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THE DINOFLAGELLATE GENUS *PROROCENTRUM* (PROROCENTRALES, PROROCENTRACEAE) FROM THE NORTH ARABIAN SEA

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Abstract

The present paper reports the occurrence of four species of *Prorocentrum* viz., *P. compressum, P. gracile, P. rhathymum* and *P. micans* from the North Arabian Sea shelf of Pakistan. *P. micans* was the only bloom forming species found and *P. compressum* was more common than other species.

Introduction

The dinoflagellate genus *Prorocentrum* Ehrenberg is one of the most diverse and wide spread genus in marine tropical areas (Böhm, 1936; Wood, 1963, Faust *et al*., 1999; Hernández-Becerril *et al*., 2000). It belongs to the family Prorocentraceae Stein and includes 56 marine species (Gómez, 2005). Most of the members of this genus are marine, planktonic and benthic and some are known to cause toxic blooms that represent physical danger (Steidinger & Tangen, 1997; Faust & Gulledge, 2002; Cohen-Fernandez *et al*., 2006). Identification at the species level within the genus is often difficult and mainly based on gross morphology examined by Light Microscope (LM). Some morphological characters of taxonomical value can only be noticed in detail using Scanning Electron Microscope (SEM).

In contrast to some other genera of dinoflagellates, fewer studies have been executed on the genus *Prorocentrum* in the Arabian Sea (Kuzmenko, 1975; Taylor, 1976) especially on Pakistan's shelf (Hassan & Saifullah, 1971). The main objective of this study is to give latest information on the morphology, taxonomy and distribution of *Prorocentrum* taxa in North Arabian Sea Shelf of Pakistan.

Materials and Methods

The present work is based on the samples that were collected during the cruise of Norwegian research vessel, "Dr. Fridtjof Nansen" carried out jointly by Pakistan and Norwegian governments. This cruise lasted for 6 months covering a period of 19.01.1977 to 20.6.1977. The ship surveyed the Pakistani waters, between the 15m-depth contour and 150 nautical miles offshore. 230 standard stations were sampled repeatedly from several depths. Temperature and salinity were measured by reversible a thermometer and salinometer respectively during the cruise (Anon, 1978). The details of sampling methods and position of stations are given elsewhere (Gul, 2004).

The phytoplankton samples were collected by horizontal net tow of five minutes duration with mesh size of 40µm. After collection all phytoplankton samples were immediately fixed with 4% formalin. Water samples mount by using trypan blue were examined to obtain information on plate patterns to aid species identification and photographs were taken by digital camera and some samples were mounted on stubs for scanning electron microscope (Jeol-JSM-6380 LV. Japan) for detailed identification. Ocular micrometer was used for measuring the size. Slides were prepared in a drop of glycerine and edges of cover slips sealed with nail polish. They were also stained with cotton blue for better result.

Observations

Prorocentrales Lemmermann

Prorocentraceae stein

***Prorocentrum* Ehrenberg:** Small to medium sized cells; cell shape elongate-oval, anterior end mostly pointed with spinous projection at pole; posterior end acute, theca consist of two porulate plates, two anterior flagella.

*Prorocentrum compressum (*Bailey) Abé *ex* Dodge: Figs. 1a, b

Steidinger & Williams, 1970, p. 60, fig.133; Taylor, 1976, p. 21, pl.1, Figs. 8, 9; Steidinger & Tangen, 1997, p. 420, pl. 9.
Syn: *Exuviaella compressa* (Bailey) Ostenfeld
Body broadly elliptical, broadest in the middle, base round, anterior end has two thick small spines; thecae with rows of pores.

Dimensions
Length: 35-50µm
Width: 20-30 µm
Length of spine: 5-7 µm

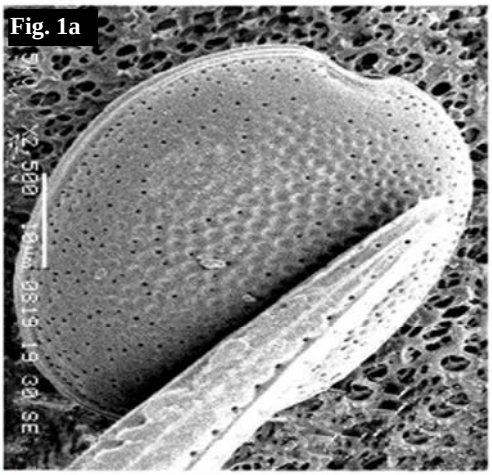
Local distribution: Pakistan's shelf. 30, 103, 112, 114, 116, 130, 140, 143, 148, 153, 165, 204, 254, 286, 288, 301, 319.

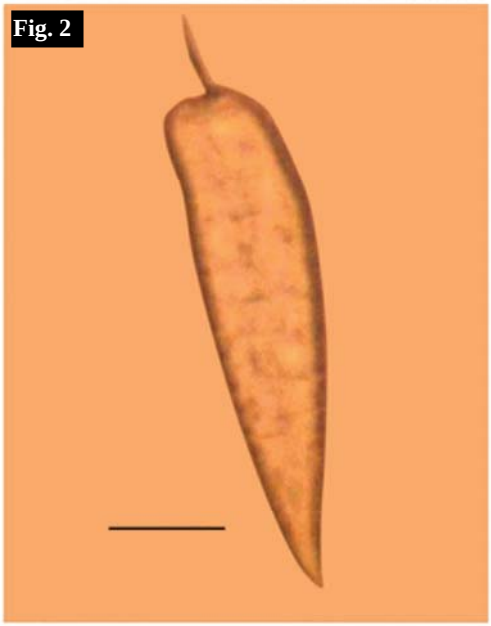
Geographical distribution: Indian Ocean (Taylor, 1976) South Pacific Ocean (Gómez *et al*., 2008).

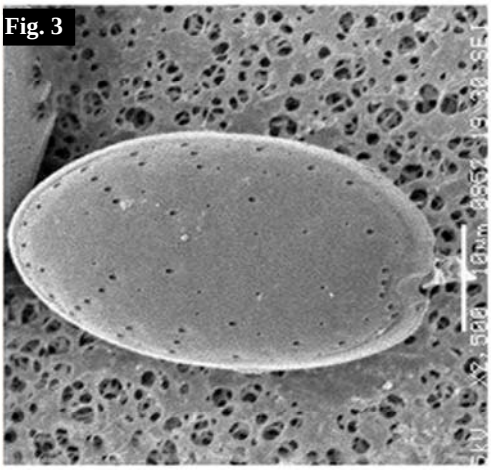
Prorocentrum gracile Schütt Fig. 2

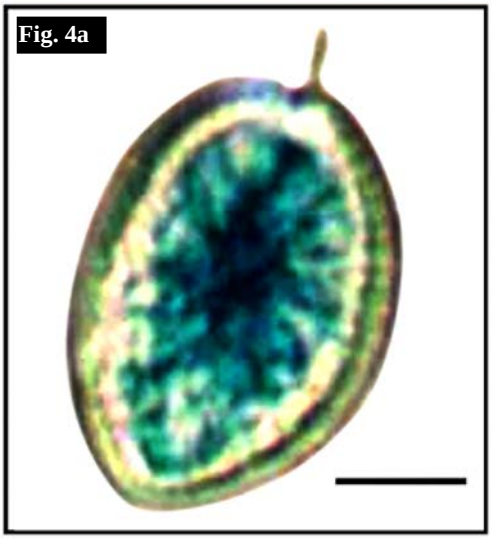
Schütt, 1895, pl.1, Fig.3; Schiller, 1933, p.37, Figs. 39a,b; Taylor, 1976, p. 22, pl.1, Fig. 2; Hernández-Becerril, 1988, p.424, Fig. 2; Steidinger & Tangen, 1997, p. 423, pl. 8.

Body elongate and lanceolate, anteriorly rounded and posteriorly pointed; widest about one-third of the distance from apex; a spine attached anteriorly which is long sigmoid and winged; poroids distributed all over the thecae.









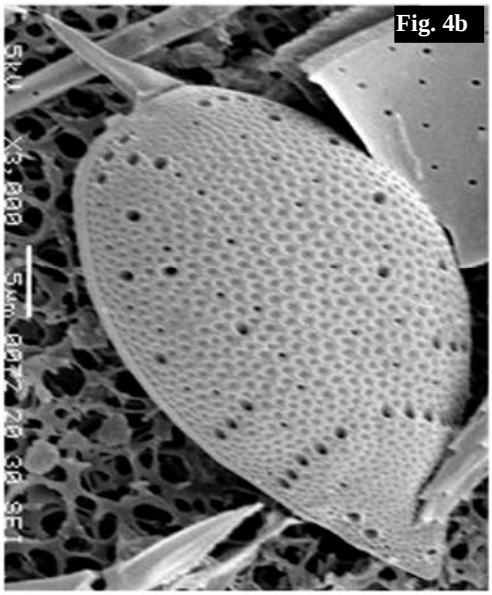


Fig. 1a,b. *Prorocentrum compressum*
Fig. 2. *Prorocentrum gracile* (Scale Bar= 25 µm)
Fig. 3. *Prorocentrum rhathymum*
Fig. 4a. *Prorocentrum micans* (Scale Bar= 18 µm)
Fig. 4b. *Prorocentrum micans*

Dimensions
Length: 45-60µm
Width: 20-30 µm
Length of spine: 7-10 µm

Local distribution: Pakistan's shelf, 09, 82, 216, 267.

Geographical distribution: Red Sea (Ostenfeld & Schmidt, 1901); Arabian Sea, Indian Ocean (Schröder, 1906); Caribbean Sea (Wood, 1968); Indian Ocean (Taylor, 1976); Mexican Pacific Coast (Hernández - Becerril *et al*., 2000; Cohen-Fernandez *et al.,* 2006).

***Prorocentrum rhathymum* Loeblich III, Sherley & Schmidt**
Fig. 3

Loeblich *et al*., 1979; Fukuyo, 1981, p. 968, Figs. 5-7, 47; Cortès-Altamirano & Sierra-Beltran, 2003, p. 221-225, Fig.1; Aligizaki *et al*., 2009, p. 305, Fig. 7; Cohen-Fernández *et al*., 2010, p. 35.

Cell oval with rounded margins, circular in outline with thick theca, theca surface smooth with numerous trichocyst pores laying in shallow depressions; apical tooth with or without thin spine.

Dimensions
Length: 30-40 µm
Width: 18-24 µm

Local distribution: Pakistan's shelf, 80, 109, 155, 204, 207, 214, 236, 254, 255, 259, 286, 298, 300, 303, 319.

Geographical distribution: South Pacific Ocean (Gómez *et al*., 2008); Greek and Italian coastal waters (Simoni *et al*., 2004, Dolapsakis *et al*., 2008, Aligizaki *et al*., 2009).

***Prorocentrum micans* Ehrenberg**
Figs. 4a, b

Schiller, 1933, p. 35, Fig. 37; Dodge, 1975, p. 112, pl. 2 A-C, Fig. 3A; Taylor, 1976, p. 23; Steidinger & Tangen, 1997, p. 424, pl. 8; Hernández-Becerril *et al.*, 2000, p. 116, Fig. 21.

Cells medium sized, elliptical, tear-shaped, compressed laterally, anteriorly rounded, concave, posteriorly pointed and middle portion wider; anterior end has prominent spine.

Dimensions
Length: 35-70 µm
Width: 22-35 µm
Length of spine: 8-12 µm

Local distribution: Pakistan's shelf, 80, 88, 107, 164, 192, 199, 267, 300, 303.

General distribution: Red Sea (Ostenfeld & Schmidt, 1901); Arabian Sea, Red Sea (Schröder, 1906); Caribbean Sea (Wood, 1968); Indian Ocean (Taylor, 1976); Mexican Pacific Coast (Cohen-Fernandez *et al*., 2006).

Discussion

The genus *Prorocentrum* Ehrenberg is a desmokont dinoflagellate, which is characterized by apical insertion of the flagella and absence of cingulum and sulcus (Hernández-Becererril *et al*., 2000). The cell consists of two lateral thecae which are joined by marginal edges (Fensome *et al.,* 1993; Steidinger & Tangen, 1997).

P. compressum (Figs. 1a, b) is a planktonic species and it resembles closely with the specimens described by Taylor (1976). Dodge (1975) and Cohen-Fernandez *et al.,* (2006) consider *Prorocentrum sigmoides* to be synonymous with *P. gracile*. The former species is similar to the latter species except that *P. gracile* (Fig. 2) is concavely depressed along one seam margin and in having an apical depression with regular and trichocyst pores (Tafall, 1942).

P. rhathymum (Fig. 3) is a photosynthetic, toxic and epibenthonic species (Cortés-Altamirano & Sierra-Beltrán, 2003; Pearce *et al*., 2005; Cohen-Fernández *et al.*, 2010). It was for a long time considered as a synonym of *P. mexicanum* (Steidinger, 1983; Faust, 1990), but differs on the basis of pore arrangement and number of horned spines. The pores are arranged in organized pattern in the *P. mexicanum* while disorganized in *P. rhathymum* (Cortés-Altamirano & Sierra-Beltrán, 2003, Aligizaki *et al*., 2009). Moreover, former species has 2 to 3 horned spines whereas latter species only one simple spine which is the main difference.

The cosmopolitan *P. micans* (Figs. 4a,b) is the type species of the genus (Ehrenberg, 1835). Although it is capable of producing extensive blooms, it is usually considered harmless (Taylor & Seliger, 1979; Graneli *et al*., 1990). It is similar to that described by Hassan & Saifullah (1971). *P. micans* and *P. gracile* differ from each other on the basis of body size and patteren of pores which is slightly different. Besides, *P. gracile* is more elongated than *P. micans* and broader than *P. gracile*.

P. compressum, P. gracile and *P. micans* are cosmopolitan (Taylor, 1976; Steidinger & Tangen, 1997). *P. rhathymum* is a benthic species and occurs preferably in the tropical waters (Taylor, 1987; Licea *et al.,* 2004).

Generally most species were either neritic or neritic-oceanic (Wood, 1968) because the study area included mostly the shelf area and partly deep sea vicinity.

Species diversity was higher towards the Indus delta and less towards the Balochistan shelf because the former area was more heterogeneous in environmental parameters than the later (Anon, 1978; Saifullah, 1979). The intrusion of Indus river water into the delta disturbs the uniform temperature and salinity regimes, causing heterogeneity in the delta area, which favours high diversity.

High temperature and low salinity values are known to favor growth of dinoflagellates (Qasim *et al.,* 1972; Joseph & Pillai, 1975; Dodge & Marshall, 1994). It is evident (Fig. 5) that most species were eurythermal occurring in wide range except *Prorocentrum gracile*. As regard the salinity tolerance it appears that all the species were stenohaline because the salinity values showed little variation during the period of study (35.7-36.8psu). Species of *Prorocentrum* occurred more frequently on the Indus delta shelf than on Balochistan shelf most probably because they prefer high temperature and lower salinity values. The discharge of Indus water in the delta is responsible for low salinity values (Table 1).

The study period included the NE monsoon season (Jan-March) and the spring intermonsoon period between the NE and SW monsoon season (April- June). A majority of the species occurred in the latter period (Table 1) indicating their preference for relatively higher temperatures.

Table 1. Number of stations occupied by different species in different seasons, areas and frequency of occurrence.

No.	Name of species	Seasonal occurrence		Different areas		Total stations	Frequency of occurrence (%)
		N-E monsoon (Jan. to Mar.)	Transition period (Apr to Jun)	Indus delta	Balochistan		
1.	*P. compressum*	07	10	10	07	17	7.39
2.	*P. gracile*	01	02	01	02	03	1.304
3.	*P.rhathymum*	04	11	11	04	15	6.522
4.	*P. micans*	03	06	06	03	09	3.913

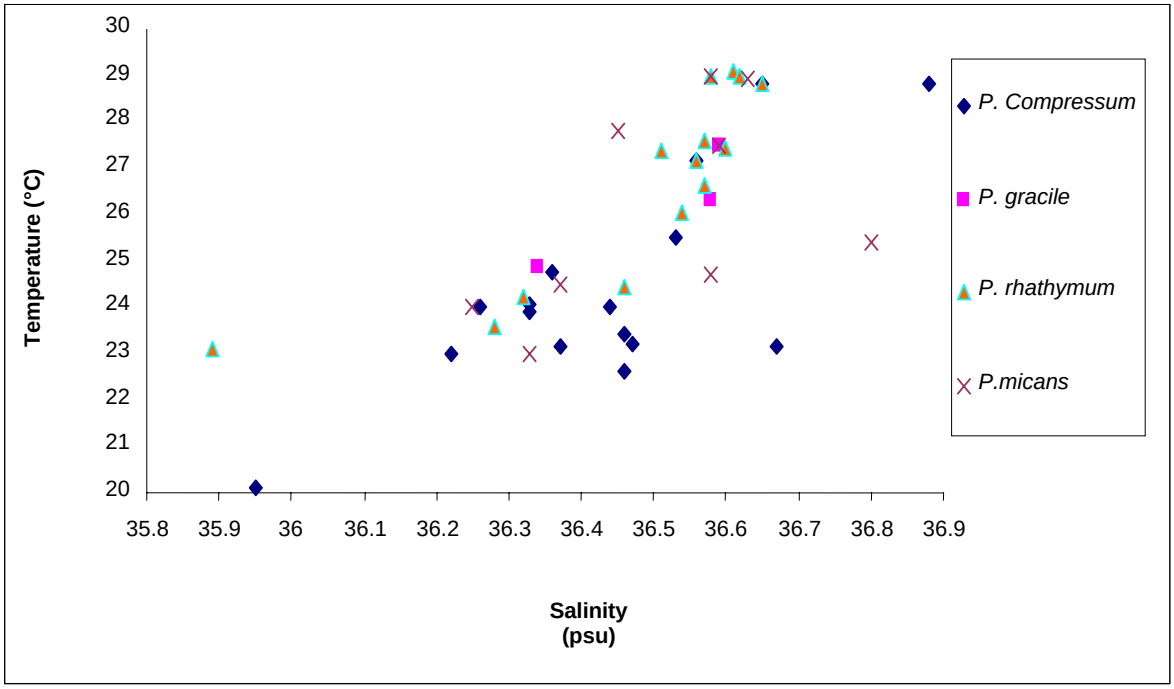


Fig. 5. Temperature and salinity diagram of the occurrence of *Prorocentrum* species in the North Arabian Sea.

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