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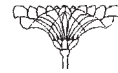
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Taxonomic and biogeographical notes on Okavango desmids (Zygnematophyceae, Streptophyta)

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Abstract. – In October 2007, a selection of water bodies in the Okavango Delta (Botswana) and the southwestern part of the Zambezi Basin (Namibia) were sampled for desmid algae. In this paper 27 taxa belonging to the genera *Penium*, *Closterium*, *Pleurotaenium*, *Triplastrum*, *Tetmemorus*, *Euastrum* and *Micrasterias* are separately discussed and figured. Five taxa are newly described: *Closterium okavangicum*, *Tetmemorus euastroides* var. *africanus*, *Euastrum attenuatum* var. *groenbladii*, *Euastrum okavangicum* and *Euastrum sudanense*. The names of five taxa are newly given or recombined: *Euastrum africanum*, *Euastrum compereanum*, *Euastrum fritschii*, *Euastrum scottii* and *Micrasterias schmidleana*. The majority of the taxa discussed can be characterized as African endemics.

Key words: Desmids, Okavango Delta, Zambezi Basin, new taxa, biogeography.

Introduction

Unlike most rivers that flow into the sea, the Okavango River terminates in a shallow depression of the Kalahari Desert (Botswana), forming a large alluvial fan that covers about 40,000 square kilometers. The delta consists of a mosaic of marshes, canals and islands and is considered the biggest inland delta in the world. Human activities had no noticeable effects on the water quality so far. About 12,000 square kilometers of the Okavango Delta is actually wetland of which approximately a third part is permanently flooded (Wolski & Murray-Hudson 2006). Inflowing water is poor in nutrients as the Kalahari sands have a low mineral content and because most of the nutrients are absorbed by plants. A small part of the inflowing water evaporates directly from the surface, but most of it infiltrates the soil and evaporates through the vegetation. As a result of this process salts accumulate in the soil keeping the surface water fresh (Cronberg & al. 1996). Vegetation is found mainly near the outer margins of the islands where fresh water is available, whereas the saline interior is only scarcely wooded.

The Okavango Delta has a wet summer season with January and February as the wettest months and a dry winter season with almost no rainfall in June and July. Water table rises only far into the dry season because of the long time the water needs to pass the delta. Water inflow from the

Okavango River and direct precipitation also change from year to year resulting in highly fluctuating water levels.

The Okavango Delta is renowned for its huge biodiversity (e.g., Mendelsohn & el Obeid 2004, Junk & al. 2006). Remarkably enough, despite the large area of aquatic and palustrine habitats relatively little research has been done on aquatic microcenoses (Junk & al. 2006). Cronberg & al. (1995, 1996) performed extensive investigations into bacterial and plankton cenoses but mainly in a quantitative sense. As for desmids, inventories are only known of the Okavango river itself where it borders Namibia, some 150 km before it branches into the proper delta (Grönblad & Croasdale 1971). As the Okavango Delta, with its numerous shallow bodies of nutrient-poor, almost stagnant water could be considered an excellent habitat for desmids the present authors undertook a sampling trip entering the complex system of tributaries from various directions. In this paper we discuss a number of desmid species of the genera *Penium*, *Closterium*, *Pleurotaenium*, *Triplastrum*, *Tetmemorus*, *Euastrum* and *Micrasterias* which are of special interest from a taxonomic or biogeographical point of view.

Material and methods

Our trip to the Okavango Delta and the Caprivi Strip was undertaken in the period of October 3-14, 2006. The main sampling sites are indicated in fig. 1. Surroundings of Chief's Island were sampled from a mokoro (kind of canoe), the other three sites from the firm shore. Algal material was collected by squeezing submerged plants, preferably those with finely dissected leaves, such as *Utricularia* species. When sampling for desmids, also geographic co-ordinates (by means of a GPS) and electric conductivity of the water sampled (in $\mu\text{S cm}^{-1}$, by means of a portable meter) were recorded. Samples were fixed with formaldehyde to a final concentration of about 3 % on the day of collection. All samples are stored in the plankton collection of the Amsterdam University herbarium.

Specification of samples:

Chief's Island

01. - October 03, Latitude 19° 30' 20" S, Longitude 23° 08' 46" E, Conductivity 107 μS
02. - October 03, Lat. 19° 30' 18" S, Long. 23° 08' 31" E, Cond. 102 μS
03. - October 03, Lat. 19° 30' 15" S, Long. 23° 08' 25" E, Cond. 110 μS
04. - October 03, Lat. 19° 30' 13" S, Long. 23° 08' 20" E, Cond. 126 μS
05. - October 04, Lat. 19° 30' 12" S, Long. 23° 08' 19" E, Cond. 170 μS
06. - October 04, Lat. 19° 30' 09" S, Long. 23° 07' 33" E, Cond. 99 μS
07. - October 04, Lat. 19° 30' 08" S, Long. 23° 07' 27" E, Cond. 98 μS
08. - October 05, Lat. 19° 30' 27" S, Long. 23° 08' 50" E, Cond. 102 μS
09. - October 05, Lat. 19° 30' 34" S, Long. 23° 09' 08" E, Cond. 153 μS
10. - October 05, Lat. 19° 30' 33" S, Long. 23° 09' 13" E, Cond. 118 μS
11. - October 06, Lat. 19° 30' 44" S, Long. 23° 08' 47" E, Cond. 117 μS
12. - October 06, Lat. 19° 30' 36" S, Long. 23° 08' 59" E, Cond. 107 μS

Moremi

13. - October 08, Lat. 19° 14' 12" S, Long. 23° 21' 13" E, Cond. 301 μS
14. - October 08, Lat. 19° 14' 17" S, Long. 23° 21' 17" E, Cond. 65 μS
15. - October 09, Lat. 19° 15' 07" S, Long. 23° 24' 09" E, Cond. 201 μS
16. - October 09, Lat. 19° 14' 11" S, Long. 23° 21' 12" E, Cond. 62 μS
17. - October 09, Lat. 19° 16' 58" S, Long. 23° 22' 32" E, Cond. 96 μS
18. - October 10, Lat. 19° 11' 40" S, Long. 23° 16' 15" E, Cond. 50 μS
19. - October 10, Lat. 19° 11' 41" S, Long. 23° 16' 15" E, Cond. 55 μS

Mohango

20. - October 12, Lat. 18° 13' 20" S, Long. 21° 45' 10" E, Cond. 44 μS
21. - October 12, Lat. 18° 13' 19" S, Long. 21° 45' 10" E, Cond. 61 μS

Caprivi

22. - October 13, Lat. 17° 46' 15" S, Long. 23° 20' 21" E, Cond. 135 μS
23. - October 13, Lat. 17° 52' 33" S, Long. 23° 19' 06" E, Cond. 720 μS
24. - October 13, Lat. 17° 52' 58" S, Long. 23° 19' 06" E, Cond. 132 μS
25. - October 14, Lat. 17° 52' 37" S, Long. 23° 18' 19" E, Cond. 147 μS

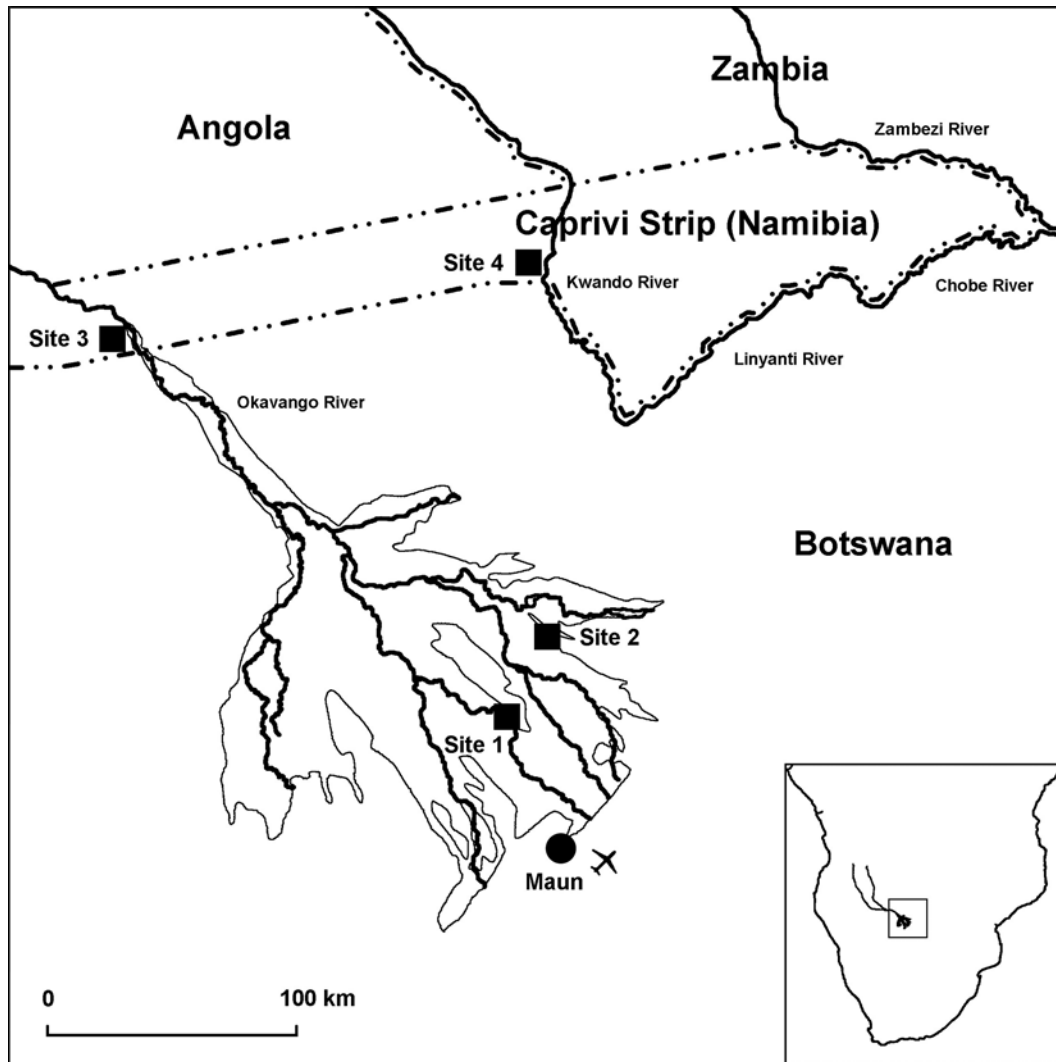


Figure 1. Map of the Okavango Delta with location of the sampling sites.
Site 1: Chief's Island; site 2: Moremi Wildlife Reserve;
site 3: Mohango Game Reserve; site 4: Caprivi Game Park.

Taxonomic account

Because of huge difficulties to trace and examine type specimens of desmid taxa in the original sample material, in the taxonomic account given below, for all synonyms provided, the illustrations making part of the original description are considered the type material (holotype). As, moreover, it is almost unfeasible to preserve a single cell as a type specimen, according to art. 37.5 of the Vienna Code (McNeill & al. 2006), in the present paper names of new taxa are connected to illustrations as well.

Penium gonatozygiforme Claassen

Fig. 2

J. S. African Bot. 42: 382, fig. 8-20 (1976).

Penium gonatozygiforme was described by Claassen (1976) from southwestern Transvaal. Most striking characteristic is its cell wall ornamentation in the form of numerous small spines. In that respect *Penium gonatozygiforme* resembles given representatives of the genus *Gonatozygon*, in particular *G. aculeatum* Hastings. However, contrary to *Gonatozygon*, a shallow but nevertheless distinct sinus, as well as clearly marked girdle bands may be distinguished. For that matter, from French Guiana Bourrelly (1977) described *Gonatozygon chadefaudii*, a species very much resembling *Penium gonatozygiforme* and anyhow better to be placed in the genus *Penium*.

Apart from Transvaal, *P. gonatozygiforme* is also known from Madagascar (Bourrelly & Couté 1991). In the Okavango Delta it appeared to be widely distributed and locally rather common on the site of Chief's Island.

Closterium okavangicum Coesel et Van Geest **sp. nov.**

Fig. 3-5

Cellulae incrassatae 4- ad 5-plo longiores quam latiores 70-80° arcuatae apicibus late truncatis anguliscum rotundatis extremitatibus cellularum admodum infra apicem leviter recurvatis. Parietes cellulae laevis, incoloratus et sine liniis cingulatis. Dimensiones: cellularum longitudo 120-145 µm, latitudo 27-30 µm, latitudo apicis 10-13 µm. – *Typus*: figura nostra 3.

Cells thick-set, 4-5 times longer than broad and curved with 70-80° of arc. Apices broadly truncate with rounded angles. Cell ends just below the apex slightly recurved. Cell wall smooth, colourless and without girdle bands. Cell length 120-145 µm, cell breadth 27-30 µm, breadth of apex 10-13 µm. – *Type*: our fig. 3. *Type locality*: marshy site at camping site Third Bridge, in Moremi Wildlife Reserve (sample nr. 16), P.F.M. Coesel, 9 October 2006, plankton collection # 2006.57 in the Amsterdam University herbarium.

Unfortunately, the formaldehyde fixed cell material did not allow reliable examination of the chloroplast. Remnants of chloroplasts suggested the occurrence of longitudinal ridges with scattered pyrenoids (fig. 4).

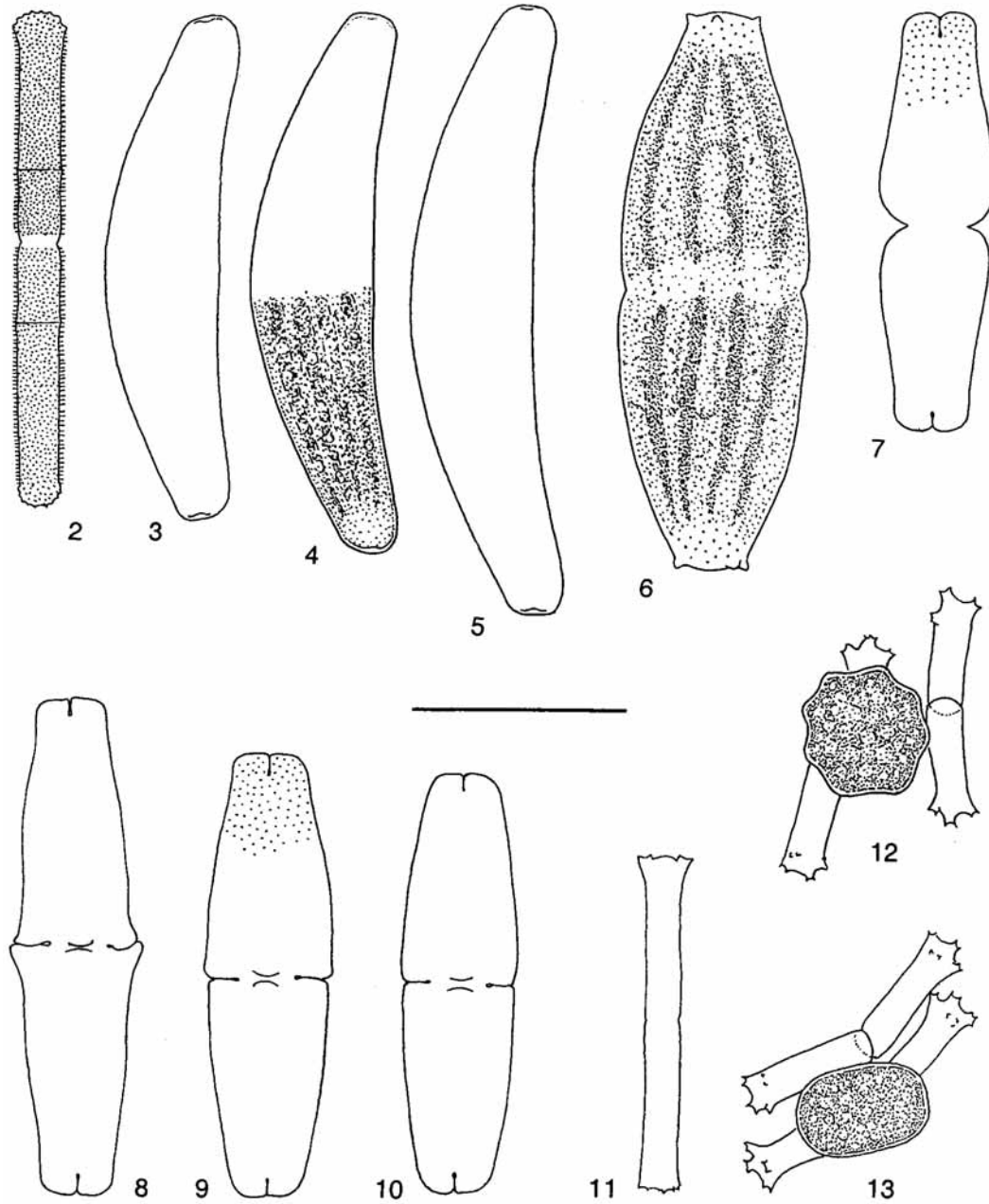
Our newly described *Closterium* species was encountered in sample nrs 1, 2 (Chief's Island) and 16 (Moremi), but only in low cell numbers. The species in question, with its remarkably uniform, characteristic morphology is readily to be recognized. The only other *Closterium* species with which it may be confused is *Closterium compactum* Nordst., known from *Sphagnum* mires in New Zealand (Nordstedt 1888, Skuja 1976). *Closterium compactum* cells, with a length to breadth ratio of 3-4, are even more compact (thick-set) than those of *Cl. okavangicum* but otherwise are about similar in morphology.

Pleurotaenium engleri Schmidle

Fig. 6

Bot. Jahrb. Syst. 26: 23, pl. 1, fig. 16 (1898).

Pleurotaenium engleri is a most characteristic species that hardly can be confused with any other known *Pleurotaenium* species. It was originally described by Schmidle (1898) from the Wembere marshes, in Tanzania. To our mind unjustly, Krieger (1937) transferred it as var. *engleri* to *Pleurotaenium breve*, a species described by Raciborski (1895) from British Guiana. When doing so, Krieger (l. c.) slightly changed Schmidle's original figure, making it more alike Raciborski's original illustration of *Pl. breve*. Until now, after Schmidle's (1898) original description, *Pl. engleri*



Figures 2-13. 2: *Penium gonatozygiforme*; 3-5: *Closterium okavanicum*, 3: *holotype*;
6: *Pleurotaenium engleri*; 7: *Tetmemorus euastroides* var. *africanus*, *holotype*; 8-10: *Euastrum fritschii*;
11-13: *Triplastrum abbreviatum*, 12: *zygospore in frontal view*, 13: *zygospore in lateral view*.
Scale bar = 50 μ m.

was only recorded (as *Pl. breve* var. *engleri*) by Lind (1971) from Uganda, and by Claassen (1976) from Southwestern Transvaal. So, most likely, it can be considered an African endemic. Claassen (1976), referring to the cell dimensions stated by Schmidle and Lind, assumed that both authors found but a single specimen of the species in question. She herself, examining more than a hundred slides, encountered only three specimens and concluded it to be an extremely rare taxon.

Also in our own investigation *Pl. engleri* was encountered only incidentally, both on the sites of Chief's Island (sample nrs 9, 10 and 12), Moremi (nr. 16) and Mohango (nr. 21).

Triplastrum abbreviatum (W.B.Turner) Iyengar et Ramanathan
J. Ind. Bot. Soc. 21: 228 (1942).

Fig. 11-13

The above-mentioned species was originally described by Turner (1892) as *Triploceras abbreviatum*. Iyengar & Ramanathan (1942) transferred it to the newly erected genus *Triplastrum*. In our opinion, a number of other *Triplastrum* species described later on belong to this same species, for there is no essential difference between *Triplastrum abbreviatum*, *T. indicum* Iyengar et Ramanathan, *T. spinulosum* (Kisselev) Gauthier-Lièvre and *T. simplex* (Allorge) Iyengar et Ramanathan.

When taking this wider species conception, *T. abbreviatum* is known from tropical and subtropical regions in both Asia, Africa and (incidentally) Europe. In the Okavango Delta it appeared to be widely distributed and locally rather common on the site of Chief's Island. In sample nr. 10 it was found in sporulating condition. Until then, zygospores were only described by Iyengar & Ramanathan (1942). As appears from our fig. 12, 13, zygospores are about pumpkin-shaped (compressed spherical, in top view with undulate margins).

Tetmemorus euastroides A.M.Scott et Prescott
var. ***africanus*** Coesel et Van Geest var. nov.

Fig. 7

A varietate typica differt apicibus cellularum capitatis. Dimensiones: cellularum longitudo 97-105 µm, latitudo 25-29 µm, isthmi latitudo 12-14 µm. – *Typus*: figura nostra 7.

Differs from the nominate variety by capitate cell ends. Cell length 97-105 µm, cell breadth 25-29 µm, breadth of isthmus 12-14 µm. – *Type*: our fig. 7. *Type locality*: water-course near Chief's Island (sample nr. 3), P.F.M. Coesel, 3 October 2006, plankton collection # 2006.44 in the Amsterdam University herbarium.

The algal form pictured in our fig. 7 most likely is identical to *Tetmemorus pseudoeuastroides*, described by Bourrelly & Couté (1991) from Madagascar. According to Bourrelly & Couté (l.c.) *T. pseudoeuastroides* would differ from *T. euastroides*, described by Scott & Prescott (1958) from Australian Arnhem Land, in the presence of cell wall granules that are lacking in *T. euastroides*. However, the illustration of *T. pseudoeuastroides* in Bourrelly & Couté (1991: pl. 2-2) shows perfectly smooth cell outlines without any indication of granules. The present authors, in their Okavango samples, encountered cells quite similar in morphology to those pictured in Bourrelly & Couté (l.c.) but definitely smooth-walled. So, most likely, Bourrelly and Couté mistook cell wall pores (or their mucilage extrusions) for cell wall granules (for that matter, cell wall granules are unknown in the genus *Tetmemorus*). The only difference between the nominate variety of *T. euastroides* and our above-described var. *africanus* is in the shape of the cell ends: attenuate in var. *euastroides*, capitate in var. *africanus*.

Bourrelly & Couté (1991) recorded *T. pseudoeustroides* from a single locality in Madagascar, sampled in 1930. Until now, no other records of that taxon are known. In the Okavango Delta *T. eustroides* var. *africanus* was encountered, rather incidentally, on the sites of Chief's Island (sample nrs. 2 and 3), Moremi (sample nr. 16) and Mohango (sample nr. 21).

Euastrum africanum (Bourrelly) Coesel et Van Geest **stat. nov.** Fig. 22-24
Basionym: *Euastrum evolutum* (Nordst.) W. et G.S. West var. *glaziovii* (Børgesen) W. et G.S. West
forma *africanum* Bourrelly, Bull. Inst. Franç. Afr. Noire, Sér. A, 19: 1061, pl. 3, fig. 27-28 (1957).

No doubt, the taxon represented in our fig. 22-24 is identical to *Euastrum evolutum* var. *glaziovii* forma *africanum* described by Bourrelly (1957) from Mali. However, it should be also clear that it has but little to do with *Euastrum evolutum* as originally described by Nordstedt (1877, as *Eu. abruptum* var. *evolutum*) from Brazil. Whereas *Eu. evolutum* is characterized by marked lateral lobes in between the apical and the basal semicell lobes, there is no trace of such lateral lobes in our alga under discussion. In respect of that, *Eu. evolutum* var. *glaziovii* described by Børgesen (1890, as *Eu. glaziovii*) from Brazil somewhat better fits our material but still the morphological differences are big enough to justify distinction at species level. Actually, our newly named *Eu. africanum* rather resembles *Eu. sachlanii* as described by Scott & Prescott (1961) from Sumatra (see also Coesel & Dingley, 2005). Differences, however, are in cell length to breadth ratio, depth of the median apical incision and the arrangement of cell wall granules on the central semicell inflation.

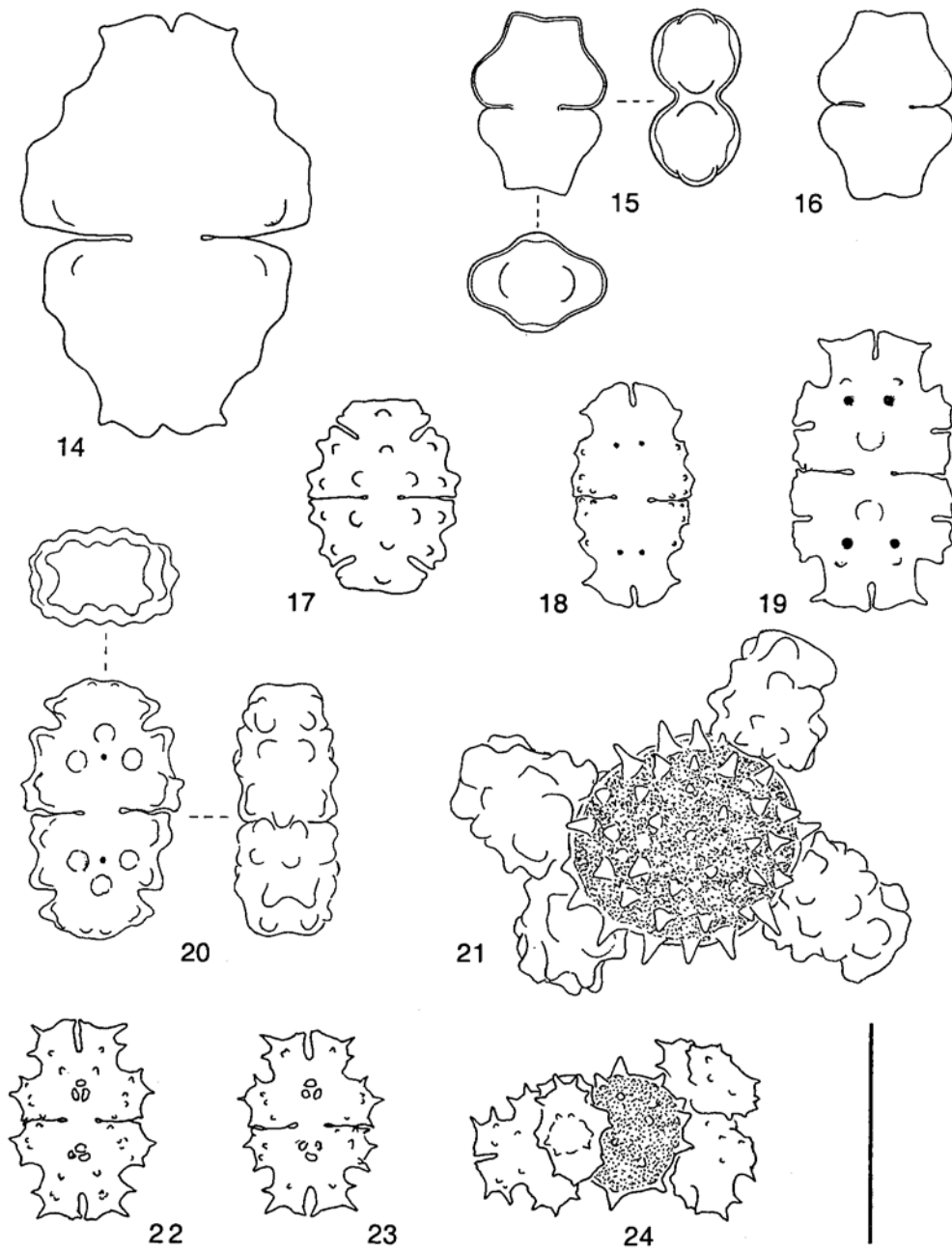
In the Okavango Delta, *Eu. africanum* appeared to be one of the commonest desmid species, encountered in almost all samples. Zygosporangia were found in sample nr. 1.

Euastrum attenuatum Wolle
var. ***groenbladii*** Coesel et Van Geest **var. nov.** Fig. 36
A varietate typica differt lobo polari brevior, lobis basalibus indivisis et sinu late aperto. Dimensiones: cellularum longitudo 52-60 µm, latitudo 28-31 µm, isthmi latitudo 10-11 µm. – *Typus*: figura nostra 36.

Differs from the nominate variety by a shorter polar lobe, undivided basal lobes and a widely open sinus. Cell length 52-60 µm, cell breadth 28-31 µm, breadth of isthmus 10-11 µm. – *Type*: our fig. 36. *Type locality*: water-course near Chief's Island (sample nr. 3), P.F.M. Coesel, 3 October 2006, plankton collection # 2006.44 in the Amsterdam University herbarium.

Euastrum attenuatum was originally described by Wolle (1884) from the United States. Afterwards, quite a series of infrapacific taxa have been described. None of those taxa fits the combination of characters given above for our var. *groenbladii*. Grönblad & al. (1958) figured this same taxon under the name of *Euastrum attenuatum* var. *splendens* (F.E. Fritsch et F. Rich) Grönblad et A.M. Scott, neglecting the fact that cells of *Euastrum splendens* as originally described by Fritsch & Rich (1937) are characterized by a lower length to breadth ratio and distinctly bilobed basal lobes.

As far as could be checked, *Euastrum attenuatum* var. *groenbladii* is only known from Sudan (Grönblad & al. 1958), Botswana and Namibia (our finds). Its closest relatives are *Eu. attenuatum* var. *brasiliense* described by Grönblad (1945) from Brazil, and var. *japonicum* described by Hinode (1962) from Japan, both differing from var. *groenbladii* by bilobed basal lobes. In our area of investigation *Eu. attenuatum* var. *groenbladii* was widely distributed (all four sites) but nowhere abundant.



Figures 14-24. 14: *Euastrum corpulentum*; 15, 16: *Eu. sudanense*, 15: *holotype*; 17: *Eu. truncatiforme*; 18: *Eu. scottii*; 19: *Eu. praemorsum*; 20, 21: *Eu. sympageum* var. *elaboratum*; 22-24: *Eu. africanum*.
Scale bar = 50 μ m.

***Euastrum compereanum* Coesel et Van Geest nom. et stat. nov.**

Fig. 34

Synonym: *Euastrum subhypochondrum* F.E.Fritsch et F.Rich var. *croasdaleae* Compère, Bull. Jard. Bot. Belg. 46: 465, fig. 15 (1976).

Euastrum subhypochondrum belongs to the group of desmids that in a previous paper provisionally was defined the *Euastrum mononcyllum* group (Coesel 2000). Comparison of *Eu. subhypochondrum* var. *croasdaleae* with the nominate variety of *Eu. subhypochondrum* (fig. 34 and 25) shows essential morphological differences. Semicells of var. *croasdaleae* are marked by lateral lobes that are strongly curved upward and the semicell centre is in want of the concentric series of granules that are characteristic of all other species of the *Eu. mononcyllum*-allied species complex. In our opinion, those differences are big enough to consider var. *croasdaleae* a species of its own. The name of *Eu. croasdaleae* already having been given (Grönblad 1956), we like to name it after Pierre Compère who contributed so much to our knowledge of African desmids.

Up to then, *Euastrum compereanum* was only known from Chad (Compère 1976) and Zambia (Thomasson 1960, as *Euastrum* sp.). In the Okavango Delta we encountered it occasionally in sample nr. 16 (Moremi) and nr. 21 (Mohango).

***Euastrum corpulentum* Grönblad et A.M.Scott**

Fig. 14

Acta Bot. Fennica 58: 12, fig. 74-76, 353 (1958).

Euastrum corpulentum was described by Grönblad et al. (1958) from Sudan. Despite the fact that it concerns a rather large-sized, characteristically shaped species, no later records are known. In our Okavango samples we encountered only one single cell (in sample nr. 16) so, presumably, we have to do with a rare, African species.

***Euastrum divergens* Joshua**

Fig. 29

J. Linn. Soc. Bot. 21: 640, pl. 23, fig. 8, 9 (1886).

Euastrum divergens, just like a number of other species discussed in the present paper, belongs to the *Euastrum mononcyllum*-allied species group. It is widely distributed on both the Asian, the Australian and the African continent (records from South America refer to other species). Our Okavango material best fits var. *subbifidum* described by Claassen (1961) from South Africa. However, in our opinion, the morphological differences between this variety and the nominate variety are too small to justify distinction of a separate taxon.

In our Okavango collection, *Eu. divergens* was occasionally encountered in a number of samples from the sites of Chief's Island and Caprivi.

***Euastrum fritschii* Coesel et Van Geest nom. et stat. nov.**

Fig. 8-10

Synonyms:

Euastrum brasiliense Borge var. *africanum* F.E.Fritsch et F.Rich, Trans. Roy. Soc. South Africa 11: 330, fig. 9 (1924).

Euastrum solum (Nordst.) Grönblad et A.M.Scott var. *africanum* (F.E.Fritsch et F.Rich) Grönblad et A.M.Scott, Acta Bot. Fennica 58: 17, fig. 13, 31, 32, 342 (1958).

The recombination of *Euastrum brasiliense* var. *africanum* by Grönblad et al. (1958) to *Euastrum solum* var. *africanum* is understandable in view of its elongate cell shape fitting that of *Eu. solum*

rather than that of *Eu. brasiliense*. In our opinion, however, var. *africanum* deserves the status of a separate species as it differs from *Eu. solum* by lateral semicell sides that, from base to apex, are not fluently concave but more or less bulgy in the middle part. Since in this paper the name of *Euastrum africanum* has already been used for another species, we decided to name the species after Felix Eugen Fritsch, one of the original describers of the taxon under discussion. As is shown in our fig. 8-10, cell outline is pretty variable. Most likely, *Eu. solum* var. *angustum* Grönblad et al. (1958) described by Grönblad et al. (1958) from the same region as where they encountered *Eu. solum* var. *africanum* is within that wide morphological range, so does not deserve the status of a separate variety.

So far, *Eu. fritschii* – as *Eu. brasiliense* var. *africanum*, or *Eu. solum* var. *africanum* – was only recorded from South Africa (Fritsch & Rich 1924, Williamson 1994) and Sudan (Grönblad et al. 1958). In the Okavango Delta it was locally rather common on the sites of Chief's Island and Moremi.

***Euastrum hieronymusii* Schmidle**

Fig. 28

Bot. Jahrb. Syst. 26: 42, pl. 2, fig. 35 (1898).

Euastrum hieronymusii, described by Schmidle (1898) from Zanzibar, was recombined to *Euastrum sphyroides* Nordst. var. *hieronymusii* by Krieger (1937). However, when comparing *Eu. hieronymusii* with *Eu. sphyroides* (our fig 28 and 31) distinction on species level seems to be justified. *Eu. hieronymusii*, as compared to *Eu. sphyroides*, is distinctly larger in cell size. In addition to that, its cell wall spines are much stouter and less equal in distribution than that in *Eu. sphyroides*. In view of that, affiliation of *Eu. hieronymusii* to *Eu. subhypochondrum* is more plausible.

Of *Eu. hieronymusii* only a few reliable records are known, i.e., from Tanzania (Schmidle 1898), Zambia (Thomasson 1965) and Chad (Compère 1967). In our Okavango samples it was only incidentally met with (sample nr. 1).

***Euastrum mononcyllum* (Nordst.) Racib.**

Fig. 30

Pamiętn. Akad. Umiejętn. w Krakowie, Wydz. Mat.-Prz. 10: 94 (1885).

Coesel (2000) rendered this species a central position in a hypothetical scheme of radiating evolution lines resulting in clusters of closely affiliated *Euastrum* species. This so-called *Euastrum mononcyllum* group of species displays its highest diversity in tropical Africa. Whereas, from that region, related species such as *Eu. spinulosum*, *Eu. divergens* and *Eu. platycerum* are commonly reported, of *Eu. mononcyllum* itself only a very few records are known. The impression that *Eu. mononcyllum* is a relatively rare species was confirmed by our collections, for it was only encountered (in small cell numbers) in sample nr. 25, originating from the Caprivi strip.

***Euastrum okavangicum* Coesel et Van Geest sp. nov.**

Fig. 32, 33

Longitudo cellularum circa eadem ac latitudo. Sinus profundus, majore parte clausus semicellulis a fronte visis truncatis-pyramidalibus quinquelobatis invaginatione inter lobum apicalem latum et lobos laterales profundiore quam invaginatione inter lobos laterales et basales. Semicellulae in centro protuberatione plana circulo granularum decoratae verrucam grandem includenti. Lobi semicellularum granulis aliquot dispersis, granulis in centro loborum basaliu tuberculo similibus dilatatis. Dimensiones: cellularum longitudo 34-40 μm , latitudo 32-38 μm , crassitudo circa 20 μm , isthmi latitudo 5-6 μm . – *Typus*: figura nostra 32.

Cells about as long as broad. Sinus deep, closed for the greater part. Semicells in frontal view approximately truncate-pyramidal, five-lobed. Invagination between the broad apical lobe and the lateral lobes deeper than that between the lateral lobes and the basal lobes. Semicells with a flat protuberance in the centre, decorated with a circle of granules enclosing a large verruca. Semicell lobes with some scattered granules, those in the midregion of the basal lobes tubercle-like enlarged. Cell length 34-40 µm, cell breadth 32-38 µm, cell thickness circa 20 µm, breadth of isthmus 5-6 µm. – *Type*: our fig. 32. *Type locality*: water-course near Chief's Island (sample nr. 2), P.F.M. Coesel, 3 October 2006, plankton collection # 2006.43 in the Amsterdam University herbarium.

Unmistakably, also *Eu. okavangicum* belongs to the above-mentioned *Euastrum mononcyllum*-allied species group. Of the species generally accounted this group, *Eu. spinulosum* Delponte is near to our newly described *Eu. okavangicum*. Actually, *Eu. okavangicum* can be characterized as a smaller-sized form of *Eu. spinulosum*, with a relatively broad apical lobe and only a shallow invagination between lateral and basal lobes. A suchlike form has been described much earlier from Bulgaria, i.e., by Petkoff (1925) as *Eu. bulgaricum*, recombined to *Eu. spinulosum* var. *bulgaricum* by Krieger (1937). Remarkably enough, this taxon has never been recorded for a second time. Although our *Eu. okavangicum* resembles *Eu. bulgaricum* we prefer to render it the status of a separate species. Invaginations between the semicell lobes in *Eu. bulgaricum* are deeper than those in *Eu. okavangicum* and, more relevant, the ornamentation pattern of granules on the face of the semicell is distinctly different.

In the Okavango Delta *Eu. okavangicum* appeared to be a widely distributed and locally common species on the sites of Chief's Island and Moremi.

Euastrum osmondii Couté et Rousselin

Fig. 35

Bull. Mus. Hist. Nat. (Paris) 277: 98, pl. 5, fig. 3 (1975).

Euastrum osmondii, with its diverging, broadly rounded apical lobes marked by a deep, narrow apical incision, is a characteristically shaped species that hardly can be confused with any other *Euastrum* species. After its description by Couté & Rousselin (1975) from Mali it has never been reported again. However, there can be no doubt that the alga labeled *Eu. turneri* in Gerrath & John (1988: pl. 8-10) from Ghana refers to this same species.

In the Okavango Delta it was only encountered in sample nr. 11.

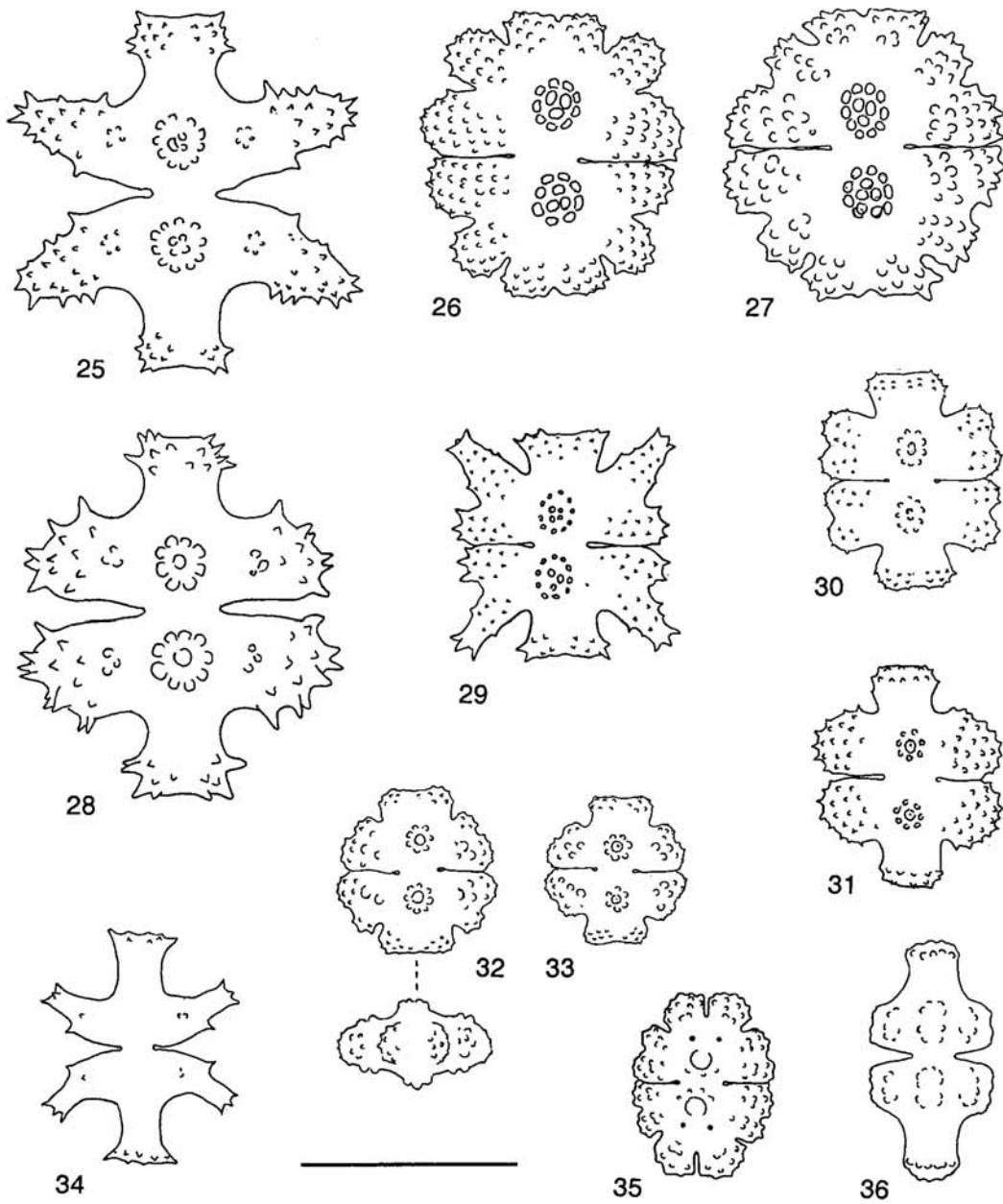
Euastrum scottii Coesel et Van Geest **nom. et stat. nov.**

Fig. 18

Synonym: *Euastrum praemorsum* (Nordst.) Schmidle var. *simplicius* Grönblad et A.M.Scott, Acta Bot. Fennica 58: 15, fig. 69, 73 (1958).

Although, objectively considered, there are only a number of minor differences between the nominate variety of *Euastrum praemorsum* and its var. *simplicius*, their overall appearance is quite distinct (fig. 18 and 19). In our Okavango samples both taxa occurred next to each other, without transitional forms. In our opinion, this finding justifies raising in rank of var. *simplicius* to species level. The name of *Euastrum simplicius* already having been used by Turner (1892), *Euastrum scottii* is chosen as new species name.

Up to then *Euastrum scottii* (as *Eu. praemorsum* var. *simplicius*) was only known from Sudan (Grönblad & al. 1958) and Zambia (Thomasson 1960). *Eu. praemorsum* var. *simplicius* reported from Madagascar (Bourrelly & Couté 1991: pl. 14-6) and from Uganda (Grönblad & al. 1964:



Figures 25-36. 25: *Euastrum subhypochondrum*; 26: *Eu. spinulosum* var. *spinulosum*;
 27: *Eu. spinulosum* var. *inermius*; 28: *Eu. hieronymusii*; 29: *Eu. divergens*; 30: *Eu. mononcyllum*;
 31: *Eu. sphyroides*; 32, 33: *Eu. okavangicum*, 32: *holotype*; 34: *Eu. compereanum*; 35: *Eu. osmondii*;
 36: *Eu. attenuatum* var. *groenbladii*, *holotype*.

Scale bar = 50 μ m.

pl. 2-19) do not refer to our taxon under discussion but to the nominate variety of *Euastrum prae-morsum*.

On the Okavango sites of Chief's Island, Moremi and Mohango *Eu. scottii* appeared to be widely distributed and locally rather common.

Euastrum sphyroides Nordst.

Fig. 31

Kongl. Svenska Vetenskapsakad. Handl. 22 (8): 32, pl. 3, fig. 3 (1888).

Euastrum sphyroides was originally described by Nordstedt (1888) from bogs in New Zealand. Later on it was reported also from the African and the Asian continent. Most of the records originate from tropical Africa and all of them make mention of somewhat larger cell dimensions than in Nordstedt (l.c.). Whether this is ground for distinguishing a separate infraspecific taxon, like forma *lata* Schmidle (1898), however, is questionable.

In the Okavango Delta, *Eu. sphyroides* was only incidentally encountered (sample no. 2).

Euastrum spinulosum Delponte

Fig. 26, 27

Mem. Reale Accad. Sci. Torino 28: 97, pl. 6, fig. 17, 18 (1876).

var. ***spinulosum***

var. ***inermius*** (Nordst.) C.Bernard, Protococcacées et Desmidiées: 126 (1908).

Euastrum spinulosum is the most common and widely distributed representative of the *Euastrum mononcyllum*-allied species complex, occurring in (sub)tropical regions on all continents (Krieger 1937). *Eu. spinulosum* is a polymorphic species of which quite a number of infraspecific taxa have been described. No doubt, some of those taxa have to be attributed only little significance (e.g., *Eu. spinulosum* subsp. *africanum* Nordst.) while others rather deserve the status of a separate species [e.g., *Eu. spinulosum* var. *orbiculare* (G.C.Wall.) De Wild.].

In the Okavango Delta, the nominate variety of *Eu. spinulosum* was commonly distributed on the sites of Chief's Island and Moremi. Var. *inermius*, differing from the nominate variety by a broader and more flattened apex, as well as by a more elaborate cell wall sculpturing, was less common (e.g., in sample nr. 1).

Euastrum subhypocondrum F.E.Fritsch et F.Rich

Fig. 25

Trans. Roy. Soc. South Africa 25: 176, fig. 10 (1937).

Euastrum subhypocondrum, belonging to the *Euastrum mononcyllum*-allied group of species (Coesel 2000) is rather close to *Eu. platycerum* Reinsch. *Eu. platycerum* var. *eximium* Grönblad et A.M. Scott even may be considered a bit intermediate between these two species. For that matter, in our opinion, the transfer of var. *eximium* to *Eu. subhypocondrum* by Bourrelly & Couté (in Couté & Rousselin 1975) is less desirable. For, var. *eximium* is marked by lateral lobes that are broadly rounded and slightly inflated at their end whereas *Eu. subhypocondrum* as originally described by Fritsch & Rich (1937) is characterized by attenuating lateral lobes. Actually, typical *Eu. subhypocondrum* is only known from a few African countries, i.e., South Africa (Fritsch & Rich 1937), Mali (Bourrelly 1957) and Zambia (Thomasson 1960).

In the Okavango Delta, *Eu. subhypocondrum* was encountered in sample nrs 1, 2 and 10 from the site of Chief's Island.

***Euastrum sudanense* Coesel et Van Geest sp. nov.**

Fig. 15, 16

Cellulae parum longiores quam latiores sinu profundo majore parte clauso semicellulis a fronte visis trapeziformibus lateribus lateralibus retusis apice truncate indentatione media lata, non profunda, angulis apicalibus anguste rotundatis vel papillatis, angulis basalibus late rotundatis. Semicellulae apicali visa ellipsoideae depressione mediana lata, pariete cellulae laevi. Dimensiones: cellularum longitudo 38-44 μm , latitudo 30-33 μm , crassitudo circa 24 μm , isthmi latitudo 9-12 μm . – *Typus*: figura nostra 15.

Cells slightly longer than broad. Sinus deep, closed for the greater part. Semicells in frontal view trapeziform with retuse lateral sides. Apex truncate with a wide, shallow, median indentation. Apical angles narrowly rounded or papillate. Basal angles broadly rounded. Semicells in apical view ellipsoid with a broad median inflation. Cell wall smooth. Cell length 38-44 μm , cell breadth 30-33 μm , cell thickness circa 24 μm , breadth of isthmus 9-12 μm . – *Type*: our fig. 15 (after Grönblad & al. 1958: fig. 42-44).

Originally, the above-described algal form was labeled *Euastrum gessneri* Willi Krieg. et Bourrr. (Grönblad & al. 1958). It should, however, be clear that *Eu. gessneri* as recorded by Grönblad & al. (l.c.) from Sudan refers to another species than *Eu. gessneri* as originally described by Krieger & Bourrelly (1956) from the Venezuelan Andes. Semicells of *Eu. gessneri* are characterized by a big, globose, central tumour that is lacking in *Eu. sudanense*. In addition to that, cell wall in *Eu. gessneri* is distinctly scrobiculate versus perfectly smooth in *Eu. sudanense*. Finally, apical angles in *Eu. gessneri* cells are broadly rounded as against acute in *Eu. sudanense*.

As far as could be traced, up to then our newly described *Eu. sudanense* was only known from Sudan. In the Okavango Delta only a few cells were encountered in sample nr. 16. In some of those cells a couple of minute papillae were observed, positioned at the base of the semicells, about half-way the sinus incision.

***Euastrum sympageum* W. et G.S.West**

var. ***elaboratum*** (Grönblad et A.M.Scott) Coesel
Nord. J. Bot. 22: 250.

Fig. 20, 21

As argued earlier (Coesel 2002), *Euastrum subcrassum* described by Fritsch & Rich (1937) from Transvaal should be considered identical to *Euastrum sympageum* described by West & West (1895) from Madagascar. Both taxa are only known from Africa. *Eu. sympageum* var. *elaboratum*, differing from the nominate variety by a more elaborate cell wall sculpturing has been recorded (as *Eu. subcrassum* var. *elaboratum*) from Sudan (Grönblad & al. 1958), Kenya (Lind 1967), Mozambique (Rino 1971) and Madagascar (Bourrelly & Couté 1991).

In the Okavango Delta it was widely distributed and locally rather common on the sites of Chief's Island and Moremi. Zygosporangia (which up to then have not been described) were encountered in sample no. 2.

***Euastrum truncatiforme* G.S.West**

J. Linn. Soc. Bot. 38: 113, pl. 7, fig. 3 (1907).

Fig. 17

Euastrum truncatiforme is a characteristically shaped desmid taxon that cannot be readily confused with any other *Euastrum* species. It has only been recorded from tropical African countries, i.e.,

Tanzania (West 1907, Lenzenweger 1980), Sudan (Grönblad & al. 1958), Uganda (Grönblad & al. 1964), Chad (Compère 1967), Namibia (Grönblad & Croasdale 1971) and Sierra Leone (Gerrath & Denny 1988).

In our area of investigation *Euastrum truncatiforme* was encountered in some samples from the sites of Chief's Island (1, 2, 12), Moremi (16), Mohango (21) and Caprivi (22, 25).

Micrasterias ambadiensis

Fig. 37, 38

(Grönblad et A.M.Scott) Thomasson ex Kurt Först., *Algol. Studies* 28: 245 (1981).

Micrasterias ambadiensis was originally described as *Micrasterias radians* var. *ambadiensis* (Grönblad & al. 1958), raised to species level by Thomasson (1960) and nomenclaturally validated by Förster (1981). It is only known from a series of African countries (Förster 1982).

In our collections it was only encountered on the sites of Moremi (sample nrs 16, 18) and Caprivi (sample nr. 25).

Micrasterias tropica Nordst.

Fig. 40, 41

var. *elegans* W. et G.S.West, *J. Bot.* 35: 86, pl. 366, fig. 2 (1897).

var. *elongata* Schmidle, *Bot. Jahrb. Syst.* 26: 48, pl. 3, fig. 13 (1898).

Whereas the nominate variety of *Micrasterias tropica* is known from all continents (Krieger 1937), var. *elegans* and var. *elongata* have a more limited distribution. Var. *elegans*, originally described by West & West (1897) from Angola has mainly been recorded from African countries (e.g., Thomasson 1960, Grönblad & al. 1964, Lind 1971, Compère 1977) but also from India (Agarkar & al. 1983). Var. *elongata*, described by Schmidle (1898) from Tanzania, is exclusively known from the African continent (e.g., Grönblad & al. 1958, Thomasson 1960, Lind 1971, Gerrath & Denny 1988).

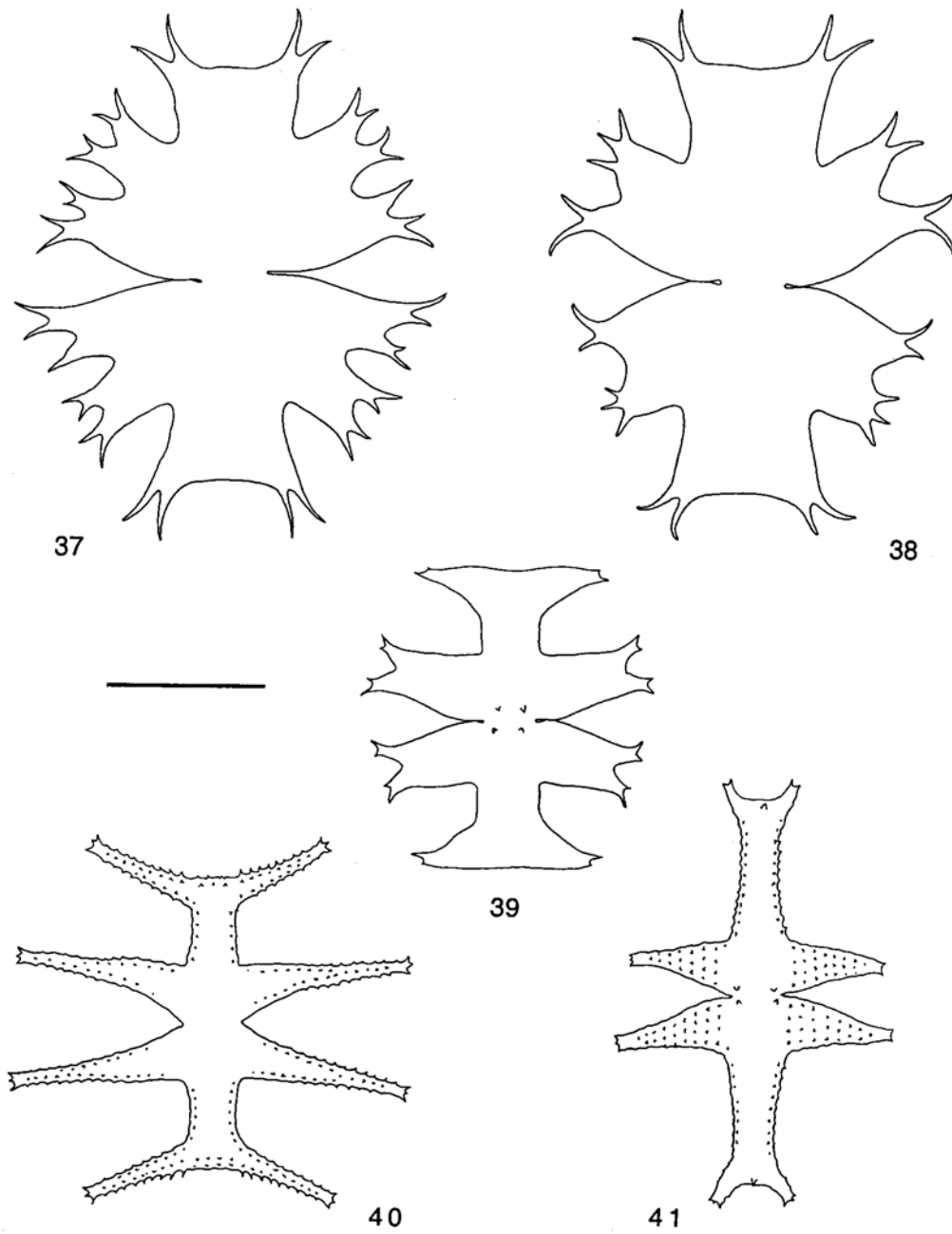
In the Okavango Delta, *M. tropica* var. *elegans* appeared to be commonly distributed on the sites of Chief's Island and Moremi, var. *elongata* was much rarer (e.g., sample nr. 3). No other varieties (including the nominate variety) of *M. tropica* were encountered.

Micrasterias schmidleana Coesel et Van Geest **nom. et stat. nov.**

Fig. 39

Synonym: *Micrasterias pinnatifida* Ralfs var. *divisa* W.West forma *major* Schmidle, *Bot. Jahrb. Syst.* 32: 73, pl. 2, fig. 7 (1902).

When Krieger (1937: 21) distinguished *Micrasterias divisa* (W.West) Willi Krieg., he created a nomenclatural chaos. For, as type of that species not *Micrasterias pinnatifida* var. *divisa* W.West was indicated, but *Micrasterias pinnatifida* var. *divisa* W.West forma *major* Schmidle. To add to this confusion he renamed *M. pinnatifida* var. *divisa* W.West to *M. pinnatifida* var. *furcata* Willi Krieg. Apart from this confusing nomenclature, however, he was right in considering West's taxon and Schmidle's taxon to belong to different species. *M. pinnatifida* var. *divisa* W.West, originally described from the USA (West 1891) differs from the nominate variety of *M. pinnatifida* by furcate (in stead of simple) lateral lobes. In view of the fact that not seldom janus forms may be encountered that combine a semicell with simple and a semicell with furcate lobes (e.g., Krieger 1937: pl. 99-12), only little taxonomic significance should be attributed to this morphological difference. *M.*



Figures 37-41. 37, 38: Micrasterias ambadiensis; 39: M. schmidleana;
40: M. tropica var. elegans; 41: M. tropica var. elongata.

Scale bar = 50 μ m.

pinnatifida var. *divisa* forma *major* Schmidle described from Tanzania (Schmidle 1902), on the contrary, is not only characterized by furcate lateral lobes but also by an upward curve of those lobes, larger cell dimensions and a couple of supraisthmial tubercles at the base of the semicell. Such a cell wall sculpturing is unknown in any other infraspecific taxon of *M. pinnatifida* and may justify its raising in rank to species level (see also Ruzicka 1981: 572).

M. schmidleana seems to be endemic to Africa. Although it is only known with certainty from Tanzania (Schmidle 1902) and Botswana/Namibia (our present paper), most likely it has been found also in a number of other African countries. *M. pinnatifida* var. *polymorpha* described from Madagascar (Bourrelly & Manguin 1949) and afterwards also recorded from Sudan (Grönblad & al. 1958), Uganda (Lind 1971), Sierra Leone (Gerrath & Denny 1989) and Nigeria (Opute 1992), as well as *M. pinnatifida* var. *transvaalensis* described from South Africa (Claassen 1961) much resemble *M. schmidleana*, except for the absence of the supraisthmial tubercles. Actually, our Okavango material showed supraisthmial acute granules rather than tubercles. As it is imaginable that those granules or tubercles, particularly in chloroplast-filled cells, are overlooked, at least part of the above-mentioned records might refer to *M. schmidleana*.

In the Okavango Delta *Micrasterias schmidleana* was only found in low cell numbers on the Moremi site (sample nrs 15, 16, 18).

Discussion

Of the four sites sampled, Mohango and Caprivi were much poorer in desmid species than Chief's Island and Moremi. It is not clear whether this has to do with a more laborious accessibility of the Mohango and Caprivi sites resulting in a smaller number of samples, or with less optimal environmental conditions for desmids on those sites. Anyhow, the sites of Chief's Island and Moremi, with species numbers of around 100 per sample, appeared to be true desmid treasuries. In view of the habitat conditions found in that part of the Delta this finding is not at all surprising. According to Cronberg & al. (1996) pH values in the central part of the Delta are circumneutral and conductivity values range from 40 to 220 $\mu\text{S cm}^{-1}$, whereas on account of low chlorophyll contents the swamps may be characterized as oligo-mesotrophic. Together with the abundant occurrence of submerged aquatic weeds offering a suitable substrate for benthic and tychoplanktic organisms those conditions create a most favourable habitat for desmids.

As could be expected, the desmid flora of the Botswana Okavango Delta appears to have much in common with that in other tropical African countries. Of the 27 taxa separately discussed, no fewer than 21 have only been recorded from the African continent. The present paper exclusively deals with some of the smaller desmid genera with emphasis on *Euastrum* and within that genus with a special focus on the *Euastrum mononcyllum*-allied species group. As stressed before (Coesel 2000), the highest diversity of this group is encountered in tropical Africa. In our collections some 8 different species could be distinguished (for that matter, one of the most common representatives of this species group, i.e., *Eu. platycerum* Reinsch, was wanting).

Despite the high desmid species richness encountered in the Delta and the high percentage of African endemics making part of it, some of the most conspicuous taxa described from tropical Africa were wanting. Species such as *Micrasterias sudanensis* Grönblad et Prowse et A.M.Scott, *Allorgeia valiae* Gauth.-Lièvre and *Allorgeia incredibilis* (Grönblad et Prowse et A.M.Scott) Thomasson, known from (sub)equatorial Africa (Grönblad & al. 1958, Gauthier-Lièvre 1958, Thomasson 1960) were not recorded. Cronberg & al. (1995: 164) do mention the occurrence of *Micrasterias sudanensis* and *Allorgeia incredibilis* in the Okavango Delta but, unfortunately, there

is no support of that finding by any drawings or photographs. Maybe, for the species in question the Okavango Delta is about at the border of their tropical African distribution area and consequently climatologically less optimal.

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