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# A new diatom genus : *Rimoneis* M.Garcia (Fragilariaceae, Bacillariophyceae) : a new hyaline araphid genus based on observations of frustules from Southern Brazil

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**Abstract**

Sand samples collected from three freshwater and brackish sandy beaches in Southern Brazil have revealed the presence of a new hyaline araphid diatom belonging to a new genus. The new genus, *Rimoneis* M.Garcia, is characterized by the presence of two slits at each apex, a wide sternum, small areolae occluded by hymenes, striae with internal openings in a cavity, valve edge with simple spines or a ridge, the absence of rimoportulae, and plain open bands. Two species belong to the new genus : the type species *Rimoneis* M.Garcia sp. nov. from Southern Brazil and *Rimoneis densestriata* (Hust.) M. Garcia comb. nov. from Java (Asia). *Rimoneis* is ecologically and morphologically different from the marine hyaline diatoms *Pravifusus*, *Hyaloneis* (both without areolae), *Synedropsis* and from freshwater fragilarioid genera such as *Pseudostaurosira*, *Pseudostaurosiropsis* and *Synedrella* (distinct in colony formation, areolae occluded by volae and simple striae with internal openings).

**Key index words :** araphid diatom, epipsammon, hyaline valve, Lagoa dos Patos Lagoon, *Rimoneis* gen. nov., *Rimoneis inanis* sp. nov.

## Introduction

In the course of a study of freshwater and brackish water sandy beaches of Lagoa dos Patos lagoon, a hyaline araphid diatom was found attached to sand grains. Light microscopy (LM) showed that the diatom was similar to *Fragilaria densestriata* Hust. as illustrated by Simonsen (1987, *pl. 320. f. 30-37*). Analysis of several specimens from the lagoon using Scanning Electron Microscopy (SEM) showed morphological similarity to *F. densestriata* but several distinct features that support the description of a new species to science. These two species, present a specific combination of features that are not found in any other araphid diatom genus.

Araphid diatoms with a hyaline valve face are known in intertidal marine / brackish environments. Genera such as *Hyaloneis* Amspoker and *Pravifusus* Witkowski, Lange-Bert. & Metzeltin, described from muddy and sandy substrates respectively, have both a totally hyaline valve face and apical pore field at each apex. The main differences between these two genera are the wide valvocopula in the former in contrast with the bands of the same width in the latter, and the presence of spines at the valve face edge in the latter. In addition to the characteristics cited above, it is worthwhile highlighting the presence of six slits in the apical slit field in *Hyaloneis* (Amspoker 2008) in contrast to the presence of few poroids on the apices of the valves in *Pravifusus* (Garcia 2005). Among planktonic diatoms, totally hyaline valves are found in species of *Synedropsis* Hasle, Medlin & Syvertsen with striae located at the valve face and the mantle junction, narrow and simple girdle bands, apical

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pore/slit fields with slits internally noticeable and one rimoportula per valve (Prasad & Livingston 2005). These diatoms with a valve faces deprived of striae are different from both our specimens and *F. densestriata* with very short striae near the valve margin. Therefore, the new genus, *Rimoneis* M.Garcia is described based on our specimens collected in Southern Brazil and from SEM pictures of *F. densestriata* provided by Simonsen (1987).

## Materials and Methods

The Lagoa dos Patos lagoon is the largest lagoon in Brazil and has a surface area of 9,910 km$^2$. The lagoon coastline is essentially composed of unconsolidated Quarternary sediments forming extensive and continuous sandy beaches and spits. Sands along the western side of the lagoon are poorly sorted, with fine to coarse sand grains (Toldo *et al.* 2003).

Samples were collected along beaches in Barra do Ribeiro (30°16′55″S - 51°18′02″W) in 1988 and 1995, and were also collected in Barra do Ribeiro (30°18′11″S - 51°17′07″W), Arambaré (30°55′52″S - 51°30′14″W) and São Lourenço do Sul (31°21′48″S - 51°57′40″W) during 2004 and 2005 (Table 1).

In all of these sites, the upper two millimeters of the sand were collected from the uppermost area of the intertidal zone. The samples were fixed with Lugol's solution at 0.3% in the field and later, formaldehyde at 4% was added in the laboratory. The permanent type slide was deposited at ICN (Universidade Federal do Rio Grande do Sul Herbarium, Departamento de Botânica, Porto Alegre, Brazil). Subsamples from each site were cleaned following the technique described by Simonsen (1974). Part of the material was mounted onto a glass slide with Naphrax to make a permanent slide and observed with a Zeiss Axiovert 135 microscope using phase contrast optics.

About 200 valves of all diatoms present in permanent slides were counted at 1000×. At least, two slides per station were observed. In all of the slides studied, the whole cover-slip surface was observed under 400× in order to check the occurrence of *Rimoneis*.

For SEM cleaned specimens were dried onto a stub, coated with platinum at 40 mA for 100 seconds using the Baltec SCD 050 sputter coater. The specimens were observed using a JEOL JSM-6060 microscope at an accelerating voltage of 15-20 kV. The working distance was 10 mm.

The general terminology followed Barber & Haworth (1981) and Round *et al.* (1990). The areolae occlusion terminology was the one described by Cox (2004).

## Results

The new genus *Rimoneis* M.Garcia and a new species *Rimoneis inanis* M.Garcia are described below. The transfer of *Fragilaria densestriata* Hust. into the new genus *Rimoneis* is also made. *Rimoneis* can be included in the family Fragilariaceae.

***Rimoneis*** M.Garcia gen. nov.

Frustula in coloniis retilineis dispositae. Valvae hyalinae, lanceolatae, marginibus convexis. Externum amplum. Striae uniseriatae in margine faciei valvaris et supra mantum. Margo valvaris cum spiniis vel prominentiis. Pori duo elongati in quoque apice valvae. Taeniae apertae, plurimae et cum idem latitudine.

Frustules in ribbon-like colonies. Valves lanceolate, hyaline with convex margins. Valve face with wide sterna. Uniseriate striae in the margin of the valve face and on the mantle. Valve margin with spines or ridge. Two apical slits per valve apex. Several open bands same in width.

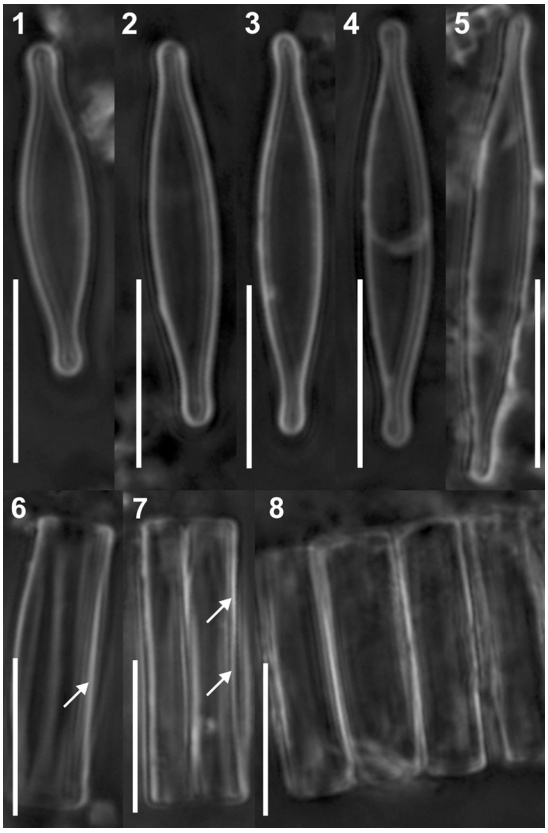
**Etymology :** From the latin rima (slit) related to the presence of the 2 slits at each valve apex.

**Type species :** ***Rimoneis inanis*** M.Garcia sp. nov.

***Rimoneis inanis*** M.Garcia sp. nov. (Figs 1-21)

Frustula in coloniis retilineis dispositae Valvae hyalinae, lanceolatae, marginibus convexis in coloniis retilineis dispositae. Externum amplum. Striae uniseriatae in margine faciei valvaris et supra mantum. Prominentia marginis valvaris canale centrali et filiformi. Pori duo elongati in quoque apice valvae. Taeniae apertae, plurimae et cum idem latitudine. Longitudo 17-25 μm, latitudo 2.7-3.3 μm cum 52-60 striis in 10 μm.

Frustules in ribbon-like colonies. Valves lanceolate, hyaline. Valve face with wide sterna. Uniseriate striae in the margin of the valve face and on the mantle. Ridge at the valve face edge with




**Figs 1-8.** LM images. **Figs 1-5**. Valve views showing valves with a distinct outline. Note the slightly curved apices. **Figs 6-8**. Girdle views. Note the ridge (arrowed). Scale bars = 10 μm

a central linear canal. Two apical slits per valve apex. Several open bands same in width. Apical axis 17-25 μm long, transapical axis 2.7-3.3 μm wide and 52-60 striae in 10 μm.

**Holotype**: Herbarium ICN, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil. Accession number. Slide **160318 (ICN) Fig. 1**

**Type locality**: Guaíba River Barra do Ribeiro (30°18′11″S and 51°17′07″W). March 07, 2004. Rio Grande do Sul State, Brazil.

**Etymology**: From the latin *inanis* (empty) related to the valve nature deprived of structures in LM.

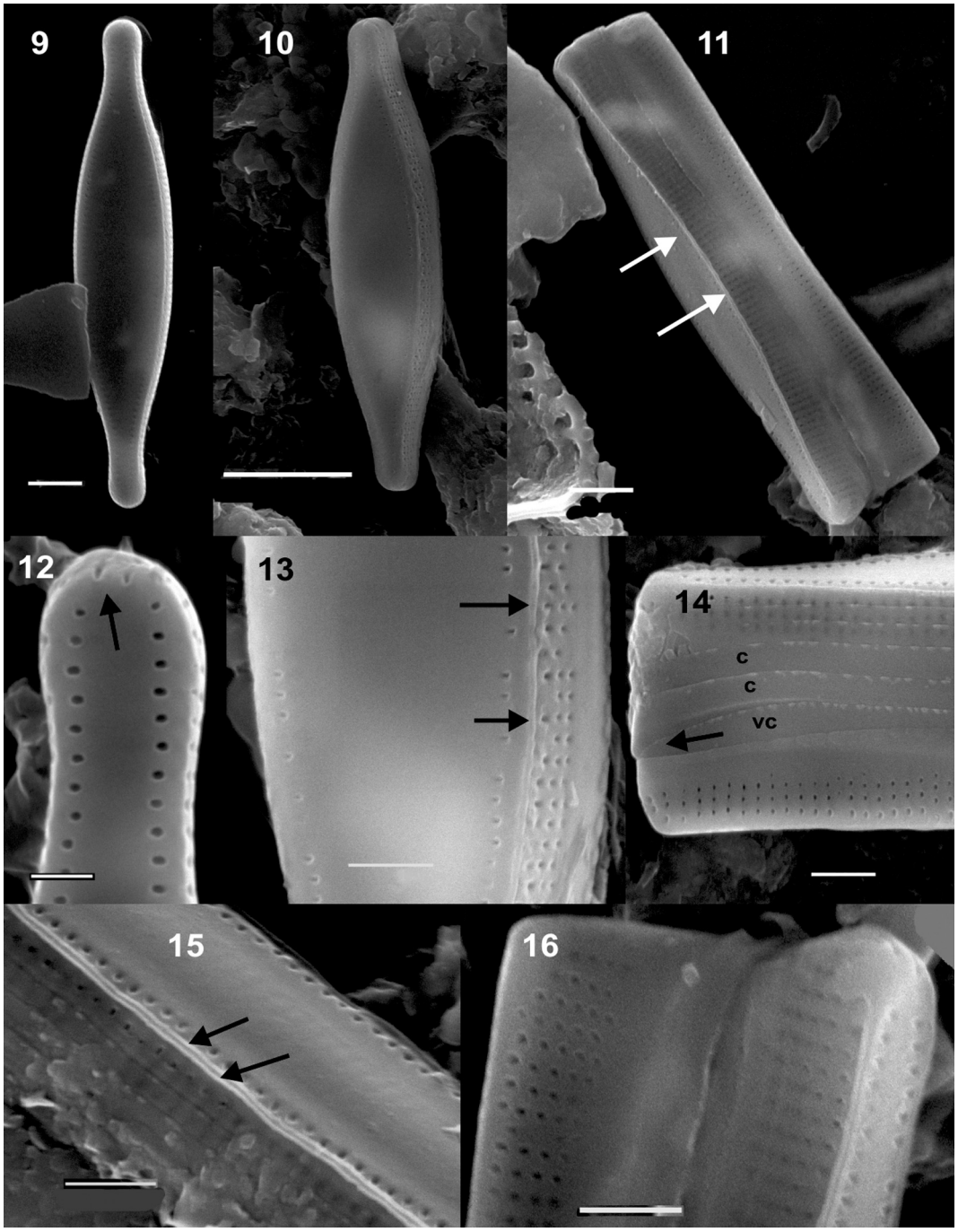
**Observations**: The valves are linear-lanceolate with subrostrate, round and slightly-bent apices (Figs 1-5); 17-25 μm long, 2.7-3.3 μm wide and 52-60 striae in 10 μm ($n$ = 24). The cells are attached to sand grains and form straight chain colonies (with 2-6 cells, Fig. 8). The cells are rectangular in girdle view (Figs 6-8, 11). Several bands (about five), open, plain and of the same width are present (Figs 14-16). The copula margin presents a continuous and simple smooth lip (Fig. 19). The valve face is flat and abruptly falls to the mantle (Figs 9, 10). The sternum is wide and occupies almost all valve face (Figs 13, 15). The striae are uniseriate, parallel and consisted areola in number from three to five. The areola row is present from the valve face to the mantle and is decoupled at the valve shoulder (Figs 13, 14, 16). Internally, the striae open in a transapically elongated and thin cavity (Figs 20, 21). The areolae form varies from round to elliptical and are occluded by a hymen. The ridge present along the valve face edge has a linear canal at its center (Figs 13, 15, 16). Apical pore fields are present at both ends of the valve and consisted of two elongated slits (Figs 12, 20, 21). Rimoportula is absent.

**Remarks**: *Rimoneis inanis* presents restricted distribution to freshwater/brackish water (of low conductivity) sandy beaches of the western side of the Lagoa dos Patos lagoon and Guaíba River. It is found all year round always in low frequency. Several times, during the counting procedure *R. inanis* was not found in the 200 valves counted and in these cases its frequency was registered as $<$ 1.5% at the 5% significance level. Table 1 presents the frequencies of *R. inanis* with some environmental data and the common species in the samples. The most common species are benthic freshwater/brackish taxa as *Plagiogramma tenuissimum* Hust., *Planothidium delicatulum* (Kütz.) Round & Bukht., *Planothidium rostratum* (Østrup) Round & Bukht. and *Staurosira obtusa* (Hust.) M.Garcia.

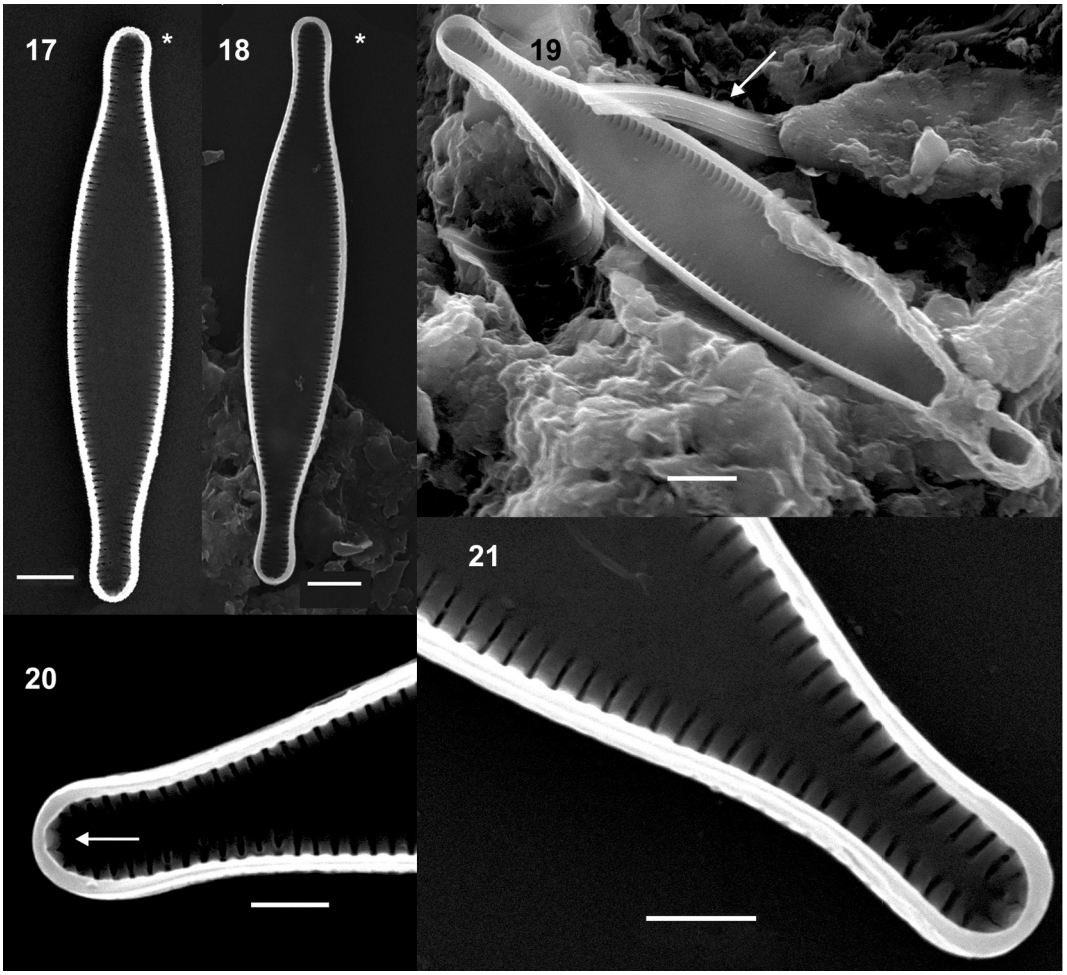
***Rimoneis densestriata*** (Hust.) M.Garcia comb. nov.

**Basionym**: *Fragilaria densestriata* Hust., Arch. Hydrobiol., Suppl. **15**: 153. *pl. 10. f. 65-67.* 1937.

*Rimoneis densestriata* forms short chains (with 2-3 cells). The valves are linear lanceolate with subrostrated and round apices varying from 9-11 μm in length. On the valve face edge, there is a line of simple and cuneate spines (Simonsen 1987, *pl. 321. f. 1-5*). The spines are absent at the apices. The striae density is 32 in 10 μm




**Figs 9-16.** External views in SEM. **Figs 9, 10.** General valve views. **Fig. 11.** Frustule in girdle view. Note the marginal ridge (arrowed). **Fig. 12.** Detail of an apex showing the two apical slits. Note the slightly curved apex and the presence of one row of areolae on the valve face. **Fig. 13.** Detail of the central portion of a valve, showing the arrowed ridge. **Fig. 14.** Detail of a frustule at the apex. The bands are open and of the same width. The open valvocopula (vc) and copulae (c) are indicated. **Fig. 15.** Detail of a frustule at the center showing the marginal ridge with a central linear canal and several bands of the same width. **Fig. 16.** Detail of Fig. 11. showing a frustule apex, and the central linear canal in the marginal ridge. Scale bars = 5 µm (Fig. 10), 2 µm (Figs 9, 11), 1 µm (Fig. 13-16), and 0.5 µm (Fig. 12).




**Figs 17-21.** Internal valve views in SEM. **Figs 17, 18.** General valve views. Note the apices (at the top and indicated by '*') slightly curved to the right (Fig. 17) and left (Fig. 18) side, respectively. **Fig. 19.** The plain copula with a continuous and smooth lip. **Figs 20, 21.** Apices detail showing the presence of two slits and absence of rimoportulae. Note the internal areolae apertures. Scale bars = 2 μm (Figs 17-19), and 1 μm (Figs 20, 21).

and they are on the valve face edge as a single row of elliptical areolae. Internally, the striae open in a transapically elongated cavity (Simonsen 1987, *pl. 321. f. 6*, *7*). On the valve mantle, the striae are formed by several elliptical areolae varying in number from two to four (Simonsen 1987, *pl. 321. f. 3*, *4*). Several bands (Simonsen 1987, *pl. 321. f. 1-3*), open, plain and of the same width are present. The valvocopula margin is simple and not fimbriated (Simonsen 1987, *pl. 321. f. 3*).

*Rimoneis densestriata* differs from *R. inanis* in the presence of spines along the valve face edge while the absence of ridge with a central linear canal.

## Discussion

Williams & Round (1987) and Round *et al.* (1990) suggested *Fragilaria densestriata* (=*Rimoneis densestriata*) be included in *Fragilariforma* Williams & Round, although the new combination has not been made. *R. densestriata* is, however, distinct from *Fragilariforma* because the latter has one rimoportulae per valve, striae on the valve face, and bands ornamented by one row of poroids.

*Rimoneis* shares some features with marine genera characterized by a totally hyaline valve

**Table 1.** Occurrence and frequency of *Rimoneis inanis* in Southern Brazil with some environmental data and common co-occurred species.

| Locality | Date | Occurrence of *R. inanis* | pH | Conductivity ($\mu S\ cm^{-1}$) | Common co-occurred species |
|---|---|---|---|---|---|
| Barra do Ribeiro | March 1988 | <1% | - | - | *Navicula porifera* var. *opportuna* (Hust.) Lange-Bert.<br>*Planothidium rostratum* (Østrup) Round & Bukht.<br>*Staurosirella* sp. |
| | February 1995 | <1% | 7.06 – 7.08 | 42.9 – 45.5 | *Cocconeis* sp.<br>*Navicula porifera* var. *opportuna* (Hust.) Lange-Bert.<br>*Planothidium rostratum* (Østrup) Round & Bukht.<br>*Staurosirella* sp. |
| | March 2004 | <1-4% | - | 240 | *Cocconeis* sp.<br>*Planothidium rostratum* (Østrup) Round & Bukht.<br>*Staurosira obtusa* (Hust.) M.Garcia |
| | December 2004 | <1% | - | - | *Planothidium rostratum* (Østrup) Round & Bukht. |
| | March 2005 | <1% | 8.0 – 8.7 | 64 – 69 | *Planothidium rostratum* (Østrup) Round & Bukht.<br>*Staurosira obtusa* (Hust.) M.Garcia |
| Arambaré | March 2004 | <1% | - | 280 | *Plagiogramma tenuissimum* Hust.<br>*Cocconeis* sp. |
| São Lourenço do Sul | March 2004 | <1% | - | (1400–1500) | *Plagiogramma tenuissimum* Hust.<br>*Planothidium delicatulum* (Kütz.) Round & Bukht. |
| | August 2004 | <1% | 6.5 – 7.0 | (220–230) | *Cocconeis* sp.<br>*Plagiogramma tenuissimum* Hust.<br>*Planothidium delicatulum* (Kütz.) Round & Bukht.<br>*Staurosira obtusa* (Hust.) M.Garcia |
| | December 2004 | <1% | - | - | *Staurosira obtusa* (Hust.) M.Garcia<br>*Staurosirella martyi* (Hérib.) E.Morales |
| | March 2005 | <1% | 6.28 – 7.0 | (1090–1190) | *Cocconeis* sp.<br>*Plagiogramma tenuissimum* Hust.<br>*Staurosirella martyi* (Hérib.) E.Morales |

**Table 2.** Summarizing data relating the two species of *Rimoneis*, similar freshwater genera (*Pseudostaurosira*, *Synedrella* and *Pseudostaurosiropsis*) and marine brackishwater genera *Synedropsis* (the most similar genus), *Pravifusus* and *Hyaloneis*, and their respective characteristic features.

| | ***Rimoneis inanis*** | ***Rimoneis densestriata*** | ***Pseudostaurosira*** | ***Synedrella*** | ***Pseudostaurosiropsis*** | ***Synedropsis*** | ***Pravifusus*** | ***Hyaloneis*** |
|---|---|---|---|---|---|---|---|---|
| Apical structure | 2 slits | 2 slits | Apical pore field absent or few poroids | Ocellulimbus | Few poroids (maximum 3) | 2-8 slits | 2 slits with few poroids (2 poroids in *P. inane*) | 6 slits with 4 crossing bars |
| Areolae occlusion | Hymen | Hymen | Branched volae | Branched volae | Disk-like closing plate | Vola | - | - |
| Cingulum | Few (3-6) open copulae | Several open copulae | Several, open, plain, ligulate copulae. Valvocopula large. | Open, not ornamented | Several open, plain, ligulate copulae | Several very thin closed copulae | Several thin open copulae (*P. inane*) | Wide valvocopula and few copulae (2-3) |
| Colony formation | Linear chains | Short linear chains | Linear | Short linear chains | Linear chains | Solitary or star colonies | Linear chains (*P. inane*) | Solitary |
| General Morphology | Linear lanceolate | Linear lanceolate | Linear elliptical, undulate | Elliptical, central constriction | Round to elliptical | Linear; needle-shape | Linear lanceolate Cymbiform | Linear lanceolate |
| Habitat | Fresh/brackish water sand | Freshwater phytoplankton | Freshwater | Freshwater epiphytic | Freshwater | Marine phytoplankton | Marine sand (*P. inane*) | Marine mud |
| Geographic distribution | Subtropical | Tropical | Widespread | Widespread | ? | Artic, Antartic, Tropical | Subtropical | Subtropical |
| Rimoportula | Absent | Absent | Absent | Absent | Absent | Present | Absent | Absent |
| Spines | Ridge present | Simple | Flattened or branched | Ridge present | Simple, branched | Absent | Absent | Absent |
| Stauro | Absent | Absent | Absent | Absent | Absent | Present | Not applicable | Not applicable |
| Sternum | Wide | Wide | Wide | Wide | Wide | Wide | Not applicable | Not applicable |
| Striae | Short. Very small areolea | Short. Very small areolea | Short. Large areolae | Short. Large areolae | Short. Large areolae | Short. Very small areolea | Absent | Absent |
| Striae internal opening | Cavity | Cavity | Simple | Simple | Simple | Simple | Not applicable | Not applicable |
| References | This study | Simonsen (1987) (Plates 320, 321) | Williams & Round (1987) Morales (2001) Morales *et al*. (2001) | Round & Maidana (2001) Morales (2003) | Morales (2001) | Prasad & Livingston (2005) | Garcia (2005) | Amspoker (2008) |

face such as *Hyaloneis*, *Pravifusus*, and *Synedropsis* but presents ecological and morphological differences summarized in Table 2.

The presence of two slits at the valve apices in hyaline isopolar valves suggests the relationship of *Rimoneis* with *Pravifusus* and *Hyaloneis*, although substantial differences are detectable. In *Pravifusus*, the description included apical pore fields with few poroids (Garcia 2005; although the illustration in Witkowski *et al.* 2000, *pl. 27. f. 18* shows two slits at the apex in internal view). On the other hand, *Hyaloneis* has that composed of approximately 6 vertical slits crossed by about 4 horizontal bars (Amspoker 2008). They both are clearly distinct from that of *Rimoneis* composed of two slits. The slits of *Rimoneis* could be considered homologous with rimoportulae as Simonsen (1987) suggested.

The spines included in the description *Pravifusus hyalinus* Witkowski, Lange-Bertalot & Metzeltin (not visible with LM) and later in *Pravifusus inane* (Giffen) M.Garcia are simple in construction and ornamentation with produced apices (Witkowski *et al.* 2000, Garcia 2005), while in *R. densestriata*, they are also simple but with cuneate apices. The occurrence of a ridge with a central linear canal in *R. inanis* is a distinctive characteristic for this species.

The type of areolae (absent in *Pravifusus* and in *Hyaloneis*) occlusion is another difference between *Rimoneis* and *Synedropsis*. It is a vola in *Synedropsis* and a hymen in *Rimoneis*.

Over all these observations, the fresh and slightly brackish habitat of *Rimoneis* completely differs from the related marine genera (*Pravifusus*, *Hyaloneis* and *Synedropsis*).

Some freshwater fragilarioid genera as *Pseudostaurosira* (Grunow) D.M.Williams & Round, *Pseudostaurosiropsis* E. Morales and *Synedrella* Round & Maidana present similar features with *Rimoneis*, as striae with one areolae on the valve face, reduced apical pore field and the absence of rimoportula (Table 2). *Rimoneis* differs from those by the small size of the areolae (visible only by SEM observations), areolae occlusion (hymen), apical structure formed by two slits and internal striae opening in cavity.

The cingulum in *Rimoneis* presents specific morphological characteristics. It is composed of open and non-ornamented bands, features present in *P. inane*. The bands are narrower and in higher number in *Rimoneis* than in other diatoms with hyaline valve face.

*Rimoneis densestriata* differs from *R. inanis* in the presence of spines, dimension data, geographic distribution and habitat (Table 2).

Besides *Hyaloneis* and *Synedropsis*, *Rimoneis* should belong to family Fragilariaceae because it matches the diagnostic features of *Fragilaria sensu lato* summarized by Morales (2001).

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