

**NEW RECORD FOR ASIA-PACIFIC OF *Protoberidinium anomaloplaxum*
(Peridinales, Dinophyceae) FROM VIETNAMESE WATERS**

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ABSTRACT

Minusculum (Lebour) Balech is one of four subgenera of the genus *Protoberidinium* Bergh 1881. Only five species of this subgenus have been discovered worldwide, most of which are distributed in cold waters. In this study, *Protoberidinium anomaloplaxum* (Balech) Balech is reported from Vietnam and thus for the first time from Asia-Pacific waters. This species is illustrated with line drawing, light and scanning electron microscopic photographs and described details of the ornamentation of the thecal plates as well as its geographic distribution.

Keywords: *Minusculum*, *Protoberidinium*, Asia Pacific Ocean, distribution, new record, Vietnam.

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INTRODUCTION

Protopteridinium is the largest genus of dinoflagellates and occurs in all the oceans of the world (Balech, 1988). Balech (1974), when re-instating the genus *Protopteridinium* Bergh (1881), had transferred 231 marine species of *Peridinium* Ehrenberg (1830) to the *Protopteridinium*. He further subdivided the genus *Protopteridinium* into three subgenera based on the number of anterior intercalary plates and precingular plates: *Minusculum* (6 precingular and 3 intercalary plates); *Archaeperidinium* (7 precingular, 2 intercalary plates); and *Protopteridinium* (7 precingular, 3 intercalary plates). Faust (2006) later erected the subgenus *Testeria* Faust which has 7 precingular plates and 1 intercalary plate and no apical pore, for the *Protopteridinium* species.

The subgenus *Minusculum* comprises only five species: *P. adulterum* and *P. defectum* are endemic species to the Antarctic (Balech, 1974, 1988), *P. bipes* occurs in the Western Atlantic Ocean and Subantarctic waters (Balech, 1988), and *P. anomaloplaxum* found in Argentinean (Balech, 1988) and Brazilian waters (Jardim & Cardoso, 2013). Recently, *Protopteridinium smithii*, a new species belonging to the subgenus *Minusculum*, has been described from the Ross Sea in Antarctica (Phan-Tan et al., 2018).

There were a number of studies on the genus *Protopteridinium* in Vietnamese waters. Species diversity of the subgenus *Protopteridinium* (sections *Conica*, *Tabulata*, and *Oceanica*) and subgenus *Archaeperidinium* has been studied by Phan-Tan et al. (2016a,b, 2017). The ecology of the genus *Protopteridinium* (Nguyen Luong Tung et al., 2017) was done for Con Dao Island.

In this paper, *P. anomaloplaxum* is reported for the first time from Vietnamese waters and it is also the first report of the species of the subgenus *Minusculum* from tropical waters. We present light and scanning electron microscopy of *P. anomaloplaxum* and describe details of the ornamentation of the thecal plates.

MATERIALS AND METHODS

Sampling

Phytoplankton samples were collected with vertical net hauls (20 µm mesh size and net diameter 30 cm) from near the ocean floor to the surface in different locations of Vietnamese coastal waters. Samples were fixed with formaldehyde to a final concentration of approximately 5% and then stored in 25 ml dark glass bottles, reserved at the Institute of Oceanography, Nha Trang, Viet Nam.

Analyses of samples

The samples were examined under a Leica LDMB light microscope and by scanning electron microscopy (SEM). Observations of plate patterns were made with Calcofluor White M2R according to Fritz & Triemer (1985). Digital camera Olympus DP71 was used for light and epifluorescence microphotography.

For SEM observation, cells of *Protopteridinium* were isolated from preserved samples and placed on a 5 µm carbon membrane filter, rinsed with distilled water, dehydrated through an ascending ethanol series (15, 30, 50, 70, 2x 96% and 2x absolute ethanol) and air dried. The filter was mounted onto an aluminum stub with carbon tape and finally sputter coated with gold. The stubs were examined on a Hitachi FM-SEM (model S4800 Field Emission-Scanning Electron Microscope) at the National Institute of Hygiene and Epidemiology (NIHE), Ha Noi, Vietnam.

RESULTS AND DISCUSSION

Systematics

Class Dinophyceae Pascher, 1914

Order Peridiniales Haeckel, 1894

Family Protopteridiniaceae Balech, 1988

Genus *Protopteridinium* Bergh, 1881

Subgenus *Minusculum* (Lebour, 1925) Balech, 1974

***Protopteridinium anomaloplaxum* (Balech, 1964) Balech, 1974**

Members of this subgenus are characterized by their small size, strongly asymmetrical epitheca with four apical plates, three anterior intercalary plates, and only six

precingular plates. The 6'' plate is large and extends to the dorsal side of the cell and overlaps partially or totally the 5'' plate (Balech, 1974, 1976, 1988).

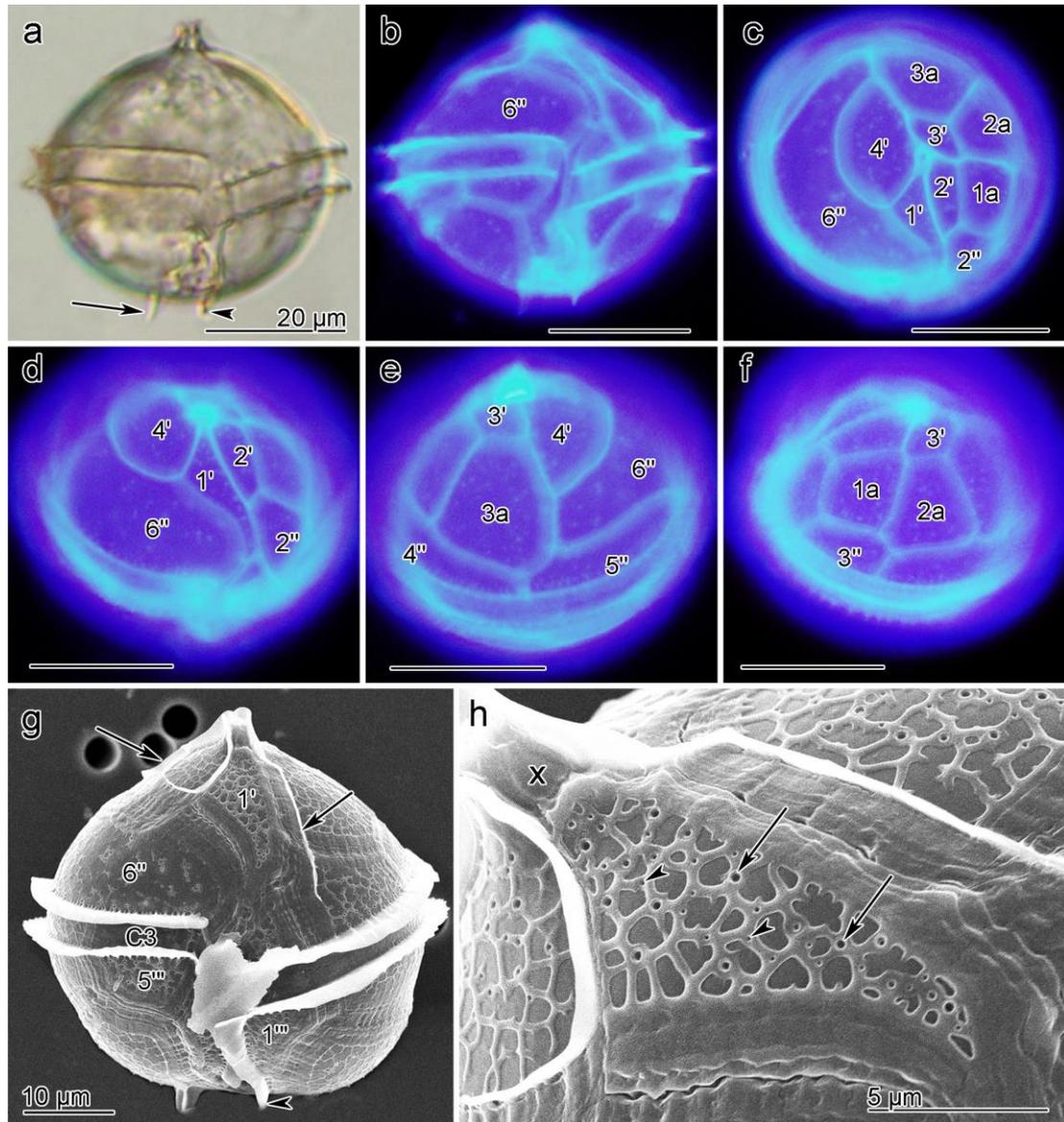


Figure 1. Protoperidinium anomaloplaxum: a (LM), b (Epi) & g (SEM): a cell in ventral view showing the descending cingulum, plate pattern of thecal plates, right antapical wing spine (arrow), and left sulcal list (arrowhead), ornamentation of the thecal plates, narrow membrane along the sutures of apical plates (arrows), and wide striated intercalary bands; c (Epi): showing plate patterns of epitheca in apical view; d (Epi): showing the epitheca plate patterns in ventral view; e & f (Epi): showing the intercalary plates (1a, 2a, and 3a) in lateral view; h: (SEM): part of the theca with reticulation, pores of the varying size (arrows and arrowheads) and canal plate (x). Epi: epifluorescence, LM: light microscope, and SEM: Scanning electron micrograph

Redescription of species

Protoperidinium anomaloplaxum
(Balech, 1964) Balech, 1974 (Figure 1a–1h,
2a–2c)

Basionym: *Peridinium anomaloplaxum*
Balech, 1964

Balech, 1964: p. 28, pl. III (34–46);
Balech, 1974: p. 53; Balech, 1988: p. 82, pl.
22, Figs. 9, 11–13; Jardim & Cardoso, 2013:
634, Fig. 1H & I.

Description: The cells have napiform,
wider than long (Figs. 1a, b, g, 2a, b) with a
total length (including antapical spine) of 43–
47 μm , 38–40 μm length, 40–45 μm wide,
and 30–32 μm dorso-ventrally. The epitheca
has short apical neck without an apical horn
(Figs. 1a, 1b, 1g, 2a, 2b). There is a
membrane along the sutures of apical plates
(Figs. 1g, 2a, 2b). Plate 1' has five sides
(meta-type), long and narrow, very
asymmetrical, with the right posterior side
being strongly concave (Figs. 1b–1d, 1g, 1h,
& 2a–2c). There are six precingular plates, the

plate 6'' is exceptionally large, and extends
onto the dorsal side of the cell (Figs. 1c–1e,
1g, 2a–2c). There are three anterior intercalary
plates with the plate 2a of the penta-type. Due
to the asymmetrical tabulation the intercalary
plates lie on the left side of the cell (Figs. 1c,
2c). The cingulum descends about one girdle
width (Figs. 1a, 1b, 1g, & 2a, 2b) and is
bordered by wide lists supported by spines
(Figs. 1e–1g, 2c). The cingular plate C1 very
narrow, plate C3 is narrow (Figs 1b, 2b) or
wide (Figs 1g, 2a), and plate C2 is wide and
surrounding more or less the whole cell
(Figs 1b & 1g, 2b). The hypotheca is
hemispherical with only one antapical wing-
spine on the right and a left sulcal list
extended looking as a spine (Figs. 1a, 1g, 2a,
2b). The sulcus expands distally more towards
the right than towards the left (Figs. 1b, 1g, &
2a, 2b). The surface of the thecal plates is
ornamented with reticulation and pores of the
varying size (Figs. 1g, 1h). Our observations
showed that the sutures with wide striated
intercalary bands (Figs. 1g–1h).

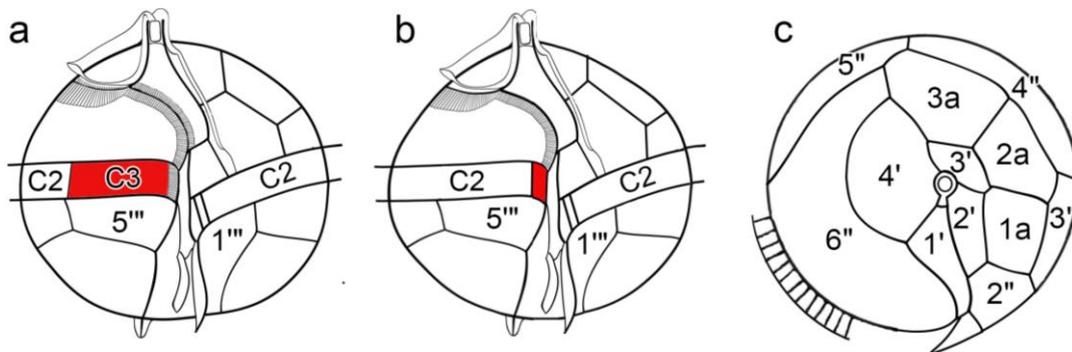


Figure 2. *Protoperidinium anomaloplaxum*: line drawing in ventral view showing wide cingular plate C3 (a), very narrow C1 and C3 plates (b), and the plate patterns of epitheca in apical view (c)

Morphological notes

The shape and tabulation of the Vietnamese material of *Protoperidinium anomaloplaxum* is identical to the type description, *Peridinium anomaloplaxum* Balech, 1964. The cingular plates C1 and C3 were very narrow (Figs. 1b & 2b) (Balech, 1964, p. 29, pl. III, Figs. 34, 41; Balech 1988,

pl. 22, Fig. 9). However, in a few cases, cells have wide cingular plate C3, nearly equal to the fifth postcingular (5''') plate (Figs. 1g & 2a). *Protoperidinium anomaloplaxum* is similar to *P. adulterum* with regard to the shape of the cell. However, the present species has a 2a-plate of the “penta-type”, one antapical spine and a list lining the left side of the sulcus; whereas *P. adulterum* has a 2a-

plate of the “quadra-type” and two antapical spines in addition to a sulcal list (Balech, 1974, 1988).

Yamaguchi et al. (2007) questioned the taxonomic status of the subgenus *Minusculum* as molecular data suggested that *Protoperidinium* (*Minusculum*) *bipes* should be included in the subgenus *Protoperidinium*. However, there are distinct morphological differences between the two subgenera (Phan-Tan et al., 2016b, 2017, 2018). The molecular data presented by Yamaguchi et al. (2007) also suggested that *P. pentagonum* which appears to morphologically belong to the *Conica*-group is related closer to the *Divergentia*-group. In our opinion, these discrepancies between the molecular data and the morphology of the species need to be clarified further before taxonomic conclusions can be drawn.

Ecology and Distribution

According to Balech (1988), *P. anomaloplaxum* has a particular distribution occurring between 37°39'S-38°42'S and 53°33'W-57°20'W in the waters off Mar del Plata, Argentina at temperatures from 14.6 to 18.0°C, and salinities from 35.0 to 36.114 psu. Jardim & Cardoso (2013) found *P. anomaloplaxum* in the Rio Grande do Sul, Brazil (29°59'05" S, 50°08'01" W) at temperatures from 14.5 to 23°C, salinities from 21.5 to 27.8 psu. In this study, *P. anomaloplaxum* has been found in Vietnam in the waters off Da Nang, Nha Trang Bay, and in the coastal waters of Con Dao Island at temperatures from 26 to 29°C, and salinities from 33 to 34 psu.

CONCLUSION

P. anomaloplaxum of the subgenus *Minusculum* is reported for the first time in Vietnamese waters and also the first report in tropical waters. The species was previously only found in temperate waters of Argentina and Brazil and now in tropical waters showing its wide distribution and would be found in other waters. However, since it was only reported three times, this species may be considered as a rare species. Our finding is

presently contributing to knowledge on the morphology and distribution of the species in the world.

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