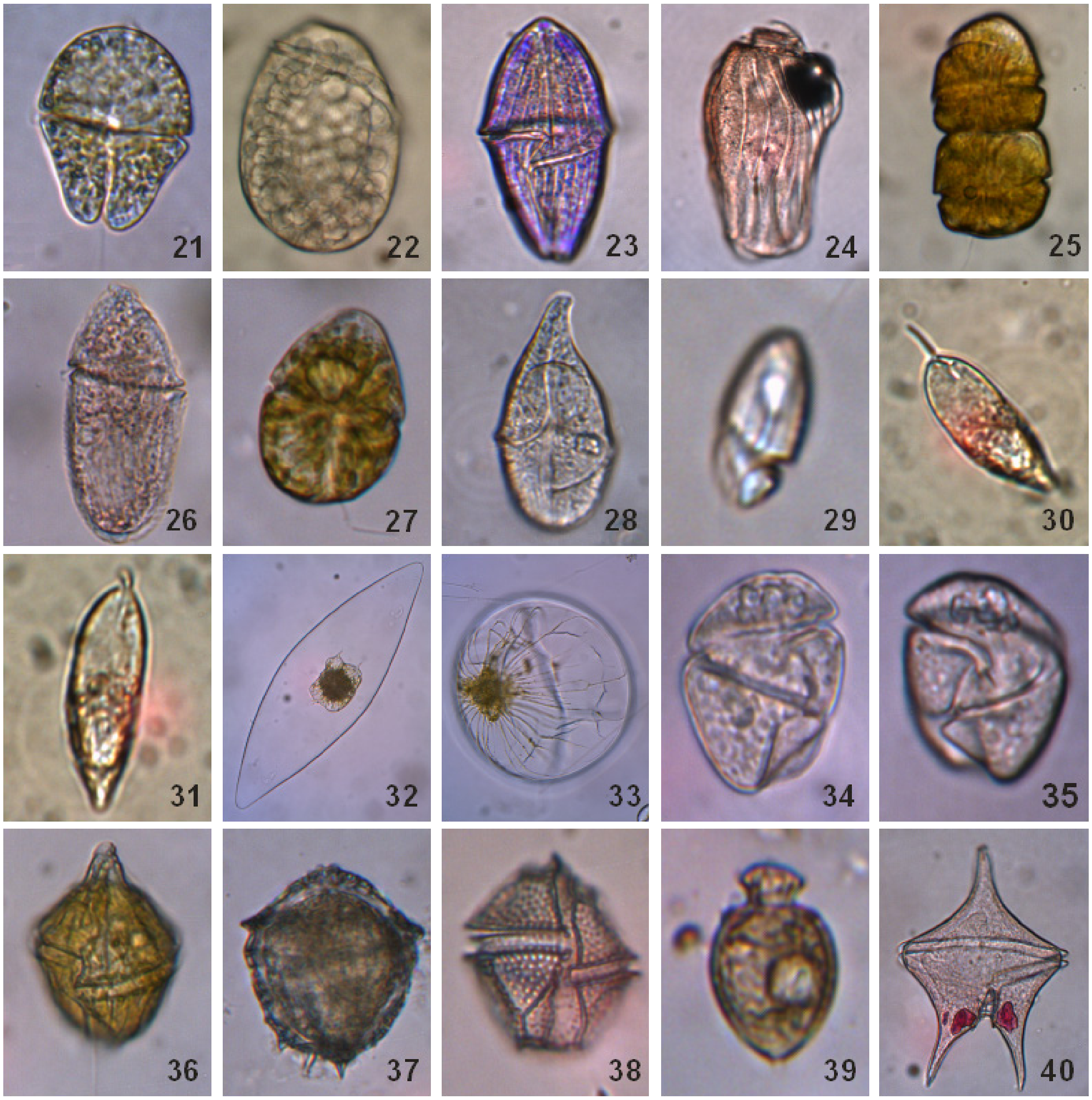
Regional distribution: previously reported in the western coast of Baja California (Venrick, 2000), and in Bahía de Acapulco (Meave del Castillo *et al*., 2012). This is the first finding of the species in the Gulf of California.

Prorocentrum robustum B. Osorio-Tafall, 1942 (Figs. 44–45)

References: B.F. Osorio-Tafall 1942, pl. 34, figs. 9, 10, Hernández-Becerril *et al*. 2000, 26, p. 149; Alonso-Rodríguez *et al*. 2008, p. 49; Muciño-Márquez *et al*. 2011, p. 6, fig. 3F.

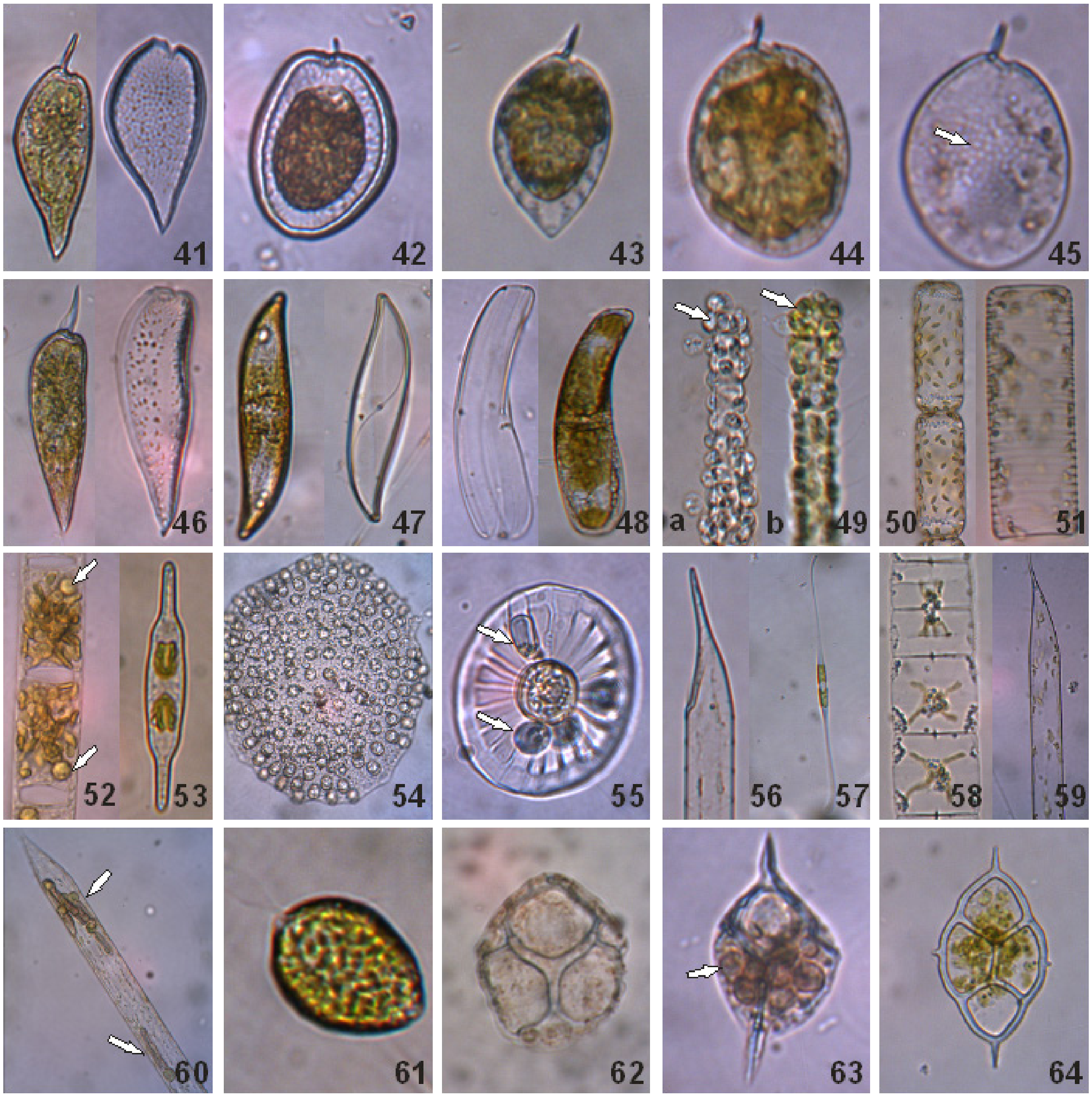
Dimensions: cells are 30-38 µm long and 24-28 µm wide.

Regional distribution: first record for the



Figures 21-40. Light microphotographs of dinoflagellates; (21) *Akashiwo sanguinea;* (22) *Ankistrodinium semilunatum;* (23) *Balechina coerulea;* (24) *Erythropsidinium agile;* (25) *Cochlodinium polykrikoides,* (26) *Gymnodinium gracile,* (27) *Gymnodinium* sp. (28) *Gyrodinium lachryma;* (29) *Katodinium glaucum;* (30-31) *Pronoctiluca acuta;* (32) *Pyrocystis fusiformis;* (33) *Pyrocystis noctiluca; (34-35) Sclerodinium calyptroglyphe* in ventral view; (36) *Gonyaulax polygramma;* (37) *Heterodinium milneri;* (38) *Lingulodinium polyedrum;* (39) *Oxytoxum sphaeroideum;* (40) *Protoperidinium venustum.*

Bahía de La Paz. *P. robustum* has been recorded mainly in Bahía de Acapulco (Osorio-Tafall, 1942), and in several lagoons from the coast of Sinaloa (Hernández-Becerril *et al*., 2000; Alonso-Rodríguez *et al*., 2008). It has been also reported for the Sontecomapan coastal lagoon, Veracruz, Gulf of Mexico (Muciño-Márquez *et al*., 2011). *P. robustum* is currently regarded as a taxonomic synonym of *P. scutellum* Schröder (Dodge, 1975). However, *P. scutellum* shows a more acute posterior end, a more developed wing on the anterior spine, which is less pointed, and it is larger (Dodge, 1985). *P. robustum* has a rounded posterior end (Osorio-Tafall, 1942; Hernández-Becerril *et al*., 2000; in this study). *P. scutellum* is a heart-shaped species (see Dodge, 1975; 1985; Yamaji, 1982; Steidinger & Tangen, 1997) whereas cells of *P. robustum* are elliptical (Figs. 44–45). Due to these morphological characteristics *P. robustum* should be recognized as a different species than *P. scutellum*.



Figures 41-62. Light microphotographs of dinoflagellates, diatoms, cyanobacteria, raphidophytes, ebridian and silicoflagellates; (41) live and empty cell of *Prorocentrum gracile;* (42) *Prorocentrum mexicanum;* (43) *Prorocentrum micans;* (44) live cell of *Prorocentrum robustum;* (45) empty cell of *Prorocentrum robustum* showing the numerous pores (white arrow); (46) live and empty cell of *Prorocentrum sigmoides;* (47) Valve view of *Carinasigma* sp.?; (48) girdle view of *Carinasigma* sp.?; (49) *Leptocylindrus mediterraneus* (a) chain covered of *Solenicola setigera;* (b) chain covered by *Solenicola setigera* and an unusual greenish pigmentation due to the cyanobacterium *Synechococcus*-like*,* indicated by a white arrow*;* (50) *Cerataulina pelagica;* (51) *Cerataulina dentata ;* (52) *Hemiaulus membranaceus* with trichomes of the cyanobacteria *Richelia intracellularis* (white arrows); (53) *Mastogloia rostrata;* (54) *Planktoniella muriformis;* (55) *Planktoniella sol* with some epibionts (white arrow); (56) *Proboscia alata* f. *gracillima;* (57) *Nitzschia longissima* var. *reversa;* (58) *Stauroneis membranacea;* (59) *Pseudosolenia calcar-avis;* (60) *Rhizosolenia clevei* with six trichomes of the cyanobacterium *Richelia intracellularis;* (61) *Chattonella marina;* (62) *Ebria tripartita* (63) *Hermesinum adriaticum* with *Synechococcus*-like endosymbiotic cyanobacterium*,* indicated by a white arrow*;* (64) *Dictyocha californica.*

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