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New distribution records of Dinophyta in Brazilian waters

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ABSTRACT: New records of marine dinoflagellates are reported for the municipality of Tramandaí (29°59'05" S; 50°08'01" W), including new records, not only for the state of Rio Grande do Sul, but also for Brazil. These records were based on sampling carried out in the region in 1976, by Kremer and Rosa (1983), as well as new samples taken in 2011, in the same location as the previous work. In total, we present 20 new records, 13 of them for Rio Grande do Sul and 7 for Brazil as a whole.

Floristic studies of dinoflagellates in Brazil are relatively few, but among the several important contributions are those of Passavante (1979) for the state of Pernambuco; Passavante *et al.* (1982) for Ceará, Kremer and Rosa (1983) for the region of Tramandaí-Imbé in Rio Grande do Sul, Cardoso (1995, 1997, 1998) for northern Santa Catarina Island and Arvoredo Island in Santa Catarina, Koening and Lira (2005) with species of the genus *Neoceratium* in Pernambuco, Haraguchi and Odebrecht (2010) and Islabão and Odebrecht (2011) for the area between Albardão-Chuí, Rio Grande do Sul, and the Cabo da Santa Marta in Santa Catarina. The small number of studies of Dinophyta in Brazilian waters increases the chances of finding new occurrences for both states and the country, especially because the world biodiversity is estimated at 1555 species (Gómez 2005) in the marine environment. According to the Brazilian Flora List (Odebrecht *et al.* 2012), 352 Dinophyta taxa have been recorded for Brazilian marine waters, 170 of them occurring in Rio Grande do Sul (RS). This paper provides comments regarding the taxonomy and distribution of 19 taxa newly recorded in RS and / or Brazil, seeking to establish distribution patterns related to the seasonality of different water bodies off this coast.

The region is influenced by the convergence of the Tropical Water (TW, T> 20°C, S> 36) (Emilsson 1961) and the Subantarctic Shelf Water (SASW; T 4-15°C, S 33.70 to 34.15; Sverdrup *et al.* 1942; Thomsen 1962), and the mixture of these water masses with the Subtropical Water, also called the South Atlantic Central Water (SACW). The South Atlantic Central Water (SACW) is a water mass rich in nutrients flowing into the pycnocline region, with temperatures between 6 and 20° C and salinity between 34.6 and 36 (Braga and Niencheski 2006; Silveira *et al.* 2000). In addition to these water masses, the region receives a considerable influence of continental discharges from the La Plata River and Patos Lagoon. The influence of the Plata Plume Water (PPW; T >10°C, S <33.5) significantly affects an area extending from the Mar del Plata in Argentina to the coast of Santa Catarina, with seasonally variable flow. The Plata Plume Water (PPW) mixed with Tropical Water (TW) forms another water mass with potential importance in the region: the Subtropical Shelf Water (STSW), which has temperatures higher than 14°C and salinities between 33.5 and 36 (Moller *et al.* 2008). The discharge of the La Plata River and Patos Lagoon water contributes large amounts of dissolved nutrients, as well as lowering the salinity along the southern coast of Brazil, primarily depending on the season and El Niño events. El Niño events cause a high discharge of fresh water in the region due to high rainfall, generating a broad zone of low-salinity and nutrient-rich water (Moller *et al.* 2008; Seeliger and Odebrecht 2010). The water temperature and salinity were used to classify the kind of water during this study, according to Moller *et al.* (2008).

The study area is located on the northern coast of RS in the municipality of Tramandaí (29°59'05" S, 50°08'01" W), where two sampling points were selected: the beach area and near the Petrobras monobuoy. Aliquots from qualitative samples (collected with a plankton net, 48 µm mesh) taken in the region in 1976 (Kremer and Rosa 1983) were inspected. These were donated by the herbarium (Registration Number in Alarich Schultz's herbarium - HAS 2419, 2421, 2430, 2436, 2443, 2442, 2478, 2484, 2490, 2496, 2500 and 2504) of the Natural Sciences Museum (MCN) of the Zoobotanical Foundation of Rio Grande do Sul (RS-FZB). New sampling in these same locations was conducted in summer (January, February and March) and winter (July, August and September) of 2011. Qualitative (plankton net, 64 µm mesh) and quantitative (Van Dorn bottle) sampling followed established protocols for these analyses (Sournia 1978). Some physical and chemical variables were measured simultaneously during the sampling: water temperature (with a mercury thermometer), salinity (measured later in the laboratory in a hydrometer) and water transparency (Secchi disk).

Optical microscopy (Olympus IX30 and Zeiss West) and the sodium hypochlorite technique for observation of thecal plates (Balech 1971) were used for the identification of the species, using basic references (Schiller 1933, 1937; Sournia 1978, 1984, Balech 1964b, 1971, 1978, 1988; Balech *et al.* 1984), and in some cases, specific references for each taxon. Some species of the genus *Preperidinium* Mangin and *Protoperidium* Bergh were identified through an epifluorescence microscope (Zeiss Axion Vert 135)

using a fluocromo Calco fluor white specific for cellulose with the aim of highlighting the plates cellulosic (Fritz and Triemer 1985). Zeiss Camera and AxioCam ErC5s software was utilized to the capture of the images. For quantitative analysis, an inverted microscope (Zeiss Telaval 31) was employed, using the Utermöhl (1958) method, where a fixed volume of 25 mL was counted completely. The new occurrences for RS and/or Brazil were verified by consulting the Brazilian Flora List (Odebrecht *et al.* 2012).

The distribution of species as well as comments regarding the ecology and taxonomy are included for each taxon, in addition to tabulation (1' and 2a) for the genus *Protoperidinium.* At the end of the comments of each species there is a literature where illustrations for each taxon are found. The taxa validation and the geographical distribution on a global scale were confirmed by consulting the Algae Base (Guiry and Guiry 2012) and World Register of Marine Species (Appeltans *et al.* 2012). Photographs of some species were taken using a microscope (Leica DM750) with attached camera (DFC290HD) and the software Leica Application Suite Version 3.4.1. The species illustrated in the photographs were the most frequent and/or for which a satisfactory view of the plates was obtained (for the genera *Preperidinium* and *Protoperidinium*).

The genus *Protoperidinium* was prior identified by combination of morphology of the plates, one located in the ventral (1') and a dorsal region (2a). The first may be Ortho, Meta or Para depending on if it has contact with four, five or six plates, respectively. The second may be Quadra, Penta or Hexa following the same concept mentioned above. Besides these standard tabular characteristics such as size, shape and the cingulate displacement were important for accurate identification for the genus (Hoppenrath *et al*. 2009).

Of the 20 new occurrences found in this study, 13 were new for the state of Rio Grande do Sul, and 7 for Brazil (Table 1). The largest number of new records was for members of *Protoperidinium* (55%), followed by *Gonyaulax* (15%) and *Neoceratium* (10%).

***Ceratium aestuarium* Schroder** (Figure 1A)

This species was recorded only in winter 2011 (Table 1), with a density of 20 ind.L^{-1}. Occurred at low temperature (13-14°C), and salinities from 29.29 (beach point), and 34.63 (monobuoy point), conditions associated with PPW and SACW, respectively.

Size: 200 – 250 µm (long); 70 – 80 µm (wide); 30 µm (length of anterior body); 42 µm (length of posterior body); 160 – 210 µm (length of apical horn); length of horns 20 µm (right) and 25 µm (left) (2 specimens).

Distribution: First occurrence in Brazil. This species was found by Balech *et al*. (1984) in Argentinean waters, mentioned as uncommon and rarely recorded around the world, only for the Mediterranean Sea and the Adriatic Sea (Balech 1988).

Comments: This species belongs to the genus *Neoceratium* created by Gómez *et al*. (2009), due to its essential characteristics for this taxon and living in the marine environment. However, it wasn't transferred to *Neoceratium*, which leads to confusion in identifying needs. Based upon the characteristics defined in *Neoceratium* to Gómez *et al*. (2009), this species should be transferred to this genus, requiring revisions and nomenclatural discussions about this taxon.

When considered a variety of *Neoceratium hexacanthum* (Gourret) F. Gómez, D. Moreira and P. López-Garcia, which may cause confusion in determining its geographical distribution. As a variety of *N. hexacanthum* it has been recorded only in France (Mediterranean Sea) (Balech 1988) leading to the conclusion that its distribution is restricted and rare. Based on its morphological characteristics, *N. hexacanthum* has a regularly reticulate body (Kremer and Rosa 1983) and a left horn twisted antapically, unlike *C. aestuarium*. The latter may be a morphotype adapted to colder waters, unlike *N. hexacanthum*, which has a wide distribution (in all regions) along the Brazilian coast, and is most often associated with the Brazil Current (Balech 1988). According to Fig. 1, it was evident that is *C. aestuarium.*

***Cladopyxis brachiolata* Stein**

This species was found only in the winter of 2011 (Table 1), at a temperature of 13°C and salinity 34.63; associated with SACW. Absent in the quantitative samples.

Size: 50 µm (long); 44 µm (wide) (1 specimen).

Distribution: In Brazil, recorded in the Northeast (BA) and Southeast (ES, RJ) regions. First occurrence for RS. It occurs in the Tropical Atlantic, Mediterranean Sea, Indian Ocean, western Pacific and a coral reef in Australia (Wood 1963).

Comments: Balech (1964b) found this species in a higher temperature (24°C) than in the present study, and in similar salinities. Balech found mainly variations in the size of the horns. The single specimen found in this study accorded with the morphology described by Balech (1964b), and differed from the report of Balech (1964a), where the horns were longer. Notably, the study of Balech (1964b) was conducted in Argentinean waters, near the site of the present study, while Balech (1964a) reported species from Pacific waters.

The Details of the morphology can be viewed in Balech (1988, plate 71, figs. 1-3).

***Gonyaulax diegensis* Kofoid**

This species occurred only in quantitative samples in August 2011 (20 ind.L^{-1}) (Table 1), at a temperature of 15°C and salinity 31.36; associated with PPW.

Size: 72 µm (long); 35 µm (wide) (1 specimen).

Distribution: In Brazil, recorded in the North (AP, AP) and Northeast (RN) regions. First occurrence for RS. Species distributed from tropical waters (Gulf of Mexico) to temperate waters (UK, North Sea) (Guiry and Guiry 2012).

The details of the morphology and the tabulation can be viewed in Balech (1988, plate 74, fig. 10)

***Gonyaulax fragilis* (Schütt) Kofoid**

This species was only observed in summer 1976 (Table 1), at a temperature of 23°C and salinity 27.2; associated with PPW.

Size: 44µm (long); 35µm (wide) (1 specimen).

Distribution: In Brazil the species is recorded only in the North (AP) and the South (SC). First occurrence for RS. It has a worldwide distribution from the tropics to

temperate zones (Guiry and Guiry 2012).

Comments: According to Cardoso (1998), this species prefers warm water. Cardoso (1998) found it at similar temperatures to the present study (21 to 27°C), but at higher salinities (32.91 to 34.73). Balech *et al.* (1984) recorded this species in Argentinean waters, but did not mention the temperature and salinity. Balech *et al.* (1984) speculated about the similarity of this species to *Gonyaulax hyalina* Ostenfeld and Schmidt. The single specimen found in this study had the dimensions within those recorded by Cardoso (1998), which suggests that this morphotype is adapted to the southwest Atlantic.

The details of the morphology and the tabulation can be viewed in Cardoso (1998).

***Gonyaulax spinifera* (Claparède and Lachmann) Diesing**

This species occurred only in winter 1976 (Table 1), at a temperature of 16°C and salinity from 27.1; associated with PPW.

Size: 49 µm (long); 37 µm (wide) (1 specimen).

Distribution: In Brazil it is found in all regions: North (PA), Northeast (RN), Southeast (RJ) and South (SC). First occurrence for RS. According to Esqueda-Lara and Hernández-Becerril (2010) it is a tropical and subtropical species.

Comments: It has also been found in Antarctica (Balech 1976), but is not considered an inhabitant of these waters, where it was noted as invasive. Prefers cold waters, occurring in low temperatures (2.15 to 15.55°C) and salinities between 33 and 35 (Balech 1988).

The details of the morphology and the tabulation can be viewed in Balech (1988, plate 74, figs. 1-4)

***Lingulodinium polyedrum* (F.Stein) J.D.Dodge** (Figure 1B-C)

Occurred only in summer 1976 (Table 1), at a temperature of 23°C and salinity 27.2; associated with PPW.

Size: 40-55 µm (long); 35-45 µm (wide) (2 specimens).

Distribution: In Brazil, recorded in North (AP), Northeast (MA, RN, PE) and South (SC). First occurrence for RS. Elsewhere, it is recorded in tropical and temperate waters (Guiry and Guiry 2012).

Comments: Species easily identifiable by its characteristic polyhedral shape in lateral view. In apical view has almost circular outline (Cardoso 1998).

Balech (1988) listed this species from the Brazil Current, always occurring rarely in the southwest Atlantic (between 38°30'S and 43°33'W) and in warm waters. Kofoid (1911) cited this species as very abundant in the summer plankton in Baja California, reaching high densities in the summer peak, and that intra-specific variation occurred mainly in the size and development of the reticulum.

***Neoceratium balechii* var. *longum* (Meave, Okolodkov and Zamudio) F. Gómez, D. Moreira and P. López-Garcia** (Figure 1D)

This species occurred widely in winter 2011 (Table 1), with a peak density of 220 ind.L^{-1} in August. It is recorded in temperatures from 13 to 16.5°C and salinities from 29.29 to 36.35; associated with PPW, SASW and SACW.

Size: 120 – 155 µm (long); 50 – 60 µm (wide) (4 specimens).

Distribution: First occurrence for RS and Brazil. This species was referred to as *Neoceratium dens* (Ostenfeld and Schmidt) F. Gómez, D. Moreira and P. López-Garcia, and was distinguished from this by Meave del Castillo *et al.* (2003). Therefore, many previous records of taxa such as *N. dens* in Brazil likely refer to *N. balechii*. Its occurrence in Brazil should be reviewed, because of the taxonomic change. Widely distributed in the Mexican Pacific, also with records on the coasts of Ecuador, Peru and Chile (Meave del Castillo *et al.* 2003).

Comments: The specimens found in samples from winter 2011 were quite similar to those recorded by Balech (1988) as *Neoceratium dens*. Recently, Meave Del Castillo *et al.* (2003) described *N. balechii*, differentiating it from *N. dens*. The former has the two antapical horns small, with the left horn slightly more robust, whereas the latter has the left anti-apical horn longer, reaching almost to midlength of the apical horn (Meave del Castillo *et al*. 2003).

***Neoceratium setaceum* (Jørgensen) F. Gómez, D. Moreira and P. López-Garcia**

This species occurred only in summer 1976 (Table 1), in temperatures from 23 to 25.5°C and salinity 27.2; associated with PPW.

Size: 180 µm (long); 50 µm (wide) (1 specimens).

Distribution: In Brazil, its distribution extends to all regions of the coastal zone: Northern (AP, AP), Northeast (RN, BA), Southeast (SE, SP, RJ) and South (PR, SC). First occurrence for RS. The world distribution includes both tropical and temperate regions (Guiry and Guiry 2012).

Comments: Species very similar to *Neoceratium pentagonum* (Gourret) F. Gomez, D.Moreira and P.Lopez-Garcia, differs from it by owning a typically longer apical horn of up to 408 µm (Gonçalves *et al*. 2006), a lower diameter cell and antapical left horn of greater length (20 - 50 µm - Gonçalves *et al*. 2006).

This species seems to be very uncommon in the area, because Balech (1988), over decades of study, did not find it in the southwest Atlantic. According to Wood (1968) it is a tropical species, but closer inspection of the records indicates that it occurs from tropical to temperate environments. It seems to be more associated with the Brazil Current, because it frequently occurs off the northern coast of the country (Wood 1968).

The details of the morphology of this species can be viewed in Gonçalves *et al.* (2006).

***Preperidinium meunieri* (Pavillard) Elbrächter** (Figure 1E-G)

Occurred only in both winters (Table 1), at temperatures from 13 to 16.5°C and salinity from 19 to 36.35. Present in quantitative samples with low density (40 ind.L^{-1}); associated with SACW, SASW and PPW.

Size: 30 – 40 µm (long); 45 – 60 µm (wide) (3 specimens).

Distribution: In Brazil, it has only been found in the North Region (PA). First occurrence for RS. It has a cosmopolitan distribution in the world (Balech 1976).

Comments: Balech (1988) mentioned it as a highly thermotolerant dinoflagellate because it has records from -2 to 24°C. This species has a heterotypic synonym: *Diplopeltopsis minor* (Paulsen) Pavillard, and was transferred to the genus *Preperidinium* in 1993 by Elbrächter (Guiry and Guiry 2012).

Tiny pores were observed (Figure 1G) on the entire cell surface as reported by Balech (1988). According to this author, the cingular membrane of *P. meunieri* has denticulate edge, detail observed in specimens found.

***Protoperidinium anomaloplaxum* (Balech) Balech** (Figure 1H-I)

Species found only in 1976 (Table 1), in temperatures from 14.5 to 23°C and salinities from 21.5 to 27.8; associated with PPW.

Size: 45 – 50 µm (long); 47 – 52 µm(wide) (2 specimens).

Distribution: First occurrence for RS and Brazil. The only previous record was by Balech (1988) in Argentinean waters between latitudes 37°39'S and 38°42'S, which is adjacent to this study region (30°S).

Tabulation: Ventral tabulation of epitheca type *Meta* and dorsal type *Penta*.

Comments: The material was first identified as *Protoperidinium sphaeirodeum* (P. Dangeard) Balech, but after thorough analysis of other specimens, it was apparent that the 2a plate in *P. anomaloplaxum* (penta) is distinct from *P. sphaeirodeum* (quadra). Furthermore, plate 1' has a different morphology, with the sinuous edge with the 6'' (Balech 1988). Balech (1988) cited it as a species with a very particular distribution, as it was always seen in the same latitudes. Its distribution does appear to be restricted to the southwest Atlantic, because it has not been found elsewhere. This species, together with *Protoperidinium lipopodium* (Balech) Balech, have no records elsewhere, suggesting that they could be endemics of the southwest Atlantic.

The details of the morphology and the tabulation can be viewed in Balech (1988, plate 22, figs. 11-13)

***Protoperidinium brochii* (Kofoid and Swezy) Balech** (Figure 1J-L)

This species occurred in both years (Table 1), in temperatures from 14.5 to 23°C and salinity from 19 to 31.36. Present in quantitative samples (20 ind.L^{-1}) only in August 2011. It is associated with PPW.

Size: 70-92 µm (long); 75 µm (wide) (2 specimens).

Tabulation: Ventral tabulation of epitheca type *Meta* and dorsal type *Quadra.*

Distribution: In Brazil it occurs in the Southeast (SP) and the South (SC). First occurrence for RS. Outside Brazil, the species is widely distributed from the tropics to temperate zones (Guiry and Guiry 2012). According to Esqueda-Lara and Hernández-Becerril (2010) it is a subtropical and temperate species.

Comments: Balech (1988) mentioned that this species almost always occurred at temperatures above 13°C; in that study, it was found in temperatures from 9 to 20°C and salinities from 33 to 36. Cardoso (1997) recorded this species from southern Brazil in ranges of temperature (21-27°C) and salinity (32-35) slightly higher than in the present study, with a maximum density of 100 ind.L^{-1} in summer.

This species can be confused with *Protoperidinium divergens* (Ehrenberg) Balech because they have similar shapes, and the tabulation of plates is identical (1' *Meta*; 2a *Quadra*). Balech (1988) considered *P. divergens* more angular than *P. brochii,* which we also observed, and the latter has a strongly sinuous contour (Cardoso 1997), different from the former, which also has a more prominent apical horn.

The details of the morphology and the tabulation can be viewed in Balech (1988, plate 41, figs. 4-7)

***Protoperidinium conicoides* (Paulsen) Balech** (Figure 2A-B)

This species occurred only in winter in both years (Table 1), in temperatures from 14.5 to 16.5°C and salinity from 19 to 36.35; associated with SACW and PPW.

Size: 40 – 50 µm (long); 35 – 42 µm (wide) (3 specimens).

Tabulation: Ventral tabulation of epitheca type *Ortho* and dorsal type *Hexa*

Distribution: First occurrence in Brazil. It occurs mainly in temperate regions (Guiry and Guiry 2012).

Comments: This species is usually found at lower temperatures than in the present study (5-11°C) (Balech 1988). Occurs more frequently in temperate and polar regions (Appeltans et al. 2012; Guiry and Guiry, 2012) which confirms it as a cold-water species. Balech (1988) compared this species with *Protoperidinium conicum* Gran (Balech), however the latter species is more elongated anteroposteriorly, and the edge of *P. conicoides* is more convex.

The details of the morphology and the tabulation can be viewed in Balech (1988, plate 26, figs. 7-11).

***Protoperidinium elegans* (Cleve) Balech**

Only one individual of this species was observed, in a sample from 1976 (Table 1), at a temperature of 23°C and salinity of 21.5; associated with PPW.

Size: 165 µm (long); 100 µm (wide) (1 specimen).

Tabulation: Ventral tabulation of epitheca type *Meta* and dorsal type *Quadra*.

Distribution: First occurrence for RS and Brazil. Elsewhere, *P. elegans* occurs in tropical and temperate regions (Guiry and Guiry 2012).

Comments: Species very similar to *Protoperidinium grande* (Kofoid) Balech differing by having a greater width between the antapical horns – and larger hypotheca height (Balech 1988). Furthermore, *P. grande* presents minimum values for larger diameter (112 µm) greater than *P. elegans* (85 µm), checking this variable in Balech (1988).

Species widely variable in size (Balech 1988). According to Balech (1988), it is a thermophilic species and appears to be intolerant, and is rarely found in the southwest Atlantic.

The details of the morphology and the tabulation can be viewed in. Balech (1988, plate 43, figs. 1-4).

***Protoperidinium globulus* (Stein) Balech** (Figure 2C-D)

This species occurred in both years, more frequently in summer (Table 1), however with a maximum density (300 ind.L^{-1}) in winter. The limits of temperatures (13-25.5°C)

and salinity (21.5 to 34.63) were wide; associated with SASW, TW, SACW and PPW.

Size: 30 µm (long); 25-30 µm (wide) (4 specimens)

Tabulation: Ventral tabulation of epitheca type *Meta* and dorsal type *Hexa*.

Distribution: In Brazil, it is distributed in the North (PA), Northeast (MA) and South (SC). First occurrence for RS. It is widely distributed in warm waters (Wood 1964).

Comments: Species easily recognized by its globular shape and small dimensions. It was observed difficulties in the visualization of the plates even with Fritz and Triemer's techniques (Fritz and Trimer 1985).

Seems to be a tolerant species, because in southern Brazil it occurred in high densities (100 cells. L^{-1}) in summer (Cardoso 1997), and in high abundance in winter in this study.

The details of the morphology and the tabulation can be viewed in Cardoso (1997).

***Protoperidinium granii* (Ostenfield) Balech**

This species occurred in both years analyzed (Table 1), over a range of temperatures from 13 to 25.5°C and salinities 29.29 to 34.63; associated with SASW, SACW and PPW.

Size: 58 µm (long); 52 µm (wide) (1 specimen).

Tabulation: Ventral tabulation of epitheca type *Meta* and dorsal type *Penta*.

Distribution: In Brazil, it has been recorded in the Northeast (PE, BA), Southeast (ES, RJ) and South (SC). First occurrence for RS. A widely distributed species, from tropical to polar regions (Guiry and Guiry 2012).

Comments: Balech (1988) mentioned a possible preference for cold-temperate waters, based on its global distribution. Balech cited its resemblance to *Protoperidinium mite* (Pavillard) Balech, which differs especially in having less-developed horns, non-excavated cingulum and the equatorial region of the cell is less rounded (Balech 1988).

The details of the morphology and the tabulation can be viewed in Balech (1988, plate 40, figs. 9-12).

***Protoperidinium lipopodium* (Balech) Balech** (Figure 2E-F)

This species was recorded only in 1976 (Table 1), in temperatures from 16 to 25°C and salinities from 27.2 to 32.1; associated with PPW.

Size: 45 – 50 µm (long); 43 – 52 µm (wide) (2 specimens).

Tabulation: Ventral tabulation of epitheca type *Meta* and dorsal type *Quadra.*

Distribution: In Brazil, it has been recorded only in the South region, in SC by Cardoso (1997). First occurrence for RS. It has not been recorded elsewhere (Guiry and Guiry 2012), except by Balech (1988).

Comments: Species with characteristic shape (piriformis) with the presence of two antapical spines curved to the right, with the left larger than the right (Cardoso 1997).

Cardoso (1997) suggested that this species is restricted to the southwest Atlantic, because the only record prior to her study was by Balech (1988). Currently, there is no record of this species other than southern Brazil and Argentinean waters, which probably confirms the opinion of Cardoso (1997), making the species an indicator for the region.

The minimum wide was below than reported by Balech (1988). The other measures were within the limits found by this author.

The details of the morphology and the tabulation can be viewed in Balech (1988, plate 31, figs. 1-4).

***Protoperidinium pacificum* (Kofoid and Michener) F. J. R. Taylor and Balech ex Balech** (Figure 2G)

This species occurred only in summer 1976 (Table 1), in temperatures from 23 to 25.5°C and salinities from 27.2 to 33; associated with PPW.

Size: 50 – 65 µm (long); 55 – 60 µm (wide) (2 specimens).

Tabulation: Ventral tabulation of epitheca type *Meta* and dorsal type *Quadra*.

Distribution: First occurrence for RS and Brazil. Elsewhere, it is known from tropical and temperate regions (Balech 1988; Okolodkov 2008). Balech (1988) found specimens of this species always near the Malvinas Current, with few records above 14.5 °C.

Comments: The wide was larger than found by Balech (1988).

The details of the morphology and the tabulation can be viewed in Balech (1988, plate 40, figs. 13-18).

***Protoperidinium rampii* (Balech) Balech**

This species was recorded only in summer 1976 (Table 1), at a temperature of 23°C and salinity of 21.5; associated with PPW.

Size: 55 µm (long); 50 µm (wide) (1 specimen).

Tabulation: Ventral tabulation of epitheca type *Para* and dorsal type *Quadra.*

Distribution: First occurrence for RS and Brazil. No world records were found in the literature, except by Balech (1988) for Argentinean waters.

Comments: Balech (1988) commented on its similarity to *Protoperidinium pacificum*, differentiating this with respect to plate 1' (*Meta* in *P. pacificum* and *Para* in *P. rampii*) and the size of the horns. These distinctive features were observed in the specimens analyzed. The antapical horns of *P. pacificum* are slightly longer, and have a less sinuous contour compared with *P. rampii*.

According to Balech (1988), it is widely distributed in the cold waters of Argentina, rarely above 14°C, but was recorded in this study at a higher temperature. Together with *P. anomaloplaxum* and *P. lipopodium,* no other record exists in the literature, except in the southwest Atlantic, making it a likely indicator of the region.

The details of the morphology and the tabulation can be viewed in Balech (1988, plate 47, figs. 5-8).

***Protoperidinium steinii* (Jorgensen) Balech**

This species was found in both years analyzed, more often in summer (Table 1), but with maximum density in winter (40 ind.L^{-1}). It was recorded in temperatures from 15 to 25°C and salinities from 27.1 to 32.1; associated with TW and PPW.

Size: 60 – 70 µm (long); 30 – 45 µm (wide) (3 specimens).

Tabulation: Ventral tabulation of epitheca type *Meta* and dorsal type *Penta*.

Distribution: In Brazil, it has been recorded in all regions: Northern (AP, AP), Northeast (BA), Southeast (SE, SP, RJ) and South (SC). First occurrence for RS. It is distributed in tropical and temperate regions (Guiry and Guiry 2012).

Comments: At first sight, the species was confused with *Protoperidinium ovum* (Schiller) Balech, but there were details that distinguished the two species. *P. ovum* is more ovoid, and the epitheca and the hypotheca are the same size (Balech 1988), which differs from *P. steinii*, which has a higher epitheca than hypotheca (Cardoso 1997). Furthermore, the 1' and 2a plates of *P. steinii* (*Meta* and *Penta*) and *P. ovum* (*Para* and *Hexa*) are different.

The details of the morphology and the tabulation can be viewed in Cardoso (1997).

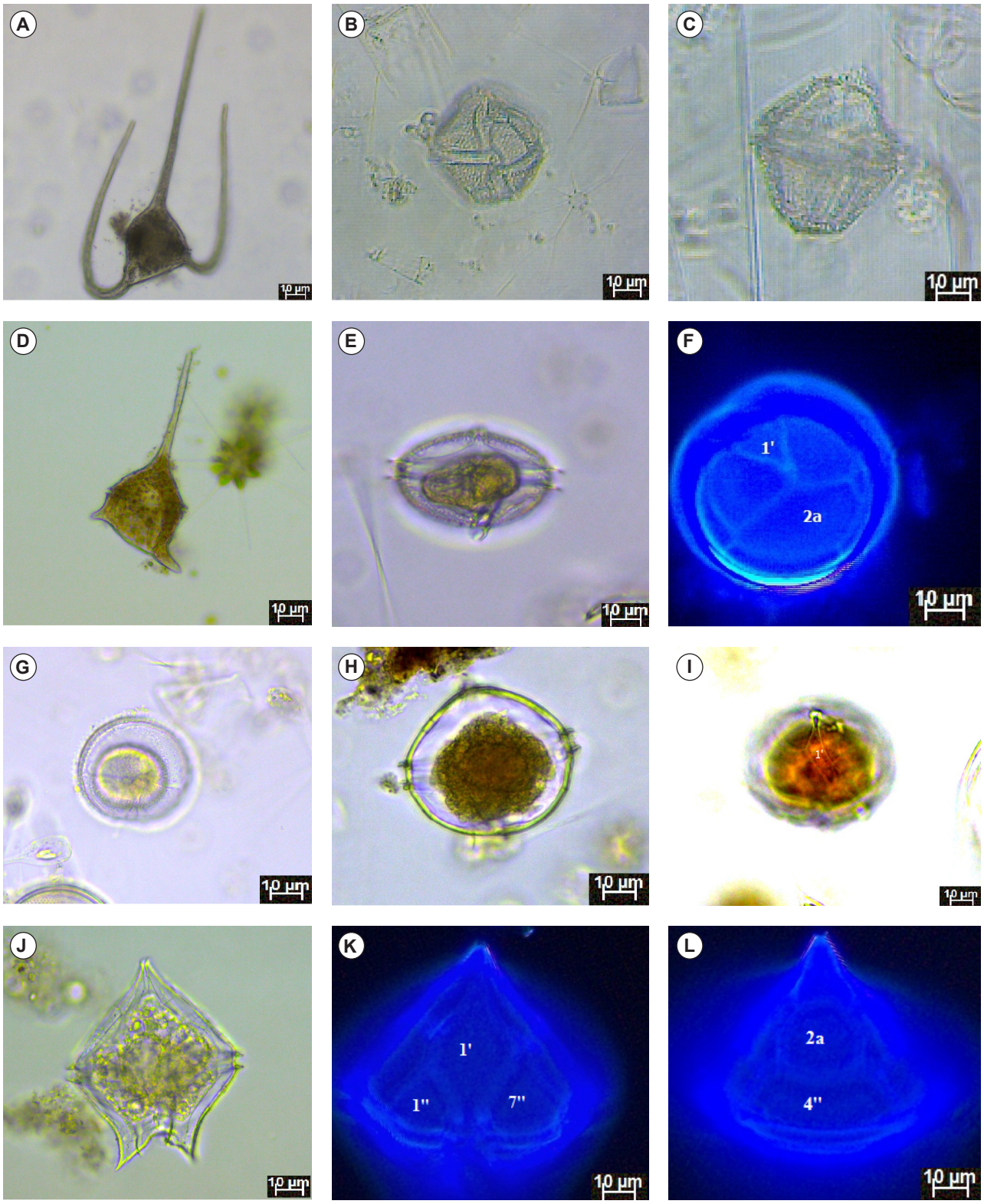

Figure 1. A) *Ceratium aestuarium*; B-C) *Lingulodinium polyedrum*; D) *Neoceratium balechii* var. *longum*; E) *Preperidinium meunieri*, overview; F) *P. meunieri*, apical view; G) *P. meunieri*, apical view (optical microscope); H) *Protoperidinium anomaloplaxum*, overview; I) *P. anomaloplaxum*, view of the plate 1'; J) *P. brochii*, overview. K) *P. brochii*, view of the plate 1'; L) , view of the plate 2a.

***Protoperidinium symmetricum* (Halim) Balech** (Figure 2H-J)

This species was observed only in summer 2011 (Table 1) in temperatures from 23 to 23.5°C and salinities from 29.61 to 33.88; associated with TW. Absent in the quantitative samples.

Size: 75 µm (long); 76 µm (wide) (1 specimen).

Tabulation: Ventral tabulation of epitheca type *Ortho* and dorsal type *Hexa*.

Distribution: The only previous record was from Southeast Brazil (RJ). First occurrence for RS.

Comments: According to Balech (1988), this is a tropical species found in Brazilian waters in temperatures between 20 and 26°C, associated with the Brazil Current. It is very similar to *Protoperidinium abei* (Paulsen) Balech, however can be easily distinguished mainly by the morphology (Balech 1988). *P. abei* is longer and narrower than *P. symmetricum*., and in the latter the antapical spine is easily viewed.

It was difficult in identifying the species found in 1976. Many cells were damaged due to prolonged action of formaldehyde along of 35 years, and the calcofluor analyses were impossible to run because that. Besides that, some was rare and it difficult to obtain photographs of them. Therefore, we intend to confirm some new occurrences in future work, with records made by

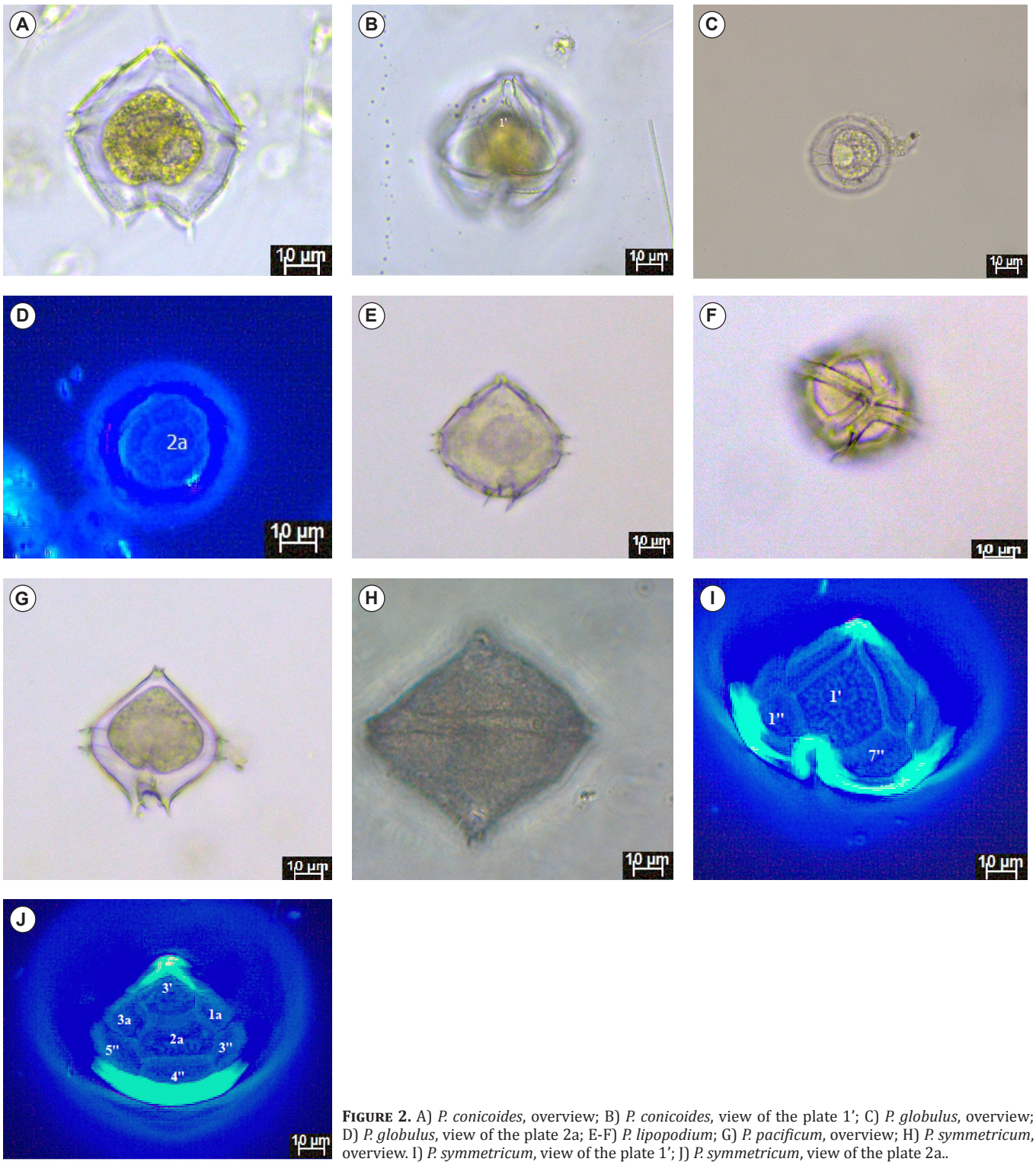

Figure 2. A) *P. conicoides*, overview; B) *P. conicoides*, view of the plate 1'; C) *P. globulus*, overview; D) *P. globulus*, view of the plate 2a; E-F) *P. lipopodium*; G) *P. pacificum*, overview; H) *P. symmetricum*, overview. I) *P. symmetricum*, view of the plate 1'; J) *P. symmetricum*, view of the plate 2a..

photographs.

Most species found here for the first time in Rio Grande do Sul and /or Brazil belong to the genus *Protoperidinium*. This disproportion is associated with the greater difficulty in identifying species from this genus, which are distinguished by the epithecal plates, added to a lack of studies on this genus. *Gonyaulax* was second in number of first records, for the same reason, requiring analysis of the cellulosic plates. For more comprehensive studies of dinoflagellates, other microscopical techniques should be used, such as scanning electron and fluorescence microscopy, because of the great difficulty of identifying dinoflagellates with optical microscopy alone.

This relatively large number of first occurrences of species illustrates the need for more taxonomic and ecological research on dinoflagellates in Brazilian waters, in order to better understand an important group that is being neglected in Brazil for lack of specialists.

Table 1. New records for Rio Grande do Sul and Brazil (*). (B= beach, M = monobuoy)

	Jan/76	Feb/76	Mar/76	Jul/76	Aug/76	Sep/76	Jan/11	Feb/11	Mar/11	Jul/11	Aug/11	Sep/11
*Ceratium aestuarium**										B,M		
Cladopyxis brachiolata										B		
Gonyaulax diegensis											M	
Gonyaulax fragilis			B									
Gonyaulax spinifera						B						
Lingulodinium polyedrum			B									
*Neoceratium balechii var. longum**										B,M	M	B,M
Neoceratium setaceum			B									
Preperidinium meunieri					B,M					B,M	B	B,M
*Protoperidinium anomaloplaxum**	B				M	B,M						
Protoperidinium brochii	B		B		B,M	B,M						
*Protoperidinium conicoides**					B,M	M						M
*Protoperidinium elegans**	B											
Protoperidinium globulus	B	M	B		M			M	M	B		
Protoperidinium granii		M								B, M		
Protoperidinium lipopodium		B	B			M						
*Protoperidinium pacificum**		M	B									
*Protoperidinium rampii**	B											
Protoperidinium steinii	B	B	B			B,M	B	B	M		M	
Protoperidinium symmetricum								B,M				

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