South African Journal of Botany 167 (2024) 145–149

Contents lists available at ScienceDirect

South African Journal of Botany

journal homepage: www.elsevier.com/locate/sajb

Reviewing taxonomy, expanding geography, and supplying supporting evidence for the morphology of *Euastrum compereanum* from Mozambique and Namibia

Sanet Janse van Vuuren*, Anatoliy Levanets

Unit for Environmental Sciences and Management, North-West University, Potchefstroom, South Africa

ARTICLE INFO

Article History:
Received 13 October 2023
Revised 12 February 2024
Accepted 15 February 2024
Available online 17 February 2024

Edited by: Dr K. Glennon

Keywords:
Bio-indicators
Desmids
Euastrum subhypochondrum var. *croasdaleae*
Geographical distribution
Tropical and subtropical species

ABSTRACT

In this study, the authors report the discovery of a rare desmid species (*Euastrum compereanum*) in Mozambique and Namibia. The species was previously documented from only three African countries, namely Chad, Zambia, and Botswana. In a prior publication about desmids from Namibia a line drawing of this species was included, but the species was identified as *E. platycerum* var. *eximium* forma. This paper aims to address this taxonomic discrepancy, rectify the identification, and provide a definitive name assignment. Furthermore, our research expands the known distribution of *E. compereanum* by introducing a novel geographical record in Mozambique. Aside from the taxonomic correction and geographical distribution expansion, the paper offers the very first photographic documentation of its cellular morphology. Previous publications on this species solely relied on line drawings, making this publication a significant advancement in the understanding of its cell structure.

1. Introduction

Desmids belong to a taxonomically intriguing group of green algae classified in the Phylum Charophyta (Guiry and Guiry, 2024). They are bilateral symmetrical single cells and their relatively large cell sizes, together with remarkable symmetry, highly ornamented cell walls, and distinctive shapes, are distinguishing characteristics used in identification. Their complex morphological features make desmids a sought after subject to study by both taxonomists and phylogeneticists. While their taxonomy and phylogeny have been subjects of extensive study, desmids continuously offer new insights into algal evolution, ecology, and the biogeography of aquatic ecosystems.

Desmids are predominantly freshwater inhabitants, and their presence is particularly pronounced in pristine aquatic ecosystems, although some species can occupy nutrient-rich, eutrophic waters (Brook, 1981). Desmids are renowned for their utility as bioindicators of water quality, serving as sensitive indicators of environmental pollution (Coesel, 2003; Neustupa et al., 2023). They can respond rapidly to changing ecological conditions, which emphasise their significance, not only in algal ecology but also in the biomonitoring of freshwater environments. In this context, continued research on desmids not only enhances our understanding of algal diversity, but also contributes to our ability to assess and conserve aquatic ecosystems (Coesel, 2003).

The Desmidiales shows exceptional diversity, and currently there are more than 3 000 taxonomically accepted species in this Order (Guiry and Guiry, 2024). Prominent genera, consisting of more than 100 species include *Cosmarium* (1 139 species), *Staurastrum* (716), *Euastrum* (332), *Closterium* (212), *Xanthidium* (126) and *Micrasterias* (102) (Guiry and Guiry, 2024). *Euastrum*, the third most diverse desmid genus, is widely distributed, especially throughout the tropical and subtropical regions of the world (Coesel, 1996; Moresco et al., 2009). Previous studies showed that *Euastrum* prefers oligo- to mesotrophic, slightly acidic waters with low conductivity levels (Coesel and Meesters, 2007; Stastny, 2010). The genus is known to be polymorphic, but usually has apical (polar) lobes with a median incision, which can be U or V-shaped (Aquino et al., 2017; Kanetsuna and Yamagishi, 2018).

One of the few exceptions to the former morphological trait can be seen in an extremely rare species, *Euastrum compereanum* Coesel & Van Geest. Thomasson (1960) found this species in Zambia, but failed to identify it to species level, and indicated it as *Euastrum* sp. in line drawings (reproduced in Fig. 2C). According to the line diagram published in Grönblad and Croasdale (1971), they also found the same species in samples from Namibia but identified the cell as *E. platycerum* var. *eximium* forma (reproduced in Fig. 2D). The species was eventually taxonomically described by Compère (1976) as a new variety of *E. subhypochondrum*, namely *E. subhypochondrum* var.

* Corresponding author.
E-mail address: sanet.jansevanvuuren@nwu.ac.za (S. Janse van Vuuren).

https://doi.org/10.1016/j.sajb.2024.02.027
0254-6299/

croasdaleae, after being found in samples from Lake Chad. The only other country in which this species was recorded from was Botswana (Okavango Delta; Coesel and Van Geest, 2008). However, the morphology of *E. subhypochondrum* var. *croasdaleae* (Fig. 2E) differed to such an extent from that of the nominate variety (*E. subhypochondrum*, Fig. 2B) that Coesel and Van Geest (2008) decided to elevate it to a new species, *E. compereanum*. The species was named after Pierre Compère (1934–2016), a Belgian phycologist, as a tribute to his work on African desmids.

In this paper the authors not only report on a new geographical record for this scarce African desmid species, but our contribution exceeds previous publications by presenting the first photographic documentation of *E. compereanum*. All previous references to this desmid species were confined to line drawings, leaving a gap in our understanding of its intricate morphology. The micrographs presented contribute to existing knowledge of *E. compereanum* and serve as a valuable reference for future taxonomic and ecological investigations.

2. Material and methods

During the current study cells of *E. compereanum* were found in samples from Mozambique and Namibia.

2.1. Mozambican samples

Grab samples were collected during February 2012, approximately 35 km southeast of the Tanzanian border in an inland wetland system near Palma, Mozambique (coordinates: 10°49′51.00″S, 40° 31′50.81″E). Water samples were collected from seven sites with a substrate consisting of soft black peat-like sediment.

2.2. Namibian samples

Vogel Pan (coordinates 19°45′31.92″S, 20°28′58.55″E) is a small waterbody, approximately 2 km long and 1.5 km wide, located in the Otjozondjupa region in Namibia. It forms part of a group of wetlands located in a radius of approximately 20 km within the Naye-Naye concession area located towards the far north-eastern side of Namibia, close to the Botswana border. The area was formerly known as Bushmanland but is currently referred to as the Tsumkwe District. The geology restricts drainage (Simmons et al., 1999), resulting in the formation of several interconnected pans in the area. The area holds important numbers of rare and threatened bird species, several of which are probably on passage between Etosha and Makgadikgadi Pans in Botswana (Simmons et al., 1999). Grab samples of surface water were taken from Vogel Pan during December 2019.

All samples were fixed with 10% ethanol and transported to the phycology laboratory of the North-West University (Potchefstroom, South Africa), where it was screened for algae using a Nikon i80 light microscope equipped with a Nikon DS-Fi1 5MP digital camera and phase contrast objectives (Mozambican samples), as well as a Leica DM 2500 LED light microscope with a Leica Flexacam C3 camera (Namibian samples). During the light microscopic investigations cells of *E. compereanum* were detected and photographed. Cell dimensions were measured by means of a linear stage micrometer. Samples containing *E. compereanum* cells were deposited in the South African National Diatom Collection (SANDC) at the North-West University, Potchefstroom, South Africa (assession numbers: SANDC 12–141 and 19–703).

An investigation of all scientific literature, phycological inventories, technical reports and internet databases was carried out to account for existing geographical records of the species.

3. Results

Unique cells (Fig. 1) with atypical morphology, compared to most species of the genus *Euastrum* that usually has a U or V-shaped indentation at the polar lobe, were found in samples from Mozambique and Namibia. Cells were longer than wide, deeply constricted at the center, with a linear sinus. Semicells were trilobed and the lateral lobes were rounded at the apex. The polar lobe was rectangular, and slightly depressed in the middle. The upper margin of the lateral lobe was concave, while the lower margin was convex. The sinus was

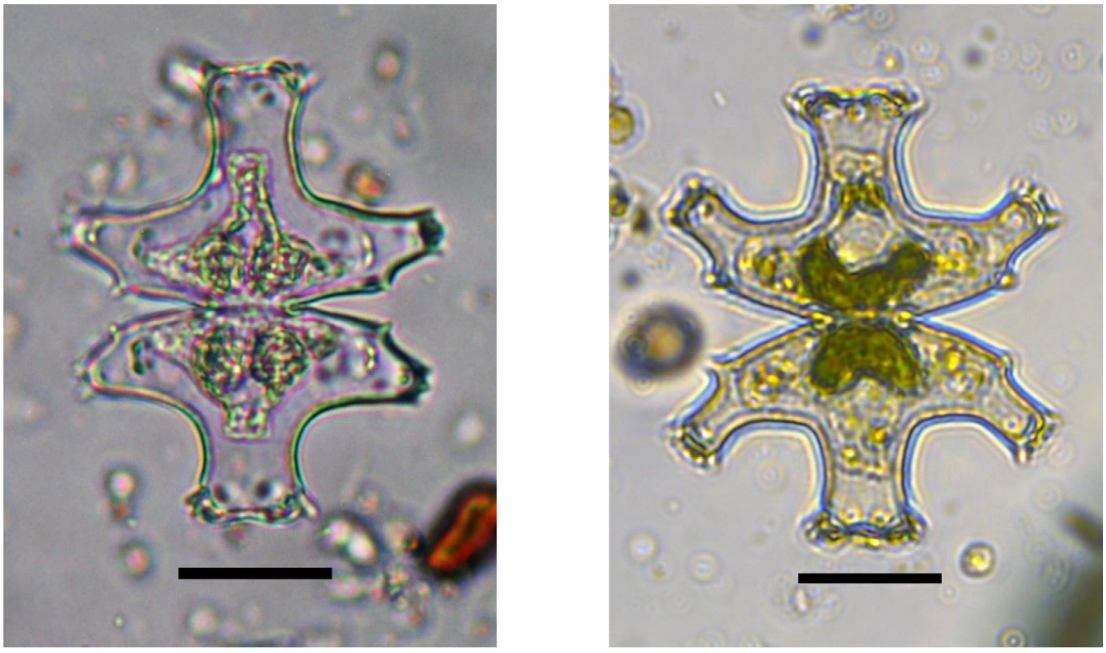

Fig. 1. Light microscope images of *Euastrum compereanum* cells from Mozambique (**A**) and Namibia (**B**). Scale bars = 20 μm.

Table 1
A comparison of cell dimensions found in samples from Mozambique and Namibia with known dimensions from previous publications by Thomasson (1960), Compère (1976, 1977), Grönblad and Croasdale (1971) and Coesel and Van Geest (2008).

Dimensions (μm)	Janse van Vuuren and Levanets (current study)		Thomasson (1960)	Compère (1976, 1977)	Grönblad and Croasdale (1971)	Coesel and Van Geest (2008)
	Mozambique	Namibia	Zambia	Chad	Namibia	Botswana
Cell length	58.6	62.6	58.5	58.0–65.0	64.0	53.0
Cell width	47.6	50.5	52.5	52.0–55.0	55.0	45.0
Istmus	10.2	10.6	8.9	10.3	13.0	7.5

widely open and V-shaped. Ornamentations were less prominent, and the cells had a more slender appearance than the type variety. No median verruca could be observed, but two verrucae, consisting of granules, were observed on each semicell, one on each side of the lateral lobe. A small spine (tooth) was observed on the lower margin of each lateral lobe, located approximately one-third of the distance from the apex. Small spines were also present at the apexes of the polar and lateral lobes.

In Table 1, the dimensions of cells found in the current study are presented, alongside dimensions documented in previous records.

4. Discussion

E. hypochondrum (Fig. 2A) was originally described by Nordstedt (1880) from Venezuela. According to Nordstedt (1880) cells of *E. hypochondrum* are longer than wide, deeply constricted at the center with a linear sinus. The semicells are deeply trilobed, with granules and a large central granulated verruca above the isthmus. The lateral lobes are semi-ovate and rounded at the apex. On the upper side, there is a very small, slightly elongated polar lobe, ornamented with granules arranged in vertical rows. The polar lobe is square, with a slightly depressed middle (seen from the top as rectangular) and granulated. When viewed from the top, it appears oblong with both poles blunt, and there are granulated elevations on either side. When viewed from the side, they appear rectangular with a large, wide basal elevation, and a truncated apex. The width of the polar lobe is about one-third of the transverse cell diameter. Dimensions were given as follows: Length to width ratio >8; thickness 26 μm; isthmus width 14 μm; polar lobe width 20 μm. This species is highly similar to *E. stellatum* Nordst. and *E. substellatum* Nordst., with the main difference being the absence of pyramidal lateral lobes, resulting in a linear median sinus.

Fifty-seven years later, a new species, *E. subhypochondrum* (Fig. 2B), was described from South Africa by Fritsch and Rich (1937). In *E. subhypochondrum* the upper margin of the lateral lobes almost forms a straight line, while the lower margin is more or less convex

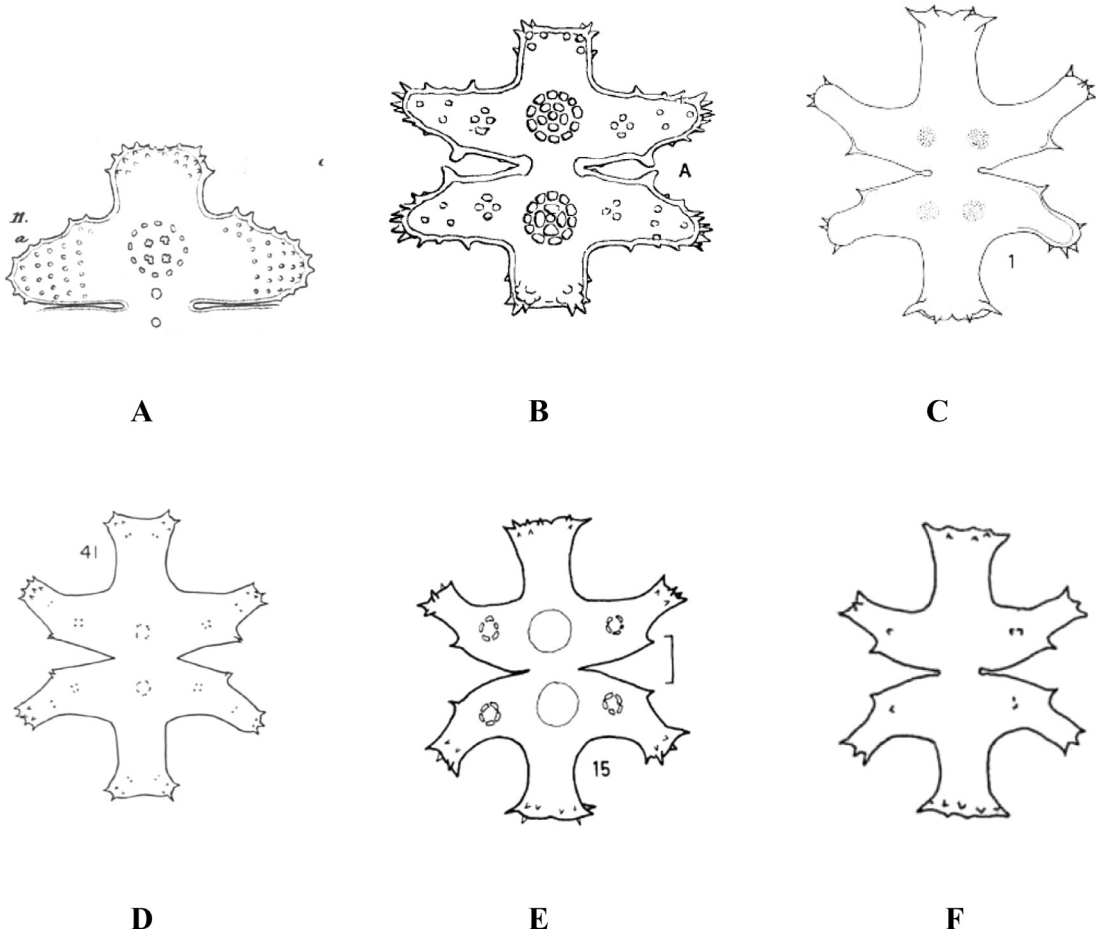

Fig. 2. Comparison of the morphology of *Euastrum compereanum* with closely related species and varieties. **A**: *E. hypochondrum* (from Nordstedt, 1880); **B**: *E. subhypochondrum* (from Fritsch and Rich, 1937); **C**: *Euastrum* sp. (from Thomasson, 1960) **D**: *E. platycerum* var. *eximium* forma (from Grönblad and Croasdale, 1971) **E**: *E. subhypochondrum* var. *croasdaleae* (from Compère, 1976); **F**: *E. compereanum* (from Coesel and Van Geest, 2008; reproduced with permission).

(Fig. 2B). The sinus is widely open, although projecting teeth, situated near the middle of the lower margin of each lateral lobe, may almost meet face-to-face. There may also be a second tooth near the isthmus. The median verruca is more strongly developed than that of *E. hypochondrum* (compare Figs 2B and A) and bears a central granule apart from the two peripheral series. The single granule just above the isthmus is lacking, but on either side of the central verruca are faint 3–5-granulate verrucae; the remaining granules show no definite arrangement. The spines at the angles of the semicells are better developed than in *E. hypochondrum* (compare Figs 2B and A). Coesel and Van Geest (2008) mentioned that *E. subhypochondrum* is rather close to *E. platycerum* and that *E. platycerum* var. *eximium* may be considered as an intermediate between these two species. Bourrelly and Couté (in Couté and Rousselin, 1975) proposed the transfer of *E. platycerum* var. *eximium* to *E. subhypochondrum*, but Coesel and Van Geest (2008) opposed the transfer, because the lateral lobes of *E. platycerum* var. *eximium* are broadly rounded and slightly inflated at their ends, in contrast to attenuating lateral lobes in *E. subhypochondrum* (Fritsch and Rich, 1937). Besides South Africa, cells of *E. subhypochondrum* was found by Bourrelly (1957) in Mali and by Thomasson (1960) in Zambia. Other species with which *E. subhypochondrum* can be compared include *E. bellum* Nordst., *E. hieronymusii* Schmidle, and *E. stellatum* Nordst.

Compère (1976) described a new variety of *E. subhypochondrum*, namely *E. subhypochondrum* var. *croasdaleae* (Fig. 2E) from Lake Chad. *E. subhypochondrum* var. *croasdaleae* differs from the type variety (Fig. 2B) by its less robust ornamentation and more slender appearance. Compère (1976) mentioned that the ornamentations of the semicells seem to be quite variable as specimens from Lake Chad generally show two small rings of verrucae (one on each side), those from Namibia show three rings of verrucae (one in the center and one on each side), and those from Lake Bangweulu show no ornamentation on the semicells. In the original paper on the desmids of Namibia (Grönblad and Croasdale, 1971), cited by Compère (1976), a line drawing (Fig. 41) was presented, coupled to the name *E. platycerum* var. *eximium* forma. Compère (1976) stated that, due to its open sinus, *E. subhypochondrum* var. *croasdaleae* certainly belongs to *E. subhypochondrum* and not *E. platycerum*. The authors suspect that Compère (1976) realised the incorrect identity published by Grönblad and Croasdale (1971), and corrected it in the 1976 publication, when stating that *E. subhypochondrum* var. *croasdaleae* was found in Namibia. With this paper the authors propose to rectify the identification by Grönblad and Croasdale (1971) and assign the name *E. subhypochondrum* var. *croasdaleae* (currently *E. compereanum*) to their line drawing (Fig. 41 in Grönblad and Croasdale (1971), Fig. 2D in current paper).

Coesel and Van Geest (2008) published notes about the desmids from the Okavango Delta in Botswana. They re-investigated and compared the morphology of *E. subhypochondrum* var. *croasdaleae* (Fig. 2E) with the nominate variety of *E. subhypochondrum* (Fig. 2B) and concluded that morphological differences between them are sufficient to consider *E. subhypochondrum* var. *croasdaleae* a species of its own. These differences include the semicells of *E. subhypochondrum* var. *croasdaleae* with lateral lobes strongly curving upwards and the lack of a concentric series of granules at the centre of the semicell. As a result, *E. subhypochondrum* var. *croasdaleae* was elevated to a new species, namely *E. compereanum* (the name *E. croasdaleae* was preoccupied), by Coesel and Van Geest (2008). Currently *E. subhypochondrum* var. *croasdaleae* is considered a synonym for *E. compereanum* (Guiry and Guiry, 2024). Compère (1976) stated that the ornamentations of *E. subhypochondrum* var. *croasdaleae* is less robust compared to that of the nominate variety and highly variable, ranging from three rings of verrucae (one in the center and one on each side) to no ornamentation at all, and as a result he presented a single line drawing (Fig. 2E) illustrating these variations. In the drawing presented by Coesel and Van Geest (2008) no centrally located granulated verruca was illustrated, but small granules were illustrated on the lateral lobes (Fig. 2F). The morphology of cells in our samples from Mozambique and Namibia corresponded to the line drawing of *E. compereanum* presented by Coesel and Van Geest (2008).

The morphology of *E. compereanum* cells collected from both Mozambique and Namibia (Fig. 2) aligns remarkably well with descriptions and line drawings provided in existing literature, notably those by Grönblad and Croasdale (1971), Compère (1976), and Coesel and Van Geest (2008). It's worth noting that some earlier publications, such as Thomasson (1960) and Grönblad and Croasdale (1971), assigned different names to line drawings of what is now recognised as the same species. Prior to this study, the available literature had exclusively featured line drawings of *E. compereanum*, making this paper the first to present micrographs of this species. Dimensions of cells from Mozambique and Namibia (Table 1), fall within dimension ranges previously reported. Compère (1976) recorded the largest cells in Chad, while the smallest cells were documented in Botswana by Coesel and Van Geest (2008).

Compilation of available literature containing line drawings and/or descriptions of *E. compereanum* revealed that this species is currently confined to the tropical and sub-tropical regions of Africa. Prior to the current study, it had been documented in four African countries, namely Zambia (as *Euastrum* sp.; Thomasson, 1960), Namibia (as *E. platycerum* var. *eximium* forma; Grönblad and Croasdale, 1971), Chad (as *E. subhypochondrum* var. *croasdaleae*; Compère, 1976), and Botswana (as *E. compereanum*; Coesel and Van Geest, 2008). The current study expands the known geographical distribution of *E. compereanum* to Mozambique and reveals it presence at a second geographical location in Namibia.

5. Conclusion

This study not only expanded the known geographic range of *E. compereanum* to include Mozambique, but it also offered the first-ever micrographs of this rare desmid species. The micrographs contributed to visual insights to an once line-drawing-exclusive morphology, thereby highlighting the importance of detailed morphological documentation to enhance our understanding of rare algal species, such as *E. compereanum*. In this paper the authors reconciled taxonomic discrepancies in earlier records and reaffirmed the dimensions of cells in Mozambique and Namibia corresponded to those in previously published ranges.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

Thank you to Prof. Louis du Preez (North-West University, South Africa) for samples collected in Vogel Pan (Namibia) and Prof. Jonathan Taylor (North-West University, South Africa) for providing samples from northern Mozambique.

References

Aquino, C.A.N., Bueno, N.C., Servat, L.C., Bortolini, J.C., 2017. The genus Euastrum Ehrenberg ex Ralfs (Desmidiaceae) in a subtropical stream adjacent to the Parque Nacional do Iguaçu, Paraná State, Brazil. Hoehnea 44 (1), 1–9. https://doi.org/10.1590/2236-8906-55/2016.

Bourrelly, P., 1957. Algues d'eau douce du Soudan Francais, région du Macina (A.O.F.). Bulletin de l'Institut Français d'Afrique Noire, Série A. Sciences Naturelles 19 (4), 1047–1102.

Brook, A.J., 1981. The biology of desmids. Botanical monographs. Oxford, London, Edinburgh, Boston & Melbourne 16, 1–276.

Coesel, P.F.M., 1996. Biogeography of desmids. Hydrobiologia 336, 41–53. https://doi.org/10.1007/BF00010818.
Coesel, P.F.M., 2003. Desmid flora data as a tool in conservation management of Dutch freshwater wetlands. Biologia 58, 717–722.
Coesel, P.F.M., Van Geest, A., 2008. Taxonomic and biogeographical notes on Okavango desmids (Zygnematophyceae, Streptophyta). Systematics and Geography of Plants 78, 27–46. https://doi.org/10.2307/20649748.
Coesel, P.F.M., Meesters, K.J., 2007. Desmids of the Lowlands Mesotaeniaceae and Desmidaceae of the European Lowlands. Zeist, KNNV Publishing.
Compère, P., 1976. Observations taxonomiques et nomenclaturales sur quelques Desmidites (Chlorophycophyta) de la région du lac Tchad (Afrique centrale). Bulletin Jardin Botanique National Belgique 46, 455–470.
Compère, P., 1977. Algues de la région du lac Tchad. VII. Chlorophycophytes (3e partie: Desmidiées) (I). Cahiers de l'Office de la Recherche Scientifique et Technique Outre-Mer. Série Hydrobiologie 11 (2), 77–177.
Couté, A., Rousselin, G., 1975. Contribution à l'étude des algues d'eau douce du Moyen Niger (Mali). Bulletin du Muséum National d'Histoire Naturelle, 3e Série (Botanique) 21 (277), 73–175.
Fritsch, F.E., Rich, M.F., 1937. Contributions to our knowledge of the freshwater algae of Africa. 13. Algae from the Belfast Pan, Transvaal. Transactions of the Royal Society of South Africa 25 (2), 153–228.
Grönblad, R., Croasdale, H.T., 1971. Desmids from Namibia (SW Africa). Acta Botanica Fennica 93, 1–40.
Guiry, M.D., Guiry, G.M., 2024. AlgaeBase. World-wide Electronic Publication. Galway Available from https://www.algaebase.org. [Accessed 12.02.2024].
Kanetsuna, Y., Yamagishi, T., 2018. Desmids of southeast Asia. Dera Dun, Bishen Singh Mahendra Pal Singh.
Moresco, C., Biolo, S., Bueno, N.C., 2009. O gênero Micrasterias Agardh ex Ralfs (Desmidiaceae, Zygnemaphyceae) em um lago artificial urbano, Paraná, Brasil. Hoehnea 36, 349–358. https://doi.org/10.1590/S2236-89062009000200012.
Neustupa, J., Stastny, J., Woodard, K., 2023. Ecological monitoring of disturbed mountain peatlands: an analysis based on desmids. Biodiversity and Conservation 32, 2671–2691. https://doi.org/10.1007/s10531-023-02624-9.
Nordstedt, C.F.O., 1880. De algis et Characeis 1. De algis nonullis, praecipue Desmidieis, inter Utricularias Musei Lugduno-Batavi. Acta Universitatis lundensis 16, 1–14 (1878–1880).
Simmons, R.E., Barnes, K.N., Jarvis, A.M., Robertson, A., 1999. Important Bird Areas in Namibia. Research Discussion Paper 31, 1–68.
Stastny, J., 2010. Desmids (Conjugatophyceae, Viridiplantae) from the Czech Republic; new and rare taxa, distribution, ecology. Fottea 10 (1), 1–74. https://doi.org/10.5507/fot.2010.001.
Thomasson, K., 1960. Notes on the plankton of Lake Bangweulu Part 2. Nova Acta Regiae Societatis Scientiarum Upsaliensis, Ser. IV 17 (12), 1–43.