

Morphological Re-examination of *Prorocentrum* spp. in Korean Coastal Waters

Eun-Young Shin, Hwan-Goo Yeo^{1,*} and Jong-Gyu Park²

Marine Living Resources Research Division, KORDI, Ansan 426-744, Korea

¹Department of Environmental Engineering, Hanseo University, Seosan 356-706, Korea

²Department of Ocean Information Science, Kunsan National University, Kunsan 573-701, Korea

Abstract – A taxonomic survey of the dinoflagellate family Prorocentraceae Stein was conducted on 17 locations off the coast of Korea. This monograph is the result of the microscopic analyses. A total of eight species have been identified and described, of which *Prorocentrum concavum* Fukuyo is new record for Korea.

Key words : dinoflagellate, *Prorocentrum*, new record for Korea

INTRODUCTION

In marine ecosystem, the phytoplankton community is mainly composed of two dominant algal taxa, diatoms and dinoflagellates, and they play an important role as a primary producer. Of these, dinoflagellates are known to cause red tide outbreaks and even to produce toxin. Recently, red tide events have frequently occurred in several embayments of the southern Korean coast and have brought serious damage to inshore fisheries. Thus, the red tide research activities including the taxonomy as well as distribution of toxic dinoflagellates have received ever increasing attention in Korean waters.

Yoo (1960, 1962) studying the phytoplankton species composition as a part of his study on the food of bivalve mollusks in Suyong (Soo-Young) bay, recorded for the first time in Korea, *Dinophysis* sp. and *Prorocentrum* sp. Since 1976, the inventories of phytoplankton, especially of dinoflagellate species, have carried out to clarify causative organisms of red tides in Korean waters by many scientists (Cho 1978; Cho 1979; Park 1979; Park 1980; Shim *et al.*

1981; Yoo 1982; Han and Yoo 1983a, b). Those researches were carried out basically with light microscopy. Later, using scanning electron microscopy, genus *Prorocentrum* was identified (Yoo and Lee 1986).

Among the dinoflagellates of Masan Bay, where known as the representative zone of recurring red tides in Korea, the genus *Prorocentrum* is the most predominant group throughout the year, and it includes some toxic species such as *Prorocentrum balticum* and *P. minimum*. In previous record, there were eight species of genus *Prorocentrum* in Masan Bay and the following three species have been already described, i.e., *Promcentrum micans*, *P. minimum* and *P. triestinum* (Yoo 1982). In spite of their importance in coastal waters, there are still many gaps in our knowledge on systematics of dinoflagellate in Korean waters as well as in Masan Bay. Therefore, it is necessary to conduct an extensive taxonomical study on red tide organisms in coastal zone of Korea.

The purpose of the present study is to clarify the fine structures of eight *Prorocentrum* species of Korean coastal waters using both light microscope (LM) and scanning electron microscope (SEM) and to describe each species with taxonomical notes.

* Corresponding author: Hwan-Goo Yeo, Tel. 041-660-1366.
Fax. 041-660-1119, E-mail. yeohg@hanseo.ac.kr

MATERIALS AND METHODS

Phytoplankton samples were collected from 17 locations near coastal areas of Korea from 1990 to 2002. Samples were vertically and horizontally obtained using plankton net, and fixed with 4% formalin or Lugol's solution. All samples were preserved and kept at the Marine Plankton Laboratory in Seoul National University, except Lugol fixed samples collected from Jinhae and Masan Bay which were deposited at the Coastal Ecosystem Research Laboratory in Korea Ocean Research and Development Institute (KORDI). The sampling locations are indicated in Fig. 1.

This monograph is the result of the microscopic analyses. Identification of dinoflagellates in water samples was usually done by using differential interference contrast (DIC), which revealed especially well the lighted thecal structures. The microscope was a Zeiss Axioskop microscope with a Mc 80 microphotosystem. For the apparent three-dimensional image, a scanning electron microscope (JEOL JSM-840A) was used. Authors consulted Taylor (1976), Balech (1976, 1988) and Dodge (1981, 1982) for the species identification.

RESULTS AND DISCUSSION

A total of eight species of the the family Prorocentraceae have been identified and described in this study.

Family Prorocentraceae Stein 1883

All species are armoured. The armour is divided by a longitudinal suture into two halves, each shaped more or less like a watch-glass. Transverse and longitudinal furrows are absent. Two flagella arise at the anterior end, one of them being directed forward during swimming, the other moving more or less spirally and thus perhaps comparable with the transverse flagellum of *Peridinium*. All species contain chloroplasts.

Genus *Prorocentrum* Ehrenberg 1833

Armored, but composed of 2 opposing thecas, with or without apical teeth or protrusions, but with apical platelet. Thecas typically with poroids, pores, reticulations, spines or other surface markings. Cell usually compressed laterally and with chloroplasts. Variously shaped from oval to

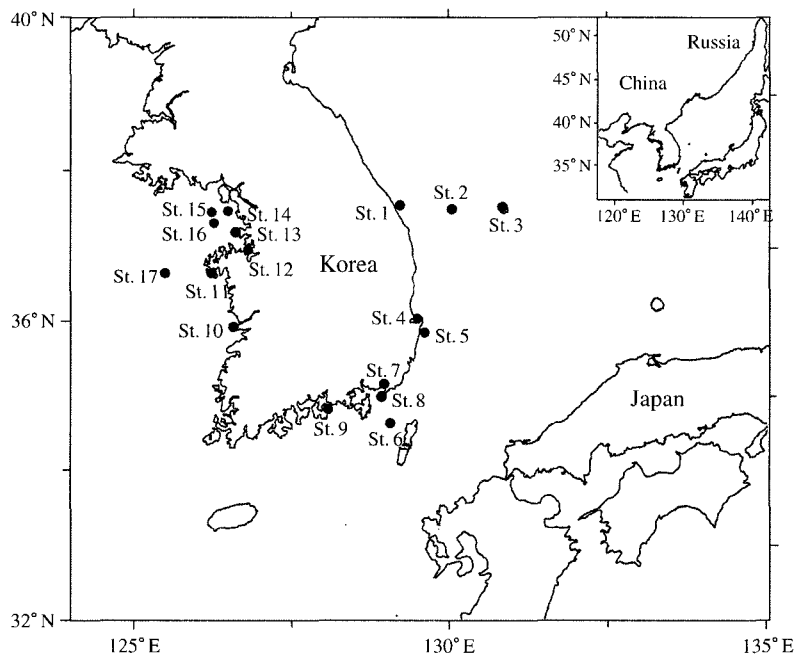


Fig. 1. A map showing the sampling locations in the coastal waters of Korea.

St. 1 Donghae-Shi, St. 2 East Sea, St. 3 Ullung-Do, St. 4 Pohang, St. 5 Wolsung, St. 6 Korea-Strait, St. 7 Masan, St. 8 Jinhae, St. 9 Samchunpo, St. 10 Mankyung, St. 11 Taean, St. 12 Ahsan, St. 13 Shiwha, St. 14 Incheon, St. 15 Youngjong-Do, St. 16 Youngheung-Do, St. 17 Yellow Sea

almost circular. Earlier this genus was maintained as distinct from *Exuviaella* by the presence of a more or less apical spine adjacent to the flagellar opening as a principle distinguishing feature of *Prorocentrum*, lacking in *Exuviaella*. After Lebour (1925) and Schiller (1937) observed *Exuviaella* having small apical spinelets. Secondly *Prorocentrum* was considered to be more compressed than *Exuviaella*, and also more acute in antapical contour. Abe (1967) also incorporated the genera *Exuviaella* and *Prorocentrum* under the latter name, a consolidation needed for many years.

Prorocentrum balticum (Lohmann) Loeblich 1970

Syn. : *Exuviaella balticum* Lohmann 1908

Plate 1, a–b

A minute species, round, ovoid cell in valve view and somewhat slightly pressed in both theca. Minute apical projections besides flagellar pores. Theca surface minutely areolated. Suture slightly indented with several regular lines.

Size: Less than 20 μm , 9~14 μm long.

Distribution: Planktonic, Warm temperate and tropical waters.

Distribution in Korea: Yellow Sea (Youngjong-Do), South Sea (Masan).

Prorocentrum compressum (Bailey) Abe ex Dodge 1975

Syn. : *Exuviaella marina* Schütt 1895

Plate 1, e–k

Cell broadly ovate in valve view: compressed in side view. Broadest at premedian or median. Cell depth is about one half of its length in usual cell, but about three-fourths in megacytic cell. Very small spines from both sides are near the exit part of flagella. Theca covered with conspicuous trichocyst pore and shallow depressions. Apical spine is very small. Apical end of cell is rounded or slightly concaved. The apical plate lies largely within the right valve, extending somewhat aslant. It has two tiny pores obliquely arranged for passage of the flagella and collar like extensions around the plate.

Size: 30~35 μm long, 27~30 μm wide

Distribution: Mostly planktonic, neritic or oceanic, cosmopolitan in cold, temperate to tropical waters.

Distribution in Korea: Yellow Sea (Youngjong-Do), East Sea (Wolsung).

Prorocentrum concavum Fukuyo 1981

Plate 1, c–d

Ovoid cell with surface areolae, apex part of the cell flat. Theca surface of cell is somewhat flat, a little longer than broad. Posterior part of the cell is round, the boundary of cell developed suture. The boundary of cell is similar to *P. minimum*, but the shape of cell is different, anterior part of this species is flat and apical teeth of this cell are small.

Size: 40 μm long, 37 μm wide (this specimen)

Distribution: Benthic, Tropical and neritic waters.

Distribution in Korea: New to Korea, South Sea (Masan).

Prorocentrum gracile Schütt 1895

Syn. : *P. hentschellii* Schiller 1933

Plate 1, l–m

Small to medium-sized, elongate *P. triestinum*-like cell that is more than twice as long as deep (dorso-ventral depth). Pyriform rather than heart shaped with pointed posterior end in valve view. Valves with shallow poroids and post median radial pore fields as in *P. micans*. Long, winged anterior spine adjacent to periflagellar area. This species has been misidentified frequently as *P. triestinum*, *P. micans*, *P. redfeldii* or *P. rostratum*.

Size: 40~60 μm long.

Distribution: Neritic and estuarine, cosmopolitan in cold, temperate to tropical waters.

Distribution in Korea: East Sea (Wolsung).

Prorocentrum lima (Ehrenberg) Dodge 1975

Plate 1, n; Plate 2, d

Cells small to medium-sized ovate, broadest behind the center and anterior part more narrowed compare posterior part: apex indented, posterior part is round, cell compressed inside.

Size: 32~50 μm long, 20~28 μm wide.

Distribution: Littoral species, neritic and estuarine, worldwide distribution.

Distribution in Korea: South Sea (Jinhae).

Prorocentrum micans Ehrenberg 1833

Plate 1, p–r; Plate 2, a, g–k

Cells have rounded middle part and strong apical spine. The thecal wall of *Prorocentrum micans* consists invariably of the two subequal bilateral valves and a small but distinct elliptical apical plate is inlaid largely in the corresponding

indentation. Depth of cell is flattened. Surface of theca, lots of small pores and a little big size of trichocyst pore.

Size: 35~70 µm long, 20~50 µm wide, 12~25 µm deep.

Distribution: Planktonic, neritic and estuarine, sometimes found in oceanic environment, cosmopolitan in cold, temperate to tropical waters.

Distribution in Korea: South Sea (Masan).

Prorocentrum minimum (Pavillard) Schiller 1933

Syn. : *P. triangulatum* Martin 1929

Plate 1, o; Plate 2, b, c, e, f, o-r

Cell triangular or heart-shaped in plate view. Posterior end narrowed, broadest at anterior end. Surface of plates covered with minute spines. At the sight of intercalary band, cell compressed laterally. Apical spine is small.

Size: 14~22 µm long, 10~15 µm wide.

Distribution: Planktonic, cosmopolitan in cold, temperate to tropical waters.

Distribution in Korea: Yellow Sea, South Sea (Masan), East Sea.

Prorocentrum triestinum Schiller 1918

Syn. : *Prorocentrum redfeldii* Bursa 1959

Plate 2, l-n, s

Small posteriorly pointed cell resembling a thin, narrow *P. micans*, cell rounded at the anterior end, pointed at the posterior, about twice as long as wide; anterior end with apical spine. Long thin apical spine, almost one fifth of body length. This species can be easily confused with *P. micans*.

Size: 20~30 µm long, 10~15 µm wide.

Distribution: Oceanic and neritic, worldwide distribution.

Distribution in Korea: Yellow Sea, South Sea (Masan).

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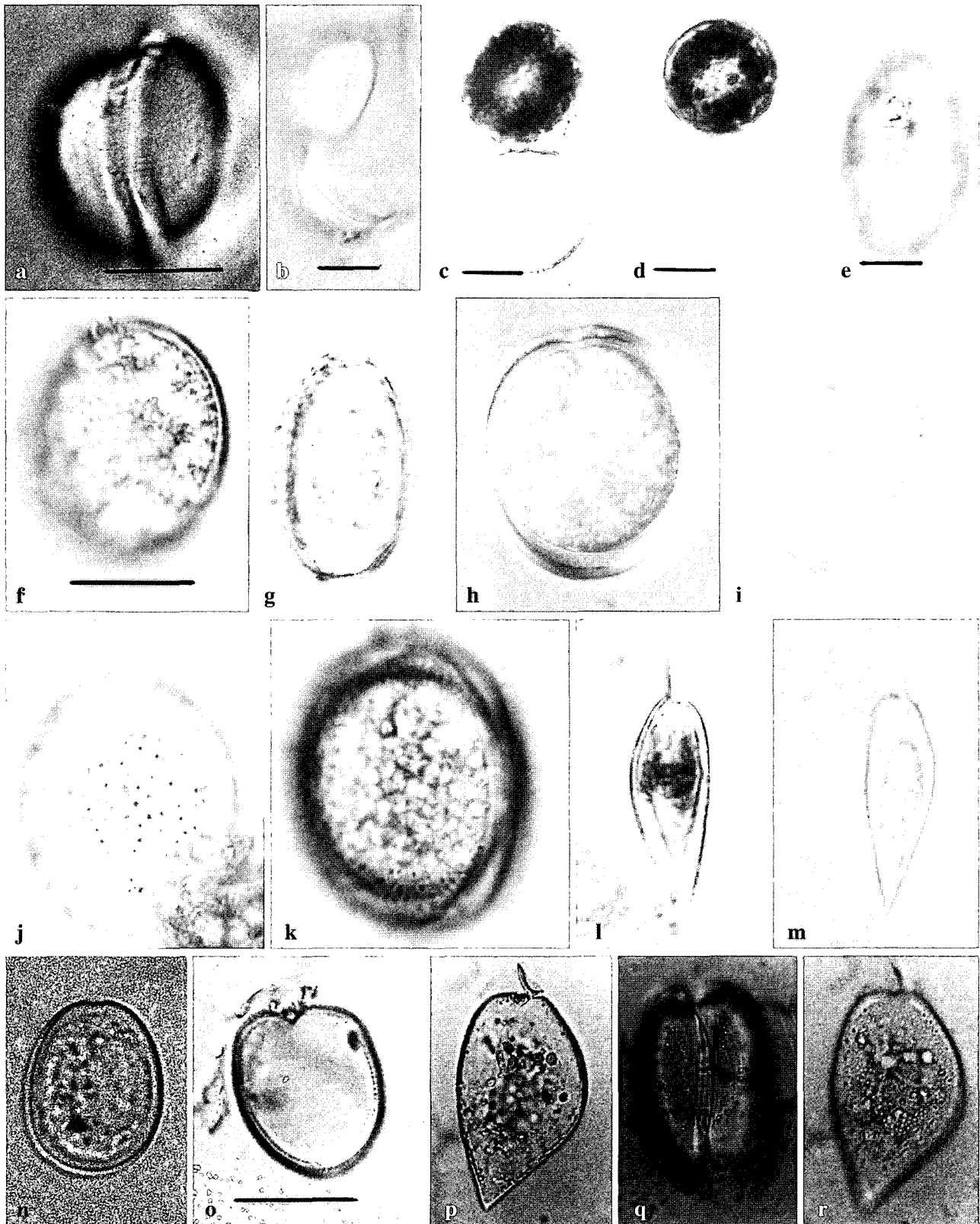


Plate 1. a–b *Prorocentrum balticum*; c–d *P. concavum*; e–k *P. compressum*; l–m *P. gracile*; n *P. lima*; o *P. minimum*; p–r *P. micans*.

Scale bars in frames a, b, e, o are 10 μm . Scales in c, d are 20 μm and scale bar (= 20 μm) in frame f applies to frame g–n and p–r.

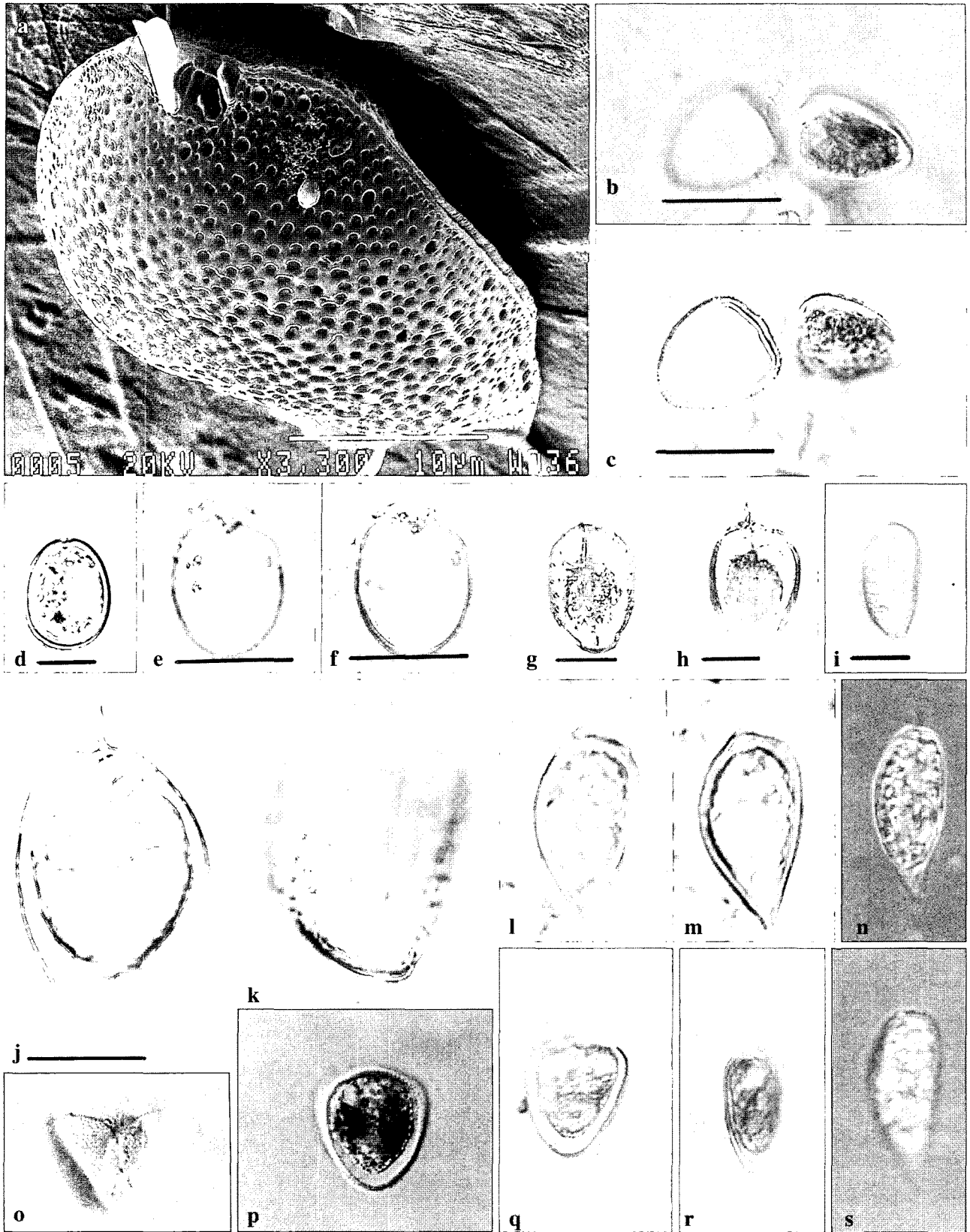


Plate 2. a, g, h, i, j, k *Procoentrum micans*; b, c, e, f, o-r *P. minimum*; d *P. lima*; l, m, n, s *P. triestinum*. Scale bars are 20 μ m and the bar (=20 μ m) in frame j applies to frame k-s.