

## CRUCICOSTULIFERA, A NEW DIATOM GENUS DESCRIBED FROM THE MAGALIESBURG MTS, SOUTH AFRICA\*

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**Abstract.** *Navicula areolata* was described by Hustedt from streams in the Magaliesburg Mts. Recent surveys of this area led to the discovery of living cells and a large number of cells were collected and observed. Although bilaterally symmetrical, *N. areolata* clearly does not belong to the genus *Navicula* s.str., and so we describe *Crucicostulifera* gen. nov. No other genus was deemed suitable for the placement of this species, which is characterized by symmetrical valves with an H-shaped chloroplast and large central pyrenoid, a very large raphe sternum, X-shaped areolae and longitudinal ridges on the external valve face.

**Key words:** Bacillariophyceae, *Crucicostulifera*, new genus, description, new combination, ecology, distribution

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### INTRODUCTION

*Navicula areolata* was described from streams in the Magaliesburg Mts near Rustenburg in 1952 by F. Hustedt (1952). The taxon was again observed in similar habitats in surveys carried out near the same locality by Cholnoky (1957). Cholnoky did not contest Hustedt's placement of *N. areolata* within the genus *Navicula* and only amended the original description by adding data on the length and breadth attained by the cells – these data are again amended in the present publication.

Since the publication of Round *et al.* (1990), many genera have been split from *Navicula* Bory s.l. This is not a senseless activity undertaken simply to create new genera, but very necessary, as *Navicula* was a highly heterogeneous genus in which most if not all diatom cells with isobilateral symmetry and a naviculoid raphe were placed, often provisionally. Only a small fraction (corresponding to sect. *Lineolatae*) of those species once classified as belonging to *Navicula* should in fact remain in the genus; others should be transferred

to more appropriate genera should they exist, or, if not, new genera need to be created. *Navicula areolata* is just such a case; it shares none of the definitive characters of *Navicula* s.str. and thus needs to be transferred to a new genus. Since no suitable genus has yet been described, we propose the placement of *N. areolata* in a new monospecific genus *Crucicostulifera*.

### MATERIALS AND METHODS

The streams from which the samples were collected are located near Rustenburg in the Magaliesburg Mts. The geology consists of recrystallized quartzite with imbedded hornfels from the Transvaal System and diabase intrusions of the Bushveld Igneous Complex (Daley & Molengraaff 1924). The climate of the area can be described as temperate, having in excess of 600 mm of rain per annum, with most of the rain falling during the early summer months (Anonymous 2002). The sample locality falls within the Highveld Climate Region, characterized by warm summers and mild winters with frost (van Zyl 2003). According to van Zyl (2003), rain is produced mostly by thunderstorms generated during the summer months. Temperatures in the study area

\* Dedicated to Dr. Kurt Krammer on the occasion of his 85<sup>th</sup> birthday

range between extremes of 38.9°C and –6.2°C although average temperatures are in line with a temperate climate. Summer highs average around 29.6°C, dipping to 15.5°C at night, whilst typical average winter temperatures range from 23.8°C during the day to 5.4°C at night (South African Weather Services 1997, <http://www.weathersa.co.za>).

The material used in this study was collected during September 2007 by members of the Buffelspoort Valley Conservancy located in the Magaliesburg Mts. Living material was collected by J. Taylor in October 2008. Material was removed with a small brush from several rocks in mountain streams; in particular, a site in the Sterkstroom above its confluence with the Sterkwater (25°48.775'S, 27°28.467'E) had a high abundance of *C. areolata*. Slides were prepared using potassium permanganate and hydrochloric acid digestion according to the methods summarized in Taylor *et al.* 2005. Material was mounted in Pleurax (von Stosch 1974) for light microscopy (Nikon 80i equipped with a 100× PlanApochromat VC 1.4. N.A. oil immersion objective, Nikon DS-U2 5MP digital camera). A portion of cleaned material was also examined under SEM (FEI Quanta 200 ESEM).

## DESCRIPTION

***Crucicostulifera*** Taylor & Lange-Bertalot, *gen. nov.*

TYPE: *Crucicostulifera areolata* (Hustedt) Taylor & Lange-Bertalot, *comb. nov.*

BASIONYM: *Navicula areolata* Hustedt, Bot. Not. **105**: 405, Fig. 126. 1952 (amended diagnosis Cholnoky, Bot. Not. **110**(3): 352, Figs 45–47. 1954). TYPE: [SOUTH AFRICA] Südafrika Magaliesberge (Magaliesburg) Rustenburg 'Fels 1', 21 Aug. 1949 [HOLOTYPE: praep. 245/94a in coll. Hustedt (AWI Bremerhaven); specimen, represented by Figs 591: 14 & 15 in Simonsen (1987) (Finder 522.5)]. The generic type is typified by the holotype of Hustedt's taxon.

*Genus adhuc monospecificum familiae incertae non designatae. Cellulae solitariae, naviculoideae. Chromatophora es lobed falsidicus per suum centre obviam unus limbus pars, quod tendo sub sulum valve visio in an H-vultus configuration. Chromatophora usitas per a validus unilateral invagination. Frustula aspectu cinguli fere rectangulata, circiter 10–20 µm lata. Valvae lanceolatae apicibus obtuse rotundatis non protractis. Longitudo 40–120 µm, latitudo 12–20 µm. Raphe anguste lateralis sed undulans et filiformis quoad extrema*

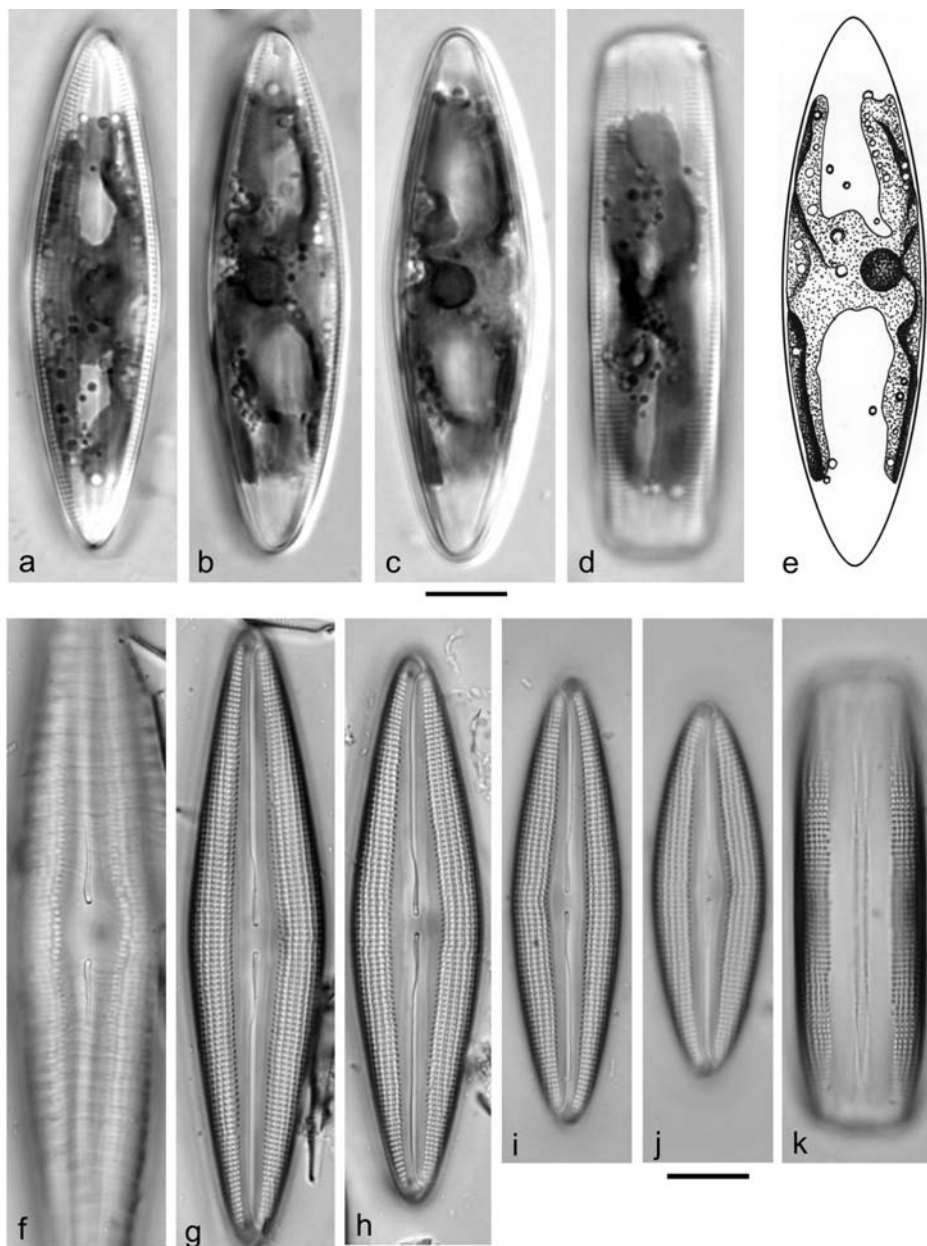
*centralia curvata versus latus primum valvae extremis valde distanter sitis inter se in speciminibus maioribus. Area axialis alias raphosternum lineari-lanceolata sine area centrali separata. Striae transapicales radiantibus omnino circiter 16 in 10 µm cum areolis transapicaliter aliquid elongatis apparentibus etiam in seriebus apicalibus regulariter formantibus aequaliter circiter 16 in 10 µm. Aspectus ultramicroscopicus externus: facies valvae plana super sternum tum plus minusve arcuata in partibus lateralibus faciei et limbi. Iunctura inter faciem et limbum vix aspectabilis quia systema superformata externa costarum apicalium. Haec costae internae absunt. Foramina areolarum seriata apicaliter in depressionibus inter costas. Foramina in forma litterae x (id est cruciata) apparentia. Raphe cum fissuris terminalibus distinctis proximaliter fissuras paulo dilatatas formans, pori centrales guttiformes vel circulares nulli. Aspectus ultramicroscopicus internus: scissura raphis simpliciter recta in sterno specioso sita (ita ut in Navicula s.str.). Extrema distincte hamata ad latus. Aperturae areolarum in alveolis angustis depressis aliquid transapicaliter elongatae et non oclusae apparentes. Cingulum e singula copula chusa pro valva constans.*

ETYMOLOGY: The epithet *Crucicostulifera* refers to the shape of the external areolar openings, which are x-shaped or cruciform, and the external longitudinal ribs separating the areolae into regular apical lines.

LM. Presently this is a monospecific genus. The cells are solitary, naviculoid, and may be observed lying in valve or girdle view; the latter is *ca* 10–20 µm broad and more or less rectangular.

Plastids are lobed, lying with their centre against one girdle side, and extend under each valve face in an H-shaped configuration (Fig. 1a–c & e). Figure 1d is a girdle view. Chloroplast usually with a strong unilateral invagination.

Valves lanceolate with obtusely rounded, not protracted ends. Length 40 to *ca* 120 µm, breadth 12–20 µm. At the poles the raphe is narrowly lateral, becoming filiform, with the undulating external raphe slit curving to the primary side of the valve – that is, opposite to the hooks of the terminal raphe fissures – towards the centre of the valve. The distance between the central raphe endings decreases conspicuously from the primary to the smallest stages of the cell cycle (Fig. 1f–k). The axial area is narrowly lanceolate without a separated central



**Fig. 1.** *Crucicostulifera areolata* (Hustedt) Taylor & Lange-Bertalot, a–c – living cells in valve view, images taken at different focal depths; d – living cell in girdle view; e – interpretative line drawing of plastid structure; f – auxospore initial cell with remains of transverse perizonium; g–j – cells from a single population, showing size range; k – girdle view. Scale bars = 10  $\mu$ m.

area. However, the sternum is slightly asymmetric, with one side being half narrowly lanceolate, the other side being more half rhombic (especially conspicuous in Fig. 1i and j, with a clear angle

in the middle). Transapical striae appear radiate throughout, composed of transapically elongate areolae which form regular apical lines, ca 16 in 10  $\mu$ m (both apical and transapical).

SEM, EXTERNAL VIEW (Fig. 2a & c–f). The valve face is only flat in the region of the sternum, after which it is laterally curved or arched and without any clear junction between valve face and valve mantle. The junction between valve face and mantle is also masked by a prominent system of supporting ribs or frets (as in some *Craticula* species, but more pronounced) which are completely lacking on the internal surface of the valve. These ribs (Fig. 2a & c) become shallow and less prominent, and may disappear on the distal part of the mantle (Fig. 2d). Externally, the areolar openings are x-shaped (Fig. 2f), arranged apically in depressions (troughs) between the ribs. The central raphe ends are moderately expanded and slit-like (Fig. 2e). The terminal fissures are broadly hooked to the secondary side (Fig. 2d).

SEM, INTERNAL VIEW (Fig. 2b & g–i). Raphe slit – unlike *Navicula* s.str. – straight, not twisted, centrally hooked (Fig. 2h) and ending in helictoglossae at the poles (Fig. 2g); an accessory rib (typical for *Navicula*) which accompanies the raphe is lacking. Apertures of the areolae are transapically slightly elongate and seem unoccluded, lying in very shallow, narrow transapical depressions (Fig. 2i). The girdle consists of a single, broad, closed copula in each valve (Fig. 2c).

#### DISTRIBUTION AND ECOLOGY

This taxon apparently is strictly limited in distribution to the Magaliesburg Mts near Rustenburg, South Africa. Despite many investigations of similar habitats in South Africa after the description of *C. areolata* in 1952, the species remains unknown from any other locality.

It is found in abundance in electrolyte-poor, slightly alkaline waters with very low levels of nutrients. It is found in abundance together with *Achanthes* (*Achnanthidium*?) *standeri* Cholnoky, *Navicula notha* Wallace, *Achnanthidium minutissimum* (Kütz.) Czarnecki, *Achnanthidium catenatum* (Bily & Marvan) Lange-Bertalot and *Gomphonema venusta* Passy, Kocielek & Lowe. This species may possibly be endemic to South Africa and may even be restricted to the Magalies-

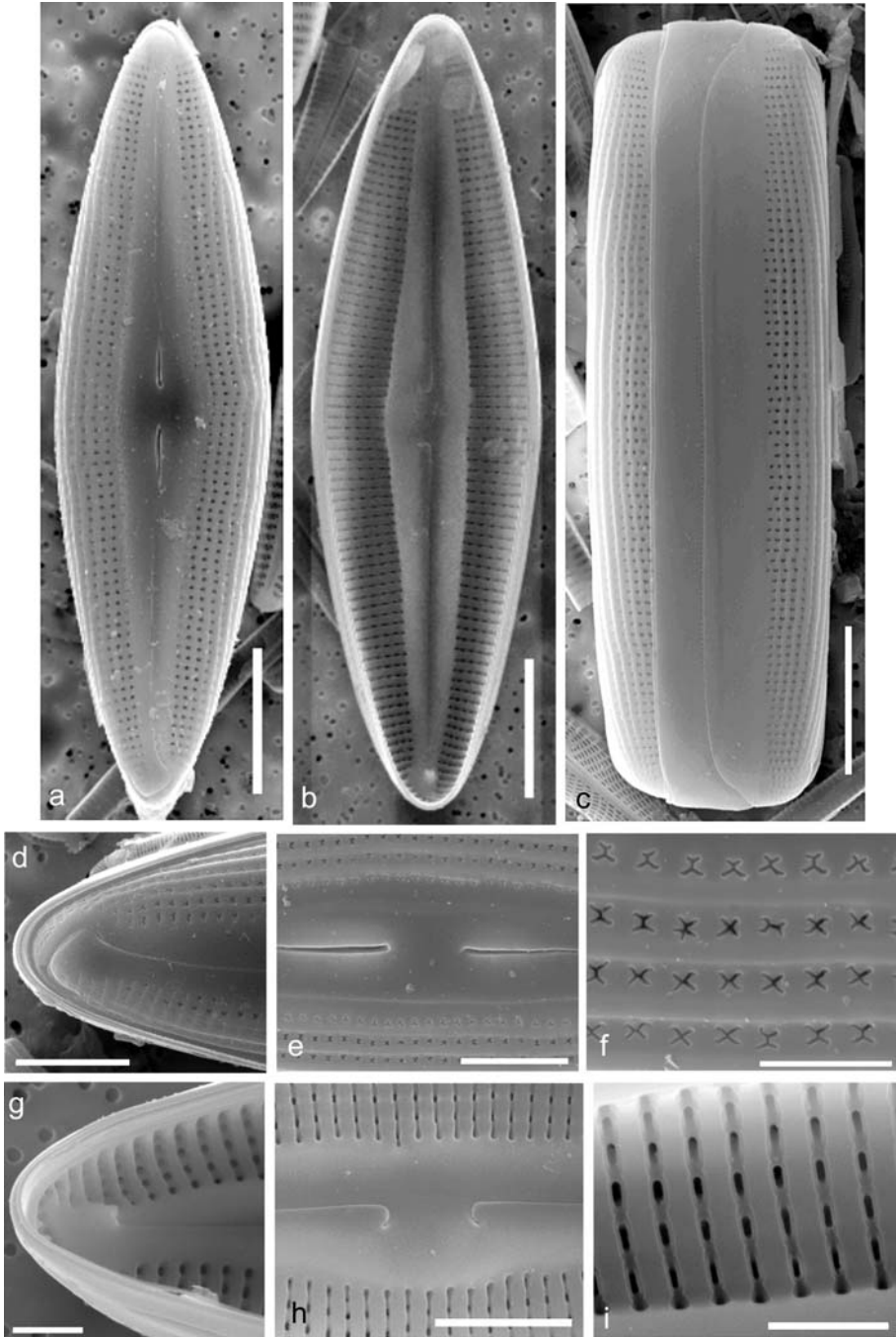
burg Mts. As for the occurrence of the genus, further critical investigation of already established taxa in *Navicula* s.l. is necessary.

#### DISCUSSION

The distinctive characteristics of *Crusicostulifera* are the arched valve face with no distinct junction to the valve mantle, the wide, lanceolate-rhombic axial area, the longitudinal ribs and the x-shaped areolar openings. No apical pore fields are present. The chloroplast structure is rather similar to that found in the cymbelloid and gomphonemoid genera, which may justify its preliminary placement in the Cymbellales D. G. Mann. Whether it belongs to the Cymbellaceae remains an open question.

Without doubt, this unique combination of characters matches neither the description of *Navicula* Bory s.str. nor any other of the established genera, in particular those split off from *Navicula* s.l. both in the past and more recently. Comparable x-shaped areolae foramina occur in, for example, several taxa of *Cymbella* (e.g., *C. mexicana*, *C. cantonatii*, *C. aspera* var. *columbiana*), but the cells are isobilateral albeit with a certain degree of asymmetry in the axial area. This, with several other characteristics, prevents this species from being placed in *Cymbella*. Jüttner *et al.* (2010) have described the genus *Oricymba* to accommodate *Cymbella* species that are only weakly dorsiventral or else almost symmetrical. This genus is characterized by a ridge along the valve face: a mantle junction and areolae that are slit-like and partially occluded by dentate projections. The structure of the areolae as well as the longitudinal ridges on the valve face serves to differentiate *Crusicostulifera* from *Oricymba*.

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**Fig. 2.** *Crucicostulifera areolata* (Hustedt) Taylor & Lange-Bertalot, a – external valve view SEM; b – internal valve view SEM; c – external valve view of cingulum SEM; d – external view of terminal raphe fissure and external openings of areolae SEM; e – external view of central raphe endings; f – x-shaped external openings of areolae SEM; g – internal view of helictoglossa SEM; h – internal valve view of central raphe fissures SEM; i – internal view of areolae SEM. Scale bars: a–c = 10 μm; d–f & h–i = 2 μm; g = 1 μm.

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