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MORPHOLOGY AND DISTRIBUTION OF *ANORTHONEIS* GRUNOW (BACILLARIOPHYTA) FROM SANTA CATARINA COAST, BRAZIL

MORFOLOGIA E DISTRIBUIÇÃO DE *ANORTHONEIS* GRUNOW (BACILARIOPHYTA) NA COSTA DE SANTA CATARINA, BRASIL

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RESUMO

O trabalho apresenta a descrição detalhada de *Anorthoneis eurystoma* e *Anorthoneis hyalina* com ilustrações de microscopia óptica (MO) e eletrônica de varredura (MEV). Este é o primeiro estudo de *A. eurystoma* e *A. hyalina* com observações em MEV de material coletado em praias arenosas brasileiras. Ambas espécies apresentam superfície valvar ondulada, bandas simples e espessamento ao redor da face valvar na valva com rafe. Elas apresentam distribuição esporádica na costa do estado de Santa Catarina. São espécies raras e foram registradas em 10 das 27 praias estudadas.

Palavras-chave: Diatomáceas psâmicas, ultra-estrutura, taxonomia

ABSTRACT

The paper presents the detailed description of *Anorthoneis eurystoma* and *Anorthoneis hyalina* with illustrations in light microscopy (LM) and scanning electron microscopy (SEM). This is the first study of *A. eurystoma* and *A. hyalina* with SEM observations from material collected in Brazilian sandy beaches. Both species present undulated valve face, simple bands and the presence of costae-like thickening around the valve face edge on the raphid valve. They present a sporadic distribution in the coast of Santa Catarina State. They are rare species recorded in ten from 27 studied beaches.

Key words: Psammic diatom, fine structure, taxonomy

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INTRODUCTION

The genus *Anorthoneis* has nine species, *A. dulcis* Hein, *A. eurystoma* Cleve, *A. excentrica* (Donkin) Grunow, *A. hyalina* Hustedt, *A. hummii* Hustedt, *A. minima* Foged, *A. pulex* Sterrenburg, *A. tenuis* Hustedt, *A. vortex* Sterrenburg. Eight out of nine species, exception made by *A. dulcis* Hein, are marine and benthic and have been recorded as rare or scarce to several areas.

Anorthoneis eurystoma, *A. excentrica*, and *A. hyalina* were first described to the North Hemisphere and more recently found in the South Hemisphere: Argentina, Cuba and South Africa by Foged (1975 and 1984), Giffen (1970, 1975 and 1976) and Sar & Ferrario (1994). *Anorthoneis minima* described by Foged (1975) is the unique species described to the South Hemisphere with no records to the North Hemisphere. This very restrict distribution of the genus around the world seems to be related to its small size. According to Sterrenburg (1988) the genus seems to have its ideal habitat on several types of coastal sediments.

According to the Tropical Data Base (BDT, www.bdt.org.br) the genera is recorded to South of Brazil only, and two species are listed: *A. eurystoma* and *A. hyalina*. However, Moreira-Filho *et al.* (1993) registered *A. excentrica* to São Paulo State and *A. hialina* to São Paulo and Rio de Janeiro States.

To the Southern states in Brazil, Paraná, Santa Catarina and Rio Grande do Sul, Moreira Filho *et al.* (1990) recorded *A. eurystoma* to Paraná state and more recently Procopiak *et al.* (2006) registered *A. excentrica, A. eurystoma* and *A. hyalina* to the same State. More specifically to Santa Catarina State, *A. eurystoma* and *A. hyalina* was recorded by Moreira-Filho *et al.* (1967) and Fernandes *et al.* (1990).

The diagnostic characteristics in LM are the presence of the raphe in only one valve in eccentric position and both valves with undulated valve face. In SEM observations, the proximal raphe ends are curved in opposite directions. This latter feature is present in *Cocconeis* Ehrenberg as well as the areolae occluded by hymenes and the chloroplast in "C"form. These features approximate both genera, *Anorthoneis* and *Cocconeis*, but the latter has the raphe loccated in the centre of the valve face and the valvocopula can present internal projections.

In the literature, we can find very few data on *Anorthoneis* with SEM observations. Round *et al.* (1990) provide details on *A. excentrica*, Sterrenburg (1988) on *A. excentrica*, *A. pulex* and, *A. vortex,* and Hein (1991) on *A. dulcis*.

This paper presents the description based on LM and SEM observations and the distribution of specimens found along the coast of Santa Catarina State.

MATERIAL AND METHODS

The Porto Belo peninsula located in Santa Catarina State, Brazil has a wide variety of beaches ranging from dissipative to reflective conditions, and each one of them is separated by a few kilometres only. Sand samples were collected from marine

sandy beaches around Porto Belo Peninsula in the beaches: Araçá, Bombas, Mariscal, Perequê, Porto Belo, Quatro Ilhas and Zimbros; and other sandy beaches located northeast: Taquarinhas, Praia Brava, Cabeçudas, Geremias, Penha, São Miguel, Gravatá, Navegantes, Calheiros e Ganchos. The sandy beaches located in the south of Ilha de Santa Catarina were: Garopaba, Guarda do Embaú , Itapirubá, Praia do Iró, Praia do Gi, Siriú, Mar Grosso, Pinheira, Praia do Cardoso e Gamboa. (see Map)

The first set of samples (121) was collected in December 1995 and in January 1996 along beach transects from the base of the dune to the swash by using a 3.7 cm diameter PVC, which was pressed down vertically into the sediment. The first centimeter of sediment was kept in flasks with 20 ml of 3% lugol solution. Fixed material was stored in the Herbarium (ICN) of the Department of Botany, Federal Unversity of Rio Grande do Sul, Porto Alegre, Brazil. The second set of samples was collected from September 2001 to July 2002 along Santa Catarina state coast, and is deposited in the Herbarium PEL of Federal University of Pelotas, Pelotas, Brazil. A total of 250 permanent slides was examined.

The sand samples were cleaned following the Simonsen (1974) technique. Aliquots were dried onto cover slips and mounted in Hyrax for permanent slides. For each sample, at least two slides were mounted. Slides were examined with an Olympus BX 40 light microscope with phase contrast. For scanning electron microscopy (SEM), cleaned frustules were dried onto a stub, coated with gold at 1kV for 4 minutes, and examined with Phillips 501B or Jeol JSM6060 at an accelerating voltage of 15 or 20 kV. An Ilford SP 4 film was used for photography.

To each permanent slide, 200 valves were counted under 1000x. The frequency of *A. eurystoma* and *A. hyalina* was determined in relation to the total number of valve counted including all diatom species in each permanent slide. At least, two slides per beach have been observed. For all slides studied, after the counting procedure, all cover-slip surface was observed under 400x in order to check the occurrence of *Anorthoneis*.

Terminology follows Round *et al.* (1990) and Barber & Haworth (1981).

RESULTS

Taxonomic part:

Anorthoneis eurystoma Cleve, *K. Svenska Vetenk.-Akad. Handl.*, **27**: 166, pl.3, fig. 12. 1895.

Figures 1, 2, 5 – 8

Raphid valve: The valve face is elliptical and undulate. The striae are slightly radiated and finely punctuated. The raphe is eccentric and straight leaving at the centre a small nodule and a central area is orbicular in shape. Its distal ends are far away from the valve margin and leave a large and plain polar nodule. The raphe sternum is linear and narrow.

Araphid valve: The valve face is undulated. The striae are radiated and composed by coarse areolae varying in shape from elliptic to quadratic. The striae vary in length. The short striae are in general composed of two to three areolae and they can be irregularly distributed among longer striae. These short striae are rarely visible in LM. The raphe sternum is wider than the one in the raphid valve. It covers almost half of the valve face at the valve centre. It has a broad elliptical shape continuing to the valve apices in narrow extensions rounded at the ends.

Observations in SEM:

Raphid valve (fig. 7): In SEM the undulated valve face is more noticeable than in LM. The slightly radiated striae are formed by round areolae that are smaller towards the edge. Around the margin, every single long striae is intercalated by one short striae composed of three or four areolae. These areolae vary in shape, from circular to elliptically elongated. Around the valve there is a costae-like thickening at the angle between the valve face and the mantle. This thickening separates the biseriate striae from the small areolae present along the valve margin. The raphe is straight and filiform. The proximal and distal raphe ends are small and in droplet-shape.

Araphid valve (Fig. 8): The striae are radiated and composed of coarse areolae varying in shape from elliptic to quadrangular. Short striae are composed of only two or three elliptic or quadrangular areoale.

Dimensions: lenght: 22-28 μm; width: 14-16 μm; striae in 10 μm in the raphid valve: 18-20 and in the araphid valve: 14-16.

Studied material: **BRAZIL**, SANTA CATARINA State, **Bombinhas**, Bombas 22/ I/ 1996 (ICN 91403), Mariscal, 22/I/1996 (ICN 91479); Mariscal, 22/I/1996 (ICN 91481); Mariscal, 07/ I/ 2002 (PEL 22569); Mariscal, 07/I/2002 (PEL 22574); Mariscal, 07/I/2002 (PEL 23403); Quatro Ilhas, 15/ XII/ 1995 (ICN 91406); Quatro Ilhas 15. XII. 1995 (ICN 91407); Quatro Ilhas 22/ I/ 1996 (ICN 91465); Quatro Ilhas, 22/ I/1996 (ICN 91466); Zimbros, 07/ I/ 2002 (PEL 23259); Zimbros, 07/ I/ 2002 (PEL 23260); **Garopaba,** Garopaba, 13/V/2002 (PEL 23265); **Itajaí**, Praia Brava, 23/I/1996 (ICN 91492); **Palhoça,** Gamboa, 8/XII/2001 (PEL 22567);13/ V/2002 (PEL 22575); 13/ V/2002 (PEL 23337); Guarda do Embaú, 08/ XII/2001 (PEL 22613); Guarda do Embaú, 08/ XII/ 2001 (PEL 22818); Guarda do Embaú, 08/XII/ 2001 (PEL 22825); Guarda do Embaú, 08/XII/2001 (PEL 23338); Guarda do Embaú, 08/ XII/2001 (PEL 23385); Pinheira, 08/XII/2001 (PEL 23256); **Penha,** São Miguel, 19/XII/ 2001 (PEL 22550).

Ecology: It grows on sand, mud and silty in the North Hemisphere according to Hustedt (1955) and Sterrenburg (1988). Giffen (1970, 1975 and 1976) recorded it as very rare species, occurring on sand and along with masses of seaweeds.

Anorthoneis hyalina Hustedt, *Bull. Duke Univ. Mar. Stn.*, **6**: 15, pl., 2; figs 3-4; pl. 5; figs 12-13, 1955. (Figures 3, 4, 9-15)

Observation in LM:

Raphid and araphid valves present undulations on the valve face with a convexity around the margin and another convexity at the centre. The striae are clearly punctuated.

Araphid valve (fig. 11): The striae are short and radiated. The areolae are rectangular and transapically allongated in shape. The axial area is very wide varying from, semicircular to semi-elliptic. The raphe vestiges are observable very often. The sternum covers 75% of the valve face and presents an irregular elliptical shape. The short striae are present between longer striae in some valves.

Raphid valve (fig 10): The striae are distinctly punctated and composed of small and round areolae. Among the long striae that reach the raphe sternum there are irregularly distributed short striae composed of a variable number of areolae. These short striae are restricted to the undulation next to the edge of the valve face. The axial area is very narrow and the central area is orbicular. The raphe is eccentric and straight leaving a small nodule at the centre. The raphe distal ends are far away from the valve margin and leave a large and plain polar nodule.

Observations in SEM:

Raphid valve: The striae are formed by a single row of round areolae on the valve face and by a double row of polyedric or somewhat triangular in shape next to the edge (fig. 15). The biseriate striae are interrupted by a costae-like thickening around the valve face edge, leaving isolated and elliptical puncta along the valve margin. The raphe is straight and filiform (fig. 13). Proximal and distal raphe ends are small and in droplet-shape. Internally, proximal raphe ends are curved in opposite directions (fig. 13).

Araphid valve: This valve has a very wide asymetric sternum at its centre (fig. 14). The striae are formed by coarse and rectangular areolae that are longer around the margin.(fig 12). Vestigial marks of striation and the raphe are very commonly observable on the external valve view.

Dimensions: lenght: 25-32 μm; width: 20-25 μm, striae in 10 μm in the raphid valve: 16-18 and in the araphid valve: 12-16.

Studied material: BRASIL, SANTA CATARINA, **Bombinhas**, Araçá, 22/I/ 1996 (ICN 91458); Mariscal, 22/I/1996 (ICN 91479); Mariscal, 22/ I/ 1996 (ICN 91480); Mariscal, 07/ I /2002 (PEL 23403); Mariscal, 07/I /2002 (PEL 22574); Quatro Ilhas, 15/ XII/1995 (ICN 91406); Quatro Ilhas, 15/XII/1995 (ICN 91416); Quatro Ilhas, 22/I/1996 (ICN 91466); Quatro Ilhas, 22/I/1996 (ICN 91467); Zimbros, 15/XII/1995 (ICN 91418); Zimbros, 07/I/ 2002 (PEL 22614); Zimbros, 07/I/ 2002 (PEL 22622); **Itajaí**, Praia Brava 23/I/1996 (ICN 91492); **Palhoça,** Gamboa, 13/V/2002 (PEL 22575); Guarda do Embaú, 08/XII/2001 (PEL 22613); Guarda do Embaú, 08/XII/2001 (PEL 22825); Guarda do Embaú, 08/XII/2001 (PEL 23385); **Penha,** São Miguel, 19/XII/2001 (PEL 22550).

Remarks: Moreira Filho *et al.* 1967 illustrated one araphid valve of *A. hyalina* with 30 µm long, 24.6 µm wide and 9 striae in10 µm. Fernandes *et al.* (1990) recorded valves with 33 – 35 µm long, 27.5 – 28.5 µm and striae in 10 µm varing from 10 to 18. All these data and the measurements presented in this paper are in agreement with the original description.

Table 1. Frequency of *Anorthoneis* spp. in the beaches studied.

Beaches	*A. eurystoma* (%)	*A. hyalina* (%)	Number of slides analysed
Araçá	Not observed	<2	7
Gamboa	<2	<2- 3.5	3
Garopaba	<2	Not observed	2
Guarda do Embaú	<2-4	<2	5
Mariscal	<2	Not observed	8
Pinheira	<2	Not observed	3
Praia Brava	<2	<2	5
Quatro Ilhas	<2 – 3.5	<2 - 3	4
São Miguel	<2	<2	2
Zimbros	<2	<2	5

Anorthoneis distribution:

Table 1 presents the occurrence and frequency of *Anorthoneis* spp. in the beaches studied. We have decided to refer to very low frequencies such as < 2% instead of specifying it since the distribution of diatoms in the slides is always aggregated.

In these beaches, *Anorthoneis* can sometimes be absent. The notation "Not observed" refers to beaches where it was never found after observation of several slides. *Anorthoneis* has wide distribution along the Santa Catarina coast, occurring in 10 of the 27 studied beaches. Its frequency is always in low number, fact that is in agreement with the scarcely rare number reported by Foged, (1975 and 1984), Giffen (1970, 1975 and 1976), Sar & Ferrario (1994) and, Sterrenburg (1988). *Anorthoneis eurystoma* is more frequently found than *A. hyalina* along the Santa Catarina coast.

DISCUSSION

The morphology and dimension data are in agreement with the original descriptions and illustrations presented by Hustedt (1955) and Simonsen (1987). *Anorthoneis hyalina* has more delicate structure than *A. eurystoma* and the raphe is more lateral in *A. hyalina*. The presence of costae-like thickening around the valve edge has been first described to *A. dulcis* by Hein (1991). In that species, it occurs in the raphid valve and is more noticeable in the internal view. In the species studied here, this feature is also observable in the raphid valve but it can be easily observable in the external view of the valve.

This study confirms the occurrence of several features which are characteristic of *Anorthoneis* such as: undulated valve face, simple bands without pores or internal projections and the presence of costae-like thickening around the valve face edge on the raphid valve.

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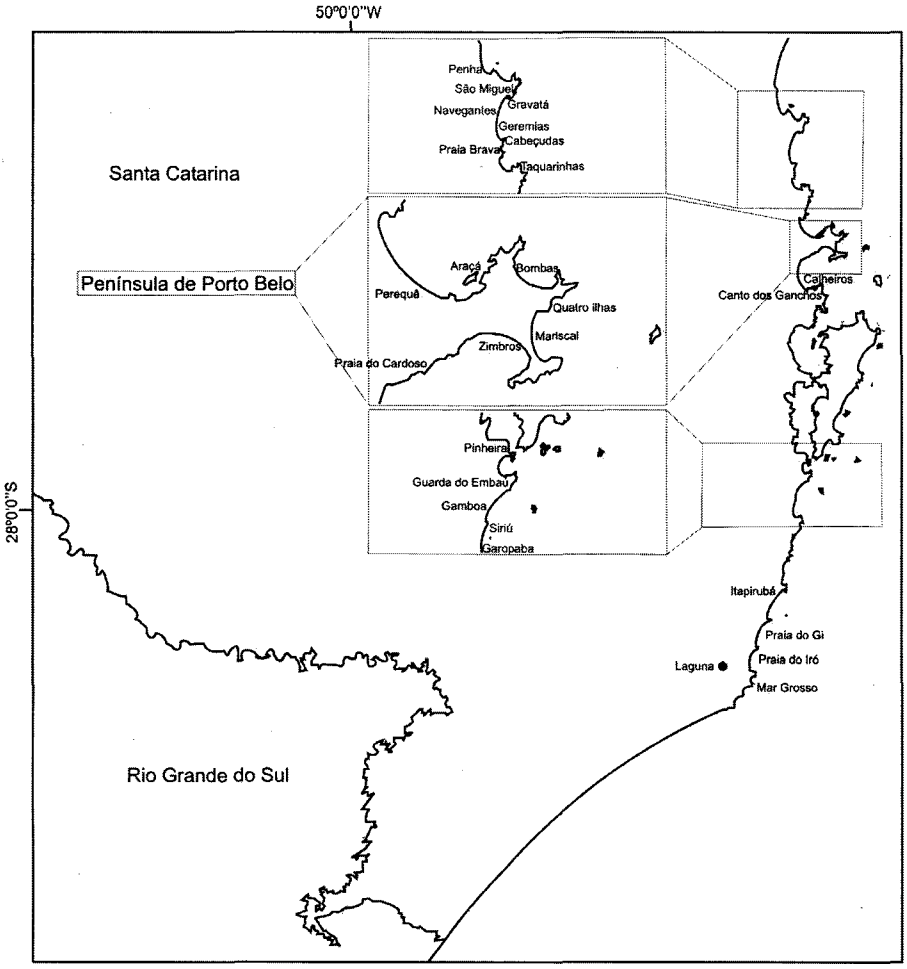
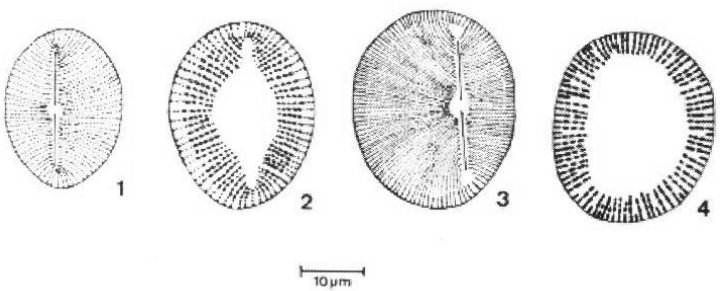
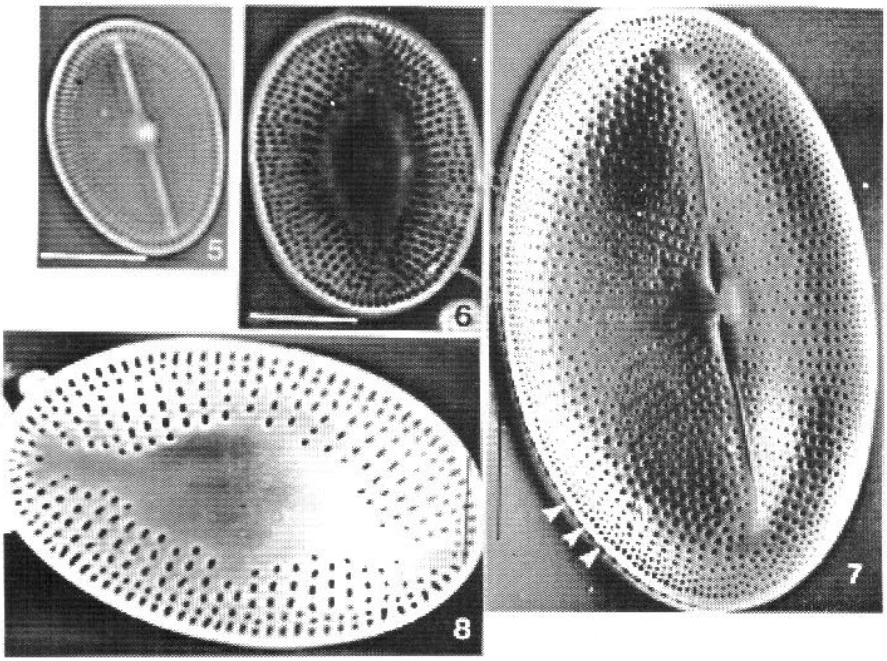


Map of Santa Catarina coast.

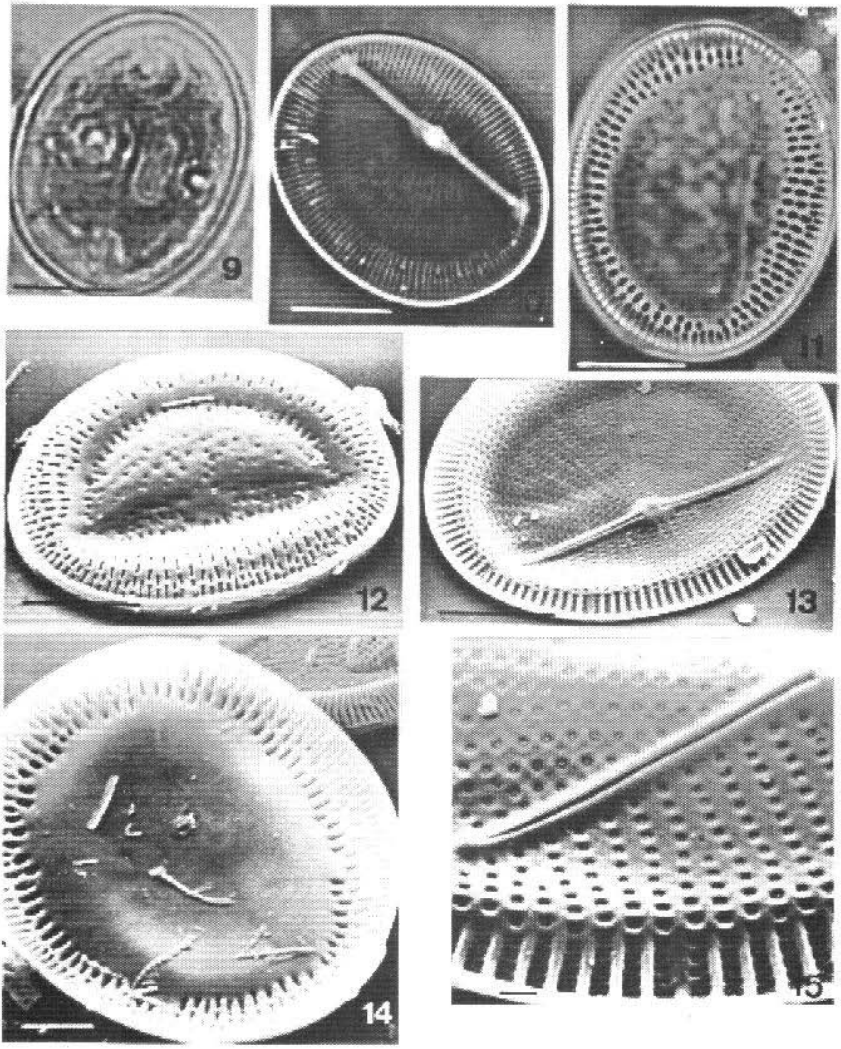


Figs 1-2. *A. eurystoma*. Light microscopy drawings. Fig 1. Raphid valve. Fig. 2. Araphid valve.
Figs 3-4. *A. hyalina*. Light microscopy drawings. Fig 3. Raphid valve. Fig. 4. Araphid valve.



Figs 5-8. *A. eurystoma.* Figs 5-6. Phase contrast. Fig.5. Raphid valve. Fig. 6. Araphid valve. Figs 7-8. SEM. Fig. 7. External view of the raphid valve. Note the costae-like thickening around the valve face edge (arrows). Fig.8. Internal view of the araphid valve.

Scale bars: Figs 5-6: 10 µm; Figs 7-8:5 µm Fig. 8 µm



Figs 9-15. *A. hyalina.* Fig.9. Light microscopy. Note the plastid somewhat in "C" form. Figs. 10-11. Phase contrast. Fig.10. Raphid valve. Fig. 11. Araphid valve. Figs 12-15. SEM. Fig. 12. External view of the araphid valve. Fig. 13. Internal view of the raphid valve. Note the proximal raphe ends turned in opposite directions. Fig. 14. Internal view of the araphid valve. Fig.15. Detail of fig 13. Note the biseriate striae around the edge. Scale bars: Figs 9-13: 10 µm; Fig. 15: 5 µm; Fig.15: 1 µm.