Ten-Hage, Loïc and Quod, Jean-Pascal and Turquet, Jean and Couté, Alain *Bysmatrum granulosum* sp. nov., a new benthic dinoflagellate from the southwestern Indian Ocean. (2001) European Journal of Phycology, vol. 36 (n° 2). pp. 129-135. ISSN 0967-0262

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**Bysmatrum granulosum** sp. nov., a new benthic dinoflagellate from the southwestern Indian Ocean

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A new benthic marine dinoflagellate, *Bysmatrum granulosum* Ten-Hage, Turquet, Quod & Couté, sp. nov., was obtained from sediment and coral samples from sites of La Réunion Island (SW Indian Ocean). This new species is described and illustrated by light and scanning electron micrographs. Cells are 40–50 µm long and 40–46 µm wide. The epitheca is conical and smaller than the hypotheca, which is trapezoidal with convex sides. Plate tabulation is typical for the genus (P⁶, X, 4', 3a, 7', 6c, 5s, 5'', 2'''); epithecal plates 3' and 4' separate the intercalary plates 2a and 3a. Thecal plates are perforated by pores and covered by both small and minute wart-like projections, linearly arranged, radiating from the apical pore. This new species differs from the three others of the genus *Bysmatrum* in the following characters: cell shape and size, size of the apical pore complex and features of thecal plates (plate shapes and ornamentations).

**Key words:** benthic dinoflagellates, *Bysmatrum granulosum* sp. nov., Dinophyceae, Indian Ocean, taxonomy

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**Introduction**

Benthic dinoflagellates are important components of subtropical and tropical marine coral reef-lagoonal environments. In these environments, identified species mainly belong to the genera *Gambierdiscus* Adachi & Fukuyo, *Ostreopsis* Schmidt, and *Prorocentrum* Ehrenberg (Fukuyo, 1981; Faust 1995a, 1996a); less known genera in these habitats include *Bysmatrum* Faust & Steidinger (1998).

The tropical benthic scrippsieloid genus *Bysmatrum* was recently established by Faust & Steidinger (1998) for three species: *B. arenicola* Horiguchi & Pienaar (Horiguchi & Pienaar, 2000), *B. caponii* (Horiguchi & Pienaar) Faust & Steidinger and *B. subsalsum* (Ostenfeld) Faust & Steidinger, the type species (Faust & Steidinger, 1998). These species, previously placed in the genus *Scrippsiella* Balech (Steidinger & Balech, 1977; Horiguchi & Pienaar, 1988a, b), are distinguished from planktonic scrippsieloids mainly by thecal reticulation and the lack of contact between intercalary plates 2a and 3a, which are separated by apical plate 3' (Faust & Steidinger, 1998). *B. subsalsum* was reported in association with floating detritus, coral rubble and sediment at Twin Cays, Belize (Faust & Steidinger, 1998), and from Florida west coastal waters (Steidinger & Balech, 1977), the Atlantic Barrier Reef (Belize) (Faust & Steidinger, 1998) and tropical coral reefs in the East China Sea (Faust, 1996b). The two other species, *B. arenicola* and *B. caponii*, were described from tidal pools, respectively along the eastern coast of South Africa (Horiguchi & Pienaar, 1988b) and in southern California (Horiguchi & Pienaar, 1988a).

During a study on the diversity of benthic dinoflagellates from La Réunion Island (SW Indian Ocean, France) among which many species are known to be toxic, a new *Bysmatrum* species, *Bysmatrum granulosum* sp. nov., was recorded. In this paper we describe the morphology of this new species isolated from coral and sediments.

**Materials and methods**

The material studied here was collected in the coral reef habitat of St Leu, La Réunion Island (21°09′12″ S, 55°17′40″ E, French Indian Ocean). The water temperature ranged from 23.3 to 29.0 °C and salinity from 34.7 to 35.2 psu. The samples were collected in this area in April 1999. The new species was present also in samples from La Saline reef complex, La Réunion Island (21°04′17″ S, 55°13′10″ E).

Dead coral branches, covered by an algal turf consisting of red algae in the Ceramiales and Gelidiales, and sediment samples from the study area, were collected by diving and placed in plastic containers. Samples were fixed with 4% glutaeraldehyde.

Cell dimensions were determined by measuring the length and width of 20 cells using an ocular micrometer on a light microscope. Fixed cells were isolated with a
capillary pipette under a compound dissecting microscope. Cells were rinsed with distilled water to remove salt and fixatives, dehydrated in a series of graded ethanol concentrations, and critical-point dried. For scanning electron microscope (SEM) observations, the preparations were coated with a layer of gold-palladium. Micrographs were taken on a JEOL 840 SEM of the Life Sciences Laboratories of the Muséum National d’Histoire Naturelle of Paris.

**Results**

*Bysmatrum granulosum* Ten-Hage, Quod, Turquet Coute, sp. nov.

Figs 1–27

Cellula in ventrale visu pentagona, in apicale visu sub-circularis. Longitudo : 40–50 µm; latitudo : 40–46 µm. Epitheca minor quam hypotheca. Cingulum in supraequatorialis position, descending 1–1.5 times its width. Sulcus deep, left sulcal list large and pointed in its terminal part. Thecal surface covered by both small and minute wart-like projections, linearly arranged. Small projections often associated with one thecal pore. Thecal formula \( P_y, X, 4', 3a, 7'', 6c, 4s, 5'', 2'''. \) Plates 2a and 3a separated. Intercalary bands finely striated. Chloroplasts many, golden brown. Stigma present.

**Holotype:** Fig. 9.

**Isotype:** Fig. 10, see also Figs 11–14, 23–27.

**Type Locality:** St Leu, La Réunion Island, French Indian Ocean (21°09'12" S, 55°17'40" E).

**Habitat:** Marine, associated with sediment or attached to coral rubble and macroalgal turf surfaces.

**Etymology:** Refers to the granular appearance of the thecal surface.

*Bysmatrum granulosum* sp. nov. is an armoured species (Figs 7, 9–14, 23). Cells measure 40–50 µm in length, 40–46 µm in width and are pentagonal in ventral view (Figs 3, 6, 10, 23) and subcircular in apical view (Figs 5, 7, 13, 25). The epithea is conical.

Figs 1–8. Light micrographs of *Bysmatrum granulosum* sp. nov. Fig. 1. Low magnification photomicrograph of five cells of *B. granulosum*. Fig. 2. Two cells in hypothecal view. Cellular contents are dense. Fig. 3. Ventral view. Arrow indicates the apical stalk. Fig. 4. Hypotheca viewed from the ventro-posterior side. Fig. 5. Hypotheca viewed from the antapical side. Fig. 6. Ventral view. Cellular content is very dense and prevents observation of the thecal structure. Fig. 7. Separated epithea in apical view showing thecal arrangement of the epithea and the apical pore complex. Arrowhead indicates plate \( P_y \) and the arrow shows canal plate X. Fig. 8. Detail of precingular plates. The thecal surface appears longitudinally striated. Scale bars represent: Fig. 1, 100 µm; Figs 2–7, 10 µm; Fig. 8, 5 µm.
Figs 9–14. Scanning electron micrographs of the surface morphology of *Bysmatrum granulosum* sp. nov. Fig. 9. Cell viewed from the ventro-posterior side. Fig. 10. Ventral view. The epitheca is conical and smaller than the trapezoidal hypotheca. Fig. 11. Dorsal view. Fig. 12. Left lateral view. The sulcus is covered in part by a large left sulcal list. Fig. 13. Detail of the architecture of the epitheca including the position of the apical pore complex. Fig. 14. Antapical view of the hypotheca. Scale bars represent 10 µm.

and smaller than the hypotheca (Figs 10, 11). In ventral view, the hypotheca is trapezoidal with convex sides (Figs 9–11, 23). The cingulum is well excavated and descends 1–1.5 times its own width (Figs 10, 23). The sulcus is narrow, often hidden, and is covered partly by a large left sulcal list (Figs 9, 12, 23, 26, 27). The thecal surface is covered by small circular wart-like projections (Figs 21, 22). These projections are linearly arranged, radiating from the apical pore (Fig. 17), so that the thecal surface appears longitudinally striated under the light microscope (Fig. 8). Two sizes of wart-like projections are present. The smallest cover all the thecal surface. The biggest projections are less numerous and are localized at the surface of epithecal and hypothecal plates (not on the cingular and sulcal plates) (Figs 17, 18, 21, 22). In addition to the wart-like projections, thecal plates are perforated by round thecal pores (Figs 21, 22). We distinguish two sizes of pores. The smaller (0.07 𝜇m) are rare and sparse. The larger (0.14–0.16 𝜇m) are more numerous, principally situated at the bottom of the largest thecal projections and/or on the edges of each thecal plate. Marginal pores are present on both sides of the cingulum (Fig. 19). These marginal pores are similar in shape and in appearance to the largest thecal pores. Intercalary bands are finely striated (Fig. 20).

The epitheca of *Bysmatrum granulosum* is composed of the apical pore plate (P1), the canal plate (X), four apical plates (4), seven precingular plates (7”) and three intercalary plates (3a) (Figs 13, 25).
The apical pore complex (consisting of the apical pore $P_o$ and the canal plate $X$) is elongate (8–10 $\mu$m long) (Figs 7, 15, 16), and slightly polygonal, with margins formed by the raised and overlapping apical borders of the four apical plates (1'–4') (Figs 13, 15, 16). The apical pore complex is directed toward the ventral centre of the cell, slightly to the cell’s right (Figs 13, 25). The $P_o$ plate is situated between apical plates 2', 3' and 4' (Figs 13, 15, 16, 25). The apical pore is round with a raised margin (Fig. 16). An apical stalk is often observed, formed by extrusion of mucilaginous material from the apical region (Fig. 3).

Arrangement of the epithecal plates is asymmetric. Apical plate 1' is pentagonal and on the right of the hypotheca. The upper end of this plate touches the canal plate and the lower end touches the anterior margin of the cingulum (Figs 10, 23). Apical plates 2', 3' and 4' are irregularly hexagonal. Apical plate 4' is the largest, whereas plate 3' is the smallest (Figs 13, 25). Plate 1a is four-sided, whereas plates 2a and 3a are respectively hexagonal and pentagonal (Figs 13, 24, 25). Plates 1a and 2a have one side in common, whereas plates 2a and 3a are separated from each other by a connection between plates 3' and 4' (Figs 13, 24, 25).

The cingulum is well excavated, is located in supraequatorial position, and descends 1–1.5 times its own width (Figs 9, 10). The cingulum is composed of six plates (6c). The right part of plate c1...
are triangular and 3 is the smallest postcingular plate. Plates 2 and apical plates (2). Plate 1 is rectangular, and 4 is made in Table 1. Cells of B. granulosum are larger than those of B. caponii (20–34 \( \mu \)m long, 20–34 \( \mu \)m wide) (Horiguchi & Pienaar, 1988b) and B. subsalsum (32–41 \( \mu \)m long, 31–51 \( \mu \)m wide) (Faust & Steidinger, 1998). B. granulosum differs also from other Bysmatrum species by the lack of prominent dorsiventral compression (Faust & Steidinger, 1998). Cells of B. granulosum are more or less pentagonal as are those of B. caponii and B. subsalsum; those of B. arenicola are ellipsoidal (Horiguchi & Pienaar, 1988a). The epitheca of B. granulosum is smaller than the hypotheca. Epithecas and hypothecae are equal in size in B. arenicola (Horiguchi & Pienaar, 1988a), B. caponii (Horiguchi & Pienaar, 1988a) and B. subsalsum (Steidinger & Balech 1977; Faust & Steidinger, 1998).

The apical pore complex of B. granulosum is similar in morphology to that of B. arenicola (Horiguchi & Pienaar, 1988a), B. caponii (Horiguchi & Pienaar, 1988b) and B. subsalsum
The thecal surface of *Bysmatrum* is covered by two distinct size classes of small wart-like projections. Wart-like projections are present on the thecal surface of *B. arenicola* (Horiguchi & Pienaar, 1988a); the surface morphology of *B. caponii* (Horiguchi & Pienaar, 1988b) and *B. subsalsum* (Faust, 1996b; Faust & Steidinger, 1998) has a reticulate surface pattern. In all four *Bysmatrum* species, thecal arrangement is arranged in longitudinal rows radiating from the apical pore.

The thecal arrangement of *B. granulosum* is similar to that of other *Bysmatrum* species: intercalary plates 2a and 3a are separated by the apical plate 3; this is an important morphological characteristic that distinguishes *Bysmatrum* species from other scripsiellid species (Faust, 1996b; Faust & Steidinger, 1998). Plate 1a is quadradral in *B. granulosum, B. caponii* (Horiguchi & Pienaar, 1988b) and *B. subsalsum* (Steidinger & Balech, 1977; Faust, 1996b; Faust & Steidinger, 1998), whereas it is pentagonal in *B. arenicola* (Horiguchi & Pienaar, 1988a). Plate 2a is hexagonal in *B. granulosum and B. caponii* (Horiguchi & Pienaar, 1988b), but pentagonal in *B. arenicola* (Horiguchi & Pienaar, 1988a) and *B. subsalsum* (Steidinger & Balech, 1977; Faust 1996b; Faust & Steidinger, 1998).

Intercalary bands of *B. granulosum* are finely striated; those of *B. caponii* (Horiguchi & Pienaar, 1988b) and *B. subsalsum* (Faust, 1996b; Faust & Steidinger, 1998) are deeply striated whereas those of *B. arenicola* are smooth (Horiguchi & Pienaar, 1988a).

*Bysmatrum granulosum* sp. nov. is a tropical benthic dinoflagellate, as are the three other *Bysmatrum* species (Faust & Steidinger, 1998).

The description of this new species contributes, with our previous recent work (Quod et al., 1999; Ten-Hage et al., 2000b), to knowledge of the diversity of benthic dinoflagellates from the southwestern Indian Ocean.

### Acknowledgements

We thank Dr M.A. Faust, Smithsonian Institution, USA, and Dr B. de Reviers, Muséum National d’Histoire Naturelle, France, for their advice. We also wish to thank G. Mascarell and M. Dumont for their technical support. L.T.H. was supported by a fellowship from Ministère de l’Education Nationale, de la Recherche Scientifique et de la Technologie. This work was carried out in part with the support of Conseil Régional de La Réunion.

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