

***Dinophysis siankanensis*, a new species of planktonic dinoflagellate (Dinophyceae) from the Mexican Caribbean Sea**

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We describe a new species of dinoflagellate, *Dinophysis siankanensis* Almazán & Hernández-Becerril *sp. nov.*, from material collected in a coastal lagoon in the Mexican Caribbean. Net plankton samples were taken at sites in the northern coastal lagoon complex of Bahía de la Ascención, within the Reserve of Sian Ka'an, México, at different seasons from 1996 to 1999. Cells of *D. siankanensis* were collected from one location where salinity was 10 psu and temperature was 28°C. Specimens were studied by light and scanning electron microscopy. The outline of the body is the main diagnostic morphological character: the cells are laterally compressed, the epitheca is reduced and the hypotheca is elongate, with a notable concavity in the ventral margin, below the median line, and the antapical portion of the cells strongly curved towards the ventral area. The anterior cingular flange shows numerous ribs and is well developed; the three ribs of the left sulcal flange are equally distant. The ornamentation of the thecae consists of well-developed areolae, with a pore in each areola. Cells are 68–70 µm long and 38–41 µm wide. The ecological isolation of the populations also supports the erection of a new species. *Dinophysis siankanensis* superficially resembles *D. caudata* f. *acutiformis*. Comparison is also made with other species of the genus.

INTRODUCTION

The genus *Dinophysis* Ehrenberg was originally described by Ehrenberg in 1839, with *D. acuta* Ehrenberg as the type species. It is one of the most diverse genera within the dinoflagellates, with more than 200 species recognized (Sournia 1986). The fact that another related genus, *Phalacrochroma* Stein, has been merged with *Dinophysis* (Abé 1967; Balech 1967) has added to this great diversity, although controversy still exists regarding the combination of these genera (Hallegraeff & Lucas 1988; Steidinger & Tangen 1997). The genus encompasses marine planktonic species and occurs worldwide: a few species have been confirmed to produce toxins (okadaic acid and related toxins) and these are responsible for diarrhetic shellfish poisoning (Lee *et al.* 1989).

Dinophysis belongs to the Dinophysiales (Fensome *et al.* 1993) and is characterized by having motile, solitary cells of small to medium size (30–120 µm), which are laterally compressed and formed of two lateral halves, including two large hypothecal plates (right and left plates); the epitheca is reduced and not prominent. The cingular flanges (lists or ala) are poorly developed. The left sulcal flange has two or three ribs and is generally wider and better developed than the right one. Species of *Dinophysis* have 18 plates in total: four epithecal plates, two small apical plates (which usually surround the apical pore), four sulcal plates, four cingular plates and four hypothecal plates (Norris & Berner 1970; Balech 1988; Steidinger & Tangen 1997). Important morphological features for species identification are the size and shape of the cells, the outline of the main body and sulcal flanges, the position of the ribs in the left sulcal flange and the presence or absence

of chloroplasts (Taylor *et al.* 1995; Steidinger & Tangen 1997). Tai & Skogsberg (1934) suggested that the sulcal plates and the ventral plates of the hypotheca might also be important for defining species. However, there is a considerable morphological variation in many species, which makes species identification difficult.

Recent studies on the genus include ecological (Durand Clement *et al.* 1988; Carpenter *et al.* 1995), ultrastructural (Vesk & Lucas 1986; Hallegraeff & Lucas 1988; Schnepf & Elbrächter 1988; Lucas & Vesk 1990), morphological and taxonomic aspects (Abé 1967; Norris & Berner 1970; Balech 1976a, b; Hernández-Becerril 1992; Giacobbe 1995; Zingone *et al.* 1998), as well as life-history investigations (Bardouil *et al.* 1991; MacKenzie 1992; Hansen 1993; Reguera *et al.* 1995; Giacobbe & Gangemi 1997; Reguera & González-Gil 2001). Most species are photosynthetic, but some are either heterotrophic or mixotrophic (Hallegraeff & Lucas 1988; Hansen 1991; Jacobson & Andersen 1994).

In this article, we deal with a species not previously described, which we name *D. siankanensis*. This is a rather distinct form, which was fairly common in a coastal lagoon of the Mexican Caribbean.

MATERIAL AND METHODS

Study area

Samples were taken from the lagoon system of the northern part of the Bahía de la Ascención, in the Reserve of Sian Ka'an, which lies along the coast of the State of Quintana Roo, México, in the Caribbean Sea (Fig. 1). The Mexican Caribbean has a high diversity of habitats: mangroves, coral reefs, sea grasses, estuaries, coastal lagoons, small embay-

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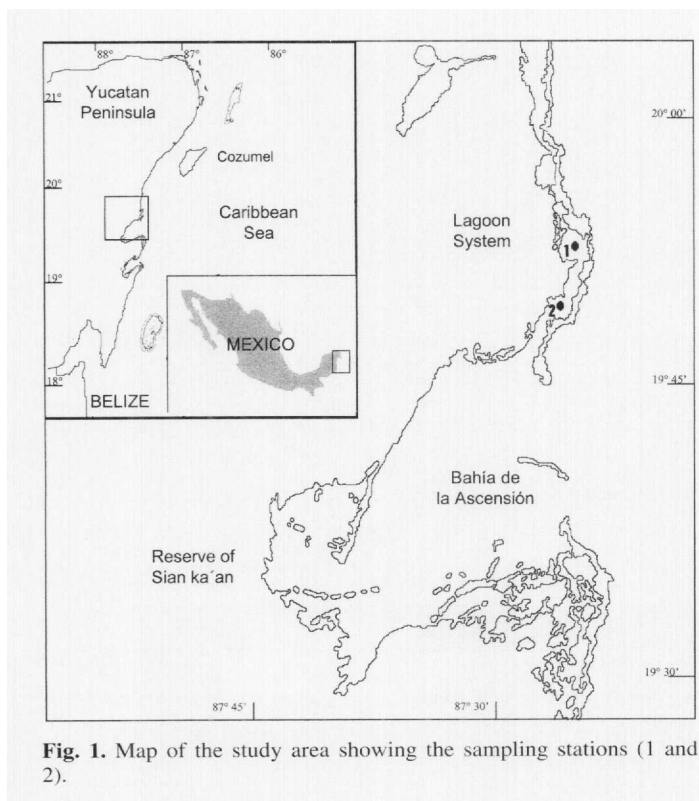


Fig. 1. Map of the study area showing the sampling stations (1 and 2).

ments and inlets (some receive periodic influx of freshwater flow). The climatic pattern includes 'wet', 'dry' and hurricane seasons, but these tend to be irregular.

The lagoon system of Bahía de la Ascención is very shallow, with an average depth of 2.5 m. It is surrounded by mangroves and has a very limited communication with the sea. The sediments are formed by layers of organic detritus mixed with carbonated sediments and the dominant vegetation is *Thalassia testudinum* Banks & Solander *ex* König, which covers an important part of the lagoon system. The lagoon receives high inputs of underground fresh water, and hence the salinity ranges annually from 6 to 22 psu; the temperature averages 25°C, with maxima of 30°C.

Sample collection and laboratory analysis

Sampling was made with a phytoplankton net (45- μ m mesh), in horizontal hauls (about 50 cm to 1 m depth), at different seasons from 1996 to 1999. Material was preserved in 4% formalin. Salinity and temperature were recorded.

Observations were made on cells rinsed with distilled water, using light (LM) and scanning electron microscopy (SEM). Measurements were made in LM (Carl Zeiss Axiolab, phase contrast and bright field) via an eyepiece graticule. Single cells were isolated with a micropipette and thecal plates were dissociated using diluted sodium hypochlorite (Taylor 1978) before study by LM. Permanent slides were also produced, using Naphrax (Northern Biological Supplies, 3 Betts Avenue, Martlesham Heath, Suffolk, UK) as a mounting medium. Single cells were also isolated for observations in the SEM: samples were rinsed, specimens were isolated using a micropipette, put on a cover slip, allowed to dry, and coated with gold in a coating unit.

The general terminology used here follows Balech (1967,

1988), Norris & Berner (1970), Fensome *et al.* (1993) and Steidinger & Tangen (1997).

OBSERVATIONS

Dinophysis siankanensis Almazán & Hernández-Becerril *sp. nov.*

Figs 2–23

Cellulae solitariae elongatae parum ellipticae. Cellula aspectu laterali curvata in extremitatibus valvae atque margine ventrali. Cellula depressa aspectu ventrali dorsalive. Epitheca redacta, hypotheca elongata, margine dorsali curvato et margine ventrali fortiter curvato. Cingulum leviter excavatum, ala cingulari anteriore prominenti costis instructa, ala cingulari posteriore angustiore. Ala sulci dextra brevis, ala sulci sinistra lata 3 costas breves ferens, ambabus alis leviter ornatis: R₁ inconspicua. Theca areolata, poro in omni areola. Chloroplasti parvi et rotundi. Cellulae 68–70 μ m longae, 38–41 μ m latae. Species planctonica. Locus typus: 19°54.53'N and 87°26.59'W.

HOLOTYPE: Slides containing the species are deposited in the Herbario Nacional de México (Instituto de Biología, UNAM), MEXU Colección Ficológica (Phycological Collection), No. 1493.

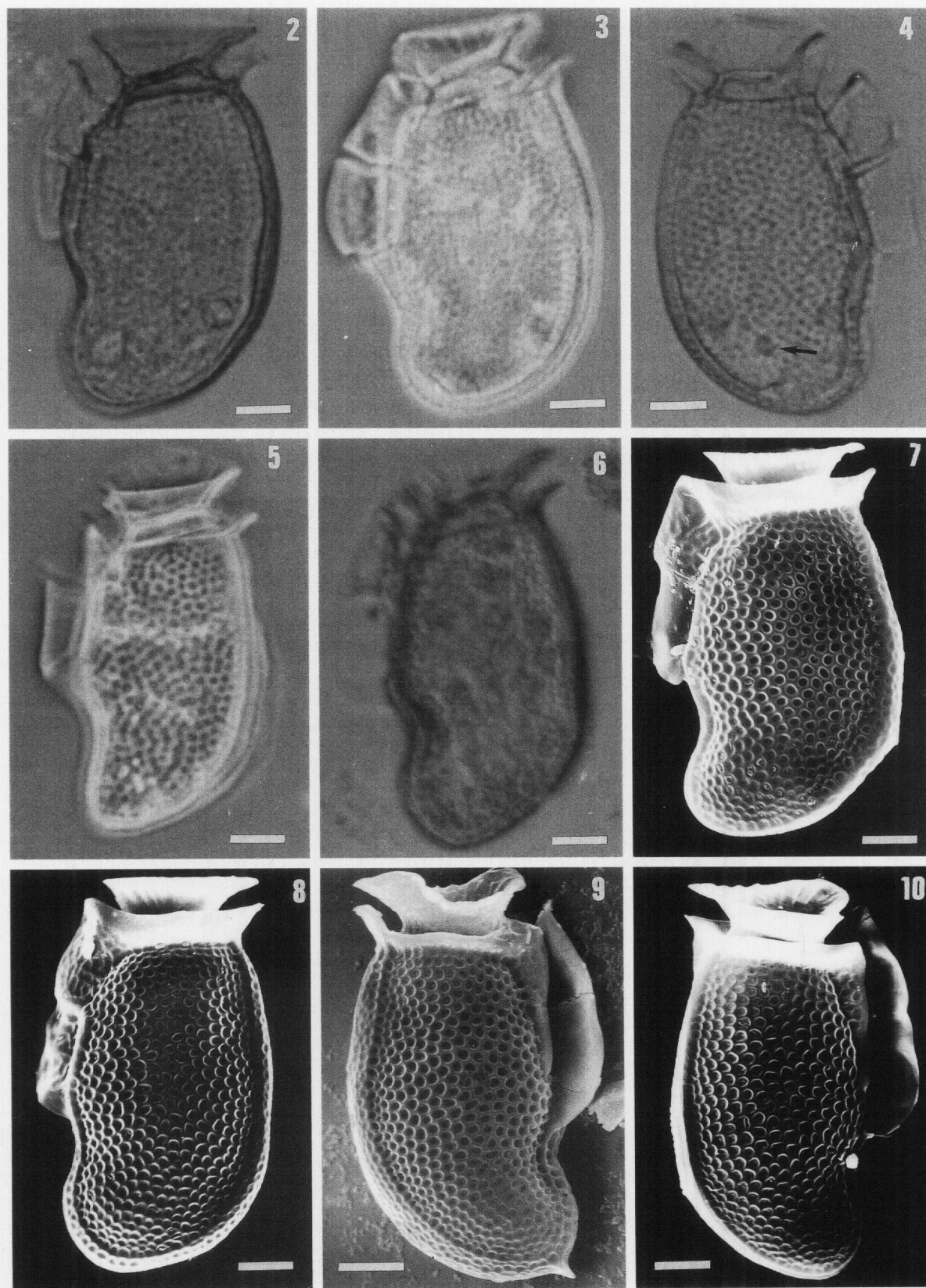
ETYMOLOGY: The species name *siankanensis* refers to the area where it was found first. Sian Ka'an, which means in Mayan 'door or gift of heaven'.

TYPE LOCALITY: Bahía de la Ascención, Reserve of Sian Ka'an, Mexican Caribbean, 19°54.53'N and 87°26.59'W. Specimens of *D. siankanensis* were found at two sampling stations (Fig. 1). We designate station 1 (19°54.53'N and 87°26.59'W) as the type locality because the species was first collected at this site. Salinity was 10 psu and temperature was 28°C. The species occurred in November–December at the study sites.

The cells found were solitary (newly divided cells joined along their dorsal margins were never observed). Cells are elongate, roughly elliptical in lateral view, with the antapical portion of the cells strongly curved towards the ventral area (Figs 2–10). The epitheca is reduced and flat, and does not project beyond the anterior cingular flange (list or ala). The hypotheca is elongate, shows a concavity on the ventral margin just below the middle of the cell, and exhibits a strong posterior curvature towards the ventral area (Figs 2–10, 18). The cells are laterally compressed and, in side view (dorsal or ventral), they have a lenticular appearance (Figs 11, 14). The dorsal margin is slightly curved from the epitheca to the middle of the cell, but then becomes strongly curved to the ventral area. Some cells, however, show a straighter dorsal margin (Figs 2, 6, 7, 10).

The cingulum is slightly excavated (Figs 2–6, 18) and the cingular plates have three transverse rows of pores (Figs 15, 19). The two cingular flanges, anterior and posterior, arise from the epithecal and hypothecal plates, respectively. The epitheca possesses pores rather than areolae and the apical pore is seen between the sutures of the larger epithecal plates (E₂ and E₃) (Fig. 13). The anterior cingular flange is well developed, whereas the posterior cingular flange is somewhat reduced (Figs 3–6, 14). Furthermore, the anterior flange has numerous ribs, although these are rather poorly developed – they do not arise from the epitheca, nor do they reach the margin of the flange (Figs 11–13) – but the posterior has no ribs at all.

The left sulcal flange is wider than the right one, attaining two thirds of the length of the cell body. It has a smoothly



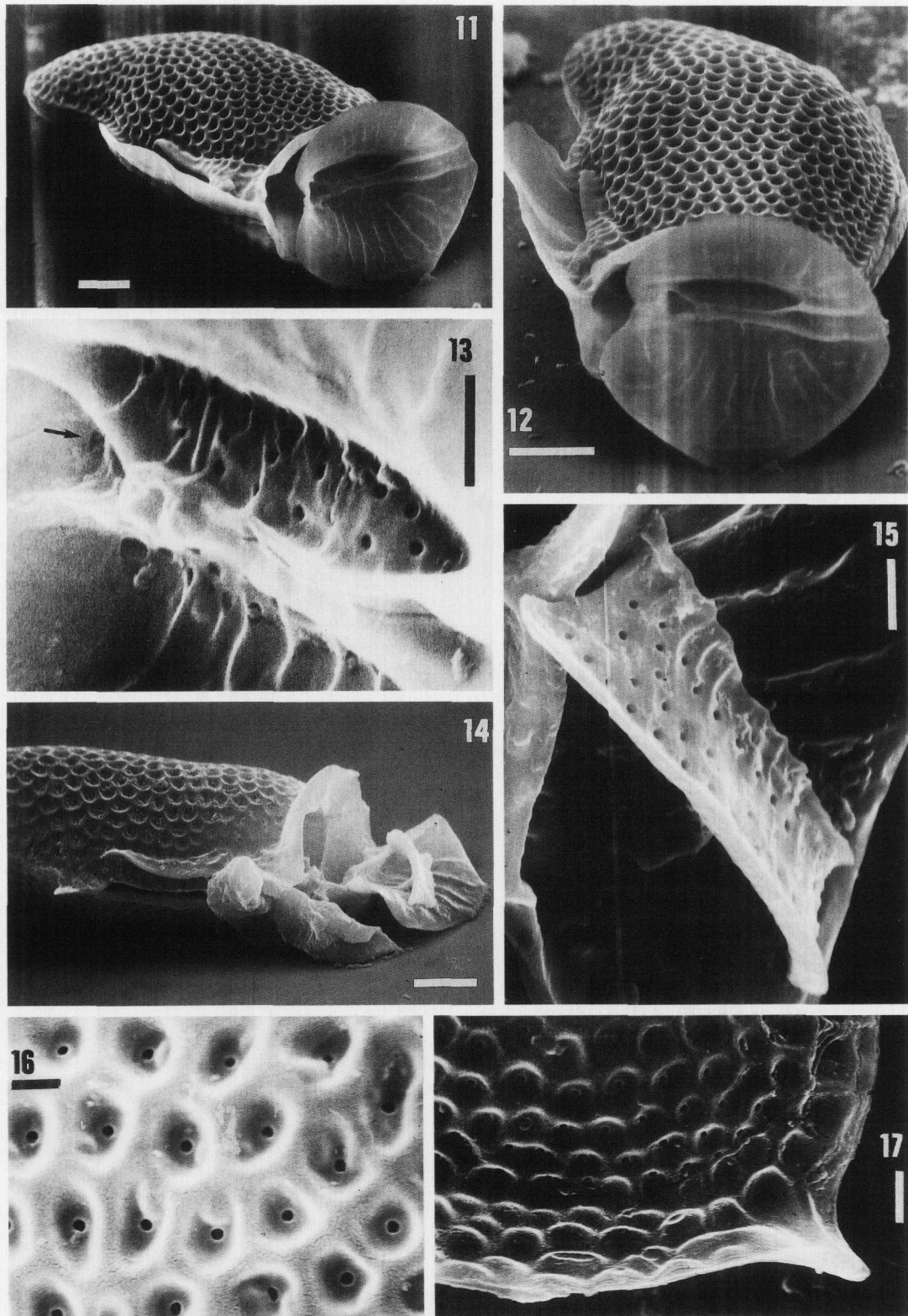
Figs 2–10. Morphological variability of *D. siankanensis*: LM (Figs 2–6) and SEM (Figs 7–10). Scale bars = 10 μ m.

Figs 2, 3, 5–8. Left lateral views.

Fig. 4. Right lateral view, in which small, rounded chloroplast-like structures are visible (arrow).

Fig. 9. Right lateral view, showing an antapical spine.

Fig. 10. Right lateral view.



Figs 11–17. *Dinophysis siankanensis*, SEM. Scale bars = 10 μm (Figs 11, 12, 14), 5 μm (Fig. 13) or 2 μm (Figs 15–17).

- Fig. 11. Ventral view of a cell, showing the sulcal and cingular flanges.
- Fig. 12. Apical view of the same cell, with detail of the anterior cingular flanges.
- Fig. 13. Detail of the epitheca with the apical pore arrowed.
- Fig. 14. Ventral view of a cell with the epitheca partially dissociated.
- Fig. 15. Detail of a cingular plate (C_3), showing longitudinal rows of pores.
- Fig. 16. Detail of the theca, with areolae and pores.
- Fig. 17. Antapical part of a cell, with a spine.

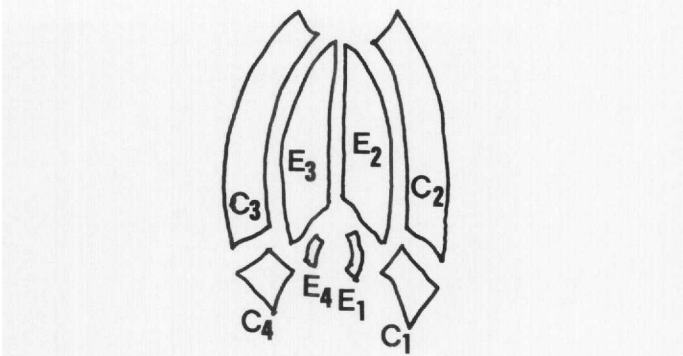
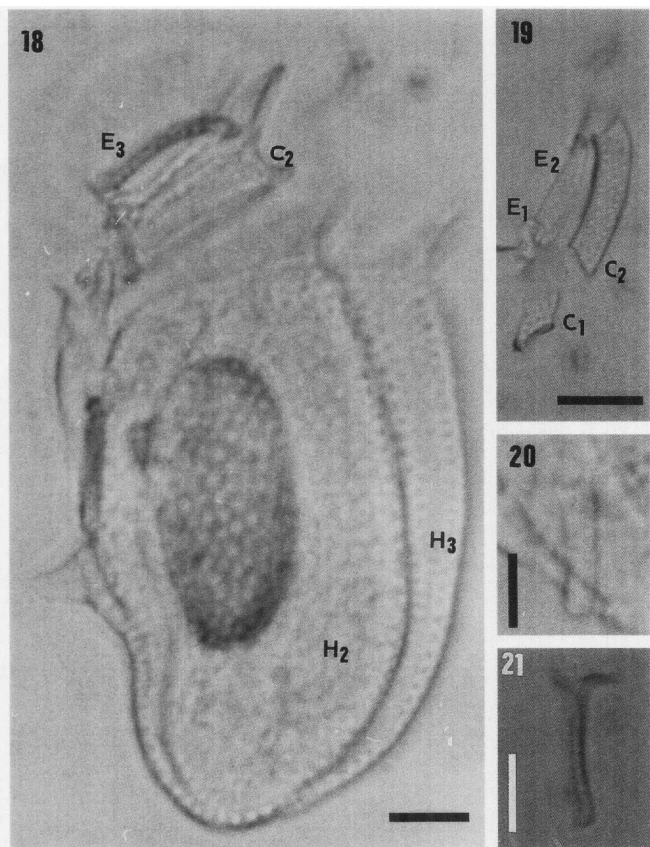


Fig. 22. *Dinophysis siankanensis*: schematic drawing of epithecal (E) and cingular (C) plates.

wide. Diagrams of the epithecal, cingular and sulcal plates are given in Figs 22 and 23.

Cell organelles were not observed in detail because of poor preservation in formalin, but several small, rounded chloroplast-like structures were detected, mainly at the posterior of the cells (Fig. 4).

The dimensions of our specimens ($N = 43$) are as follows: total length, 68–70 μm ; maximum width (excluding the left sulcal flange), 38–41 μm ; maximum height of the anterior cingular flange, 9–10 μm ; maximum height of the posterior cingular flange, 5–6 μm ; length of the cingulum, 4–5 μm ; width of the left sulcal flange, 12–13 μm ; length of the left sulcal flange, 34–35 μm and width of the right sulcal flange, 4–5 μm .

DISCUSSION

Dinophysis siankanensis was compared with the currently recognized species (selected fairly similar species are shown in Fig. 24), but no satisfactory identification could be made. The general outline of *D. siankanensis* is the most characteristic morphological feature for considering it as a new species. The concavity on the ventral margin, below the median line of the cell, and the curvature of the posterior end towards the ventral side are characters not shared with other *Dinophysis* species. Morphological variation (cell size, shape, ornamentation pattern) was very limited in the populations studied, except for the occasional presence of an

Figs 18–21. *Dinophysis siankanensis*, LM. E₁, E₂ and E₃ are epithecal plates; C₁, C₂ and C₃ are cingular plates; H₂ and H₃ are hypothecal plates. Scale bars = 10 μm (Figs 18, 19) or 5 μm (Figs 20, 21).

- Fig. 18.** A cell with dissociated thecal plates.
- Fig. 19.** Detail of the epithecal plates.
- Fig. 20.** Posterior sulcal plate (S_p).
- Fig. 21.** Lateral view of the posterior sulcal plate (S_p).

curved margin and bears three ribs, which are equally distant. The right sulcal flange has no ribs (Figs 2–10). In some specimens, only two ribs are apparent in the left flange, the third being inconspicuous (its presence is indicated only by breakage of the flange in the corresponding position) (Figs 3, 9). Both sulcal flanges are often slightly areolate (Figs 7–10, 12).

The theca is ornamented with relatively deep areolae, with a pore in each areola (Figs 16, 17). We did not find any variation of the areolation in the specimens we observed. The sagittal suture can be simple, but it can also be rimmed in some specimens (megacytic cells?) (Figs 8, 9). A few specimens with thickened sutures also develop a posterior short spine (Figs 9, 17).

Dissociation of the thecal plates made it possible to observe ultrastructural details of the epithecal plates (E₂, E₃ and E₁ in Figs 18, 19) and cingular plates (C₁, C₂ and C₃ in Figs 14, 15, 18, 19), as well as the two hypothecal plates (H₂ and H₃ in Fig. 18), which are the largest plates of the cell, and the smaller platelets of the sulcal area. The posterior sulcal plate (S_p) is elongate and tongue-shaped, with two rows of small pores running longitudinally (Fig. 20). In lateral view, S_p is very narrow and has two short projections at its apex, which are orientated perpendicular to the main axis and point in opposite directions (Fig. 21). The S_p platelet is 6 μm long and 1.9 μm



Fig. 23. *Dinophysis siankanensis*: schematic drawing of sulcal plates. S_a = anterior sulcal plate, S_d = right sulcal plate, S_p = posterior sulcal plate, S_s = left sulcal plate.

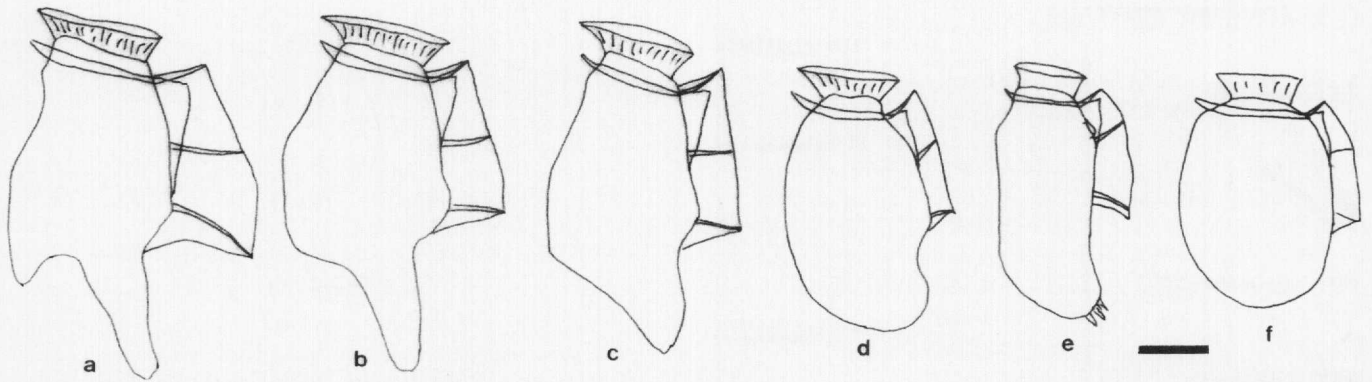


Fig. 24. Species of *Dinophysis* similar to *D. siankanensis*, approximately to scale. Scale bar = 20 μm . a, *D. tripos* (redrawn from Balech 1988, pl. 7, fig. 7); b, *D. caudata* (redrawn from Hernández-Becerril 1992, fig. 21); c, *D. caudata* f. *acutiformis* (redrawn from Hernández-Becerril & Navarro 1996, fig. 7); d, *D. siankanensis*; e, *D. sacculus* (redrawn from Stein 1883, pl. 20, fig. 10); f, *D. acuminata* (redrawn from Balech 1988, pl. 5, fig. 7).

antapical spine-like protuberance. No cysts or cells were found that could be considered as small or intermediate cells or 'gametes' (e.g. Bardouil *et al.* 1991; Reguera *et al.* 1995; Reguera & González-Gil 2001).

Dinophysis species exhibit a range of different outlines, from species that have well-developed appendages (e.g. *D. tripos* Gourret in Fig. 24a) to species without appendages (e.g. *D. acuminata* Claparède & Lachmann in Fig. 24f). Within this range, *D. siankanensis* (Fig. 24d) is most similar to the well-known and widely distributed *D. caudata* Kent (Fig. 24b), which has been documented to show very high morphological variation (Schiller 1933; Böhm 1936; Balech 1988). *Dinophysis caudata* includes a number of taxonomic varieties and forms (Schiller 1933), among which *D. caudata* f. *acutiformis* Kofoid & Skogsberg (Fig. 24c) (including *D. caudata* var. *ventricosa* Jörgensen, *D. homunculus* var. *ventricosa* Pavillard, *D. diegensis* var. *acutoides* Kofoid & Skogsberg; see Schiller 1933, figs 145a–d; Hernández-Becerril & Navarro 1996, figs 3, 7, 8; Reguera & González-Gil 2001, fig. 5B) shows some resemblance to *D. siankanensis*. *Dinophysis caudata* f. *acutiformis* has been found in small coastal lagoons or bays (Hernández-Becerril & Navarro 1996). The outline of this form resembles that of *D. siankanensis*, especially in the presence of a short appendage that turns slightly towards the ventral side. However, this appendage should be regarded as a posterior elongate process, unlike that present in *D. siankanensis*. Moreover, in *D. caudata* f. *acutiformis*, the dorsal margin is strongly curved, and the cells are larger than in *D. siankanensis*.

The other taxonomic entity that resembles *D. siankanensis* is the morphotype of *D. sacculus* Stein illustrated in the original description (Stein 1883, pl. 20, fig. 10) (Fig. 24e). However, *D. sacculus* cells are more elongate than those of *D. siankanensis* and are almost rectangular or sac-like (Zingone *et al.* 1998). Stein (1883) illustrated *D. sacculus* with the posterior part bent towards the ventral side, but this peculiar morphotype has not been recorded during the examination of several natural samples from different geographical areas, including the type locality (Zingone *et al.* 1998).

In *Dinophysis* species, reduction of the processes seems to be associated with coastal environments (e.g. in *D. caudata* f. *acutiformis*), whereas forms with elongated processes are found in oceanic conditions [e.g. *D. caudata* var. *pedunculata*

(Schmidt) Jörgensen] (Balech 1988). The morphology of *D. siankanensis* is consistent with this correlation because the species was encountered in a coastal lagoon complex. However, the adaptive significance of the processes is unknown. *Dinophysis siankanensis* was found at high temperature and low salinity in shallow waters, where the concentrations of nutrients may have been low. Other stations sampled at the same time but showing slightly different salinities (salinity range: 10–12 psu) exhibited different phytoplankton communities and no *D. siankanensis*.

Although many *Dinophysis* species are truly marine and planktonic, some have previously been found in coastal lagoons at a relatively low salinity (Margalef 1969) and *D. siankanensis* may be regarded as a brackish form. Because of the barrier to migration formed by the boundaries of the lagoon complex and strong salinity gradients, it is possible that *D. siankanensis* is a local endemic. However, other dinoflagellates and algae present in the same samples have a wider geographical distribution. Thus, for example, the phytoplankton associated with *D. siankanensis* was dominated by other planktonic thecate dinoflagellates, e.g. *Ceratium hircus* Schröder and *Pyrodinium bahamense* Plate, and also by some epiphytic diatoms. Recent studies of hitherto poorly studied habitats, such as mangroves and coral reefs, have revealed several new species of dinoflagellates, notably in the area of Belize (Faust 1990, 1993a, b, 1994, 1995; Faust & Balech 1993; Faust & Morton 1995), and also in other tropical areas (Adachi & Fukuyo 1979; Fukuyo 1981; Quod 1994; Holmes 1998). Hence, the discovery of more new species of microalgae in tropical coastal systems is not surprising.

The species concept currently used for dinoflagellates is largely morphological (phenetic), and Reguera *et al.* (1995) have suggested that some currently recognized 'species' of *Dinophysis* may in fact be stages in the life cycle of others. Recently, Reguera & González-Gil (2001) have observed small cells of *Dinophysis* in field samples and suggested that these 'may be a part of the sexual cycle'. The best way to distinguish 'true' (natural) species is the combined use of morphological characters, life cycles (studied by field observations) and molecular genetic data. However, this will be difficult unless *Dinophysis* can be cultured.

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