

## FIRST RECORD OF *Ceratium dens* (DINOPHYCEAE) IN THE GULF OF CALIFORNIA

### Primer registro de *Ceratium dens* (Dinophyceae) en el Golfo de California

**RESUMEN.** El dinoflagelado *Ceratium dens*, originalmente descrito del Océano Índico, se registra por primera vez en el Golfo de California y en el Pacífico Mexicano. Se examinaron todos los registros disponibles de *C. dens*. La distribución geográfica de esta especie es principalmente en aguas tropicales y subtropicales. La presencia de *C. dens* durante el otoño de 2009 en las aguas del Golfo de California parece relacionarse con condiciones del Evento de El Niño.

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Nine samples of sub-surface phytoplankton were collected in using a 20 mm mesh net and five samples with a 160 mm mesh net, during phytoplankton surveys in front of the Petróleos Mexicanos dock inside Bahía de La Paz (24° 13.2' N and 110° 19.1' W). Samplings were performed in September 22, October 20, and November 3, 2009. Likewise, three surface samples were collected to estimate phytoplankton abundance. Seawater surface temperature was measured with a bucket thermometer. Samples were preserved with an acidic Lugol solution and with 4% formaline. Phytoplankton abundance was estimated using sedimentation chambers and a inverted microscope. Photographic records were made using Olympus BX-41 and Zeiss Axiovert 40 C microscopes with included camera.

Sample analysis yielded 25 identified taxa of the genus *Ceratium*: *Ceratium balechii*, *C. breve* var. *parallelum*, *C. breve* var. *schmidtii*, *C. contortum* var. *contortum*, *C. contortum* var. *karstenii*, *C. declinatum* f. *normale*, *C. deflexum*, *C. dens*, *C. extensum*, *C. falcatum*, *C.*

*furca*, *C. fusus*, *C. gibberum* var. *dispar*, *C. gravidum*, *C. horridum*, *C. humile*, *C. macroceros*, *C. macroceros* var. *gallicum*, *C. massiliense*, *C. platycorne*, *C. ranipes*, *C. trichoceros*, *C. tripos* var. *atlanticum*, *C. tripos* var. *pulchellum*, *C. symmetricum* var. *coarctatum*. From these, *C. dens* was recorded for the first time inside Bahía de La Paz and the Gulf of California. Identification of this species was made following its original description (Ostenfeld & Schmidt, 1901).

***Ceratium dens* Ostenfeld & Schmidt, 1901**

**Basionym:** Ostenfeld & Schmidt, 1901 (p. 165, fig. 16).

**Synonym:** *C. dens* var. *reflexa* Schmidt, 1901 (p. 214, fig. 2).

**Records:** Jörgensen (1911, p. 31, fig. 58); Wood (1954, p. 280, fig. 204), Sournia (1967, p. 457, fig. 80).

**Sampling station:** In front of Petróleos Mexicanos dock, Bahía de La Paz (Figs. 1-11 and 15).

**Sample analysis:** Quantitative analysis of bottle samples yielded 2000 cells  $L^{-1}$  of *C. dens* during September and it was not found in bottle samples during October and November. Collected samples with both nets were exhaustively analyzed and 62 specimens of *C. dens* were found during September surveys, 40 specimens during October and 34 during November. This species appeared in solitary not in chains, coinciding with observations in Japan (Fukuyo, 2000), where solitary cells were also observed (Fig. 13). Two-cells chains were observed in Philippines (Borja, 2002; Fig. 14) and chains with up to 15 cells were recorded in the Mozambique Channel (Sournia, 1967). Specimens of *C. dens* forming chains of three to eight cells (Figs. 16-17; this study) were observed in Fort Lauderdale, Florida, USA (26° 05.01' N and 80° 02.86' W) during February 2007.

**Dimensions:** Specimens showed a total length of 140 to 394  $\mu m$  and 85 to 110  $\mu m$  of transdiameter (n=55). Specimens from Fort

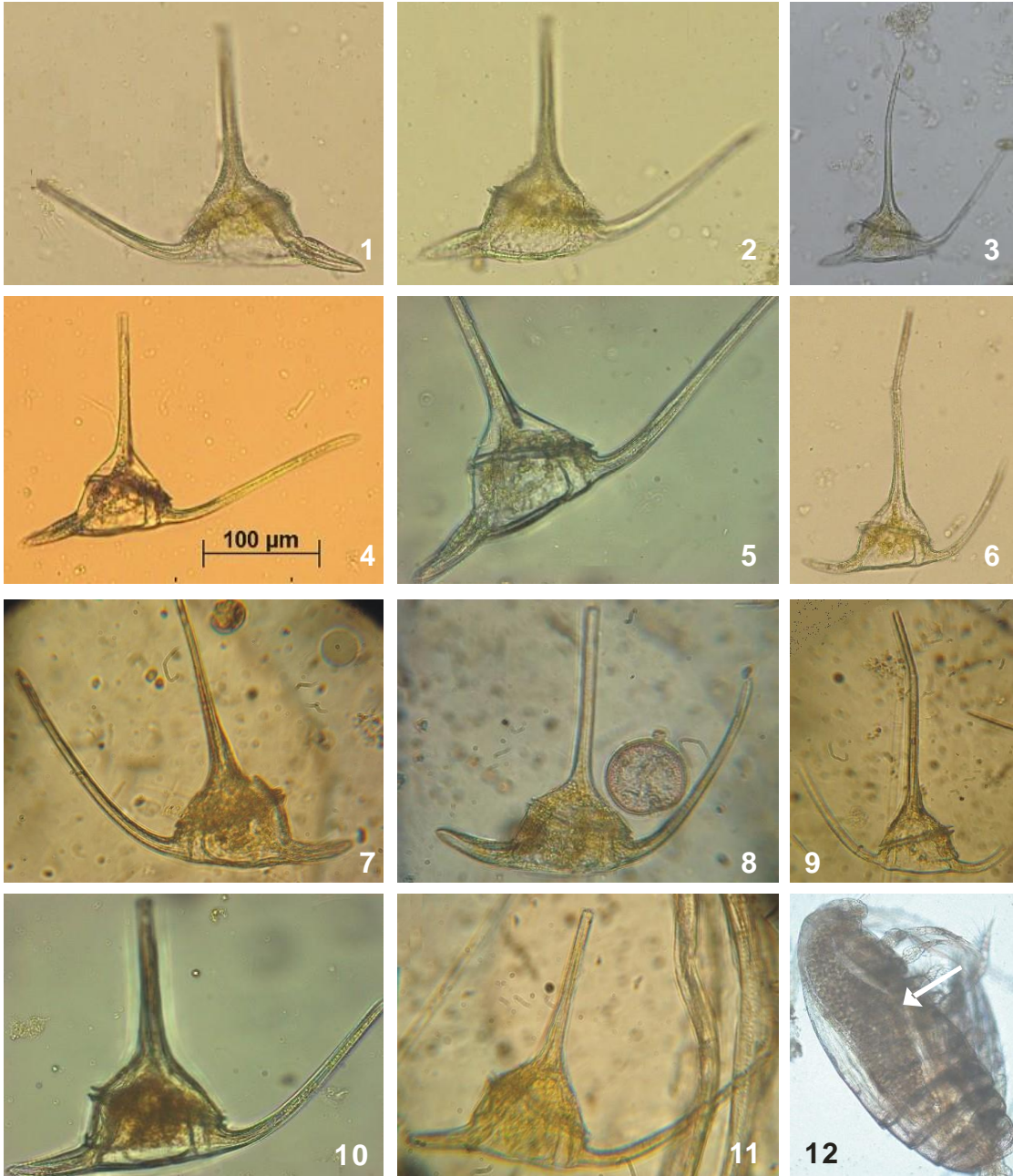
Lauderdale, Florida, showed a total length of 264 to 494  $\mu\text{m}$  ( $n=11$ ) and 100 to 110  $\mu\text{m}$  of transdiameter ( $n=4$ ).

**Characteristics:** A large and robust form with a more pronounced width than height of the cell body. Thecae structure is marked, showing curved and strong lines, with evident pores. The apical horn is strong, winged and cylindrical; wider at the base and usually longer than the left antapical horn. In some specimens (Figs. 3, 6 and 9) the antapical horn is longer than usual and slightly bent to its right. The left antapical horn is notably short, straight or slightly curved, with a short sharp closed tip, either straight or slightly curved. The right antapical horn is longer than the left one and continues from the base with an inclination forward diverging from the apical horn, and sometimes it is thinner than the other horns. The curvature of the right antapical horn is variable (Figs. 1-11). This variability in the horn direction was also observed by Ostefeld and Schmidt (1901, p. 165, fig. 16), who illustrated two specimens of *C. dens*, one with the left antapical horn pointing backwards (left drawing) and another with the left antapical horn pointing to the left or laterally (right drawing). This variation led Schmidt (1901: p. 214, Fig. 2) to describe a new variety, *C. dens* var. *reflexa*, which differs from the type variety only in the left antapical horn direction, which is bent backward. Nevertheless, the validity of *C. dens* var. *reflexa* became doubtful (Böhm, 1931) due to the variation that this species shows in the direction and size of the horns (Figs. 1-11). In this study, besides the forms described by Ostefeld and Schmidt (1901), another form was found showing a less robust body, a longer ( $\gg$  380  $\mu\text{m}$ ) and slightly curved to the right antapical horn and the left antapical horn curved upward (Figs. 3, 6 and 9). Another specimen showed an intermediate form, with robust body, left antapical horn curved upward and the right antapical horn with different inclination angles (Figs. 7 and 8). Most of the cells showed a straight horn; albeit, in some specimens it was pointed to the right (Fig. 7).

**Distribution in the Mexican Pacific:** This finding represents the first record of *Ceratium dens* for the Mexican Pacific. The name *C. dens* was wrongfully used by different authors

(Licea-Durán, 1995; Meave del Castillo & Hernández-Becerril, 1998; Cortés-Altamirano & Núñez-Pasten, 2000) to designate *Ceratium balechii*, a species that was established by Meave del Castillo *et al.* (2003). The confusion was caused by the similarity of *C. balechii* with other species (Meave del Castillo *et al.*, 2003). The wide distribution that this species shows and the quantity of examined samples, allowed Meave del Castillo *et al.* (2003) discard the occurrence of *C. dens* in the Mexican Pacific. The dinoflagellate species list published by Okolodkov and Gárate-Lizárraga (2006), which included the analysis of more than 600 phytoplankton samples, shows no presence of *C. dens* along the Mexican Pacific. Despite this, this study shows for the first time the presence of *C. dens* in the southwest portion of the Gulf of California.

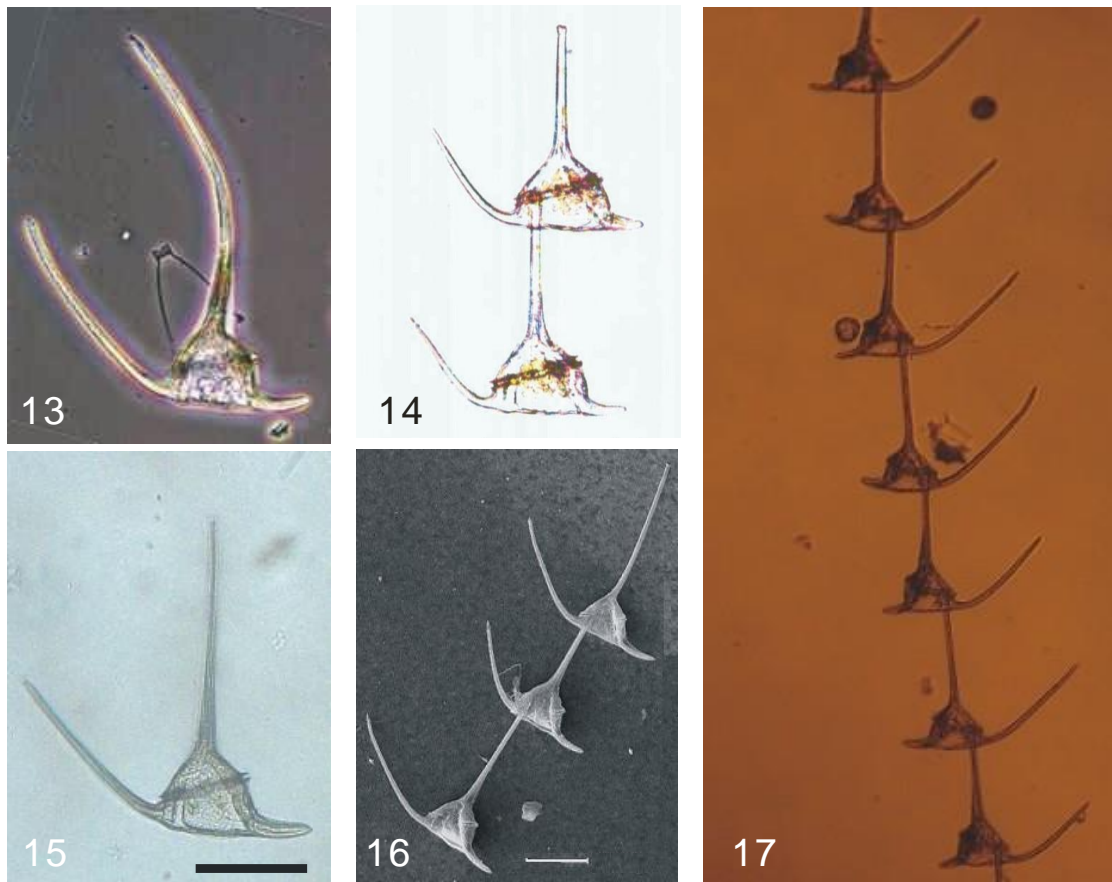
**General Distribution:** *Ceratium dens* was first described for the Red Sea and the Gulf of Aden within the Indian Ocean (Ostefeld & Schmidt, 1901). Karsten (1907) also reported it for the Indian Ocean. Böhm (1931) recorded it for the Malacca (Malaysia) coast. Steemann-Nielsen (1934) found it in samples collected inside the Torres Strait, located between Australia and Papua, New Guinea, all records for the Western Pacific. In another study for the Indian Ocean and East Asia, *C. dens* was recorded in the Mozambique Channel, in a coastal station in South Africa, in the Gulf of Thailand, in the South China Sea, Malaysia, the Sulu Sea and in the Celebes Sea (Steeemann-Nielsen, 1939). Pavillard (1935) observed it close to the Marquesas Islands, located in the East Central Pacific. In a study on Indian Ocean dinoflagellates, Taylor (1976) also considered this species as rare, but, he pointed out that it was present in the coastal station of the east portion of Bengal Bay and Andaman Sea and in three stations of the Arabic Sea. From the work of Taylor (1976) there are other records for the Indian Ocean (Subrahmanyam, 1968; Angot, 1970; Krishnamurthy *et al.*, 1980; Dowidar, 1983, Eashwar *et al.*, 2001) and a few reports for the Japan coasts (Fukuyo, 2000) and the Philippines (Borja, 2002). Steidinger and Williams (1970: p. 152, pl. XV, fig. 40) pointed out that *Ceratium* sp. resembled *C. dens* but that it could be a developmental sta-



**Figures 1-11.** Different *Ceratum dens* specimens collected in Bahía de La Paz during the autumn 2009; 1, 7, 9: *Ceratum dens* lateral view; 2, 3, 4, 5, 6, 8, 10, 11 *Ceratum dens* dorsal view; 12 Arrow shows a *Blastodinium* sp. parasitizing *Paracalanus* sp. Photographs from Figs. 1-9 and 11 were live specimens. Figs. 1-7 and 10 were collected in September 22, 2009. Figs. 8 and 9 specimens were collected in October 20, 2009 and Fig. 11 specimen was collected in November 3, 2009.

ge of another species. Figures 16 and 17 in this study could be the first record for *C. dens* in the Atlantic Ocean. Taylor (1987) considered *C. dens* as a true case of endemism (spe-

cies present exclusively in one region), because it has been observed from the north of the Indian Ocean to the southeast of Asiatic waters. This fact is presented in Figure 18, which

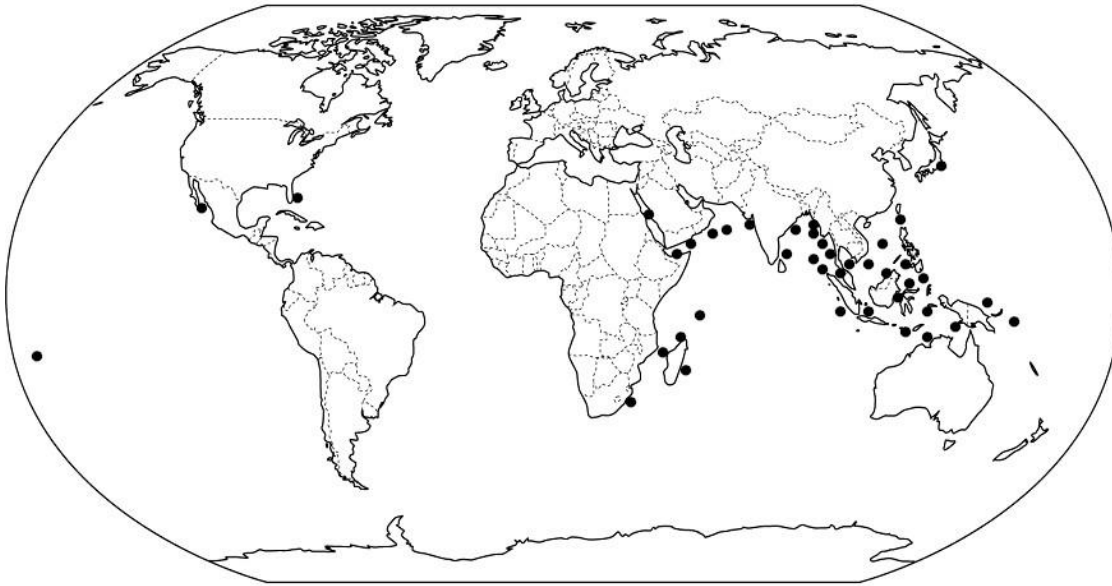


**Figures.13-17.** Different specimens of *Ceratium dens* from around the world: 13) Japan (Taken from Fukuyo, 2000); 14) Philippines (Taken from Borja, 2002); 15) Gulf of California (this study); 16-17) Fort Lauderdale, Florida, USA. Figs. 13-16 ventral view and Fig. 17 dorsal view. Bar scale 100  $\mu$ m.

shows the worldwide distribution of *C. dens*. Its presence in East Pacific could indicate that it is an invasive species, but new surveys are needed to corroborate this hypothesis.

Steemann-Nielsen (1934) and Wood (1954) considered *C. dens* a rare species, characteristic of warm waters and an indicator of sea currents. In the sampling station of this study the sea surface temperature was 29.5 °C (September), 29 °C (October) and 27 °C (November). It is possible that *C. dens* is an indicator species for warm waters such as the Costa Rica Current, also known as Western Mexican Current, which is present during this season (Badan-Dangón, 1989). Nevertheless, this can not be assured since *C. dens* has not been present in many studies on the diversity of the genus *Ceratium* carried out from the Baja California Peninsula to Perú (Hernán-

dez-Becerril, 1988; Gárate-Lizárraga *et al.*, 1990; Gárate-Lizárraga & Verdugo-Díaz, 2001; Vargas-Montero & Freer, 2004; Okolodkov & Gárate-Lizárraga, 2006; Sánchez *et al.*, 2007). The first record of *C. dens* in the Eastern Pacific was in the Marquesas Islands (Pavillard, 1935) during the El Niño 1932-1933. It is possible that the presence of *C. dens* in the mouth of the Gulf of California during September-November 2009 could be also related to the El Niño event (2009-2010) ([http://cpc.noaa.gov/products/analysis\\_monitoring/enso-update/](http://cpc.noaa.gov/products/analysis_monitoring/enso-update/)). On the other hand, the occurrence of the dinoflagellate *Blastodinium* sp., a parasite of the copepod *Paracalanus* sp. (Fig. 12), *Schuettilia mitra* and *Centrodinium pulchrum* whose distribution is mainly tropical, confirms the presence of tropical waters in the south portion of the Gulf of California during



**Figure 18.** Worldwide distribution of the dinoflagellate *Ceratium dens* (□): Sources: Ostenfeld & Schmidt (1901), Karsten (1907), Jörgensen (1920), Steemann-Nielsen (1934; 1939), Pavillard (1935), Wood (1954), Subrahmanyam (1968), Sournia (1967), Argot (1970), Taylor (1976), Krishnamurthy *et al.* (1980), Dowidar (1983), Eashwar *et al.* (2001), Borja (2002), this study.

the study period. The exhaustive review of specialized literature on the distribution of the genus *Ceratium* suggests that this finding is the first record of *C. dens* in the coastal portion of the Eastern Pacific.

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