

***Prorocentrum vietnamensis* sp. nov. (Prorocentraceae Dinophyta): A New Armored Dinoflagellate from Vietnam Coastal Waters**

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The *Prorocentrum* species, which are primarily marine, are distributed worldwide and occur in ocean, neritic, and littoral environments. *Prorocentrum* is either a planktonic or benthic genus, with some species possibly being both. Until now, about 35 species had been reported including two that are fresh-water. Some species contain toxic substances. As one of many currently active studies, we collected *P. vietnamensis* sp. nov. from Hon Mé, Gulf of Tongkin, Vietnam. Based on its cell shape, smooth valve surface, arrangement of valves and marginal pores, plus characteristics of the central pyrenoid, we propose that *P. vietnamensis* is a new species. Its attributes include straight cell sides that are parallel to each other, as well as anterior and posterior areas with rounded ends that form a short, rod-shaped cell that is unique to this species.

Keywords: morphology, *Prorocentrum vietnamensis*, taxonomy, Vietnam

Prorocentrum species are distributed worldwide and are important ecosystem components (Steidinger, 1983; Faust, 1997). These species, which are mostly marine or estuarine (Dodge, 1975; Croome and Tyler, 1987; Faust, 1997), can be planktonic, benthic, or both (Fukuyo, 1981; Dodge, 1982; Faust, 1991). None of the reported species have any known fossil records (Fensome et al., 1993), nor do form cysts.

Prorocentrum (Ehrenberg, 1833) is one of the oldest taxa. Originally, *Prorocentrum* Ehrenberg and *Exuviaella* Cienkowski were distinguished by the presence or absence of an apical spine (Schiller, 1933). However, Abé (1967) suggested that both these genera could be placed under *Prorocentrum*, stressing that no taxonomic demarcation existed, because many intermediate forms and one incompletely explored aberrant had been recorded. Later, Dodge (1975) revised the genus *Prorocentrum* to include *Exuviaella*, while also reducing 64 known species to 21 and dividing the genus into five sections according to morphological characteristics. Those groupings were based on the existence of valve ornamentation (i.e., spinules, depressions, trichocyst pores), anterior spines, and cell shape. Following that revision, 16 benthic and 2 freshwater species of *Prorocentrum* were newly described (Fukuyo, 1981; Croome and Tyler, 1987; Faust, 1997). Steidinger and Tangen (1996) then further differentiated the species of this genus according to size and shape, presence

of apical process, shape of periflagellar area, number and pattern of periflagellar plates, number and size of aerolae or poroids, pore pattern, and markings on intercalary bands. Recently, some species of *Prorocentrum* have been found to contain a ciguatera-related toxin and okadaic acid (Murakami et al., 1982; Taylor et al., 1995). In the study presented here, we describe a new species, *Prorocentrum vietnamensis*, that was obtained in Vietnam coastal waters. This species is distinguished by its cell shape as well as the number and arrangement of valve and marginal pores.

MATERIALS AND METHODS

We used a 20 µm mesh-sized plankton net to collect samples of unidentified *Prorocentrum* at a 10-m depth at Hon Mé, Gulf of Tongkin (18°74'54"N, 105°83'85"E), Vietnam, in October of 1997. Taxonomic observations were made under a light microscope with differential interference contrast optics. The valves were examined after separating the theca in a sodium hypochlorite solution and staining it with chloral hydrate KI-I₂ (Yoo et al., 2000).

RESULTS AND DISCUSSION

***Prorocentrum vietnamensis* Yoo and Fukuyo sp. nov. (Fig. 1)**

Diagnosis: Cellulae photosyntheticae, brevis bacilli-

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formis, 42 to 50 μm longae et 36 to 42 μm latae. Uterque valvae poris 58 to 72 centralibus et 65 to 75 marginibus. Apex valvae dextrae area periflagellare V-formata latae. Porus flagellaris et porus auxiliaris inaequalis. Porus flagellaris magnus et porus apicalis parvulus et sine spina apicale et vllum apicale. Nucleus in regione postica cellulae. Pyrenoides in regione centralis.

Type locality: Vietnam. At Hon Mé in the Gulf of Tongkin; species associated with floating detritus, October 1997. Mr. Chu Van Thuoc of the Haiphong Institute of Oceanology, National Center for Natural Science and Technology of Vietnam.

Holotype: Slide No. Y4404 (Fig. 1-1), deposited at the Research Institute of Marine Science and Technology, Korea Maritime University.

Isotype: Y4407 (Fig. 1-2), Y4411 (Fig. 1-3), Y4414 (Fig. 1-4). Research Institute of Marine Science and

Technology, Korea Maritime University.

Etymology: Designating the origin of the collection area.

Prorocentrum vietnamensis is about medium in size compared with other species in this genus. It is short and rod-shaped in its valve view, and has very straight sides (Fig. 1-1). The thecal surfaces of the two valves are smooth except for the pore openings. Valve pores, which number 58 to 72 per valve, are distributed unevenly except in the central area (Fig. 1-3). Marginal pores are generally rod-shaped and evenly spaced in a row on the cell flange. The number of marginal pores ranges from 65 to 75 on each valve (Fig. 1-3 and 1-4). The anterior end of the cell is indented; the right valve has a broad V-shaped depression on the periflagellar area (Fig. 1-1 and 1-4). The anterior end of the left valve is irregularly shaped, having a flat to slightly concave formation (Fig. 1-2). *P. vietnamensis* has a clear pyrenoid in the center of each valve, and also possesses a posterior nucleus.

Dodge (1975) revised this genus based on the presence or absence of valve ornamentation, anterior spines, and cell shape. Faust (1997) further rearranged 18 species of benthic *Prorocentrum* according to cell size, ornamentation, pore arrangement, apical area, and metacytic zone. Some dinoflagellate groups cannot be easily delineated by cell shape. For example, the *Alexandrium* species are almost impossible to distinguish only by shape (Balech, 1995; Taylor et al., 1995), whereas the *Ceratium* species have extensive morphological variations according to growth stage and habitat (Reinecke, 1973). Nevertheless, except for some similar species such as *Prorocentrum lima*, *P. minimum*, and *P. concavum* (Hulburt, 1965; Yoo, 2004), cell shape is the most important taxonomic key for classifying members of this genus.

The *Prorocentrum* species previously described had cells that were ovate, rotundate, elliptic, cordiform, or lanceolate (Dodge, 1975; Fukuyo, 1981; Faust, 1997). However, *P. vietnamensis* has short, rod-shaped cells with round anterior and posterior ends, as well as parallel cell sides that differ greatly from the currently known, general shape for this genus (Table 1). Those species with pore arrangements on the surface that exclude the central area include *P. vietnamensis* sp. nov., *P. caribbaeum*, *P. maculosum*, *P. emaginatum*, *P. lima*, and *P. concavum* (Fukuyo, 1981; Faust, 1993a,b). The first three are radially arranged types while *P. concavum* is distinguished by its 1,000 to 1,100 areolae per valve and a lack of marginal pores (Faust, 1990). Although *Prorocentrum lima* shares some common characteristics with *P. vietnamensis*, e.g., valve arrangement, mar-

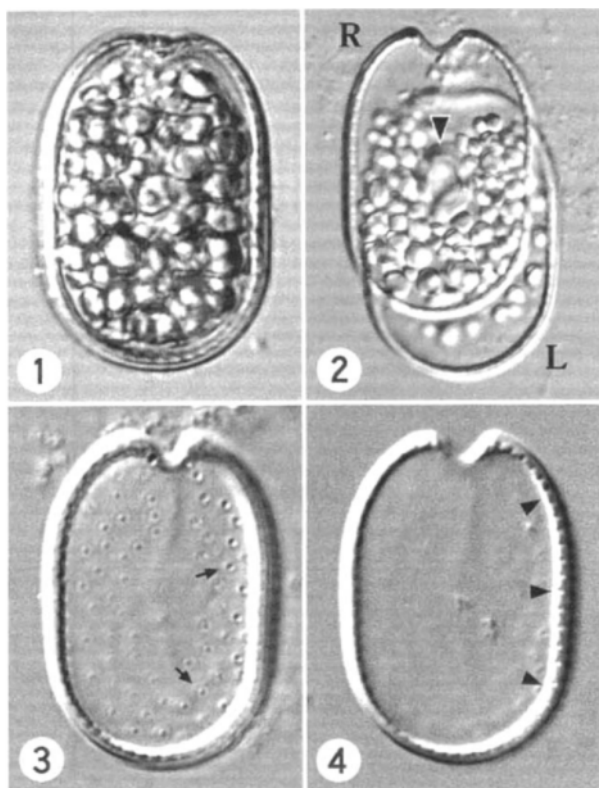


Figure 1. Light microscopy with differential interference contrast optics of *Prorocentrum vietnamensis* sp. nov.. (1) Cells are short and rod-shaped, and have straight, parallel sides. (2) Right valve (R), periflagellar area at anterior cell end; Left valve (L), anterior end of left valve is asymmetrical and slightly concave. Arrow indicates pyrenoid in center of valve. (3, 4) Unevenly distributed valve pores. Center of valve is devoid of pores, and evenly spaced marginal pores are located at margin of cell (arrow, valve pore; arrow head, marginal pore).

Table 1. Comparison of major morphological characteristics in some marine *Prorocentrum* species. Characters are designated as present (+) or absent (-). Shape; oval or ovate (1), pyriform (2), roundish (3), broadly oblong (4), triangular (5), short rod (6), posterior attenuation (7), and posterial end is pointed (8); apical spine (9), valve onamentaion; areolate (10), reticulate (11), smooth dpression (12), smooth (13), and valve spine (14), valve pore (15), radially arranged (16), scateeted pore arranged (17) and uncomplicatedlly arranged.

species	Morphological Characters																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Lenth
<i>P. arenarium</i>	-	-	+	-	-	-	-	-	-	-	-	-	+	-	+	-	+	-	30~32
<i>P. balticum</i>	+	-	+	-	-	-	-	-	+	-	-	-	-	+	+	-	+	-	9~10
<i>P. belzeanum</i>	+	-	-	-	-	-	-	-	+	-	-	-	-	+	-	+	-	-	55~60
<i>P. caribbaeum</i>	-	+	-	-	-	-	+	-	+	-	-	+	-	-	+	+	-	-	40~45
<i>P. compressum</i>	+	-	+	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	30~50
<i>P. concavum</i>	+	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	50~55
<i>P. dentatum</i>	-	-	-	+	-	-	-	+	-	-	-	-	-	+	-	-	-	-	36~60
<i>P. elegans</i>	+	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	+	15~20
<i>P. emarginatum</i>	+	-	-	-	-	-	-	-	+	-	-	-	+	-	+	+	-	-	30~40
<i>P. gracil</i>	-	+	-	-	-	-	+	+	+	-	-	+	-	-	+	-	+	-	40~60
<i>P. hoffmannianum</i>	+	+	-	-	-	-	-	-	-	+	-	-	-	-	+	-	+	-	45~55
<i>P. lima</i>	+	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	+	-	31~47
<i>P. maculosum</i>	+	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	+	-	40~50
<i>P. mexicanum</i>	+	-	-	-	-	-	-	-	+	-	-	+	-	-	+	+	-	-	30~38
<i>P. micans</i>	-	+	-	-	-	-	+	+	+	-	-	+	-	-	+	+	-	-	35~70
<i>P. minimum</i>	+	-	-	-	+	-	-	-	+	-	-	-	-	+	+	-	+	-	14~22
<i>P. reticulatum</i>	+	-	-	-	-	-	-	-	-	-	+	-	-	-	+	-	+	-	55~60
<i>P. ruetzlerianum</i>	+	-	+	-	-	-	-	-	-	+	-	-	-	-	+	-	+	-	28~35
<i>P. sabulosum</i>	+	-	+	-	-	-	-	-	-	+	-	-	-	-	+	-	-	-	48~50
<i>P. sculptile</i>	+	-	-	-	-	-	-	-	+	-	-	+	+	-	+	-	-	-	32~37
<i>P. triestinum</i>	-	+	-	-	-	-	+	+	+	-	-	-	+	-	+	-	+	-	18~22
<i>P. tropicalis</i>	+	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	+	-	50~55
<i>P. venetum</i>	-	-	-	-	+	-	-	-	+	-	-	-	+	-	+	-	-	+	19~21
<i>P. vietnamensis</i>	-	-	-	-	-	+	-	-	-	-	-	-	+	-	+	-	+	-	42~50

Sources of information: Dodge (1975), Tolomio and Cavolo (1985), Steidinger and Tangen (1996), Faust (1997), and this paper.

ginal pores, and a clear central pyrenoid, the former is clearly distinguished by its wide ovoid-shaped central inferior area. In fact, *P. vietnamensis* is the only species in the genus having short, rod-shaped cells with very straight sides.

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