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New or otherwise interesting desmid taxa from the Bangweulu region (Zambia). 1. Genera *Micrasterias* and *Allorgeia* (Desmidiaceae)

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Background and aims – As for desmids, the Bangweulu wetlands in Zambia have turned out to belong to the most species-rich areas in Africa. Because of the scarce desmid literature dealing with those wetlands the present authors visited the region in question intending to increase our knowledge of African endemic species.

Methods – Samples were collected from Lake Bangweulu and adjacent swamps as well as from Lake WakaWaka, a small isolated lake c. 150 km south-east of it. Collection was by squeezing submerged plant material or using a plankton net. Samples were partly immediately fixed for drawing desmid taxa later on, partly taken home alive for photographing and possible culturing.

Key results – Two taxa are described as new to science: *Micrasterias denboeri* and *M. radians* var. *cruxoides*. *M. truncata* var. *africana* is raised to species level. Two varieties of *M. tropica*, i.e. var. *elegans* and var. *elongata* are split off as separate species. *M. tropica* var. *crassa* is recombined to *M. robusta* var. *crassa*. The asymmetric taxa *M. sudanensis* and *Allorgeia incredibilis* are discussed for their possible relationships.

Conclusions – Most of the taxa discussed may be considered African endemics. Some of them, i.e. *M. denboeri*, *M. sudanensis* and *Allorgeia incredibilis*, presumably are even confined to the tropical central part of Africa. Most of the tropical records of *M. crux-melitensis* in literature probably have to be considered small forms of *M. radians* rather than to refer to European-North American *M. crux-melitensis*.

Key words – Desmids, *Micrasterias*, *Allorgeia*, Zambia, Bangweulu, WakaWaka, taxonomy, geographical distribution.

INTRODUCTION

Until rather recently, Lake Bangweulu and surroundings, situated in northern Zambia, were poorly accessible. Presumably this is the main reason why it has but fragmentary been investigated for aquatic microorganisms. Thomasson (1957, 1960, 1966) was one of the few researchers who studied water samples from Lake Bangweulu and adjacent swamps. He revealed this region to be one of the richest desmid areas in Africa. For that reason, and because Thomasson examined but a limited number of samples collected by other hydrobiologists, we visited this area some fifty years later to investigate the desmid flora once more, intending to increase our knowledge of African endemic species. The samples that were put on the disposal of Thomasson originated from Lake Bangweulu itself, the swamps south east of that lake, as well as from Lake Shiwa Ngandu, an isolated small lake 200 km east of Lake Bangweulu. For our own study, sam-

ples were taken from almost the same area, with exception of Lake Shiwa Ngandu. Instead of that, Lake WakaWaka, a small lake some 150 km south-east of Lake Bangweulu was investigated.

We visited the Bangweulu area in September 2012. As in most parts of the tropics, the seasonal changes in Zambia are dominated by the dramatic variation in rainfall. Zambia has a dry season from May to November and a wet season from December to April. The lowest average day and night temperatures for Samfya are 18°C and 10°C respectively in July and the highest average maximum temperatures are 30°C and 23°C respectively in October (Climatedata.eu 2013). Water levels in the Bangweulu area follow the fluctuations in precipitation. They peak in April and are at their lowest in November-December (Ramsar 2007).

As a first contribution, the present paper deals with a number of interesting representatives of the genus *Micras-*

terias, some of them being well defined, other ones making part of taxonomically complex series raising questions about their taxonomic status. In addition to that, attention is paid to the affiliated species *Allorgeia incredibilis*.

MATERIAL AND METHODS

Sampling sites

Lake Bangweulu and adjacent swamplands incorporate a complex system of wetlands, for the most part situated in the Luapula Province of Zambia (fig. 1). Part of it was designated as a RAMSAR-site (protected area) in 1991, extended from 2,500 km² to 11,000 km² in 2007, covering most of the swamp area. The lake itself (including Lake Walilupe) is about 75 km long and 35 km wide, very shallow (less than 10 m) and can best be interpreted as a part of the Bangweulu swamps that is not yet covered by vegetation. A number of smaller lakes are present in the swamplands, besides innu-

merable shallow water bodies that are linked by an intricate network of channels. Some channels are canalized for the benefit of transport by boat. Dry land is found in the form of islands, the larger of which are inhabited and farmed (Ramsar 2007). The area is fed by several rivers of which the Chambesi River is the largest, and is drained by one river, the Luapula River that eventually flows in the Congo (formerly Zaire) River. The whole area is situated at an elevation of 900–1200 m a.s.l. and extremely flat. The swamps sampled were dominated by large, more or less floating vegetations of helophytes, mainly reed and papyrus plants. In the open water stands of water lilies and water shields were abundant, besides species of pondweeds and bladderworts.

Lake WakaWaka is situated outside the swamplands (fig. 1, site A). It is an idyllic water body (WakaWaka in Swahili means 'Brilliant Light') completely surrounded by woodland that is intermingled with patches of termite savanna. The lake itself is small and shallow, at the borders passing into extensive zones with peat bog vegetation.

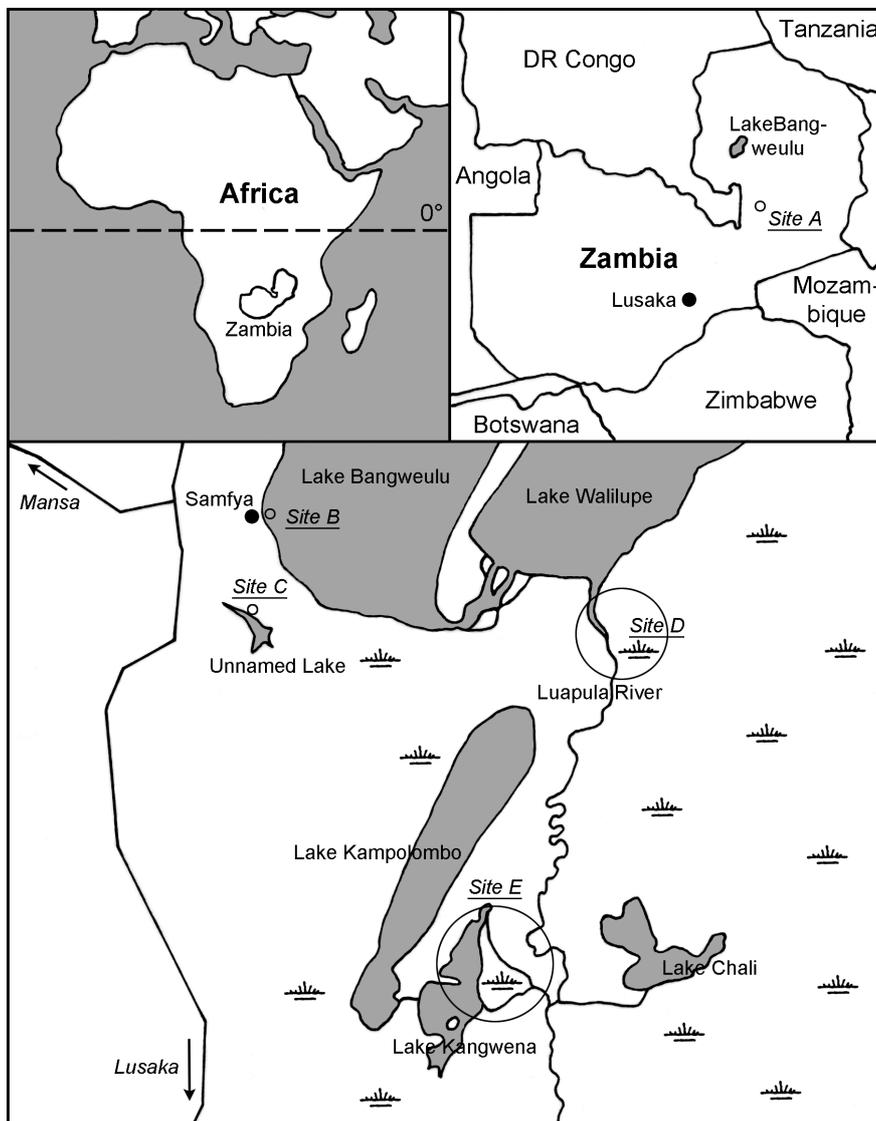


Figure 1 – Map of Zambia with location of the sampling sites A (Lake WakaWaka) and B–E (Bangweulu wetlands).

Table 1 – Specification of the samples.

Sample no.	Date	Latitude (S)	Longitude (E)	Sampling site	Sampling method
Lake WakaWaka (fig. 1, site A)					
2012072	22 Sep. 2012	12°31'14.3"	30°36'11.6"	boggy border zone	bladderwort
2012073	22 Sep. 2012	12°30'54.6"	30°36'24.7"	boggy border zone	bladderwort
2012074	22 Sep. 2012	12°30'29.5"	30°36'36.5"	boggy border zone	various subaerial substrates
2012075	22 Sep. 2012	12°30'36.6"	30°36'22.5"	boggy border zone	bladderwort
Lake Bangweulu at Samfya (fig. 1, site B)					
2012076	23 Sep. 2012	11°21'11.6"	29°33'39.3"	lake shore	net sample
Unnamed Lake (fig. 1, site C)					
2012077	24 Sep. 2012	11°26'40.8"	29°33'10.1"	lake shore	net sample
2012078	24 Sep. 2012	11°26'40.8"	29°33'10.1"	near lake shore	bladderwort
Bangweulu swamp near Mpanta (fig. 1, site D)					
2012079	24 Sep. 2012	11°27'14.8"	29°49'35.0"	Luapula River	net sample
2012080	24 Sep. 2012	11°27'03.7"	29°50'35.2"	large channel	pondweed
2012081	24 Sep. 2012	11°27'39.4"	29°52'06.4"	large channel	bladderwort
2012082	24 Sep. 2012	11°27'31.4"	29°52'04.4"	small side-channel	bladderwort
2012083	24 Sep. 2012	11°27'05.0"	29°52'12.7"	small pond	net sample
Bangweulu swamp near Chipundu (fig. 1, site E)					
2012084	25 Sep. 2012	11°42'40.9"	29°43'01.3"	Lake Kangwena	net sample
2012085	25 Sep. 2012	11°43'50.2"	29°43'45.9"	Lake Kangwena	net sample
2012086	25 Sep. 2012	11°44'12.9"	29°43'57.0"	Lake Kangwena	net sample
2012087	25 Sep. 2012	11°44'01.9"	29°46'00.7"	large channel	submerged moss
2012088	25 Sep. 2012	11°44'01.9"	29°46'00.7"	large channel	bladderwort
2012089	25 Sep. 2012	11°43'33.2"	29°46'12.1"	large channel	net sample
2012090	25 Sep. 2012	11°43'05.7"	29°45'38.9"	large channel	bladderwort
2012091	25 Sep. 2012	11°42'52.4"	29°45'21.2"	large channel	bladderwort
2012092	25 Sep. 2012	11°41'14.1"	29°43'01.6"	Lake Kangwena	net sample

The lake is fed by water that wells from the subsoil at the southern point of the lake, and drains into a small creek in the north, flowing further north into the Bangweulu area. The size, including the boggy parts is only approximately 0.5 by 1.5 km. Despite its small size this lake turned out to be a treasure box of desmid species equalling the amount of desmid species collected from the much larger Bangweulu area. Remarkably, a similar observation was made by Thomasson as for Lake Shiwa Ngandu.

Sampling

Samples were collected by manually squeezing submerged vegetation or with a small plankton net (mesh size 35 µm). Special attention was paid to vegetation containing bladderwort (*Utricularia*), known to be an ideal substrate for desmids. In Lake WakaWaka sampling could easily be done by foot, but in the Bangweulu swamps it was done with the help of local inhabitants using a large canoe referred by them as a 'banana boat'. Part of the samples were fixed on the day of

collection with formaldehyde to a final concentration of c. 4%, but fresh samples were brought back to the Netherlands for studying and photographing the live content. Geographic co-ordinates were recorded with a GPS. Conductivity, measured with a simple portable meter, ranged from 10 to 30 µS cm⁻¹ indicating electrolyte-poor conditions in all water bodies sampled. For details of sampling, see table 1.

TAXONOMIC ACCOUNT

Investigating our samples from the Bangweulu wetlands and Lake WakaWaka quite a number of tropical *Micrasterias* species were encountered. Some of them are known to have a wide, circumtropical distribution, e.g. *M. foliacea* Bailey and *M. doveri* Biswas. Other ones so far are only known from the African continent, such as *M. ambadiensis* (Grönblad & A.M.Scott) Thomasson and *M. schmidleana* Coesel & Van Geest (Coesel & Van Geest 2008). A number of species that deserve extra interest from a taxonomic point of view are separately discussed below.

Micrasterias africana (F.E.Fritsch & F.Rich) Coesel & Van Geest, **stat. nov.**
Fig. 2A

Basionym – *Micrasterias truncata* var. *africana* F.E.Fritsch & F.Rich, Transactions of the Royal Society of South Africa 11: 338, fig. 14B, C. 1924 (Fritsch & Rich 1924).

Taxonomical remarks – The above-mentioned variety of *Micrasterias truncata* Ralfs described by Fritsch & Rich (1924) from the former South African province of Natal, essentially differs from the nominate variety of *M. truncata* by narrower and more elongate apical lobes. Moreover, it is marked by larger cell dimensions and a larger cell length to breadth ratio. Quoting Fritsch & Rich (1924): *M. truncata* var. *africana* “is sharply distinguished from the type”, so raising this variety to species level is a serious option. Such is supported by the limited geographic distribution of this taxon, for it is only known from Africa. Besides Natal, it was also recorded by Claassen (1961) from Transvaal and by Bourrelly & Couté (1991) from Madagascar. Also the record of *M. triangularis* forma *scottii* by Bourrelly & Couté (1991) from Madagascar unmistakably refers to our taxon under discussion.

Micrasterias africana somewhat resembles the American species *M. tetraptera* W.West & G.S.West but has much shorter and less dilated apical lobes. Considering this characteristic, the record of *M. tetraptera* var. *madagascariensis* in Bourrelly & Couté (1991: 50, pl. 19: 3) from Madagascar refers to *M. africana* rather than to *M. tetraptera*.

We noticed *M. africana* only in a single sample (2012074) from Lake WakaWaka where it was of occasional occurrence. Cell length ranged from 150 to 184 µm, cell breadth from 133 to 152 µm.

***Micrasterias tropica* complex**

In *M. tropica* Nordst., originally described from Brazil (Nordstedt 1870), quite a series of varieties have been distinguished, many of them being only known from limited geographical regions and in our opinion deserving the status of separate species. In our Bangweulu samples we encountered the following taxa:

Micrasterias elegans (W.West & G.S.West) Coesel & Van Geest, **stat. nov.**

Basionym – *Micrasterias tropica* var. *elegans* W.West & G.S.West, Journal of Botany 35: 86, pl. 366: 2. 1897 (West & West 1897).

Taxonomical remarks – This taxon, described by West & West from Angola, differs from the nominate variety by a higher cell breadth to length ratio and more slender lateral lobes. The taxon in question is widely distributed in Africa but elsewhere extremely rare (Coesel & Van Geest 2008).

Micrasterias elegans* var. *tenuior (F.E.Fritsch & F.Rich) Coesel & Van Geest, **stat. nov.**
Fig. 2B

Basionym – *Micrasterias tropica* var. *tenuior* F.E.Fritsch & F.Rich, Transactions of the Royal Society of South Africa 25: 180, fig. 11A. 1937 (Fritsch & Rich 1937).

Taxonomical remarks – This variety is marked by divergent lateral lobes (versus slightly convergent in the nominate variety). Moreover, its lateral lobes are even longer and more slender than in the nominate variety resulting in cells that are at least as broad as long. Most likely, *M. tropica* f. *gracilior* described by Schmidle (1898) from Zanzibar, is identical to *M. elegans* var. *tenuior*. Also very related are *M. tropica* var. *ambadiensis* described by Grönblad & Scott (in Grönblad et al. 1958) from Sudan, and *M. tropica* var. *senegalensis* Nordst. as figured in Bourrelly (1957) from present-day Mali. Both taxa mainly differ from *M. elegans* var. *tenuior* by the presence of an emarginate or granulate papilla in the centre of the semicell.

In the Bangweulu region investigated, of the here discussed *M. tropica*-allied taxa, *M. elegans* var. *tenuior* was the most common one, occurring in most of our samples from both Lake WakaWaka and the Bangweulu wetlands. Actually, the algal form described as *Micrasterias tropica* var. *elegans* from the Okavango delta by Coesel & Van Geest (2008) may be accounted *M. elegans* var. *tenuior* as well.

Micrasterias elongata (Schmidle) Coesel & Van Geest, **stat. nov.**
Fig. 2C

Basionym – *Micrasterias tropica* var. *elongata* Schmidle, Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie 26: 48, pl. 3: 13. 1898 (Schmidle 1898).

Taxonomical remarks – Whereas *M. elegans* is characterized by cells that are about as long as broad, *M. elongata* is just marked by strikingly elongate cells. Actually, the morphological difference with other representatives of the *M. tropica* complex is so great that its status of separate species is fairly obvious. For that matter, the length of the apical cell lobe relative to the cell breadth is subject to some variation. Relatively short [as compared to Schmidle’s (1898)] original picture are the cells figured in, e.g. Grönblad et al. (1958), Opute (1992) and Coesel & Van Geest (2008). On the other hand, the cell represented by our fig. 2C shows an extremely long apical lobe. Another difference with Schmidle’s original figure is in the diverging lateral lobes. In want of enough cells to study possible variation we refrain from describing it as a separate variety as yet.

Micrasterias elongata is exclusively known from the African continent (Coesel & Van Geest 2008). In our samples from the Bangweulu area only a few cells were encountered (sample 2012082).

Micrasterias robusta W.West & G.S.West var. *crassa* (W.West & G.S.West) Coesel & Van Geest, **comb. nov.**
Fig. 2D–E

Basionym – *Micrasterias tropica* var. *crassa* W.West & G.S.West, Journal of Botany 35: 87, pl. 366: 5, 6. 1897 [‘*crassum*’] (West & West 1897).

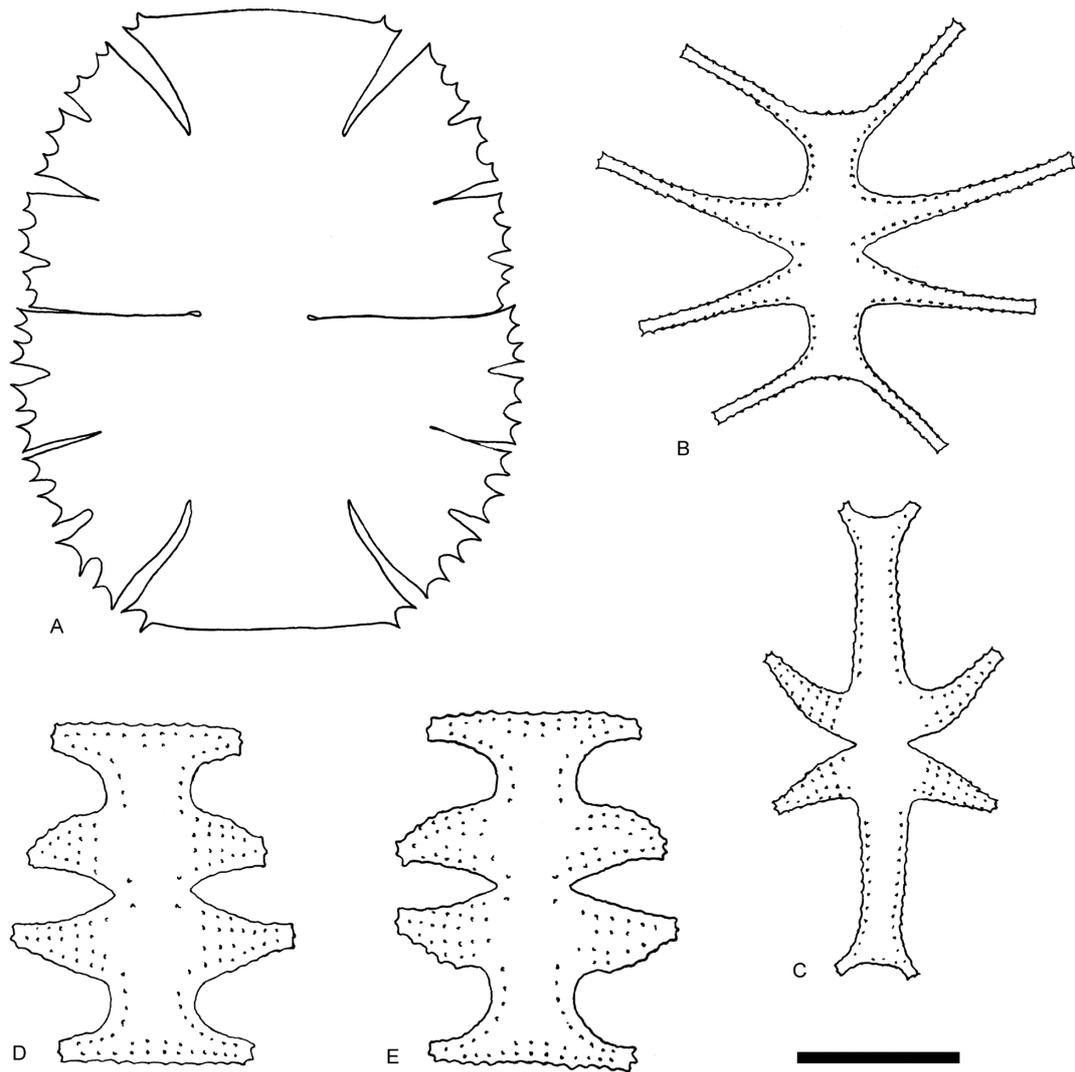


Figure 2 – Selected desmid taxa: A, *Micrasterias africana*; B, *M. elegans* var. *tenuior*; C, *M. elongata*; D–E, *M. robusta* var. *crassa*. Scale bar represents 50 µm.

Taxonomical remarks – *Micrasterias robusta* was described by West & West from the Angolan province of Huila. As its name already indicates, the species in question is marked by a robust appearance. In rough cell shape it somewhat resembles *M. tropica* but it differs by strikingly thick-set apical and lateral lobes. Remarkably, *M. robusta* was never recorded again. West & West, in their same 1897 paper, from a nearby site described *M. tropica* var. *crassa*, a taxon in its morphology intermediate between *M. tropica* and *M. robusta*. Actually, also *M. tropica* var. *crassa*, as characterized in West & West (1897), was never found again. The record by Scott & Prescott (1958) from Australian Arnhem Land obviously refers to the nominate variety of *M. tropica* and the same holds for the record by Vyverman (1991) from Papua New Guinea.

In our sample 2012074 from Lake WakaWaka we frequently encountered a *Micrasterias* taxon morphologically intermediate between *M. robusta* and *M. tropica* var. *crassa*,

giving rise to consider those taxa one and the same species. As we have obviously to do with an African endemic (maybe even confined to a relatively small part of Africa) we prefer to transfer *M. tropica* var. *crassa* to *M. robusta*.

Micrasterias radians complex

Micrasterias radians W.B.Turner, described by Turner (1893) from India has been recorded from tropical regions all over the world (e.g. Krieger 1939, Prescott et al. 1977, Ling & Tyler 2000). It is a polymorphic species. The smallest forms may be readily confused with *Micrasterias cruxmelitensis* Ralfs whereas the larger and more slender forms lead over into *Micrasterias furcata* Ralfs (fig. 3A–E). Several authors paid already attention to the extremely problematic taxonomy of the above-mentioned species complex (e.g. Grönblad et al. 1958: 19, Thomasson 1960: 22).

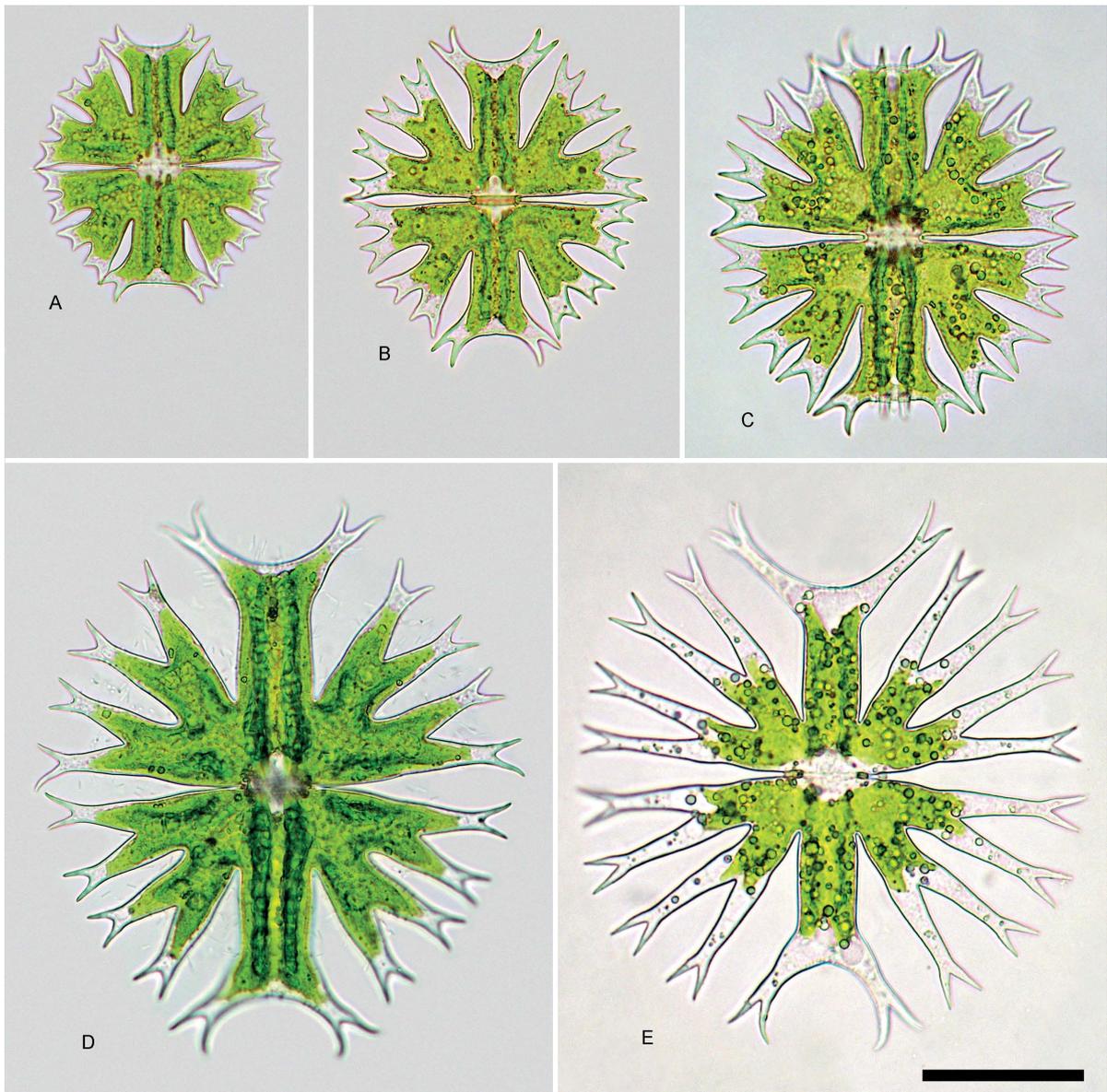


Figure 3 – Micrographs showing gradual transition of various forms of *Micrasterias radians* toward *Micrasterias furcata*: A, *Micrasterias radians* var. *cruxoides*; B, *M. radians* var. *radians*; C, *M. radians* var. *evoluta*; D, *M. radians* var. *brasiliensis*; E, *M. furcata*. Scale bar represents 50 μm .

In our present study, *M. radians* appeared to be a common species. We encountered quite a series of different cell forms representing among other things the above-mentioned questionable transition forms (figs 4A–F & 5A–D). Although the mutual differences are gradual we like to distinguish the following varieties:

Micrasterias radians* W.B.Turner var. *radians
Fig. 4D–E

Taxonomical remarks – The nominate variety of *M. radians* differs from *M. crux-melitensis* by a protruding apical lobe (distinctly standing out over the lateral lobes), deeper incisions and a deeply concave apex often furnished with curved teeth at the angles (Prescott et al. 1977).

In our present study, *M. radians* var. *radians* was encountered in various samples from Lake WakaWaka and the Bangweulu wetlands (both near Mpanta and Chipundu).

***Micrasterias radians* var. *cruxoides* Coesel & Van Geest, var. nov.**
Fig. 4A–C

Diagnosis – As compared to the nominate variety cells are generally smaller and have less deep incisions. Cell length < 130 μm , cell breadth < 115 μm .

Type: Zambia, channel in Bangweulu swamps near Mpanta, 11°27'03"S, 29°50'35"E, 24 Sept. 2012, *Hugo de Vries Lab.* 2012.03 (holo-: L), preserved as a fixed natural sample, and illustrated in fig. 4A.

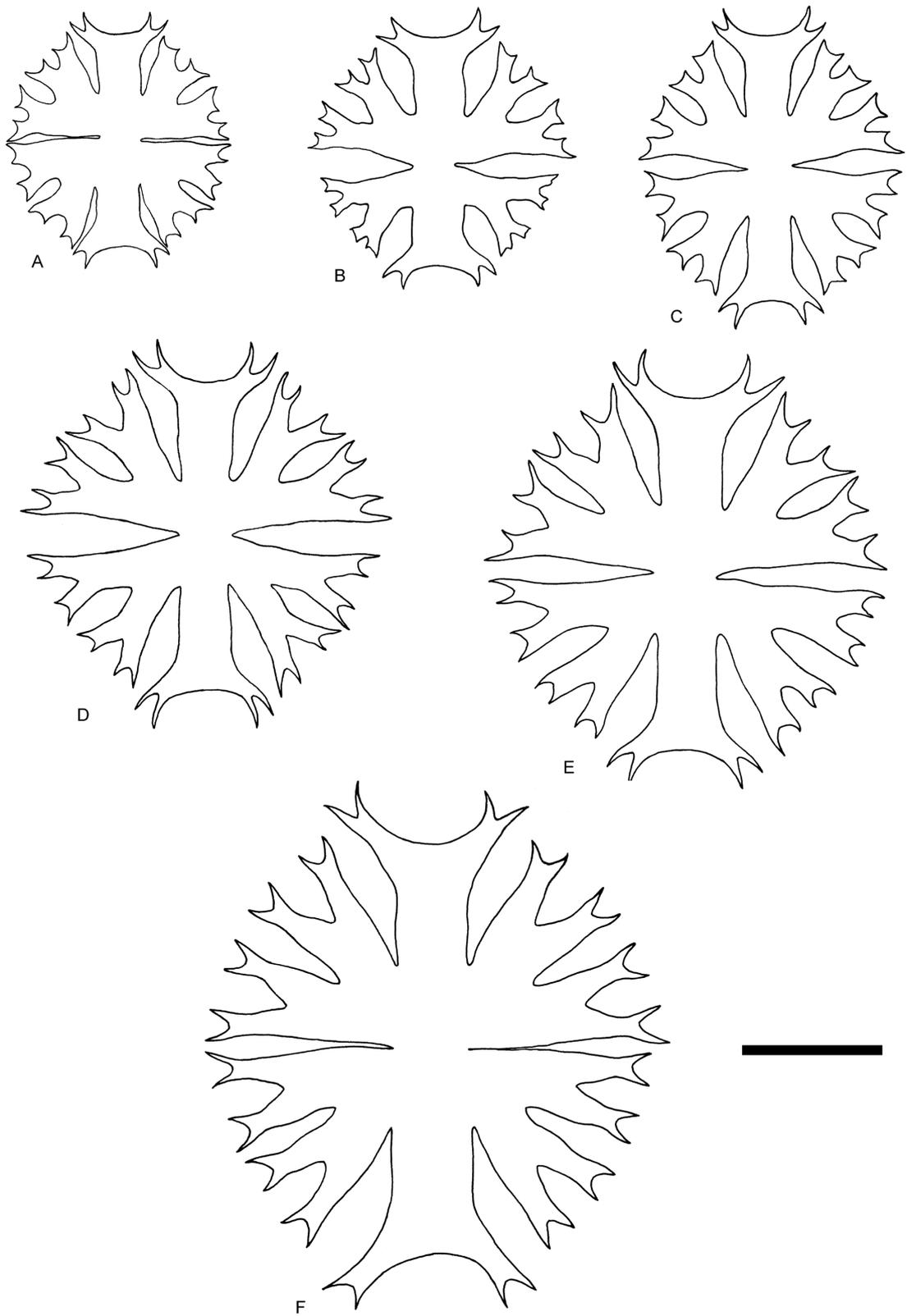


Figure 4 – Selected desmid taxa: A–C, *Micrasterias radians* var. *cruxoides*; D–E, *M. radians* var. *radians*; F, *M. radians* var. *brasiliensis*. Scale bar represents 50 μm .

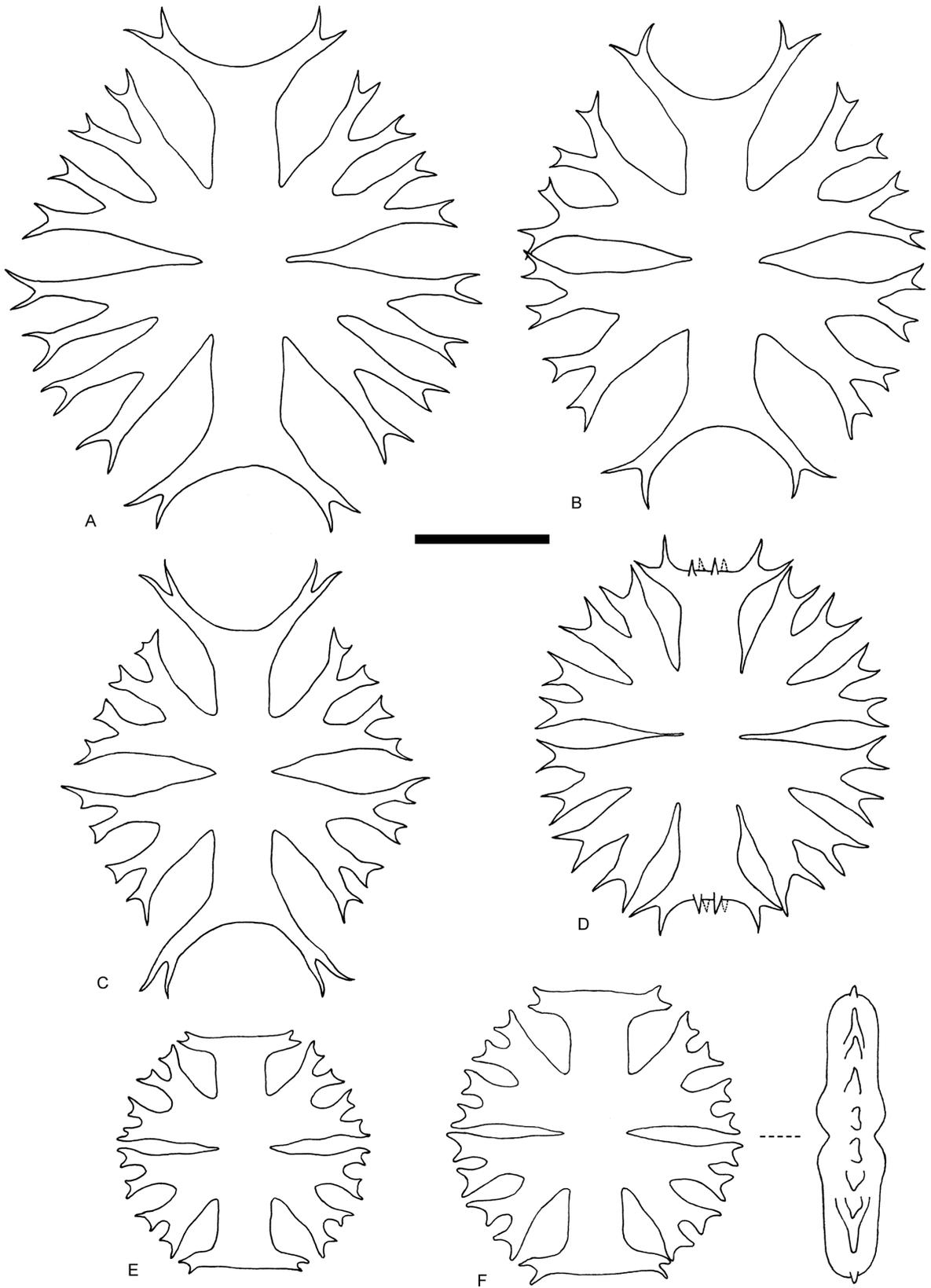


Figure 5 – Selected desmid taxa: A–C, *Micrasterias radians* var. *brasiliensis*; D, *M. radians* var. *evoluta*; E–F, *M. denboeri*. Scale bar represents 50 μm .

Taxonomical remarks – This variety is easily to be confused with *M. crux-melitensis* Ralfs. As for the African continent, the identifications to *M. crux-melitensis* (including var. *minor* W.B.Turner) by, e.g. Schmidle (1898), Bourrelly (1957), Grönblad et al. (1958), Thomasson (1960, 1966) and Compère (1977) unmistakably refer to the above newly described taxon. Our idea to consider it a variety of *M. radians* rather than of *M. crux-melitensis* is based on both morphological and distribution data. Morphologically it is distinguished from *M. crux-melitensis* by lateral lobules the outline of which is somewhat undulate linked to a more or less urn-shaped invagination between the lateral lobes of the first order. Both features are characteristic of *M. radians*. Moreover, there is a gradual transition to the nominate variety of *M. radians*. ‘True’ *Micrasterias crux-melitensis*, i.e. identical to European and North American forms of that species was not encountered in our investigation and it is questionable whether it occurs in tropical regions anyway. Possibly, future DNA analyses may gain more insight into this matter, see our Discussion section.

In our present study, *M. radians* var. *cruxoides* was encountered in various samples from Lake WakaWaka and the Bangweulu wetlands (both near Mpanta and Chipundu). Fig. 4A, representing the most characteristic form, refers to cell material occurring in sample 2012080.

Micrasterias radians* var. *evoluta (W.B.Turner) Willi Krieg. Fig. 5D

Taxonomical remarks – This taxon was originally described as a variety of *M. crux-melitensis* (Turner 1893), presumably by reason of its hardly protruding apical lobes resulting in cells that are about as long as broad. The transfer of this variety to *M. radians* by Krieger (1939) is not argued but could be based on the relatively deep semicell incisions separating lateral lobules the margins of which are slightly bent. The main characteristic of the variety under discussion would be in the ornamentation of the cell wall on either side of the apical concavity with two distinct teeth (c. 3 µm long). Probably, however, that characteristic is not a very constant one. Rich (1932, fig. 6B) depicts (under the name of *M. crux-melitensis* var. *evoluta*) a cell consisting of one semicell with and one semicell without such teeth. In that same figure (Rich 1932, fig. 6A) she depicts a cell of the newly described *M. crux-melitensis* var. *aequalis* F.Rich looking almost identical to her fig. 6B, but now without any teeth at the apical concavities. Most likely those two varieties are identical and be better characterized by the general shape of the cell (being about as long as broad) than by the presence of teeth at the apical concavities. For that matter, also Coesel (2003) already ascertained variability in the presence of apical teeth in *M. radians* var. *evoluta*.

Remarkably, although this taxon was originally described from India (Turner 1893, without any figure), all later records refer to Africa where it appears to be widely distributed (Coesel 2003). In our present study we found *M. radians* var. *evoluta* in the southern Bangweulu wetlands, be it only occasionally in a few samples (2012080, 2012086).

Micrasterias radians* var. *brasiliensis (Grönblad) Willi Krieg. & A.M.Scott
Figs 4F, 5A–C

Basionym – *Micrasterias radiata* var. *brasiliensis* Grönblad, Acta Societatis Scientiarum Fennica. Series B. Opera Biologica 2 (6): 15, fig. 82. 1945 (Grönblad 1945).

Taxonomical remarks – As compared to the nominate variety of *M. radians*, the above variety differs by deeper cell incisions and more widely separated lobes. In particular the apical lobes are salient by their highly protruding, ‘freestanding’ position. Because of the relatively deep incisions it is understandable that this taxon originally was described by Grönblad (1945) as a variety of *M. radiata* Hassall (= *M. furcata* Ralfs). Actually, some forms published under the name of *M. radiata* var. *brasiliensis* in our opinion can best be accommodated *M. radiata* indeed. Those cell forms, e.g. in Thomasson (1965, fig. 7: 3; 1966, pl. 5: 1, pl. 6: 1,2) have very deep incisions and are about as long as broad, so without remarkably protruding apical lobes. The above-described taxonomic confusion is caused by Grönblad (1945) himself. When describing the taxon under discussion, he stated that it could also be brought under *M. radians* but because of the occurrence of more slender forms recalling *M. radiata* he decided in favor of *M. radiata*. Such a slender form, depicted in his fig. 83, indeed meets the nominate variety of *M. radiata* rather than that of *M. radians* also because of its general cell shape. In our opinion those slender forms (compare also our fig. 3E) should not be classified as *M. radians* var. *brasiliensis* but as *M. furcata*. For that matter, Grönblad (1945) compares his *M. radiata* var. *brasiliensis* with *M. radians* var. *bogoriensis* (C.Bernard) G.S.West but that latter taxon, in the original description by Bernard (1908) from Java, is characterized by 12 instead of 8 lateral lobules per semicell and is in want of a distinctly protruding apical lobe.

Formally, the transfer of var. *brasiliensis* from *M. radiata* to *M. radians* in Krieger & Scott (1957) is invalidly published by want of a full reference to its basionym (McNeill et al. 2012, art. 41). By providing the reference in question as yet we herewith validate the name of *M. radians* var. *brasiliensis*.

In our present study, *M. radians* var. *brasiliensis* was encountered in various samples from Lake WakaWaka and the Bangweulu wetlands (both near Mpanta and Chipundu).

Micrasterias denboeri Coesel & Van Geest, **sp. nov.**
Fig. 5E–F

Diagnosis – Cells in frontal view about as long as broad, with a deep median constriction. Sinus slightly open, the margins 1-2-undulate. Semicells in rough outline trapeziform with convex lateral sides, deeply lobed. Apical lobes with a straight neck and an abruptly widened, flattened top. Apical angles slightly bent upwards, 2-furcate with narrowly rounded ends. Lateral lobes of the first order divided into lobes of the second order. Upper lateral lobes separated from the apical lobes by deep incisions which are narrow at the ends but very wide in the middle. Incisions between the lateral lobes urn-shaped. Lateral lobes of the second order 2-furcate with narrowly rounded ends. Cells in lateral view oblong with a moderately deep median incision and broadly

rounded ends. Semicells abruptly inflated at the base. Dimensions: cell length 75–107 µm, cell breadth 78–108 µm, cell thickness c. 25 µm.

Type: Zambia, Lake WakaWaka, 12°31'14"S, 30°36'11"E, 22 Sept. 2012, *Hugo de Vries Lab.* 2012.02 (holo-: L), preserved as a fixed natural sample, and illustrated in fig. 5F.

Taxonomical remarks – *M. denboeri* is principally characterized by the shape of its cell apex, i.e. broadly flattened like an anvil. The species in question was recorded before by Thomasson (1960, 1966) under the name of *M. crux-meliten-sis*. Although our newly described *M. denboeri* obviously is closely related to the *M. radians* complex we prefer to render it the status of a separate species rather than to make it another variety of *M. radians*. The shape of the polar lobe, showing an angle of about ninety degrees between the cylindrical base and the widened apex, precludes confusion with other taxa. As we did not find any transitional forms to other representatives of the *M. radians* complex we consider *M. denboeri* a characteristic, well delimited taxon with a restricted distribution within the African continent.

Micrasterias denboeri is named in honour of Kees den Boer to whom we are much obliged as webmaster of www.desmids.nl. As far as could be checked, this species is only known from Bangweulu and surrounded areas. Thomasson found it in the Bangweulu wetlands and in Lake Shiwa Ngandu (110 km east of Lake Bangweulu), we ourselves encountered it in both the Bangweulu wetlands and Lake WakaWaka. Particularly in some of our WakaWaka samples (e.g. 2012072) it was rather common.

Micrasterias sudanensis Grönblad, Prowse & A.M.Scott ex Förster
Fig. 6K

Taxonomical remarks – *Micrasterias sudanensis* is a striking species because of its remarkably asymmetrical cells. In this species semicell lobes run into long, curved spines that tend to point all in the same direction resulting in semicells that are no mirror image of each other (fig. 6K). The species in question was provisionally named *M. sudanica* by Gauthier-Lièvre (1958) but formally described as *M. sudanensis* in Grönblad et al. (1958), by want of indication of a nomenclatural type (McNeill et al. 2012, art. 40) validated by Förster (1981a). What at first sight seems an aberrant cell form on closer examination appears to be a well-fixed, little variable species (Gauthier-Lièvre 1958). Where cell shape appears to be relatively consistent, cell dimensions may vary considerably. In literature, cell length mentioned or derived from pictures ranges from 90 µm (Thomasson 1966) to 160 µm (Gauthier-Lièvre 1958), cell breadth from 94 µm (Thomasson 1966) to 170 µm (Thomasson 1960). Also in our Zambia material cell dimensions varied strikingly, i.e. cell length (in completely developed cells) from 137 to 174 µm, cell breadth from 134 to 180 µm.

As far as known, *M. sudanensis* is only known from the central part of tropical Africa, i.e. from southern Sudan (Grönblad et al. 1958,) Zambia (Thomasson 1960, 1966) and Congo (Gauthier-Lièvre 1958). We ourselves encountered it in both Lake WakaWaka (sample 2012075) and Bangweulu

(sample 2012081), the cells in Bangweulu being consistently smaller than those in WakaWaka.

Allorgeia incredibilis (Grönblad, Prowse & A.M.Scott) Thomasson ex Förster
Fig. 6A–J

Taxonomical remarks – This most peculiar desmid was originally described by Grönblad et al. (1958) from Sudan, as *Micrasterias incredibilis*. Thomasson (1960) transferred it to *Allorgeia*, a genus erected by Gauthier-Lièvre (1958) with as type species *A. valiae* Gauthier-Lièvre, described from Congo. Eventually, by want of a reference to its basionym (McNeill et al. 2012, art. 41) the name of *A. incredibilis* was validated by Förster (1981b).

The genus *Allorgeia* is characterized by its extreme asymmetry: lobes of the two semicells being not only different in number but also in shape. In *A. incredibilis* one of the two semicells has four lateral lobes two by two pointing to the front and the rear, the other semicell has but two lateral lobes lying in the same horizontal plane. Moreover, the apical lobes of the two semicells differ in length and terminal ornamentation (fig. 6A–J).

Allorgeia incredibilis is a rare species only known from Sudan (Grönblad et al. 1958) and Zambia (Thomasson 1960). We ourselves encountered but a very few cells in Bangweulu sample nr. 2012081.

DISCUSSION

Desmid taxonomy suffers from an excess of varieties and formae. Following Kouwets' (2008) proposal to drastically reduce the number of those infraspecific taxa, either by considering them taxonomically irrelevant phenotypes or by upgrading them to species level we decided to raise three well defined varieties of *M. tropica* in rank. As yet, such did not appear practicable for a number of varieties of *M. radians*. Although we have got the impression that the varieties in question do have a genetical base, they are mutually connected by so many transitional forms that, in practice, they better can be accounted a single species.

In literature, our newly described *M. radians* var. *cruxoides* has frequently been confused with *M. crux-meliten-sis*. Although morphological differences are small indeed, those two taxa usually can be distinguished by the shape of the lateral lobules and the apical teeth. Presumably, *M. crux-meliten-sis* as known from Europe and North America is distinctly rare in tropical regions (Růžička 1981: 613). For instance, all seven different formae of *M. crux-meliten-sis* described by Turner (1893) from India to our mind have to be accounted *M. radians* var. *cruxoides*. Also the pictures of *M. crux-meliten-sis* in Vyverman & Viane (1995), from Papua New Guinea, in our opinion refer to *M. radians* var. *cruxoides*. This could better explain the gradual transition found by those authors between 'typical' *M. radians* in tropical lowland waters and their supposed *M. crux-meliten-sis* in high altitude Papua New Guinea lakes. Interestingly, Neustupa et al. (2010) based on molecular data found some six European and North American strains of *M. crux-meliten-sis* to belong to another phylogenetic lineage than two Kenia strains of *M.*

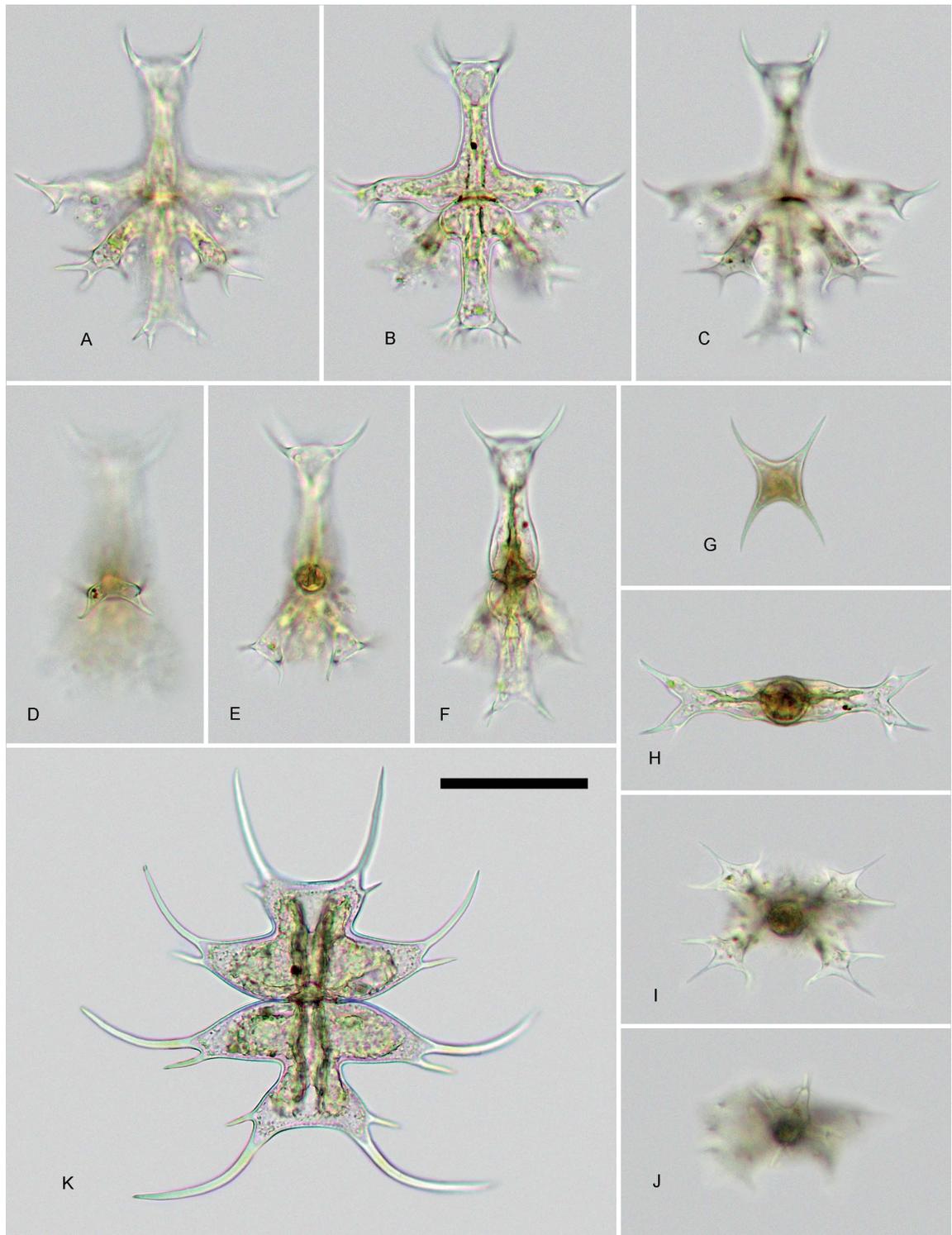


Figure 6 – A–J: *Allorgeia incredibilis*; A–C, focus-through picture of a cell in frontal view; D–F, idem of the same cell in lateral view; G–J, idem of the same cell in apical view; K, *Micrasterias sudanensis* (originating from sample 2012081). Scale bar represents 50 μm .

radians var. *evoluta*. Genbank data of a *M. crux-melitensis* strain from the Japanese NIES culture collection, however, showed a closer affiliation with *M. radians* var. *evoluta* than with the analyzed strains of European/North American *M. crux-melitensis* (Neustupa et al. 2010). Photographs of the strain NIES-152 indicate that this strain morphologically is

more similar to *M. radians* than to *M. crux-melitensis*, suggesting a possible misidentification (National Institute for Environmental Studies 2014). For that matter, it is questionable if *M. furcata* as represented in our fig. 3E is phylogenetically identical to *M. furcata* as originally described by Ralfs (1848) from Great Britain. The long, curved terminal teeth

suggest our *Zambian* taxon in question to be just another representative of the tropical *M. radians* complex. Maybe, the taxonomic differentiation in this complex could be compared with that in other tropical desmids, like the diversification in the *Euastrum monocyllum* complex (Coesel 2000).

Our find that the asymmetrical species *M. sudanensis* is remarkably uniform in its morphology is in accordance with the literature referring to this species. Of some desmid taxa with a similar type of asymmetry also a symmetrical pendant is known, compare, e.g. the South American species *Staurastrum marthae* Grönblad in Grönblad (1945) and in Scott et al. (1965). For *M. sudanensis*, however, such a pendant is not known. Yet, in our opinion, the mere feature of bipolar asymmetry in an obvious representative of the traditional genus *Micrasterias* does not justify establishment of a separate genus, *Prescottella*, as proposed by Bicudo (1976).

On the contrary, the transfer of *M. incredibilis* to the genus *Allorgeia* by Thomasson (1960) is fully understandable for this species actually does not look much like a *Micrasterias* species. *Allorgeia incredibilis*, with its tubular instead of flattened semicell body and lobes, rather reminds a monstrous form of some baculiform desmid. Most interestingly, in various recent, molecular studies the baculiform desmid *Triploceras gracile* was consistently found to be nested within a phylogenetic lineage comprising *Micrasterias* taxa (e.g. Gontcharov & Melkonian 2008, 2011, Hall et al. 2008, Škaloud et al. 2011). Possibly, also *Allorgeia incredibilis* is affiliated to some baculiform desmid taxon, such as the tropical species *Ichthyodontum sachlanii* A.M. Scott & Prescott, whose var. *parorthium* is characterized by polar dimorphism like in *A. incredibilis* (Scott & Prescott 1956).

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