

A Kryptoperidiniaceae species (Dinophyceae: Peridinales) blooming in coastal Yucatan waters, Gulf of Mexico

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Summary

A small, photosynthetic Peridinales species caused an intense bloom (up to 3.75×10^7 cells \cdot l⁻¹) in the marina of Sisal on the northern Yucatan Peninsula coast, SE Gulf of Mexico, in August 2010. The salinity was 32.4, and the water temperature was 29.5 °C. The cells were 12.5–23.7 μ m long (19.02 ± 2.03 μ m), 8.7–18.7 μ m wide (15.45 ± 2.19 μ m) and 7.5–12.5 μ m deep (dorsoventral length; 9.63 ± 1.21 μ m), the length/width ratio was 1.17 ± 0.13 and the width/depth ratio 1.83 ± 0.22 (n=200). The species had a thecal plate formula of Po, X, cp, 4', 2a, 6'', 5c, PC, 4s, 5''', 2'''. The taxon was assigned to the family Kryptoperidiniaceae, although a second (eukaryotic) nucleus was not observed, sharing its thecal features with both *Kryptoperidinium* and *Durinskia*. In subsequent years, it was occasionally found at other sites along the Yucatan coast and possibly represents a recent invasion of the southern Gulf of Mexico, preferring semi-enclosed water bodies.

Key words: algal blooms, dinoflagellates, Kryptoperidiniaceae, microalgae, phytoplankton, scanning electron microscopy, thecal morphology

Introduction

In the coastal waters of the northern Yucatan Peninsula, in the southeastern Gulf of Mexico, numerous pelagic algal blooms have been recorded in the 21st century; at least 35 species, almost exclusively diatoms and dinoflagellates, caused them (Merino-Virgilio et al., 2014). Among dinoflagellates, species of *Prorocentrum* Ehrenb., *Peridinium* Ehrenb., *Scrippsiella* Balech ex Loeblich III and *Pyrodinium* L. Platt, as well as the dinoflagellate preliminarily identified as *Kryptoperidinium* cf. *foliaceum* (F. Stein) Lindemann, have caused recurrent blooms.

The latter, although not identified to the genus level, was ascribed to the recently reestablished family Kryptoperidiniaceae according to Gottschling et al. (2017) and includes the genera *Kryptoperidinium* Lindemann, *Blixaea* Gottschling, *Durinskia* Carty et Cox, *Galeidinium* M. Tamura et T. Horiguchi and *Unruhadinium* Gottschling. This taxonomic group was called ‘dinotoms’ due to the presence of two mitochondrial genomes, one of the host dinoflagellate and another one from an endosymbiotic diatom (Imanian et al., 2011); cells harbour the chloroplasts of diatom origin from the genera *Chaetoceros* Ehrenb., *Cyclotella* (Kütz.) Bréb., *Discotella* V. Houk et R. Klee or *Nitzschia* Hassall (Yamada et al., 2017). The dinoflagellate genus *Dinotrix* Pascher may also belong to group (Gottschling et al., 2017). This group contains both planktonic and benthic marine, brackish and freshwater species, and some of them are common or abundant or even cause non-toxic blooms. Of them, it is *Blixaea quinquecornis* (T.H. Abé) Gottschling (= *Peridinium quinquecorne*, in part) that has caused most blooms in temperate and tropical coastal marine waters (Horstmann, 1980; Rodríguez-Gómez et al., 2019; see references in Okolodkov et al., 2016). In brackish and freshwater environments, *Kryptoperidinium foliaceum* has been observed in the highest abundances (Daghor et al., 2015; Alkawri, 2016; Lira et al., 2017). Recently, it was also found as blooming in a hypersaline water body in the northwestern Persian Gulf (Saburova et al., 2012b). Among *Durinskia* species, *D. baltica* is the most studied species. However, it has rarely been mentioned as blooming; it caused early spring blooms in a eutrophic freshwater body in central Mexico (Lira et al., 2017). *Durinskia capensis* was observed producing blooms in tidal pools in South Africa (Pienaar et al., 2007).

The objective of this study was to identify the causative species and to describe its morphology.

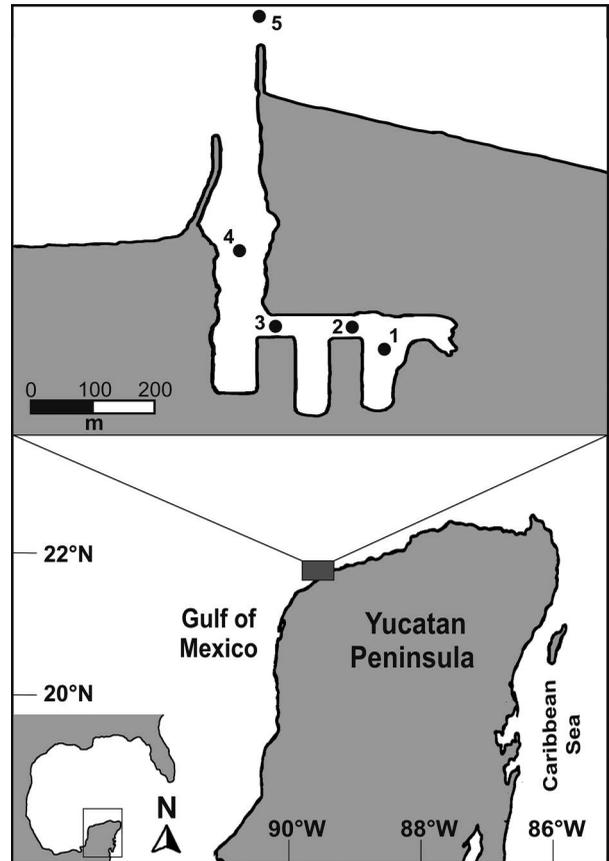


Fig. 1. Sampling sites (1-5) in the marina of Sisal, Yucatan Peninsula, in August 2010.

Material and methods

STUDY AREA

The study area is characterized by a dry, warm climate. At Dzilam de Bravo (Dzilam, hereafter), water temperature varies between 22.3 °C (February) and 31.0–32.0 °C (June–September) and salinity between 29.6 (April) and 37.3 (May). There are no rivers along the Yucatan coast. Ground water discharge causes negligible salinity variations. Three seasons can be distinguished: a dry season from March to early June, a rainy season from June to October and the “nortes” (northerly winds) season with short periods of storms and strong winds coming from the north from November to February (Herrera-Silveira, 1993).

SAMPLING, FIXATION AND MEASUREMENTS OF ENVIRONMENTAL VARIABLES

On 18 August 2010, during the monitoring of benthic dinoflagellates along the coast of the Yucatan



Fig. 2. A bloom event in the marina of Sisal, Yucatan Peninsula, on 18 August 2010.

Peninsula, SE Gulf of Mexico, in the marina of the small fishery settlement Sisal (Fig. 1), a dense dinoflagellate bloom was observed; station (st.) 1 was located at 21°9'40.22"N, 90°2'42.71"W. The water color was greenish-brown (Fig. 2), typical of chlorophyll-containing microalgae. Four seawater samples were taken in various parts of the marina and one beyond it with a bottle from the surface layer; samples were fixed with 37% formalin to a final concentration of 4%. The measured depth was 2.5 m, and visually, the bloom event was restricted to the marina.

LIGHT AND SCANNING ELECTRON MICROSCOPY

Cells were counted in 40 to 100 fields of view in two aliquots of each sample in a 1-ml Sedgwick-Rafter chamber using an Olympus CK2 inverted microscope (Olympus Optical Co., Ltd., Japan) equipped with a 40× objective. Light micrographs of empty thecae were taken using an Olympus AX70 PROVIS compound microscope (Olympus Optical Co., Ltd., Japan) equipped with phase-contrast objectives and a Media Cybernetics Evolution MP digital camera (Media Cybernetics, Inc., Silver Spring, MD, USA) and QCapture Pro (version 5.1) software (Teledyne QImaging, Surrey, BC, Canada). To examine the thecae in greater detail, the specimens were examined in a JEOL JSM-7600F (JEOL, Ltd., Tokyo, Japan) scanning electron microscope (SEM) at a working distance of 15 mm, a voltage of 5.0 kV and a low secondary electron detector (LEI) after a preliminary wash in distilled water followed by dehydration in a series

of ethanol solutions of increasing concentration (30, 50, 70, 90 and 100%). Specimens were then air dried on 0.5" aluminium mounts and sputter coated with gold-palladium using a Polaron SC7640 High Resolution Sputter Coater (Quorum Technologies, Newhaven, SXE, UK). Line drawings of the thecal plate arrangement were made based on SEM micrographs. Various cells were examined with a Carl Zeiss Axio Imager.A1 fluorescence microscope (Oberkochen, Germany) with an ApoTome attachment (Axio Imager Z1 stand). The formalin-fixed cells were stained with 0.2% acetocarmine for testing for the presence of nuclei (dinokaryon and/or endosymbiont nucleus).

Results

MORPHOLOGICAL DESCRIPTION

The described species was classified according to Fensome et al. (1993) and Kretschmann et al. (2018).

Phylum Dinoflagellata (Bütschli) Fensome, Taylor, Norris, Sarjeant, Wharton et Williams
 Subphylum Dinokaryota Fensome, Taylor, Sarjeant, Wharton et Williams, 1993
 Class Dinophyceae Pascher, 1914
 Subclass Peridiniphyceae Fensome, Taylor, Sarjeant, Wharton et Williams, 1993
 Order Peridiniales Haeckel, 1894
 Suborder Peridiniineae Poche, 1913
 Family Kryptoperidiniaceae Lindemann, 1926

Description. The causative agent of the bloom event was a small nanoplanktonic thecate dinoflagellate ascribed by us to the order Peridiniales. Examination of various cells with the use of the ApoTome equipment confirmed the presence of several dozen discoid chloroplasts of greenish color that occupied nearly all the space between the nucleus and theca. In all cells, only a dinokaryon (one per cell) was observed (Fig. 3); it was elongated and occupied a subcentral position. The cells were 12.5–23.7 μm long (19.02 ± 2.03 μm), 8.7–18.7 μm wide (15.45 ± 2.19 μm) and 7.5–12.5 μm thick (9.63 ± 1.21 μm), the length/width ratio was 1.17 ± 0.13 and the width/depth ratio 1.83 ± 0.22 (n=200). Cells in general were ovoid, and at the light microscope level the theca was smooth, with the epitheca larger (up to 1.5 times) and slightly wider than the hypotheca

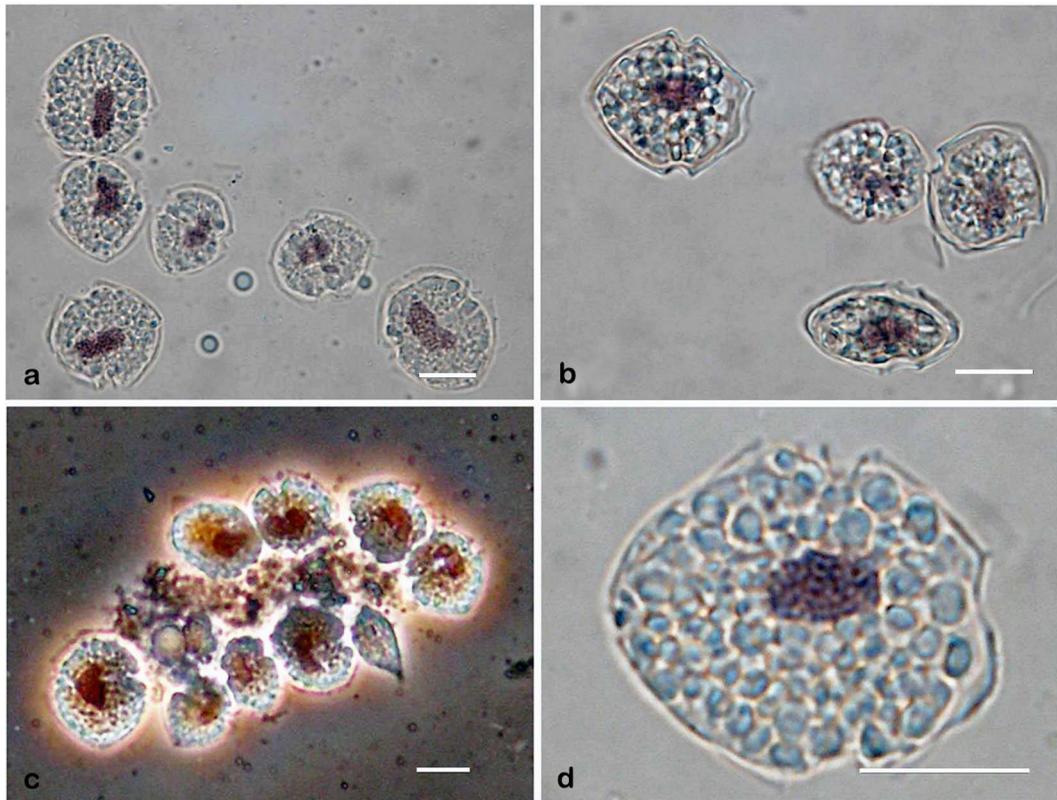


Fig. 3. Cells of the Kryptoperidiniaceae species from Yucatan waters fixed with formalin and observed with a light microscope: (a, b and d) bright field, (c) phase contrast. In all the cells the only nucleus (dinokaryon) stained with acetocarmine occupies a subcentral position. In Fig. d, the spiralized chromosomes are clearly visible. Each cell has several dozen discoid chloroplasts that occupy almost all the space between the nucleus and theca. Scale bar: 10 μ m.

and strongly compressed dorsoventrally. Thecal plate formula: Po, X, cp, 4', 2a, 6'', 5c, PC, 4s, 5''', 2'''' (Figs 4, 5). Epitheca with convex sides, slightly angulated in the middle part in ventral or dorsal view. Apical pore complex shifted to the left side of the epitheca (Figs 6 b, e, 7 a), elongated and narrow, with a flange except at the juncture of the Po and the X plates on the ventral surface. The X, or "canal" plate contacted the 1' plate and was a small rectangle (Fig. 7 d, f). The Po plate was elongated, slightly wider on the dorsal side, narrowing ventrally, bordered with the elevated margins of the 2' and 4' plates, with an elongated pore and a cover plate. Plate 1' was of ortho type, wide, asymmetrically kite-shaped, with the lateral angles closer to the apex than to the cingulum, without any large margin pore (Figs 6 a, b, e, 7 a). Plate 3' on the dorsal side of the epitheca was pentagonal or quadrangular, narrow or wide, asymmetrical, the smallest among the apicals, and slightly shifted to the left (Fig. 7 d, f). Two relatively large anterior intercalary plates

were present (Fig. 7 d–f); the 1a is slightly larger than 2a. Among the precingular plates, the plates adjacent to the 1' plate (6'' and 1'') were the largest and the longest (Fig. 6 a, b), and the 3'' plate (dorsal) was the smallest. The 4'' contacted both anterior intercalary plates (Fig. 7 f). Rarely, the 3'' plate was divided into two, forming the 4'' plate; in this case there were seven precingular plates. Cingulum strongly cavozone, with very narrow cingular lists without ribs, relatively wide (14 to 17% of the cell total length), descending, displaced 0.75 to one cingulum width (Figs 6 a–c, e, 7 a). The 1c plate was relatively narrow and trapezoidal, with its narrower side attached to the hypotheca (1''' plate). The sulcus was shallow and relatively narrow, almost reaching the antapex and not extending into the epitheca. The sulcus had a finger-shaped depression in its distal part and a trapezoidal lobe of the pore cover plate (PC) (Fig. 6 c, d). The PC was anchored to the 5th cingular plate but was free on its left side. Some authors have interpreted the PC

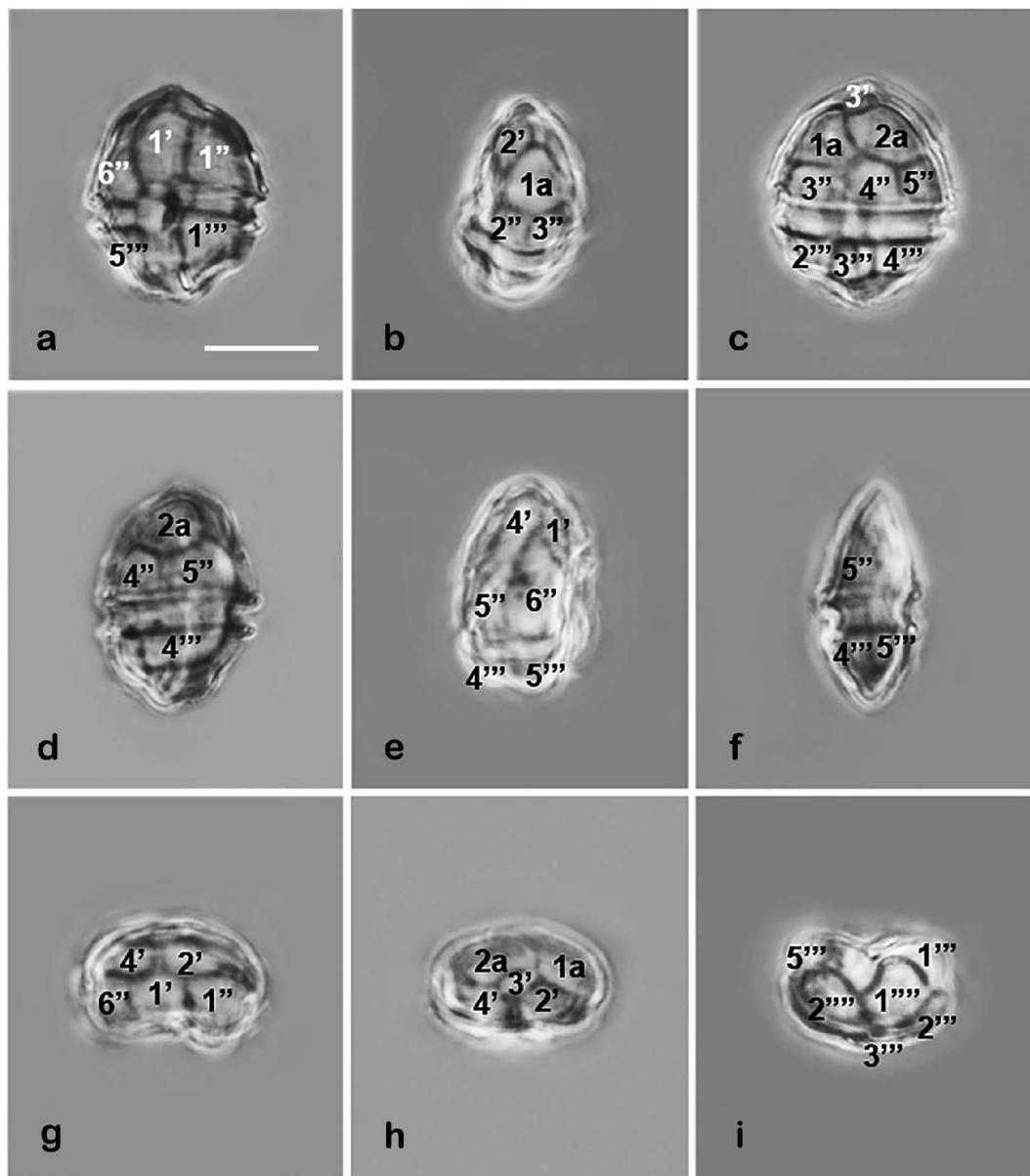


Fig. 4. Thecae of the Kryptoperidiniaceae species from Yucatan waters under a phase-contrast microscope: (a) ventral view, (b) left-side-apical view, (c) dorsal view, (d) right-side-dorsal view, (e) right-side-apical view, (f) right-side view, (g) apical view, (h) apical-dorsal view, (i) antapical view. Scale bar: 10 μ m.

as a fin extension of the underlying s.d. plate. The transverse flagellar pore was rimmed and noticeable (Fig. 6 c, d, f). Plate s.p. was subovoid, and it was a little longer than it was wide (Fig. 6 c). Hypotheca with slightly convex to straight sides in ventral view; its right side was slightly longer than the left. Antapex slightly convex, flattened or with a very shallow depression, usually with the crests radiating in a longitudinal direction, some of them terminating with short, robust spines of 0.17–0.20 μ m long (Fig.

7 b). Plate surface delicately ornamented with pores and furrows that end in pores or in older specimens end in protuberances. Ejectosome pores, possibly trichocyst or mucocyst pores, present. Rimmed circles 0.17–0.20 μ m in diameter surrounded ejectosome pores, forming a linear row along both sides of the cingulum and sparsely dispersed along the plates, including the cingular and sulcal ones (well distinguished in Figs 5 c, 6 a, c).

Habitat: coastal marine, planktonic.

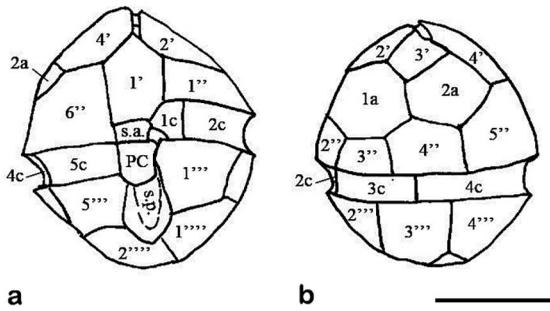


Fig. 5. A scheme illustrating the thecal pattern of the Kryptoperidiniaceae species: (a) cell in ventral view, (b) cell in dorsal view. Scale bar: 10 μm .

ENVIRONMENTAL VARIABLES AND CELL ABUNDANCES

The physical-chemical characteristics at st. 1 were as follows: water temperature 29.5 $^{\circ}\text{C}$, salinity 32.4, dissolved oxygen 0.77 $\text{mg} \cdot \text{l}^{-1}$, nitrates 1.88 $\mu\text{mol} \cdot \text{l}^{-1}$, nitrites 1.17 $\mu\text{mol} \cdot \text{l}^{-1}$, ammonium 5.91 $\mu\text{mol} \cdot \text{l}^{-1}$, urea 0.76 $\mu\text{mol} \cdot \text{l}^{-1}$, orthophosphates 1.28 $\mu\text{mol} \cdot \text{l}^{-1}$ and silicates 97.22 $\mu\text{mol} \cdot \text{l}^{-1}$. Chl-*a* concentration in the water column reached 5.25 $\text{mg} \cdot \text{m}^{-3}$ in the inner part of the marina. The bloom was almost monospecific, with very few cells of other dinoflagellates, unidentified phytoflagellates and benthic diatom species.

At Sisal the number of cells increased from the entrance of the marina (st. 4) toward its inner part (st. 1): 1.43×10^5 cells $\cdot \text{l}^{-1}$ (st. 4), 2.1×10^6 cells $\cdot \text{l}^{-1}$ (st. 3), 1.54×10^7 cells $\cdot \text{l}^{-1}$ (st. 2), and 3.75×10^7 cells $\cdot \text{l}^{-1}$ (st. 1). At st. 5 (21 $^{\circ}9'44.79''\text{N}$, 90 $^{\circ}3'2.98''\text{W}$), on the seaside, water temperature was 28.9 $^{\circ}\text{C}$, salinity was 36.47 and dissolved oxygen was 6.18 $\text{mg} \cdot \text{l}^{-1}$. At this station nanoflagellates (1.17×10^5 cells $\cdot \text{l}^{-1}$) and a few benthic diatoms were observed.

Discussion

The studied species was ascribed to the Peridinales based on the diagnosis given in Fensome et al. (1993): (a) a peridiniphyceid in which the 1' plate is symmetrical, the left lateral triple junction being essentially level with the right one; (b) there are two antapical plates placed more or less symmetrically about the midventral/middorsal plane. At first sight, the cells resembled the genus *Heterocapsa* F. Stein or *Azadinium* Elbrächter et Tillmann (in particular, *A. obesum* Tillmann et Elbrächter). However, the thecal plate formula

distinguishes our species from both *Heterocapsa* (it has three anterior intercalary plates) and *Azadinium* (it has three intercalary and six postcingular plates) (Table 1). The tabulation of our species is closest to *Kryptoperidinium* (a monospecific genus) and *Durinskia*; both belong to the family Kryptoperidiniaceae (Gottschling et al., 2017). According to Guiry and Guiry (2018), the former has the following tabulation: Po, 3–4', 2a, 6–7'', 5''', 2'''''. Figueroa et al. (2009) report the plate formula for the strains of *K. foliaceum* from NW Spain as follows: 3', 2a, 7'', 4c, ?s, 5''', 2'''''. Horiguchi (2004) gives the plate formula for *Kryptoperidinium* as Po, X, 4', 2a, 7'', 5c, 5s, 5''', 2''''', emphasizing that this genus has seven precingular plates and *Durinskia* has only six. The plate pattern of our species differs from that of *K. foliaceum* in ventral view mainly by a nearly symmetrical 1', a much smaller s.a. that connects with the 1'' plate, the absence of the narrow elongated 7'' plate and the wide s.p. that almost reaches the antapex. In addition, our species has a descending cingulum with the ends displaced by its width; in contrast, *K. foliaceum* has no or a slight displacement.

The genus *Durinskia* Carty et Cox was proposed for *Peridinium balticum* with a general plate formula: 4', 2a, 6'', 5c, 4s, 5''', 2'''' (Carty and Cox, 1986). Our species corresponds to this formula and is very similar to this species in having a descending submedian cingulum and a slightly more expanded and larger epitheca. Also, the most common plate formula for an isolate of *P. balticum* from an inland saline lake in California was described based on an SEM study: Po, X, 4', 2a, 6'', 5c, 4s, 5''', 2'''' (Chesnick and Cox, 1985). Currently five *Durinskia* species have been described: *D. agilis* (Kofoid et Swezy) Saburova, Chomérat et Hoppenrath (= *Gymnodinium agile*), *D. capensis* Pienaar, H. Sakai et T. Horiguchi, the type species *D. dybowskii* (Włoszyńska) Carty (= *D. baltica*, *Peridinium balticum*), *D. kwazulunatalensis* N. Yamada, Sym et T. Horiguchi and *Durinskia oculata* (F. Stein) Gert Hansen et G. Flaim (= *Glenodinium occulatum*). *Durinskia baltica* is considered synonymous with *D. dybowskii* as the type species (Guiry and Guiry, 2018); however, herein we prefer to use the most widely accepted name, *D. baltica*, following Kretschmann et al. (2018) who separate *D. dybowskii* and *D. baltica* (in addition, the molecular tree constructed by these authors clearly differentiates between freshwater and marine strains of *Durinskia*). Among them, the presence of seven precingular plates is a

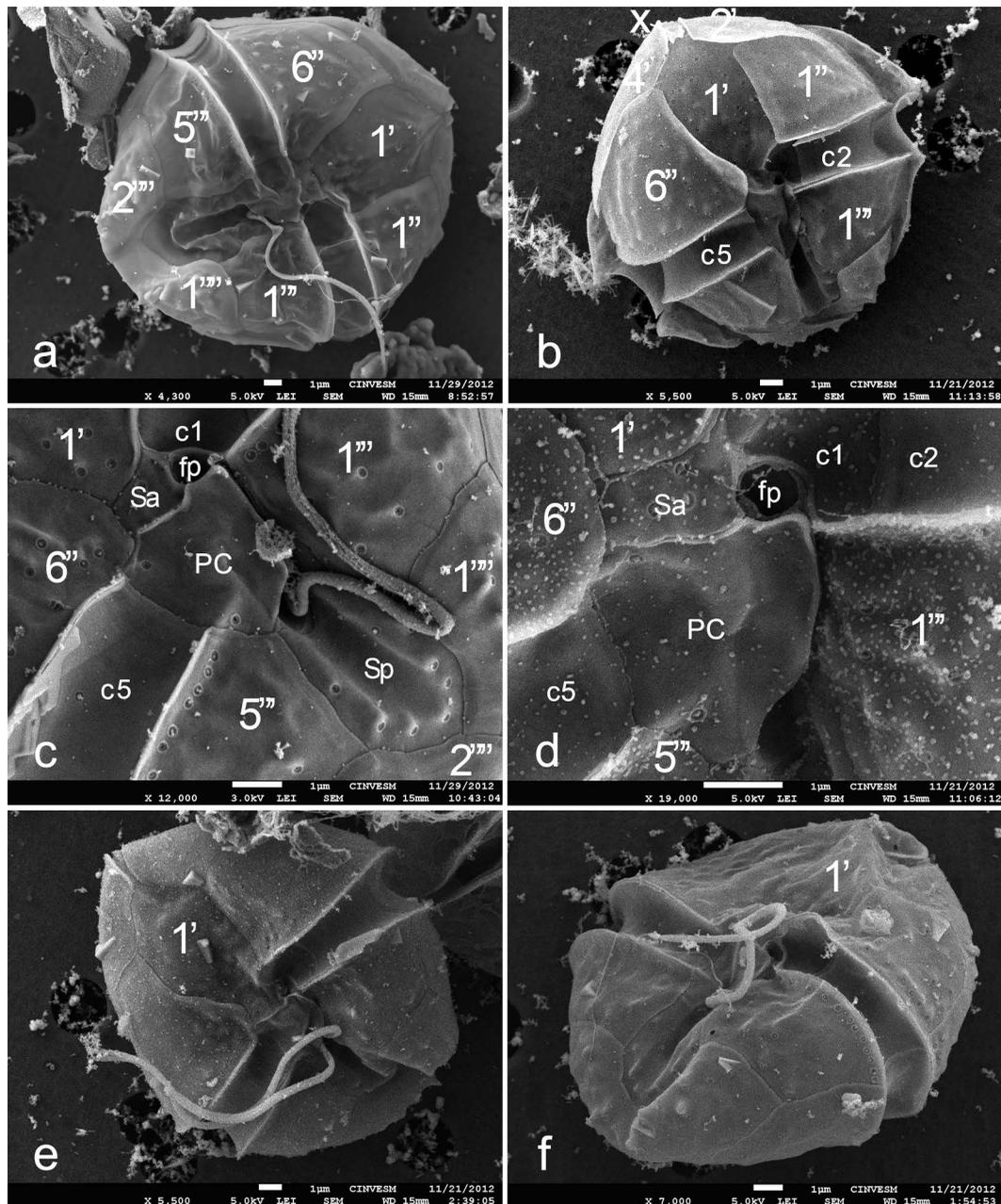


Fig. 6. The Kryptoperidiniaceae species from Yucatan waters under SEM: (a and b) cells in ventral view; (c and d) the sulcal area and adjacent plates in ventral view; (e) planozygote with two longitudinal flagella in ventral view; (f) vegetative cell with one longitudinal flagellum in ventral-posterior-left-side view. Symbols for thecal plates: 1'-4' – the apical plates; 1''-6'' – the precingular plates; 1'''-5''' – the postcingular plates; 1''' and 2''' – the posterior plates; c1-c5 – the cingular plates; fp – the flagellar pore; Sa – the anterior sulcal plate; Sd – the right sulcal plate; Sp – the posterior sulcal plate; X – the canal plate. Scale bar: 1 µm.

stable characteristic feature only in a sand-dwelling *D. agilis* (Saburova et al., 2012a); therefore, the difference in the number of the precingular plates between *Durinskia* and *Kryptoperidinium* can no longer be considered a discriminative feature. A detailed comparison of some morphological features

of our species from Yucatan with related and morphologically similar genera is given in Table 1.

By comparing both morphological and ecological characteristics, our species is different from all known *Kryptoperidinium* and *Durinskia* species. In coastal Yucatan waters, *D. capensis* has also been

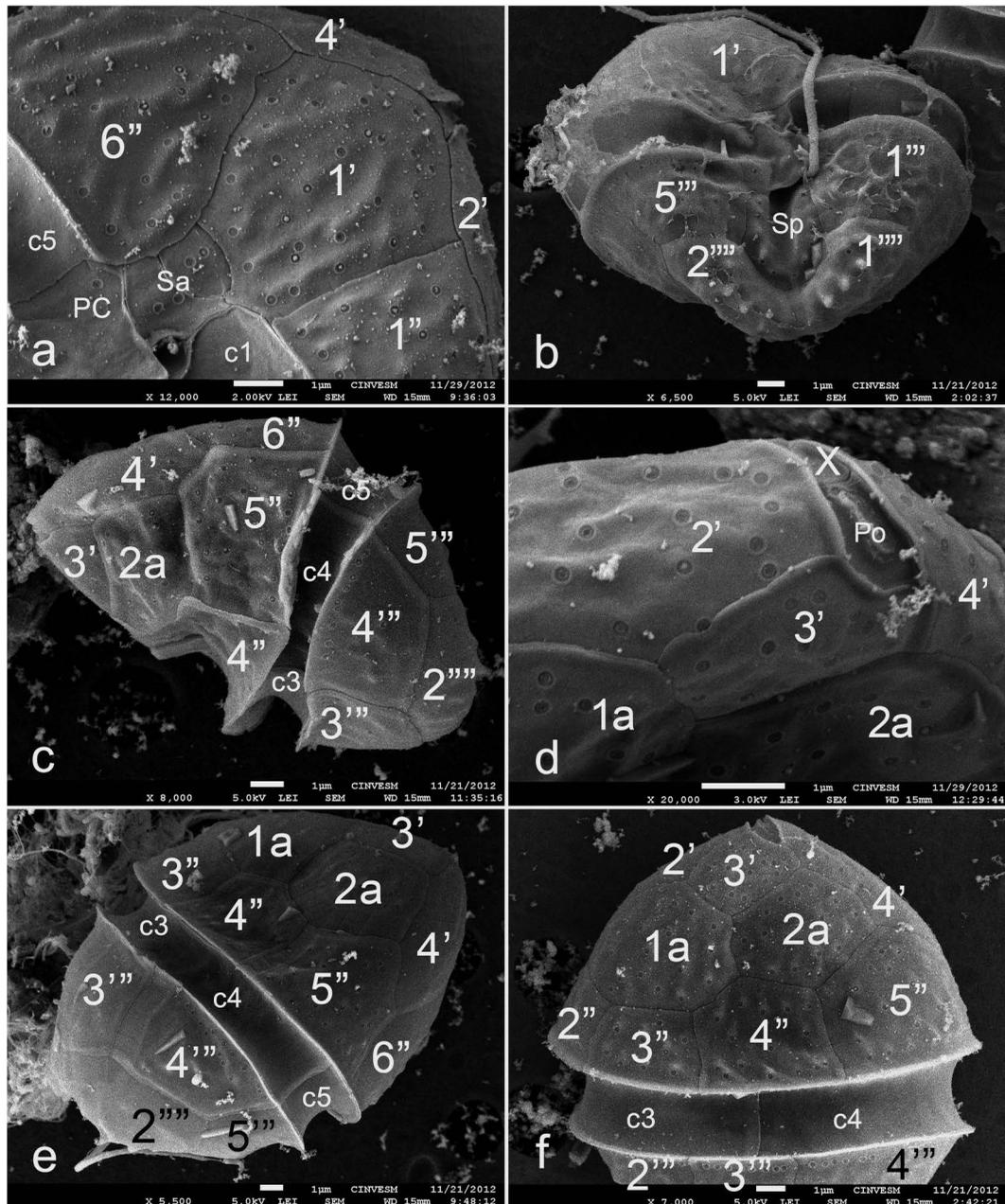


Fig. 7. The Kryptoperidiniaceae species from Yucatan waters under SEM: (a) a fragment of the epitheca and adjacent plates in ventral view; (b) cell in posterior-ventral view; (c) slightly deformed cell in dorsal-right-side view; (d) a fragment of the epitheca with the apical pore complex and adjacent plates in apical-dorsal-left-side view; (e) cell in dorsal-right-side view; (f) the epitheca and the cingulum in dorsal view; Symbols for thecal plates: 1'-4' – the apical plates; 1''-6'' – the precingular plates; 1a and 2a – anterior intercalary plates; 1'''-5''' – the postcingular plates; 1'''' and 2'''' – the posterior plates; c1-c5 – the cingular plates; fp – the flagellar pore; Po – the pore plate; Sa – the anterior sulcal plate; Sd – the right sulcal plate; Sp – the posterior sulcal plate; x – the canal plate. In Fig. a, a small platelet located between the 1' and Sa plates is noted (this anomaly has probably resulted from the division of the 1' plate). In Fig. a and d, the sparsely dispersed rimmed ejectosome pores are well distinguished. In Fig. b several short teeth are visible. Scale bar: 1 µm.

Table 1. Comparison of the Kryptoperidiniaceae species from Yucatan with related and morphologically similar genera.

| Taxon | Thecal formula | References |
|-----------------------------|--|---|
| Kryptoperidiniaceae species | Po,cp,X,4',2a,6'',5c,PC,4s,5'',2''' | present study |
| <i>Durinskia</i> | Po,X,4',2a,6-7'',5c,4-6s,5'',2''' | Chesnick, Cox, 1985; Carty, Cox, 1986; Saburova et al., 2012a |
| <i>Kryptoperidinium</i> | Po,4',2a,7'',4(5)c,(>)5s,5'',2''' | Kempton et al., 2002; Figueroa et al., 2009; Saburova et al., 2012b |
| <i>Blixaea</i> | Po,3',2a,7'',5c,5'',2''' | Gottschling et al., 2017 |
| <i>Unruhadinium</i> | Po,4',0a,6'',5c,5'',2''' or Po,3',1a,6'',5c,5'',2''' | Gottschling et al., 2017 |
| <i>Azadinium</i> | Po,4',3a,6'',6c,7s,6'',2''' | Tillmann et al., 2009, 2010, 2011, 2012; Percopo et al., 2013 |
| <i>Heterocapsa</i> | Po,X,5',3a,7'',6c,5s,5'',2''' | Iwataki et al., 2003, 2008 |

observed, but this species differs from our species with its noticeably green chloroplasts and is always epibenthic; in Veracruz, *D. capensis* has been observed only in surface sediment samples (Okolodkov et al., 2007). Above all, morphologically, our species is similar to the species found in Yemeni coastal waters, the southern Red Sea, identified as *K. foliaceum* (Alkawri, 2016); however, it is much smaller: the cells from Yucatan have dimensions 12.5–23.7 × 8.7–18.7 μm, and the cells from the Red Sea are 30–42 × 25–35 μm. We consider the Yemeni species a misidentification: the cells from the Red Sea have an almost symmetrically rhomboid 1' plate and do not have a narrow 7' plate (Fig. 7 E in the publication mentioned above), whereas *K. foliaceum* has a clearly asymmetrically subtrapezoidal 1' plate and a long, narrow 7'' plate, with both plates being well distinguished in ventral view (Kempton et al., 2002, Fig. 1; Wolny et al., 2004, Fig. 1 A, B; Figueroa et al., 2009, Fig. 1; Saburova et al., 2012b, Fig. 2 E, F). Until the present, *Kryptoperidinium* has been considered a monotypic genus. However, there is considerable diversity for the morphology and DNA sequence data, and in the molecular trees two distinct ribotypes of *Kryptoperidinium* can be distinguished (see: Gottschling et al., 2019).

It is widely known that the species of the family Kryptoperidiniaceae are characterized by the presence of two nuclei: one is a dinokaryon, and the other is a eukaryotic endosymbiont nucleus originated from diatoms (Dodge, 1971; Tomas and Cox, 1973; Tomas et al., 1973; Horiguchi and Pienaar, 1994; Schnepf and Elbrächter, 1999; Kempton et

al., 2002; Horiguchi, 2004; McEwan and Keeling, 2004; Imanian and Keeling, 2007; Figueroa et al., 2009; Zhang et al., 2011; Yamada et al., 2017, 2019). Although we did not find the second (eukaryotic) nucleus in the cells from Yucatan, we believe that the cells belong to the family Kryptoperidiniaceae species, thus being related to a monophyletic marine “dinotom” clade that contains diatom-harboring fucoxanthin-containing dinoflagellates of the genera *Durinskia* and *Kryptoperidinium* species, which is supported by molecular evidence (Horiguchi, 2004; Pienaar et al., 2007; Takano et al. 2008; Zhang et al., 2011; Saburova et al., 2012a; Yamada et al., 2017). Kempton et al. (2002) observed a mononucleate bloom isolate in South Carolina (USA) waters caused by a *Kryptoperidinium foliaceum*. Gottschling et al. (2019) also observed *Kryptoperidinium* from the western Baltic Sea without an endosymbiont nucleus. Although *Durinskia* usually has two nuclei (Moestrup and Callado, 2018), in *D. capensis* the engulfed endosymbiotic diatom nucleus may disappear (Yamada et al., 2019). Thus, based on the number of nuclei, we could not give preference to either of these two genera in identifying the genus.

No doubt, molecular analysis, observation under a transmission electron microscope (to examine the cell ultrastructure) and a light microscope (to examine an eyespot in live cells), and data on the pigment composition could give us valuable information permitting us to ascribe the studied species to genus with certainty. Further studies must reveal more details to confirm or to reject our hypothesis of a Kryptoperidiniaceae affiliation of the species and to ascribe it to a genus or even to a species (creating a new species is a possibility).

As an aside, it is interesting to note that two days before sampling for our study, a specimen of Morelet's crocodile, *Crocodylus moreletii* (Bibron et Dumeril), endemic to southeastern Mexico, Belize and Guatemala, was captured outside the marina (Gonzalo I. Puerto-Esquivel, pers. comm.); it may have been attempting to escape the bloom. The bloom of the Kryptoperidiniaceae species was observed for the first time in Yucatan waters. In subsequent years, it was occasionally also found eastward from Sisal along the northern Yucatan coast (as *Kryptoperidinium* cf. *foliaceum*; Merino-Virgilio et al., 2014). It may represent a recent invasion of the southern Gulf of Mexico from the Caribbean Sea and may prefer semi-enclosed water bodies with the salinity values lower than those of the open sea. In the Gulf of Mexico, another member of

the Kryptoperidiniaceae that was originally reported as *Peridinium quinquecorne*, has caused recurrent blooms in the coastal waters in the southwestern Gulf of Mexico (Barón-Campis et al., 2005; Aké-Castillo and Vázquez, 2011; Pérez-Morales et al., 2015; Rodríguez-Gómez et al., 2015, 2019; Okolodkov et al., 2016) and also in its southeastern part (Merino-Virgilio et al., 2014).

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