

# A re-investigation of Otto Müller's *Cymatopleura* taxa (Bacillariophyta) from East Africa

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**Background** – Otto Müller described seven varieties and forms of *Cymatopleura solea* from material from Central and East Africa. A re-investigation of the original material studied by Müller allowed us to lectotypify these taxa and describe another as new to science.

**Methods** – Permanent diatom slides from original samples collected by Dr. Fülleborn in 1899 and 1900, and deposited at the Botanic Garden and Botanical Museum Berlin, Dahlem (B) were made. Additionally, material from Lake Victoria collected during the Third Tanganyika expedition conducted by Dr. Cunningham in 1904–1905, and kept at The National History Museum London (BM) were studied. Investigations were carried out using light microscopy and where possible also with scanning electron microscopy.

**Key results** – Although *Cymatopleura solea* var. *subconstricta* and its forms *major* and *minor* are invalid, illustrations of Müller's concepts are shown and the taxon *Cymatopleura comperei* was described as new. On the other hand, the taxonomic entities var. *clavata*, var. *laticeps* and var. *rugosa* are redefined and raised to species rank: *Cymatopleura clavata*, *C. laticeps* and *C. rugosa* respectively. Additional morphological descriptions, based on light and scanning electron microscopy, are given for all these taxa where appropriate and their African distribution as based on literature and our own observations. In addition, the original slide of *Cymatopleura nyansae*, described from Central Africa by West, is also illustrated and discussed, firstly because it resembles the *Cymatopleura laticeps* valves which we observed in one of the historic samples from Lake Malawi examined by Müller, and secondly because often erroneous concepts of this taxon are present in the African literature.

**Key words** – *Cymatopleura*, diatoms, East Africa, taxonomy, typification.

## INTRODUCTION

*Cymatopleura* W.Sm. taxa are, to a lesser degree than those of the genus *Surirella* Turpin (Ross 1983, Cocquyt & Jahn 2005, 2007a, 2007b, 2007c, 2007d), a typical and specific component of the East African Great Rift flora. At the beginning of the 20<sup>th</sup> century, Müller described seven taxa (four varieties and three forms) as new belonging to the genus *Cymatopleura*. These were among his about 200 new East African diatom taxa (Müller 1904a, 1904b, 1905, 1910, Jahn 2002) from samples collected during the German “Nyassa-See- und Kinga-Gebirgs-Expedition” (Müller 1904a). The discovery of a large part of these historic samples in the Botanic Garden and Botanical Museum Berlin-Dahlem (for details see Jahn 1996 and 2002) allowed us to re-investigate these taxa.

As was done for the *Surirella* taxa (Cocquyt & Jahn 2005, 2007a, 2007b, 2007c, 2007d) and to make Müller's drawings and detailed descriptions, written in German, more accessi-

ble, we translated the original German descriptions and lectotypified each of his seven *Cymatopleura* taxa. Additional morphological characters are given after investigating historical as well as modern samples, using LM and SEM. The observation that Müller's African *Surirella* taxa with names of varieties attached to European species are to be considered independent species (Cocquyt & Jahn 2005, 2007a, 2007b, 2007c, 2007d), account also for the taxonomic re-investigation of the African *Cymatopleura* taxa. Incorrect concepts of *Cymatopleura nyansae* G.S.West (West 1907: 167, plate 8, fig. 8) often appeared in the African literature. This species is another endemic African taxon described from Lake Victoria (West 1907) and observed in the historic material from Lake Malawi, the type material of this taxon was also investigated here.

In addition to this paper, supplemental nomenclatural information will be made available via the AlgaTerra Information System (Jahn & Kusber continuously updated).

## MATERIAL AND METHODS

Material belonging to the original samples Dr. Fülleborn collected in 1899 and 1900 was oxidized with Hydrogen peroxide and embedded in Naphrax® to obtain new permanent microscopic slides.

The samples studied in this paper are listed in table 1 with collection information, the original collectors, collection localities and details as published by Müller (1904a) and translated from German. Current names of the localities are in square brackets. The last two numbers of the samples, kept at the Botanical Museum Berlin-Dahlem (B), refer to the numbering used by Müller (1904a).

Other samples from the same expedition studied by Müller and referred to in his description of *Cymatopleura* taxa (his numbers 7, 9, 10, 13, 17, 24, 28, 29) were no longer available. Also some recent samples from Lake Malawi collected by Hedy Kling were also studied (table 1).

Additionally, we studied material from Lake Victoria collected at the beginning of the 20<sup>th</sup> century (April 1905) near Bukoba during the Third Tanganyika expedition conducted by Dr. Cunningham, and kept at The National History Museum London (BM) (nos 249, 252). The studied material of BM included the type material of *Cymatopleura nyansae*. Other material from Lake Victoria studied included a sample collected by A. Borget near Entebbe (Uganda) on 23 Nov. 1904 and kept at the Museum Botanicum Hauniense, Copenhagen (Denmark).

LM investigations were done with a Zeiss Axioplan and an Olympus BX 50 and BX 51 microscope, all equipped with Differential Interference Contrast (DIC) with objective 40x, 63x (oil immersion) or 100x (oil immersion). SEM investigation of the historical material was done at B with a

Philips SEM 515 operating at 30 KV and at BR with a JEOL 5800 LV operating at 25 KV. SEM stubs of the historical material are kept at B.

## RESULTS

***Cymatopleura clavata*** (O.Müll.) Cocquyt & R.Jahn, **comb. nov.**

Figs 1–2

**Basionym** – *Cymatopleura solea* var. *clavata* O.Müll., Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie 34: 22, fig. 1. 1904 (Müller 1904a); additional figure in Schmidt (1904: plate 245, fig. 1). – Type: Malawi, Lake Malombe, after the discharge of Lake Malawi, sample B 52 0000039 (lecto-: B 40 0040250, **designated here**; the valve representing the lectotype is here illustrated in fig. 1 D).

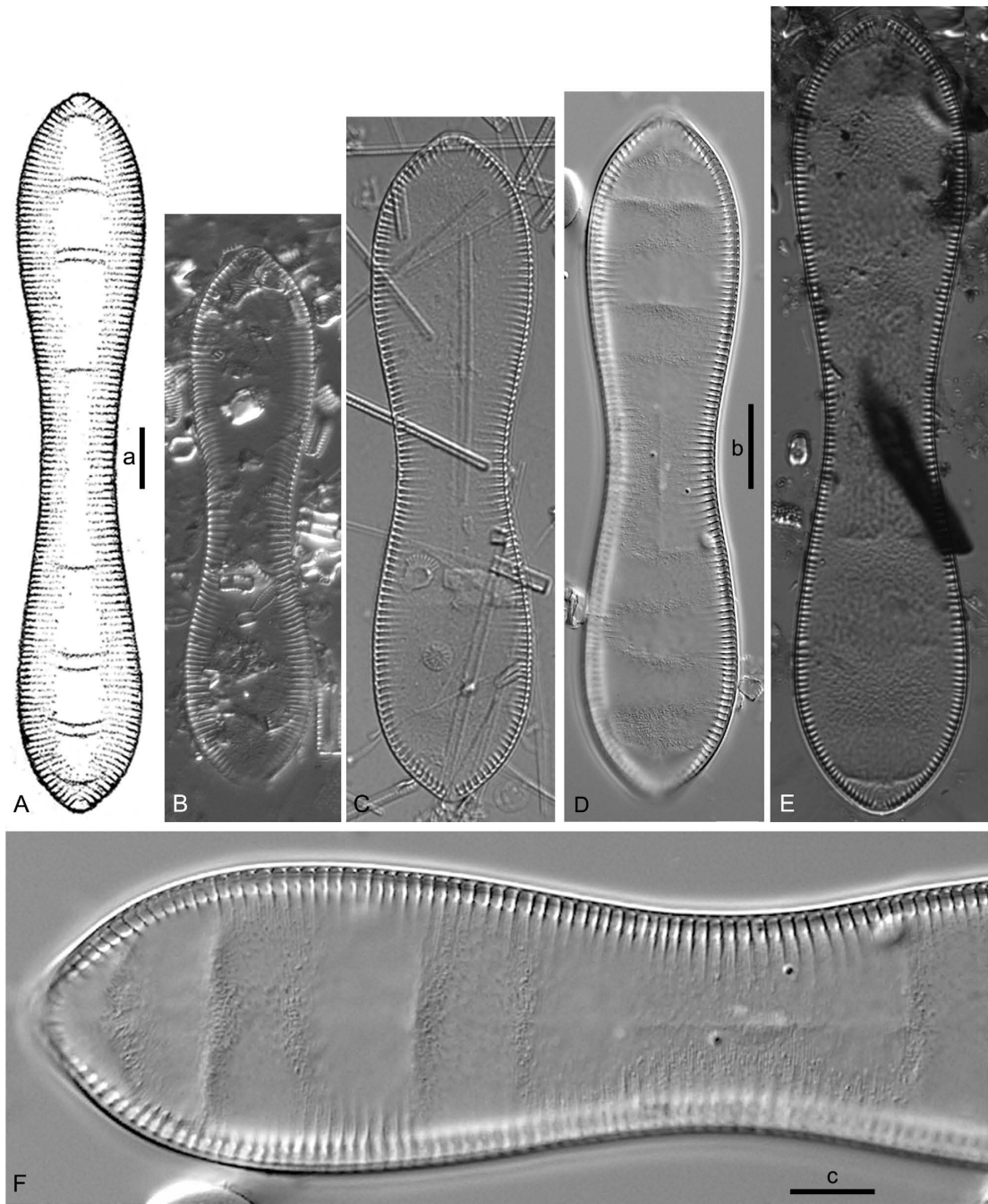
**Synonym** – *Cymatopleura solea* var. *clavata* f. *minor* O.Müll. (Müller 1904a: 22), **nom. illeg.** (see Jahn 2002); additional figure in Schmidt 1904: plate 246, fig. 10. – Type: Malawi, Lake Malombe, plankton (figure in Schmidt 1904: plate 246, fig. 10).

**Original description** – Translated into English, Müller's description of *Cymatopleura solea* var. *clavata* (Müller 1904a: 22) reads: "Valves sole shaped, elongated and narrow, more or less constricted in the middle, with round, clavate, sometimes protracted ends. Marginal costae composed of short striae, sometimes longer in the middle, 6–7 in 10 µm, with slender elongations, not reaching the pseudoraphe. Striae between the costae very thin and finely punctate. Pseudoraphe not very distinct. Valve face finely granulate with 5–7 shallow waves. Length: 110–240 µm; width in the constricted part: 19–27 µm, in the broadest part: 28–43 µm.

**Table 1** – List of samples used in the present study.

Table with information on collectors, collecting localities and details as published by Müller (1904a) and translated from German. The current name of Lake Nyassa is Lake Malawi; in square brackets is given the country to which belong the collection locality actually. The last two numbers of the samples refer to the numbering used by Müller (1904a).

number	lake	locality	habitat	collector	date
B 52 0000010	Nyassa	Langenburg [Tanzania]	plankton, 1 km off shore	Dr. Fülleborn	24 Apr. 1899
B 52 0000025	Nyassa	near the island of Likoma [Malawi]	sediments from 333 m depth	Dr. Fülleborn	31 Jan. 1900
B 52 0000037	Malombe	after discharge of Lake Nyassa [Malawi]		Dr. Fülleborn	1 Feb. 1900
B 52 0000038	Malombe	after discharge of Lake Nyassa [Malawi]		Dr. Fülleborn	7 Feb. 1900
B 52 0000039	Malombe	after discharge of Lake Nyassa [Malawi], in the course of the River Shire	marshy pond, water 1–2 m deep, label has extra word 'Diatoms'	Dr. Fülleborn	3 Feb. 1900
B 52 0000041	Malombe	after discharge of Lake Nyassa [Malawi]	label has extra word 'Plankton'	Dr. Fülleborn	
B 52 0000053		watercourse near the hot spring of Utengule [Tanzania]			11 Jun. 1899
B 52 000151	Malawi	North of Research Center in Malawi		Hedy Kling	15 May–14 Sep. 1997
B 52 000152	Malawi	near Thumbi Island in Malawi	sample from a sediment trap, at 100 m depth in the water column	Hedy Kling	15 May–8 Sep. 1997



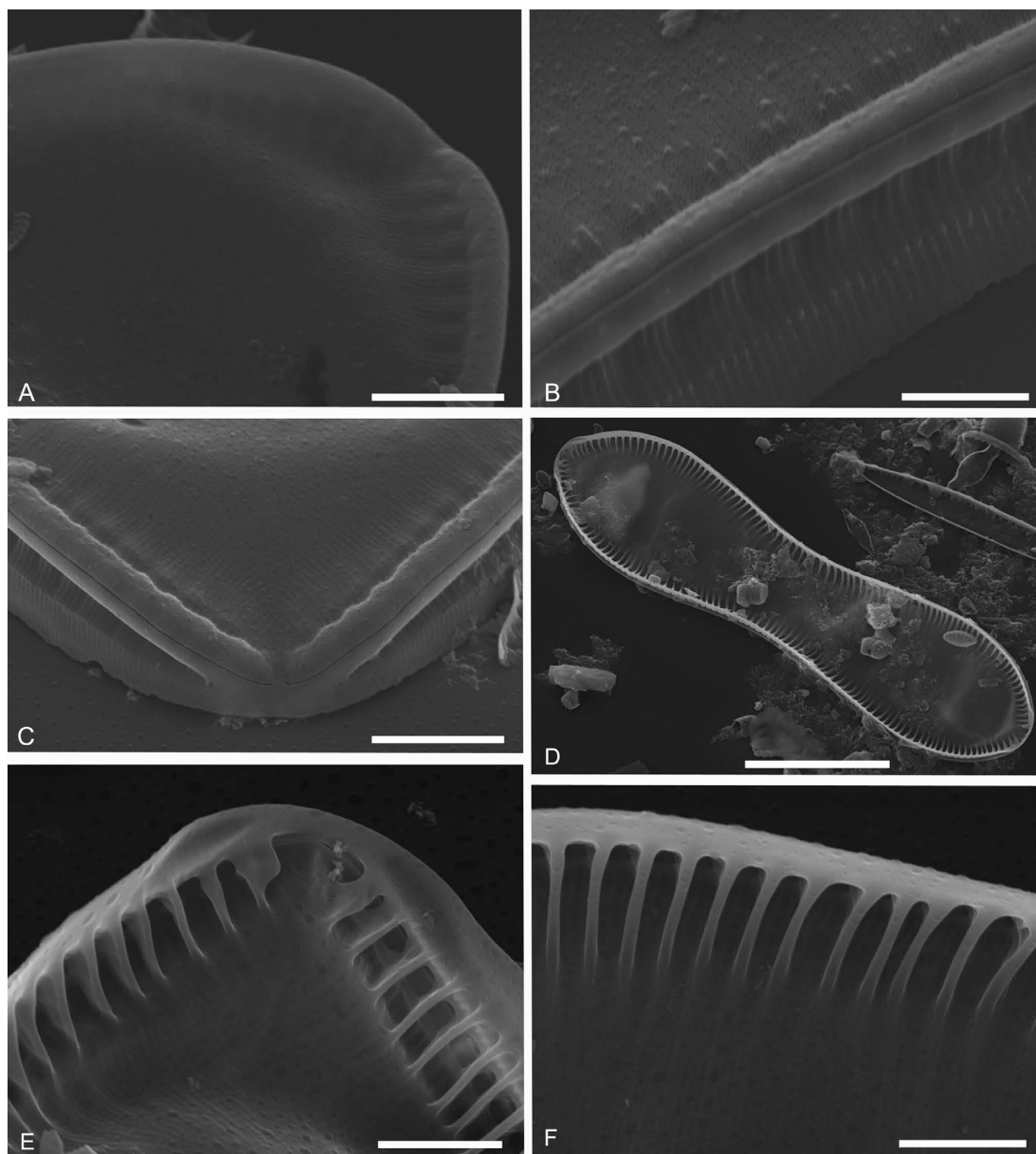
**Figure 1** – *Cymatopleura clavata*: A, original drawing of *Cymatopleura solea* var. *clavata* (Müller 1904a: 22, fig. 1); B–F, LM; D & F, valve from sample B 52 0000039, slide B 40 0040250, representing the lectotype. A, scale bar a = 20 µm; B–E, scale bar b = 20 µm; F, scale bar c = 10 µm.

Width-to-length ratio 1: 4.7–10. Present in the plankton of Lake Nyassa near Langenburg at surface (7), near Wiedhafen surface (9); in a swamp at Nyassa (28), in a pool near Nyassa (29), in Lake Malombe (37–39), in plankton from Lake Malombe (41).”

**LM: emended description** – Valves sole shaped, elongated, rather narrow and more or less constricted in the middle, with round, clavate and sometimes protracted poles; length 110–240 µm, width in the largest part 28–43 µm, in the constricted part 19–27 µm; width-to-length ratio is 4.1–4.4, and

6.0–6.6 in the constricted part. Marginal costae short, about 4.5 µm, sometimes longer in the middle but never reaching more than half of the distance to the axial area, 6–7 in 10 µm. Alar canals number 5.5–6.5 in 10 µm; striae very thin and not continuous in the middle of the valve face but leaving a small axial area which is not always very distinct. Valve face finely punctate with 5–7 shallow waves (not visible in fig. 1C as this valve is eroded). Fig. 1.

**SEM: description** – External valve view. Valve face covered by delicate reticulate thickenings, and scattered silica

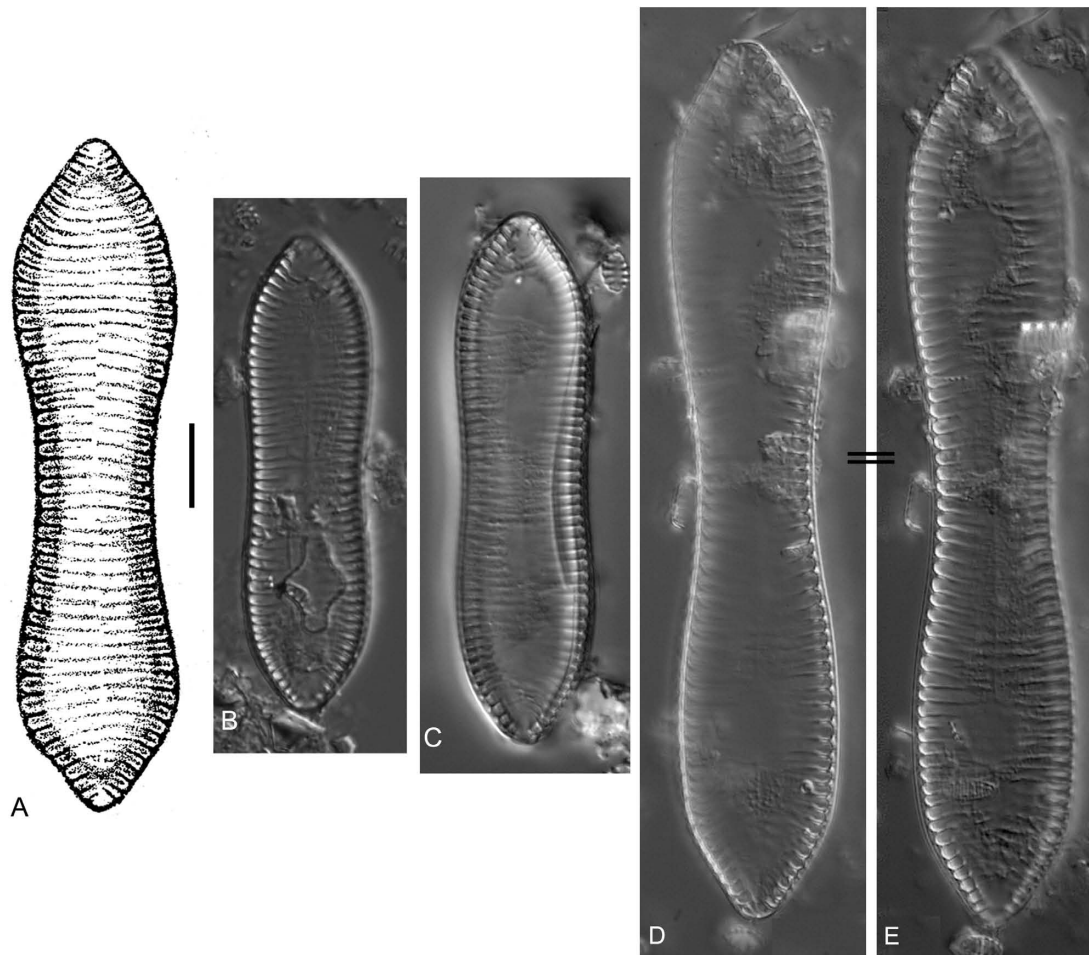


**Figure 2** – *Cymatopleura clavata* SEM: A–C, external valve view; D–F, internal valve view; A, detail mid-valve showing the valve face with an irregular reticulate surface and scattered silica granules; B, detail of the valve mantle showing indented costae on the valvocopula bearing dense uniseriate striae; C, valve pole showing the smooth raphe canal and the straight and not enlarged raphe endings; E–F, detail of the rimmed uniseriate striae, the internal fibulae and the portulae. A & C, scale bars = 6  $\mu\text{m}$ ; B, scale bar = 3  $\mu\text{m}$ ; D, scale bar = 30  $\mu\text{m}$ ; E & F, scale bars = 4  $\mu\text{m}$ .

granules; granules about 0.2  $\mu\text{m}$  in diameter. **Striae** number 55–60 in 10  $\mu\text{m}$ ; areolae almost invisible, 90–100 in 10  $\mu\text{m}$ . **Costae** only obvious near the shallow, smooth keel bearing the raphe canal. **Raphe** simple with straight, not enlarged terminal closely spaced raphe fissures. **Valve mantle** has indented costae. **Internal valve view**. **Striae** uniseriate, also in between the fibulae and in the opening of the portulae; striae composed of about 90–100 rimmed areolae in 10  $\mu\text{m}$ . **Girdle**. Valvocopula verrucose (not shown). Fig. 2.

**Habitat** – Benthic and epiphytic, may occur in the plankton; in alkaline waters.

**Distribution** – Tropical Africa. Besides Lake Malawi (= Lake Nyassa) and Lake Malombe (Müller 1904a) this taxon was reported from Lake Victoria (Ostenfeld 1909, Wołoszyńska 1914, Bachmann 1933, Van Meel 1954) and from Lake Chad (Iltis 1972, and probably Compère 1975 as *C. nyansae* G.S.West). Compère (1975) observed intermediate forms between *C. solea* (Bréb.) W.Sm. and *C. clavata* (as *C. solea* var. *clavata*) from Lake Chad but a re-investigation of the material is needed as this might have been a misinterpretation. Cocquyt (1998: plate 11, fig. 3) also depicted *C. clavata* from Lake Tanganyika without separating it from *C. solea*. Mpawenayo (1996) mentioned the presence of *C.*



**Figure 3** – *Cymatopleura rugosa*: A, original drawing of *Cymatopleura solea* var. *rugosa* (Müller 1904a: 23, fig. 3); B–E, LM; D–E, valve taken at different foci from sample B 52 0000039, slide B 40 0040252, representing the lectotype. Scale bar = 10 µm.

*nyansae* in the Rusizi Plain (Burundi); his images (Mpawenayo 1996: plate 64, figs 14–16), however, do not correspond to the description of *C. nyansae* (West 1907: 167, plate 8, fig. 8), but fit the description of *C. clavata*.

***Cymatopleura rugosa*** (O.Müll.) Cocquyt & R.Jahn, **comb. nov.**  
Figs 3–4

**Basionym** – *Cymatopleura solea* var. *rugosa* O.Müll., Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie 34: 23, fig. 3. 1904 (Müller 1904a); additional figure in Schmidt (1904: plate 245, fig. 4). – Type: Malawi, Lake Malombe, after discharge of Lake Malawi, sample B 52 0000039 (lecto-: B 40 0040252, **designated here**; the valve representing the lectotype is here illustrated in fig. 3D–E).

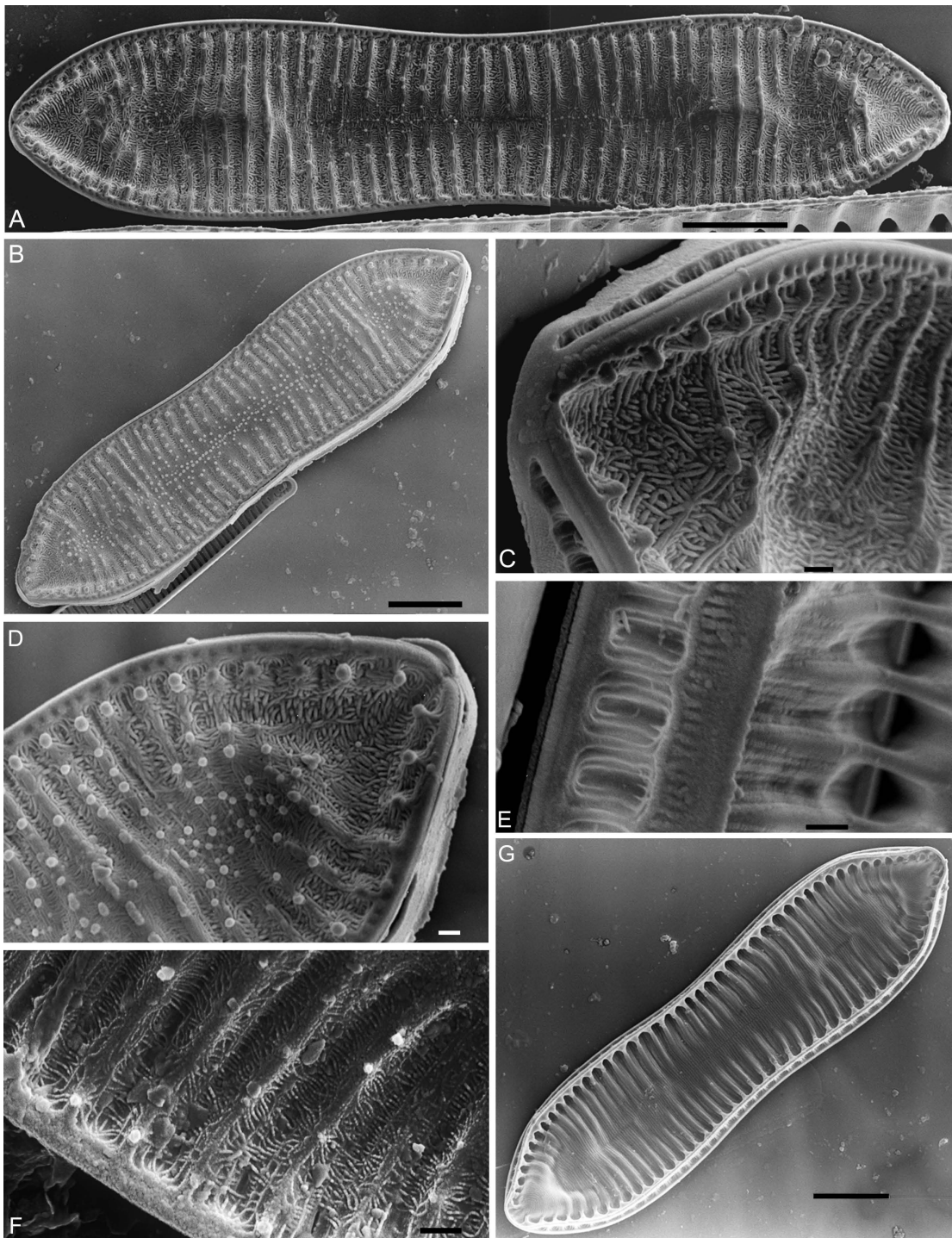
**Original description** – Translated into English, Müller’s description of *Cymatopleura solea* var. *rugosa* (Müller 1904a: 23) reads: “Valves linear, elongated with more or less constricted margins and cuneate, rounded, somewhat protracted ends. Ribs stronger near the margins, with distinct, turned elongations reaching the pseudoraphe, 5–6 in 10 µm. Striae in between the costae very thin, stronger near

the margins; pseudoraphe a continuous, indistinct line. Valve face finely punctate and slightly undulated. Length: 66–88 µm, smallest width: 12–14 µm, largest: 16–19 µm. Width-to-length ratio 1 : 4.4–7.1. Lives in Lake Malombe (39) and in its plankton (41).”

The valve length of the lectotype specimen is somewhat larger (100 µm) than the range given by Müller (1904a). The smallest and largest width (12.9 µm and 17.9 µm respectively) fall within the range given by Müller (1904a). The width of smaller valves, however, can become somewhat broader (smallest: 17 µm, largest: 20.5 µm). Müller (1904a: 23) noted that: “the graceful small variety is closely related to var. *apiculata* W. Smith, but differs in the more rounded ends and the peculiar costae”.

**LM: emended description** – Valves linear, elongate with more or less constricted margins and cuneate, rounded, somewhat protracted ends; length: 52.5–100 µm, width in the constricted part: 12–17 µm, largest width: 14.5–20 µm. Length-to-width ratio 3.6–5.6 and 4.0–7.8 in the constricted part. Costae number 5–6.5 in 10 µm, up to 8 in 10 µm in the smallest valves, almost reaching the axial area, and stronger near the valve margins. Axial area a continuous thin line, often indistinct. Valve face finely punctate and slightly undulate. Fig. 3.

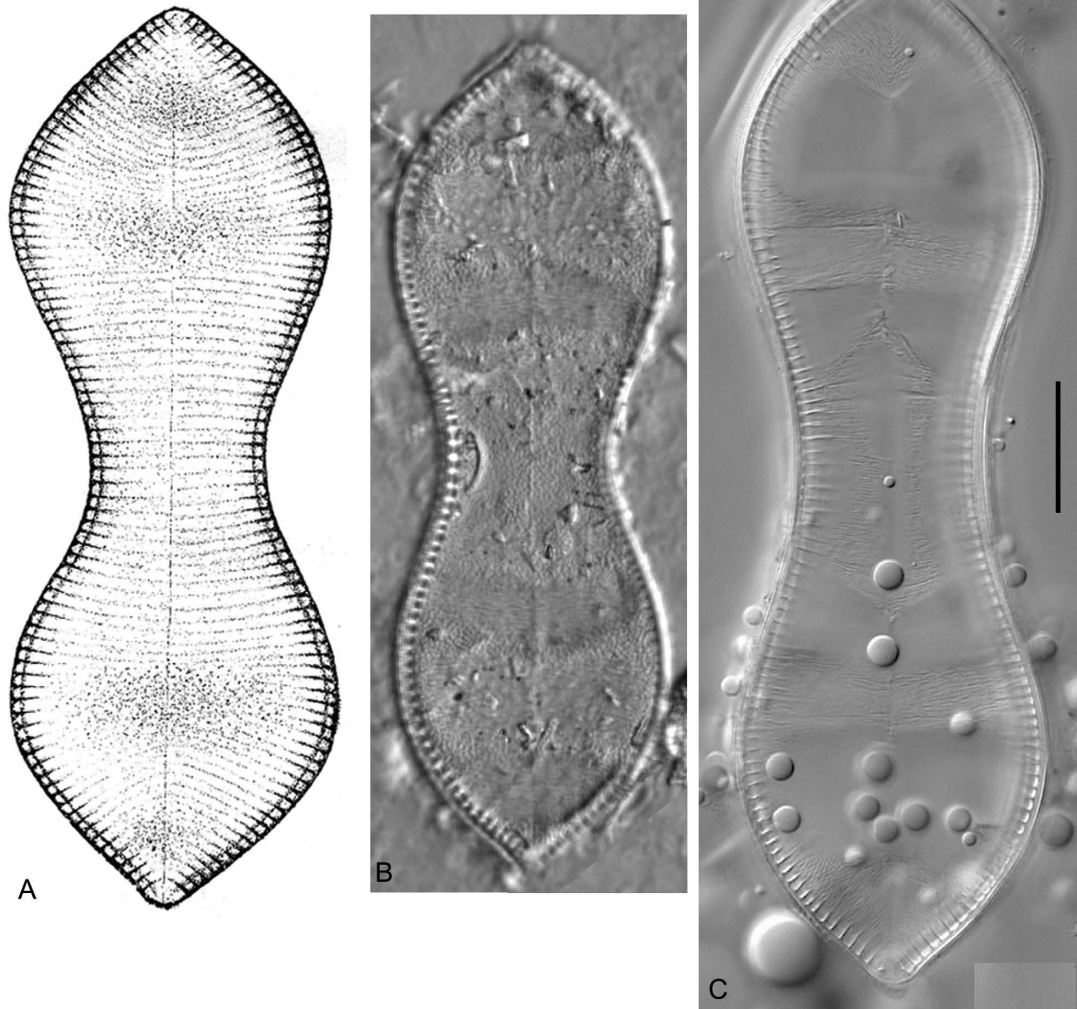




**Figure 4** – *Cymatopleura rugosa* SEM: A–F, external valve view; G, internal valve view; C, detail of the valve pole showing the smooth raphe canal and the straight and not bent raphe endings; D & F, detail of the valve face with one large silica granule at the end of the costae close to the junction with the raphe canal, and scattered granules and numerous irregular silica bars on the valve face; E, detail of the valve mantle showing indented costae. A, B & G, scale bars = 10  $\mu\text{m}$ ; C–F, scale bars = 1  $\mu\text{m}$ .

**SEM: description** – **External valve view.** Valve face bears robust costae and prominent reticulate thickenings. Silica granules on the top of the transapical valve undulation near the valve margin around 0.7  $\mu\text{m}$  in diameter. If granules present on the rest of the valve face, then much smaller, near the axial area about 0.3  $\mu\text{m}$  in diameter, and always on the top of

the alar undulations, never in the depressions. All these thickenings and granules obscure the striae so that they cannot be observed on the external valve face. 5.5 alar undulations in 10  $\mu\text{m}$ . Raphe on a shallow keel, and simple; terminal raphe fissures not enlarged and only observed near one pole, near the other pole the raphe continuous (fig. 4C). **Internal valve**



**Figure 5** – *Cymatopleura laticeps*: A, original drawing of *Cymatopleura solea* var. *laticeps* (Müller 1904a: 22, fig. 2); B–C, LM; C, valve from sample B 52 0000010, slide B 40 0040251, representing the lectotype. Scale bar = 20 µm.

**view.** *Striae* uniseriate, 31 in 10 µm, and along the middle of the valve interrupted forming a narrow line, the axial area. *Areolae* round and rimmed, about 80 in 10 µm. **Girdle.** No girdle bands observed. Fig. 4.

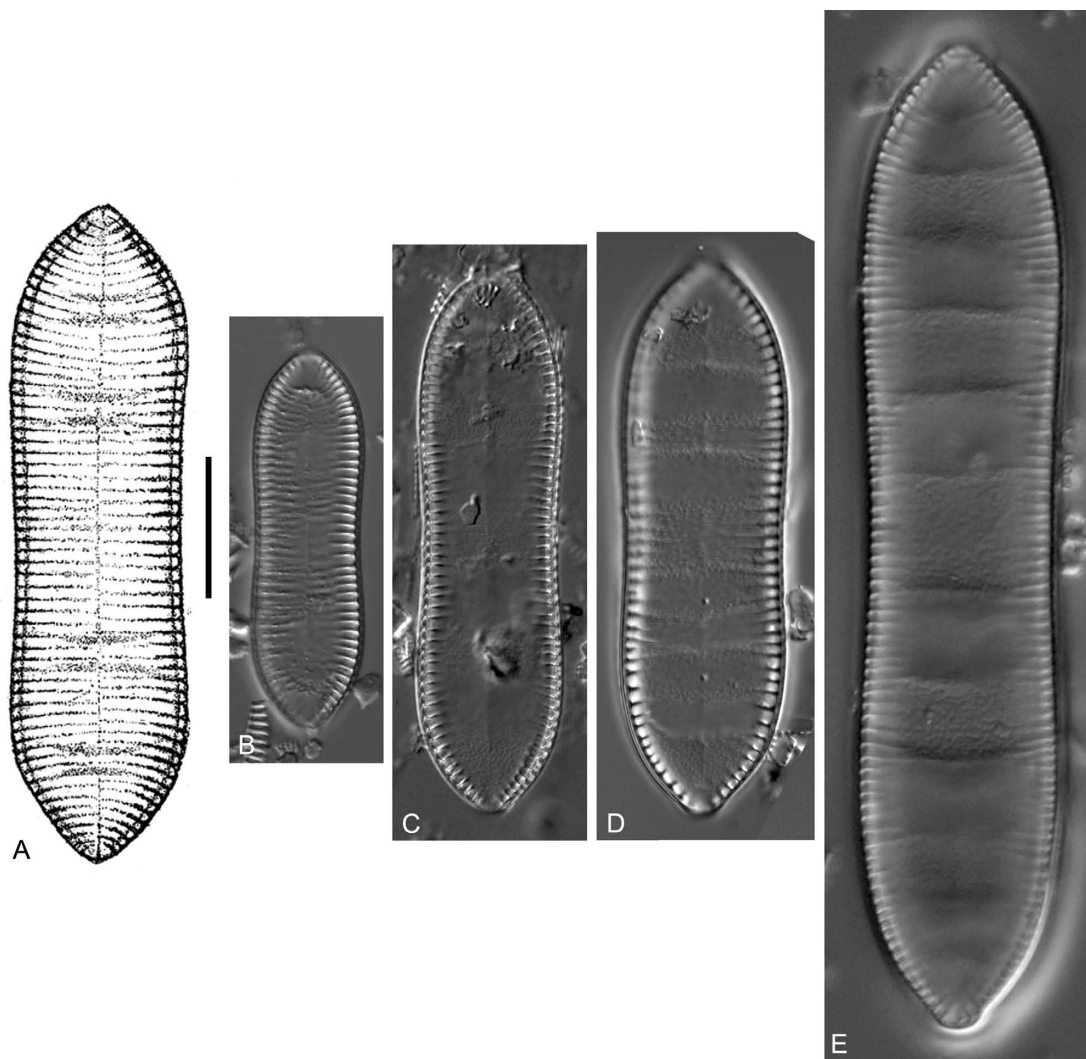
**Habitat** – Benthic and epiphytic, may occur in the plankton; in alkaline waters.

**Distribution** – Tropical Africa. Rare species; besides Lake Malombe (Müller 1904a) this taxon was reported from Lake Victoria (Wołoszyńska 1914, Bachmann 1933, Van Meel 1954), Lake Edward (= Lake Idi Amin) (Hustedt 1949), D.R.Congo (Woodhead & Tweed 1958), and Ghana (Foged 1966). This species is also present in Lake Tanganyika (personal observations) and was wrongly reported as *C. apiculata* W.Sm. [e.g. Cocquyt 1998 as *C. solea* var. *apiculata* (W.Sm.) Ralfs].

***Cymatopleura laticeps*** (O.Müll.) Cocquyt & R. Jahn, **comb. nov.**  
Fig. 5

**Basionym** – *Cymatopleura solea* var. *laticeps* O.Müll., Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie 34: 22–23, fig. 2. 1904 (Müller 1904a); additional figure in Schmidt (1904: plate 245, fig. 2). – Type: ‘Nyassaland’, Tanzania, Lake Malawi near Langenburg, sample B 52 0000010 (lecto-: B 40 0040251, **designated here**; the valve representing the lectotype is here illustrated in fig. 5B).

**Original description** – Translated into English, Müller’s description of *Cymatopleura solea* var. *laticeps* (Müller 1904a: 22) reads: “Valves panduriform with strongly constricted margins and much widened, cuneate, rounded ends. Ribs short, marginal striae with thin elongations reaching the pseudoraphe, 5 in 10 µm. Striae in between the costae thin but distinct, more than 20 in 10 µm, finely punctate, more strongly punctate on the top of the undulations. Valve face mostly built up of 5 transapical undulations. Length: 130–166 µm; smallest width: 24–29 µm, largest: 40–50 µm. Width-to-length ratio 1: 4.8–5.8. Found in mud of Lake Nyassa at 200 m depth (24), on the bottom of Lake Nyassa at 333 m depth



**Figure 6** – *Cymatopleura comperei*: A, original drawing of *Cymatopleura solea* [var. *subconstricta*] f. *minor* (Müller 1904a: 23, fig. 4); B–E, LM; D, valve from sample B 52 0000039, slide B 40 0040184, representing the holotype. Scale bar = 10 µm.

(25), in the plankton of Lake Nyassa near Langenburg, 1 km from the coast, at the surface (10), in the plankton of Lake Nyassa near Langenburg, 2 km from the coast, at 95–130 m depth (17), in the plankton of Lake Nyassa near Langenburg, at 5–8 m depth (13).”

**LM: emended description** – Valves panduriform with strongly constricted margins and widening towards the poles with cuneate, rounded ends. Length: 130–166 µm; width: 40–50 µm, and 24–30 µm in the constricted part. Length-to-width ratio 3.0–3.3 and 4.8–5.8 in the constricted part. Costae number 5–5.6 in 10 µm, distinct near the margin, indistinct on the valve face and almost reaching the axial area. Axial area narrow. Valve face finely punctate, often denser on the distinct top of the transapical valve undulations. Fig. 5.

**SEM: description** – No valves observed.

**Habitat** – Plankton.

**Distribution** – Tropical Africa. Rare species, only known from Lake Malawi.

***Cymatopleura comperei* Cocquyt & R.Jahn, sp. nov.**

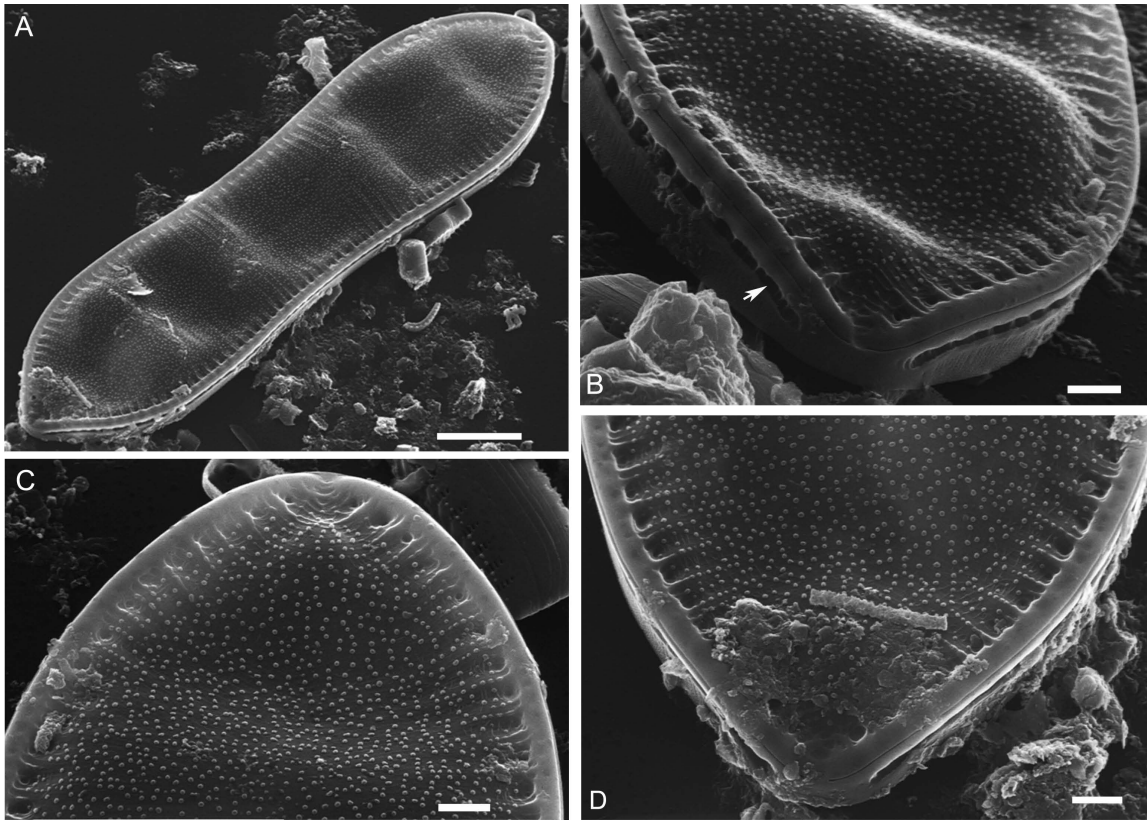
Figs 6–8

Type: Malawi, Lake Malawi near Langenburg, sample B 52 0000039 (holo-: B 40 0040184; the valve representing the type is here illustrated in fig. 6E).

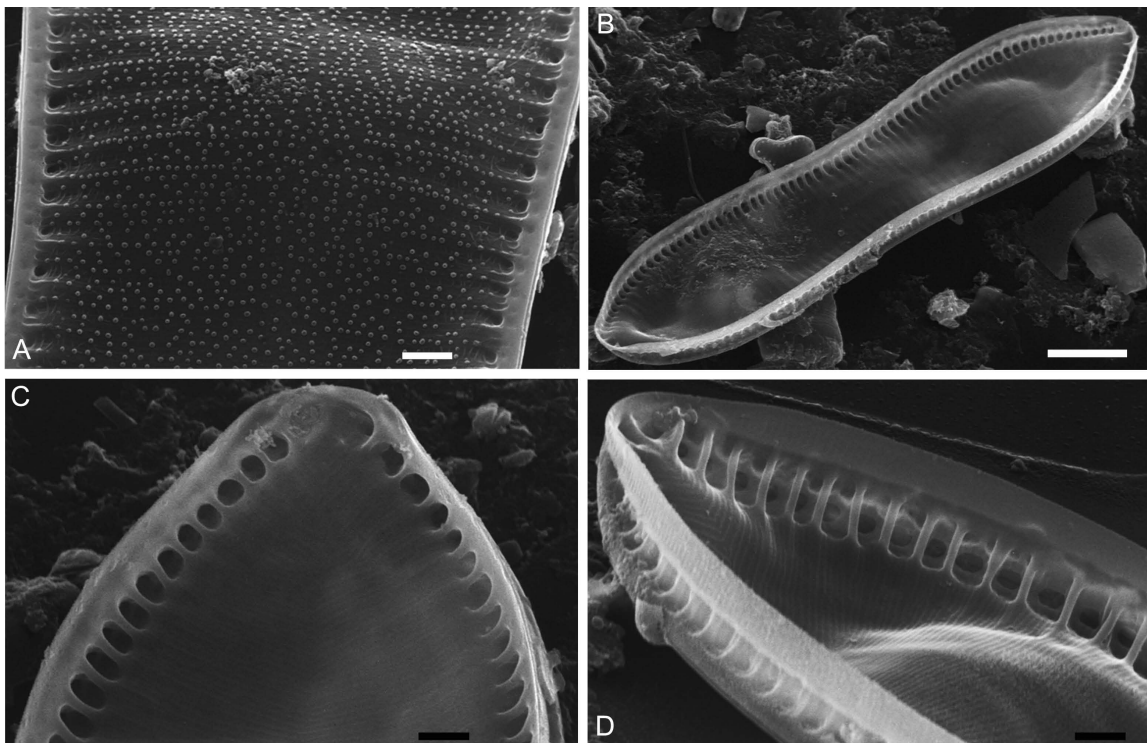
**Synonyms** – *Cymatopleura solea* var. *subconstricta* O.Müll. **nom. nudum** in Müller (1904a: 23). – *Cymatopleura solea* var. *subconstricta* f. *major* O.Müll. **nom. inval.** in Müller (1904a: 23). – *Cymatopleura solea* var. *subconstricta* f. *minor* O.Müll. **nom. inval.** in Müller (1904a: 23); figure in Schmidt (1904: plate 245, fig. 3).

**LM: description** – Valves broadly linear with almost parallel, slightly constricted margins and cuneate, rounded, sometime slightly protracted poles. Length 60–142 µm, width 16–34, 11–30 in the constricted part. Width-to-length ratio 3.3–4.5, and 3.5–5.5 in the constricted part. Costae number (5–)6.5–7 in 10 µm, strong near the margin but also visible on the rest of the valve face almost reaching the axial area. Axial area narrow, forming a distinct line. Striae distinct on





**Figure 7** – *Cymatopleura comperei* SEM: A–D, external valve view; B & D, detail of both poles showing the straight, lot enlarged terminal raphe fissures and the valve mantle with 1–2 costae more indented after a group of 3–4 costae (arrow in B); C, detail of the valve face with scattered silica granule and raised smooth raphe canal. A, scale bar = 10  $\mu$ m; B–D, scale bars = 1  $\mu$ m.



**Figure 8** – *Cymatopleura comperei* SEM: A, external valve view showing a detail of the valve face near the slightly constricted middle; B–D, internal valve view; C–D, detail showing the internal fibulae and the portulae near the pole. A & C–D, scale bars = 1  $\mu$ m; B, scale bar = 10  $\mu$ m.

the entire valve face, 22 in 10  $\mu\text{m}$ . Valve face finely punctate. Fig. 6.

**SEM: description – External valve view.** Valve face almost smooth, not covered by delicate reticulate thickenings but only scattered silica granules present. Striae uniseriate but sometimes partly biseriate, 35 in 10  $\mu\text{m}$ , composed of 70–80 round areolae in 10  $\mu\text{m}$ . Close to the valve margin and to the transition of the valve face to the smooth raphe canal, the striae become biseriate. Raphe simple with straight, not enlarged terminal fissures closely spaced. Costae not well pronounced on the valve face. Valve mantle composed of two parts: the part closest to the raphe canal has more obvious costae, of which 1–2 costae more indented after a group of 3–4 costae (fig. 7B, arrow). The second part of the mantle not indented and all costae look the same. Striae in between the costae uniseriate. **Internal valve view.** Striae composed of rimmed areolae, becoming biseriate in the portulae. Internally, the raphe continuous at one pole, and interrupted at the other pole but with terminal raphe fissures very close to each other, with almost no space in-between. **Girdle.** No girdle bands observed. Figs 7–8.

**Taxonomical remarks** – Although Müller's description of the variety is a nomen nudum and therefore also its two forms are invalid, his data represent his concept of these taxa. Translated into English Müller's description of *Cymatopleura solea* var. *subconstricta* f. *major* (Müller 1904a: 23) reads: "Valve broad linear with slightly constricted margins and cuneate, rounded ends. Costae are short, marginal striae, with thin elongations, not reaching the pseudoraphe, 6.5–7 in 10  $\mu\text{m}$ . Striae in between the costae very thin. Pseudoraphe indistinct. Valve face finely punctate, with 5 weak undulations. Length: 105–142  $\mu\text{m}$ , smallest width: 21–28  $\mu\text{m}$ , largest: 24–31  $\mu\text{m}$ . Width-to-length ratio 1: 3.7–5.1. Found in Lake Malombe (37 and 39); in a watercourse near the hot spring at Utengule (53)." And of f. *minor* (Müller 1904a: 23) writes: "as form *major*, but smaller and thinner, sometimes more constricted. Length: 60–99  $\mu\text{m}$ ; width: smallest width 11–24  $\mu\text{m}$ , largest 16–26  $\mu\text{m}$ . Width-to-length ratio 1: 3.4–5.5. Lives as the former, with which it occurs mixed". Müller (1904a: 23) remarks that it is "close to var. *regula*, but the margins are never straight".

In contrast to Müller, we think that this entity comprises only one taxon which we name *C. comperei* honouring our senior colleague Pierre Compère.

**Habitat** – Benthic and epiphytic, may occur in the plankton; in alkaline waters.

**Distribution** – Besides Lake Malombe and a watercourse in Utengule (Tanzania, north of Lake Malawi) (Müller 1904a), *C. comperei* was reported from Lake Victoria (Wołoszyńska 1914) and from Burundi and Lake Tanganyika (Mpawenayo 1996, as f. *minor*).

***Cymatopleura nyansae*** G.S.West (West 1907: 167, plate 8, fig. 8; additional figure in Schmidt 1911: plate 275, fig. 1) Figs 9–10

Type: Lake Victoria, West 252 (lecto-: BM 34183, **designated here**).

**Original description** – The original description by West (1907) was given in Latin and reads as follows: "Large and

remarkable *Cymatopleura*; cells in valvar view in the middle portion narrowed and subcylindric, in the apical parts strongly swollen subcircularly, poles sub-mamillate; costae near the lateral margins 7 in 10  $\mu\text{m}$ ; cells in girdle view as in *C. solea*. Length 189–195  $\mu\text{m}$ , width in the centre 20  $\mu\text{m}$ , maximal width (polar portions) 56–58  $\mu\text{m}$ . Not uncommon in the plankton, near Bukoba." West (1907) added at the end of his Latin diagnosis the following English comment: "This species is distinct from *C. solea* by reason of its curious dumb-bell-shaped valves. The median part of the valve is relatively narrow, and the polar portions are almost circular in outline."

**LM: emended description** – Valves panduriform, dumb-bell-shaped, with strongly constricted margins widening to strongly swollen subcircular almost circular parts. Poles rounded and slightly protracted. Length: 138–245  $\mu\text{m}$ ; width 46–59.5  $\mu\text{m}$ , and 18–26.5  $\mu\text{m}$  in the constricted part. Length-to-width ratio is 3–4.1 and 6.4–10.4 in the constricted part. Costae number 5–7.5 in 10  $\mu\text{m}$ , distinct near the margin, indistinct on the valve face and almost reaching the axial area. Axial area narrow. Valve face finely punctate. Fig. 9.

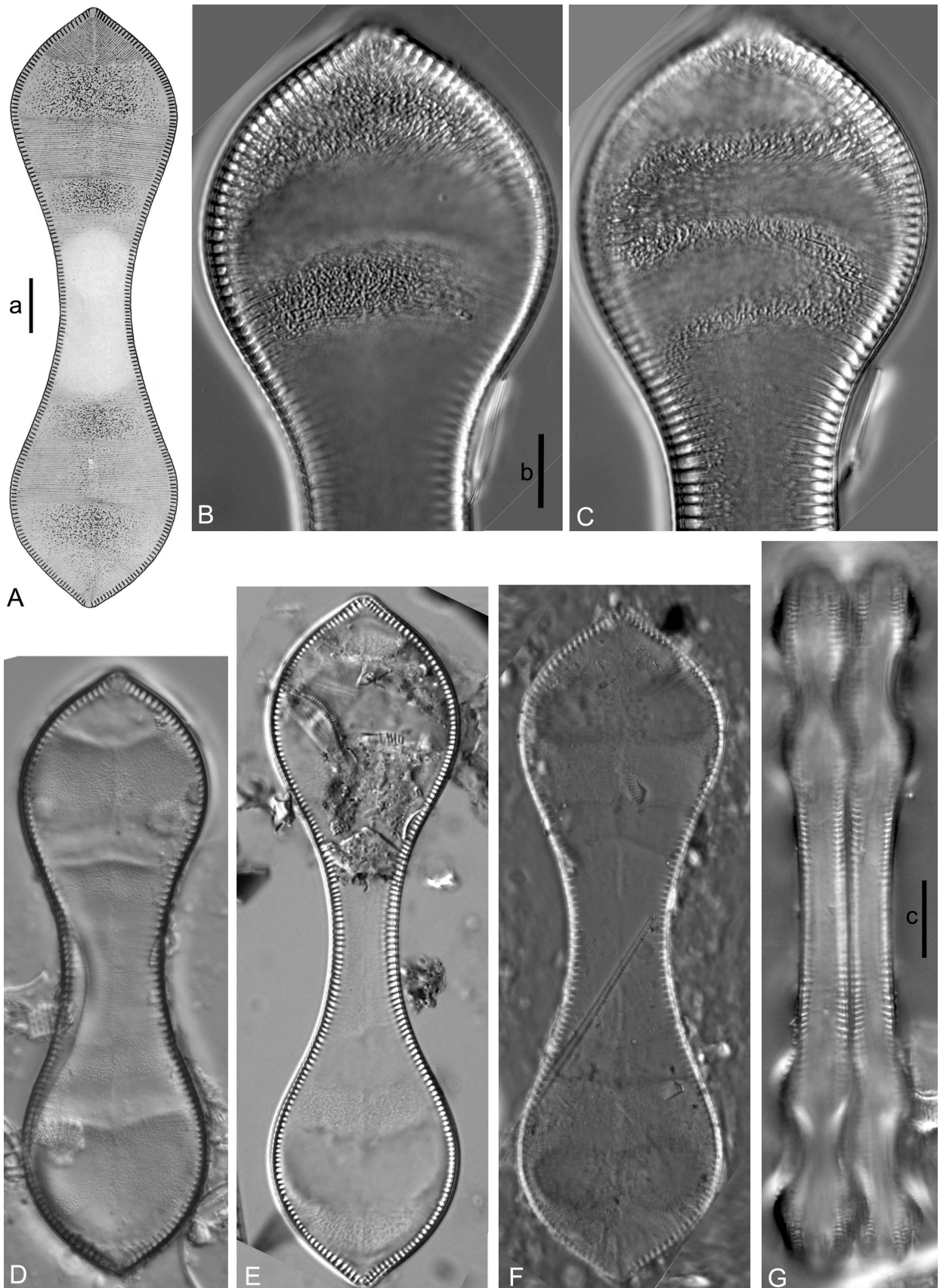
**SEM: description – External valve view.** Valve face almost flat, without costate and/or reticulate thickenings. Silica granules present and regularly distributed on the valve face. Granules semi-spherical and elliptical, around  $0.5 \times 0.4 \mu\text{m}$  with the largest diameter parallel to the transapical striae. Alar canals visible through the valve face, about 6–7 in 10  $\mu\text{m}$ . Raphe on a shallow keel. Valve face slightly indented near the raphe sternum. Valve mantle relatively high, composed of an indented part and a straight part between the intended part and the mantle margin. Mantle bears around 35 costae in 10  $\mu\text{m}$ . In the indented part the deeper lying costae correspond to the internal fibulae, and 3–4 costae less indented located at the place of the internal portulae. **Internal valve view.** The internal valve smooth with uniseriate striae, 29 in 10  $\mu\text{m}$ , reaching the axial area. Striae transapical and regularly arranged except near the axial area at the widest part of the valve where they become irregular. Areolae round, rimmed, about 50–55 in 10  $\mu\text{m}$ . Short fibulae not expanded on the valve face. Portulae almost rectangular, slightly curved near the raphe, 5–6 in 10  $\mu\text{m}$ . **Girdle.** Several open, slightly verrucose bands. Fig. 10.

**Habitat** – Plankton near Bukoba in Lake Victoria.

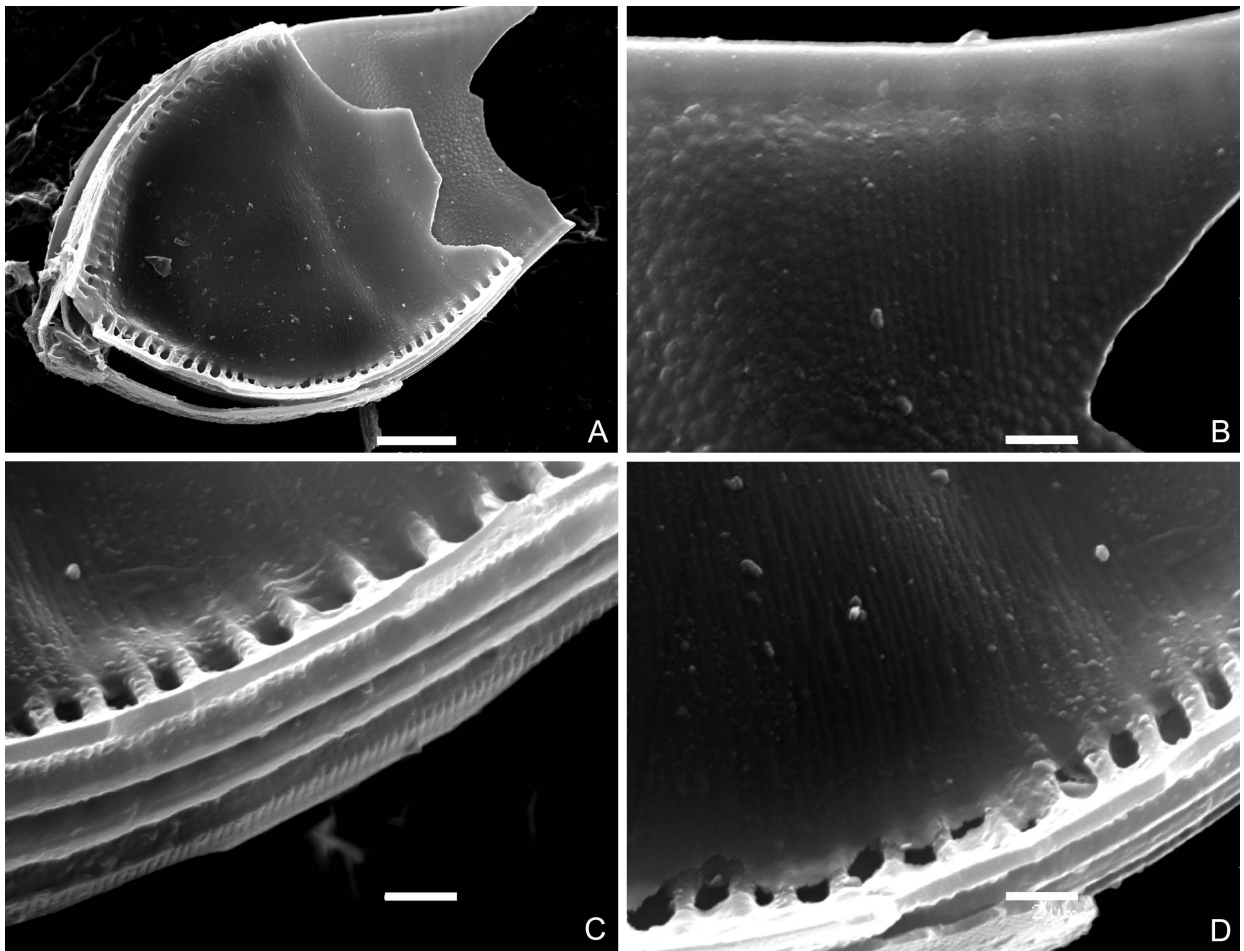
**Distribution** – Tropical Africa. Not uncommon in Lake Victoria and Lake Malawi. Only the reports from Lake Victoria (formerly Lake Victoria Nyanza) and from Lake Malawi (formerly Lake Nyassa) can be considered as correct; all other reports are to be checked. Our own investigation of Müller's material revealed the presence of this taxon in Lake Malawi although Müller apparently did not see this taxon.

## DISCUSSION

In the "Index Nominum Algarum" (Silva 2014) 88 taxa belonging to the genus *Cymatopleura* are mentioned. Among the 36 species, most infraspecific taxa belong to *C. solea* (31) and *C. elliptica* (Bréb.) W.Sm. (17). All African varieties of *C. solea* are included, with the exception of var. *subconstricta*, which is a nomen nudum. Among the observed *Cymatopleura* taxa in the East African samples, Müller (1904a) mentioned *Cymatopleura elliptica* var. *rhomboides*



**Figure 9** – *Cymatopleura nyansae*: A, original drawing (West in Schmidt 1911: plate 275, fig. 1); B–G, LM: B–C; detail of half a valve taken at different foci; G, girdle view. A, scale bar a = 20  $\mu$ m; B–C, scale bar b = 10  $\mu$ m; D–G, scale bar c = 20  $\mu$ m.



**Figure 10** – *Cymatopleura nyansae* SEM: A, C–D, internal valve view; B, external valve view; C, detail of the internal valve view and part of the mantle; D, detail of the internal valve view showing the almost rectangular portulae. A, scale bar = 10 µm; B–D, scale bars = 2 µm.

Grunow which he observed only once in Lake Malawi near Langenburg (sample 27). We could not discuss this taxon as we did not find it during our investigation of the historic material Müller studied.

The African *Cymatopleura solea* taxa discussed in this paper have been raised to species level because they are clearly different from the European *Cymatopleura solea* mainly in respect to the valve outline as well as in micro-morphological details of their respective valve faces. Schoeman & Archibald (1976) with their African experience dealt especially with the nomenclatural priority of *C. librile* Ehrenb. (versus *C. solea* (Bréb.) W.Sm.) and sunk all African varieties of *C. solea* [var. *clavata*, var. *laticeps*, var. *subconstricta* plus f. *minor* (= *comperei*)] into synonymy with *C. librile* (without mentioning f. *major*). But no matter if the European taxon is named *C. librile* or *C. solea*, the African taxa differ from *C. solea* (= *C. librile* according to Schoeman & Archibald 1976) enough to warrant their own status of species. Differences were also observed during SEM investigations: the reticulate structure on the outer valve face which hides the striae, is absent in *C. comperei*. The fibulae on the internal valve face of *C. rugosa* are stronger and closer to the axial area than in the other taxa. Even in LM, the typical large granules present near the valve margin of *C. rugosa*

can be seen as small elongated lines. Although *Cymatopleura solea* valves may have silica granules on the outer valve face, no taxon has the typical larger granules of *C. rugosa*.

Hustedt in Huber-Pestalozzi (1942: 581) subsumed *C. solea* var. *subconstricta* (= *C. comperei*) under var. *regula* (Ehrenb.) Grunow with the remark that it is only a form between the type variety and var. *regula* or at the best belong to this variety, a variety which has parallel or hardly discernable constricted margins. The valves of *C. comperei* have broadly rounded poles but in contrast to var. *regula* the valves have cuneate but not rounded poles.

At first sight, *Cymatopleura laticeps* and *C. nyansae* appear to be similar taxa. Although both species have dumb-bell-shaped valves the transition from the constricted part to swollen parts is shorter in *C. laticeps* and more elongate (and therefore more elegant) in *C. nyansae*, a characteristic that is maintained in smaller valves. The strongly swollen parts of the valve are more spherical in *C. nyansae* than in *C. laticeps*, and the axial area can be observed in LM as a continuous line in *C. laticeps* while for *C. nyansae* the line corresponding to the axial area is hardly visible. Moreover the constriction midvalve is always more accentuated in *C. nyansae* than in *C. laticeps* leaving a very narrow valve part in the middle section with a width of 18.0–26.5 µm and 24–30 µm respec-



tively. This is resulting in a higher length-to-width ration in the constricted part in *C. nyansae* (6.4–10.4) compared to *C. laticeps* (4.8–5.8). The *C. nyansae* reported from Lake Chad (Compère 1975: fig. 371; and slide BR 3125) is constricted mid-valve but the valves lack the typical constriction of *C. nyansae*. The valve outline and other morphologic characters as observed in LM point to *C. laticeps*.

According to Cholnoky (1968) the pH optimum of *Cymatopleura solea* (and its varieties) is slightly above 8, while de Almeida & Gil (2001) reported an optimum of 7.3; these authors mentioned for this taxon typical of alkaline waters a conductivity optimum of 595  $\mu\text{S cm}^{-1}$ . Cholnoky (1968) stated that *Cymatopleura nyansae* is, together with *C. calcarata*, a true planktonic species, while the other *Cymatopleura* taxa are not planktonic although they can occur suspended in the water column.

Cholnoky (1968) was convinced that the forms (and varieties) of *C. solea* all belong to a uniform series of variation and that they do not have their own specific physiological (ecological) characteristics. On the contrary, we found that there are some decisive ecological differences in the East African *Cymatopleura* taxa described by Müller (as varieties of *C. solea*): *C. laticeps* is a true planktonic species in contrast to the other varieties. This gives an additional argument to justify the elevation of this taxon to species rank. The elevation of the other varieties described by Müller from East Africa to species rank is based on morphological characters, including LM and SEM.

As for many of the *Surirella* taxa from the African Great Lakes, it seems that the concept of endemism (Cocquyt 2000) is also applicable to the *Cymatopleura* taxa of this region. *Surirella* is represented by 27 endemic taxa in Lake Tanganyika. Lakes Victoria and Malawi have no endemic *Surirella* restricted to one lake, but *S. malombae* and *S. nyansae* occur in both lakes, but not in Lake Tanganyika where a closely related species, *S. chepurnovii*, is present (Cocquyt & Jahn 2007a). Something similar can be observed in *Cymatopleura* taxa: *C. laticeps* has only been recorded from Lake Malawi while *C. nyansae* was observed in Lake Victoria and Lake Malawi. At the present no similar taxon has been observed in Lake Tanganyika.

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