Three new *Cosmarium* species from Nature Reserve Zwanenwater (North Holland, the Netherlands)

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Abstract
A study on diversity and distribution of desmids in the dune pools of Nature Reserve Zwanenwater revealed a number of forms of the genus *Cosmarium* that could not be satisfactorily identified with the pertaining literature, or led to taxonomic confusion with similar forms. Three species are described as new to science: *Cosmarium lacuscygnei*, *C. jemtlandicoides* and *C. obscurum*. Differences and similarities with related species are discussed. The ecology of these new species is described on the basis of the nature of the various sites in the area where they were encountered.

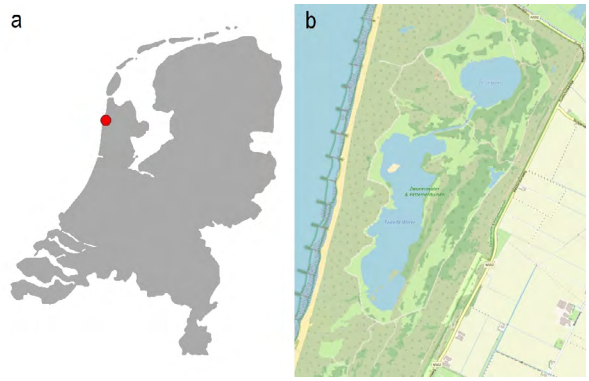

Figure 1. a Location of the Nature Reserve 'Zwanenwater' in the Netherlands. b. Detail of the Nature Reserve. (Source: Open Street Map).

Introduction

Nature Reserve Zwanenwater, located in the lime-poor dune area along the northwest coast of the Netherlands (fig. 1a), mainly consists of two large, shallow dune lakes named 'Eerste Water' and south of this 'Tweede Water'. They were formed in the course of the 18th century after the closure of sea inlets and a rise in groundwater levels (fig. 1b). The lakes are very rich in nutrients due to the many migratory and breeding birds that reside on these lakes. Along the edges of these lakes are a large number of small dune pools situated that are generally much poorer in nutrients and fed by rainwater and groundwater. At higher water levels, some of these dune pools become connected to the large dune lakes resulting in a clear nutrient enrichment. Part of the area is grazed by cattle. All this creates a wide variety of environments that host a great diversity of desmids as the dominant algae group including several rare and remarkable species, partly due to the typical character of this coastal environment.
Since 2021, the first author has been conducting research into the algae flora of Zwanenwater. Three *Cosmarium* species could not be identified with the current literature or led to taxonomic confusion. In this publication they are described as new.

Material and methods

Material used for this study was collected by squeezing moss, aquatic plants (*Chara* sp., *Potamogeton* sp.) and filamentous algae (*Spirogyra* sp., *Mougeotia* sp. *Zygnema* sp.). During each sampling pH and electric conductivity (EC) were measured with a HANNA HI98129 Combo pH & EC meter. Samples were collected in 250 ml plastic vials, that were always completely filled and stored at 4°C. Settled live material was examined microscopically over the course of about a week and a half. The algal flora of each sample was photographed and recorded as representatively as possible. At least 4 preparations per sample were examined. After 4 to 5 preparations usually no new species were found.
A Scanning Electron Microscope (SEM) was used to better visualize morphological details. Formaldehyde fixed samples where dehydrated with acetone and subsequently dried with CO_2 critical-point drying. The samples where platinum sputtered and examined in a Zeiss Sigma 300 VP SEM.

Results

Cosmarium lacuscygnei M. Schreijer & F.A.C. Kouwets 2025 spec. nov. (figs. 2a–c, 3a–h)

Description

Cells of medium size, generally slightly longer than wide, deeply constricted; sinus linear and closed. Semicells transversely elongate, basal angles broadly rounded, sides slightly convex and convergent, apex truncate; cell wall along the lateral and apical margins decorated with small granules in a rather irregular pattern, occasionally forming short series over the sides. Centre with a slight inflation consisting of a flattened wart encircled by smaller granules in an irregular oval ring, near the isthmus flanked on both sides by an extra granule. Between central and marginal decoration with a variable

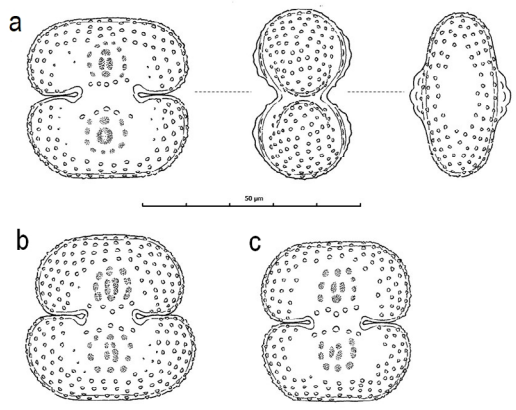

Figure 2. *Cosmarium lacuscygnei* Schreijer & Kouwets 2025.

smooth zone; apical view elliptical with a slight central inflation decorated with warts, lateral view subcircular. Chloroplast with a single pyrenoid. Zygospore unknown. Cell dimensions: L. 35–38 µm, Br. 33.5–38.5 µm, Th. 22–23 µm, I. 12–14 µm; L./Br. 0.99–1.07.

Holotype: Fixed natural sample (squeezed aquatics), leg. M. Schreijer, 29 May 2023 (L!), also represented by our fig. 2a.
Type location: Nature Reserve Zwanenwater, Province of North Holland, the Netherlands; dune pool no. 6a, fig. 4b, between Eerste and Tweede Water (52.821612° N, 4.695915° E).

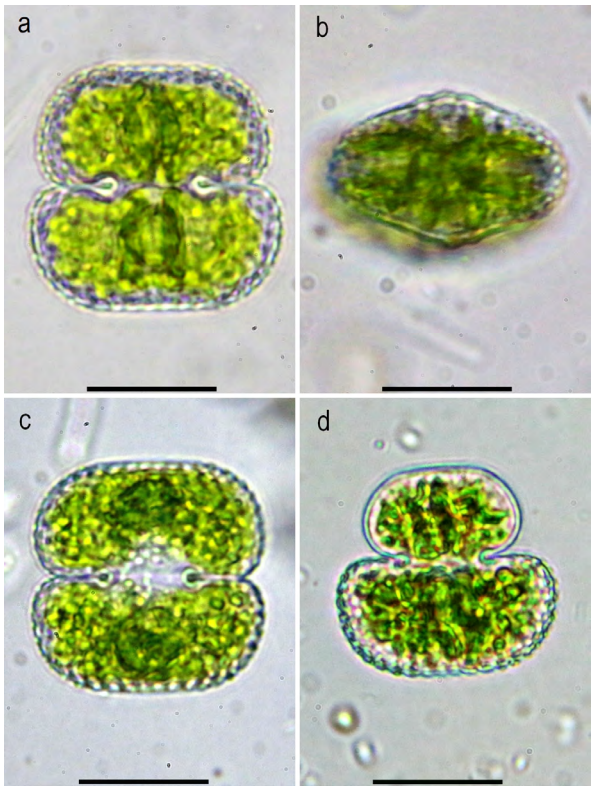

Figure 3a–d. Vegetative cells of *C. lacuscygnei*; a. Compare with fig. 2b; b. Apical view; c. Vegetative cell from location 6a; d. Dichotypic cell, probably prevegetative, location 6a. Scale bar = 20 µm. Photos © Michiel Schreijer.

Taxonomical remarks

At first glance, this species resembles *Cosmarium subpunctulatum* C.F.O. Nordstedt 1887. In the present form the central ornamentation basically consists of small granules or warts encircling an elongate wart that frequently is subdivided, itself forming an irregular oval ring. At the isthmus side the circle of small granules is flanked by an additional granule (figs 3e–h). On the other hand, in *C. subpunctulatum* the central ornamentation consists exclusively of small granules that never fuse together into a larger elongate wart (compare, e.g., Coesel & Meesters, 2023; Van Westen, 2024).
The present form shows also similarities with one of the cells figured by Croasdale (1973) under her newly described *C. punctulatum* f. *arcticum* (Croasdale l.c., p. 99, Pl. 16: 6, not 5, 7–8). That species appeared to be one of the commonest desmids in various pools on

Figure 3e, f. Empty cells; e. From location 6a; f. From location 5b. Scale bar = 20 µm. Photo's © Michiel Schreijer.

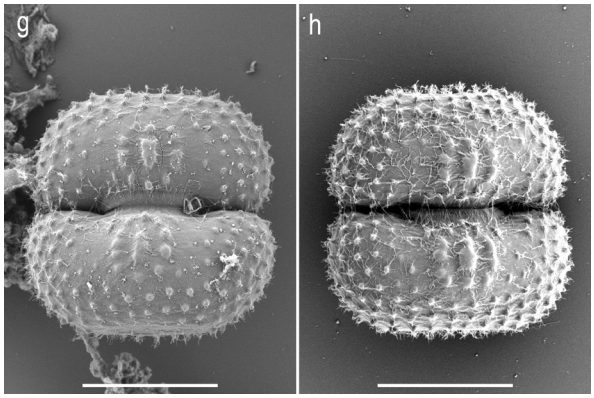

Figure 3g, h. SEM-photographs. Scale bar = 20 µm. Photos © Michiel Schreijer.

Ellesmere Island in the Canadian Arctic archipelago and type material was reported from a permanent pond with pH 7.8–8.4. However, the various forms depicted by Croasdale (l.c.) suggest that several different species were included. A microscope slide with type material appeared to contain but very few cells (by courtesy of Paul Hamilton, Canadian Museum of Nature, Ottawa) and no definitive answer could be found as to which of Croasdale's forms represented the type. We therefore propose to describe the present form as a separate new

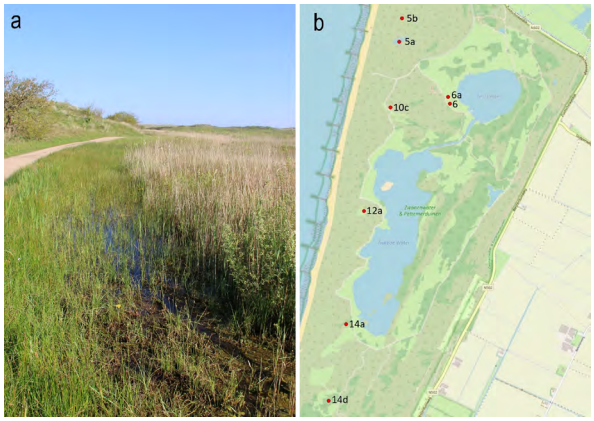

Figure 4. a. Location of the largest population of *Cosmarium lacuscygnei*. (Location 6a). Photo © Michiel Schreijer; b. Sites of *Cosmarium lacuscygnei* in nature reserve 'Zwanenwater', the Netherlands.

species *C. lacuscygnei*; its name is a tribute to the Nature Reserve Zwanenwater where it was encountered.
It should furthermore be carefully compared with *C. pseudoornatum* B. Eichler & R. Gutwiński 1894, and with various other forms associated with the problematic *C. punctulatum* L.A. de Brébisson 1856.

Ecological conditions in Zwanenwater
This species was first found in a wet depression right next to a small dune pool (fig. 4a). The depression is fed by rainwater and groundwater and dries up temporarily in summer. The supply of groundwater is notable for its iron-rich seepage. There is probably also a slight enrichment with lime due to the shell path running next to it. On this location the population of the species was relative large and dichotypic cells resembling provegetative cells could be found regularly, of which one semicell was completely undifferentiated, suggesting sexual reproduction (fig. 3d; see Schreijer, 2024). The species has also been found in some wet dune valleys on the west side of the large dune lakes, that are periodically drying out and where conditions are slightly more calcareous due to fresh dune sand blowing in from the sea (fig. 4b), but never in dune pools that connect at high water levels with the large dune lakes. pH: 6,0–7,2; EC: 294–606 µS/cm.
The species occurred together with a number of other, relatively rare Desmid species, such as *Cosmarium cosmarioides, C. conspersum* var. *latum*, *Closterium lineatum* and *Staurastrum cristatum*. In the wet dune valleys the species was found together with *C. quasillus* and also with *C. tasiussaqense*, a small and remarkable species described from the west coast of Greenland and recently re-discovered in material from a shallow pool on the Outer Hebrides (South Uist) rather similar to some of the Zwanenwater pools (see Johnson, 2024).

Cosmarium jemtlandicoides M. Schreijer & F.A.C. Kouwets 2025 spec. nov. (figs. 5a–c, 6a–g)

Description
Cells of medium size, about as long as wide, deeply constricted; sinus linear and closed, often slightly wider at the extreme end. Semicells trapeziform to depressed subsemicircular, rounded in outline. Basal angels rounded, sides strongly convex and converging. Apex truncate. Cell wall decorated with rather small, somewhat conical granules, which form short and irregular radiating series running along the sides. In frontal view these granules appear as 2–4 intramarginal concentric series. Centre smooth, occasionally with one or two very faint, barely visible flattened warts. Apical view elliptical-rhomboid with broadly rounded poles and a central thickening on either side, lateral view subcircular. Chloroplast axile with a single pyrenoid; occasionally two pyrenoids are present. Zygospore unknown.
Cell dimensions: L. 37–43 µm, Br. 34–42 µm, Th. circa 24 µm, I. 11–12 µm; L./Br. 1.0–1.08.

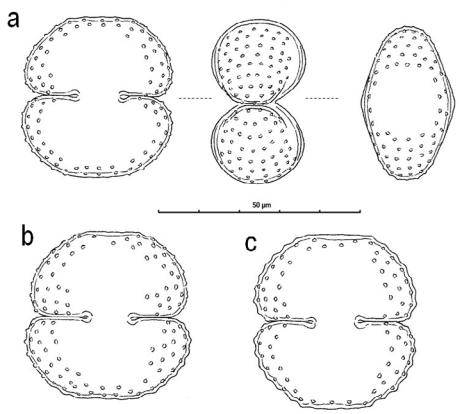

Figure 5a, b en c. *Cosmarium jemtlandicoides* Schreijer & Kouwets 2025.

Holotype: Fixed natural sample (squeezed aquatics), leg. M. Schreijer, 6 March 2023 (L!), also represented by our fig. 5a.
Type location: Nature Reserve Zwanenwater, Province of North Holland, the Netherlands; dune pool no. 11, fig. 7b, west of Tweede Water'(52.817260° N, 4.686537° E).

Taxonomical remarks
Coesel & Meesters (2023) reported this form as an unnamed 'forma' of *C. jemtlandicum* R.L. Grönblad 1963 described from Sweden, but stated that it differed in a slightly lower L./Br. and an aberrant apical view. However, Grönblad (1963, p. 24) didn't present any details about the apical appearance of his new species. In our opinion, the current material, also concerning its ecology, differs sufficiently from *C. jemtlandicum* to justify description as a new species. The semicells basically have one central pyrenoid. Occasionally a cell

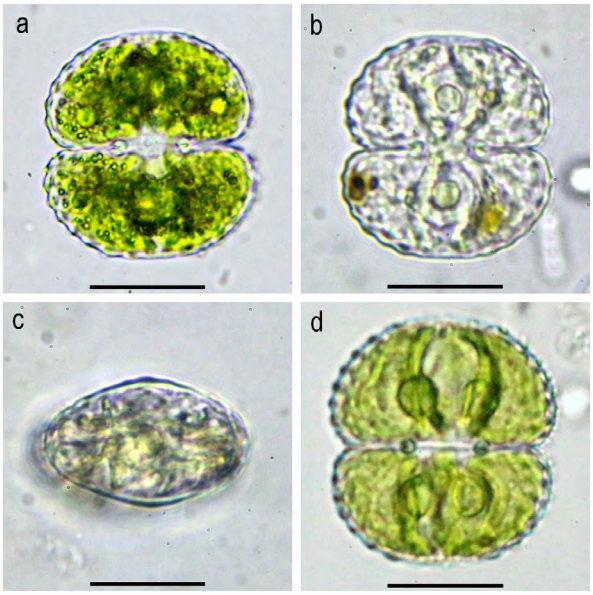

Figure 6a–d. *C. jemtlandicoides,* vegetative cells; a. Cell from location 10c; b. Cell with one pyrenoid from location 11; c. Apical view of the same cell as fig. 6b; d. Cell with two pyrenoïds from location 14a; Scale bar = 20µm. Photos © Michiel Schreijer.

with two pyrenoids was found in the same population (fig. 6d). In addition cells with very large pyrenoids were found that appeared to be split in two to a greater or lesser extent (fig. 6e).
C. jemtlandicoides should be carefully compared with *C. fictopraemorsum* Kurt Förster 1981, which has a slightly higher L./Br., and in particular with the new species *C. obscurum*, described below.

Ecological conditions in Zwanenwater
Cosmarium jemtlandicoides is often found in dune pools with a permanent presence of water, that during wet periods make contact with the very nutrient-rich large dune lakes, which enriches their environment with nutrients (e.g. location 11 and 13, fig. 7b). It is less frequent in dune pools that don't make this contact, but usually these dune pools are also enriched with nutrients. In 2024, *C. jemtlandicoides* occurred in a few dune pools with inundated shores, causing death of vegetation resulting in somewhat greater nutrient richness. *C. jemtlandicoides* was found between water crowfoot (*Ranunculus aquatilis*) and waterweed (*Elodea nutallii*) (fig. 7a–b). pH: 6,0–7,1; EC: 168–634 µS/cm.

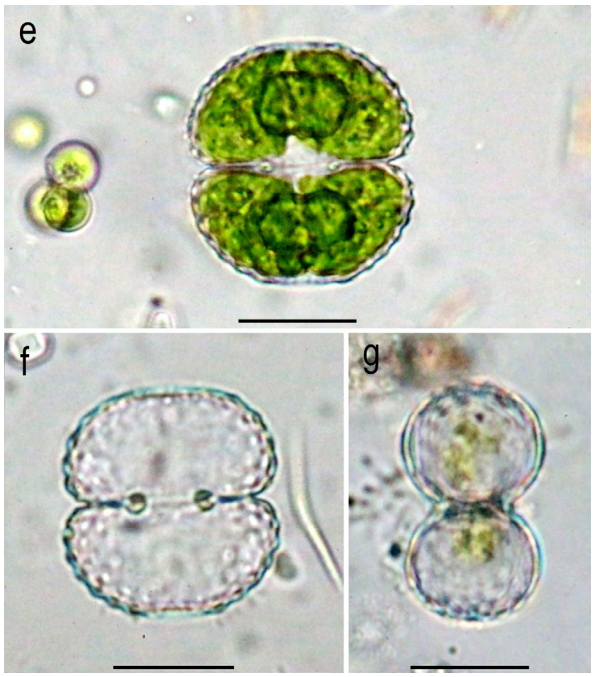

Figure 6e–g. e. Vegetative cell with one large pyrenoïd from location 11; f. Vegetative cell from location 13; g. Side view of cell from location 18; Scale bar = 20µm. Photos © Michiel Schreijer.

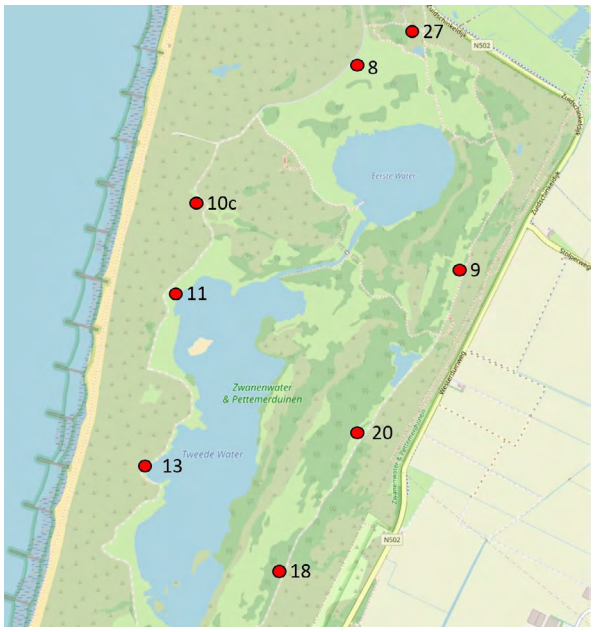

Figure 7b. Sites of *C. jemtlandicoides* in nature reserve 'Zwanenwater', The Netherlands.

Cosmarium obscurum M. Schreijer & F.A.C. Kouwets 2025 spec. nov. (figs. 8a–c, 9a–h)

Description

Figure 7a. Location of the largest population of *C. jemtlandicoides. (Location 11).* Photo © Michiel Schreijer.

Cells medium-sized, about as long as broad, subcircular in outline, deeply constricted; sinus linear and closed. Semicells rounded trapeziform to subsemicircular, basal angles rounded, sides convex and strongly convergent, apical angles obtusely rounded to almost absent, apex truncate; cell wall ornamented with short, irregular intramarginal series of small, somewhat conical granules with a few additional granules near the basal angles, centre slightly swollen and ornamented with a variable number of faint, flattened warts without a distinctive pattern; apical view elliptic with broadly rounded poles and a broad central inflation, lateral view subcircular with a truncate apex. Chloroplast with one or two pyrenoids. Zygospore unknown.
Cell dimensions: L. 45–50 µm, Br. 44–47 µm, Th. 26–28 µm, I. 14–15 µm; L./Br. 1.0–1.07.
Holotype: Fixed natural sample (squeezed aquatics), leg. M. Schreijer, 6 March 2023 (L!), also represented by our fig. 8a.
Type location: Nature Reserve Zwanenwater, Province of North Holland, the Netherlands; dune pool no. 11, fig. 10b, west of Tweede Water (52.81726° N, 4.68653° E).

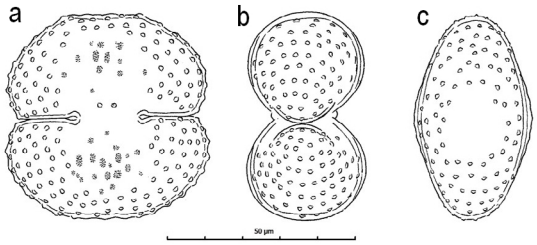

Fig. 8a, b and c. Vegetative cell of *Cosmarium obscurum* Schreijer & Kouwets 2025

Taxonomical remarks

The present form can easily be mistaken for a somewhat depressed form of *C. obtusatum* (W. Schmidle) W. Schmidle 1898a or *C. botrytis* J. Ralfs 1848. However, central ornamentation and apical view are quite different. A more similar species is *C. jemtlandicoides* (Schreijer & Kouwets; this article) which is slightly smaller (Br. mostly less than 42 µm) and generally has a smooth central area with at most one or two faint, flattened warts. Furthermore, both species can occur at the same location. It seems that the semicells of *C. obscurum* in principle have one central pyrenoid, but occasionally cells with two pyrenoids per semicell were found in the same population. Similar to *C. jemtlandicoides*, the single pyrenoid in the relatively large semicells of this species tends to split up. In our opinion the number of pyrenoids generally is a stable taxonomical character in desmids, but apparently the number can vary to some extent in some species (compare, e.g., *C. homalodermum* C.F.O. Nordstedt 1875; see Kouwets, 1997). Because of the rather indistinct central ornamentation consisting of vague flattened warts we propose the name *C. obscurum*.

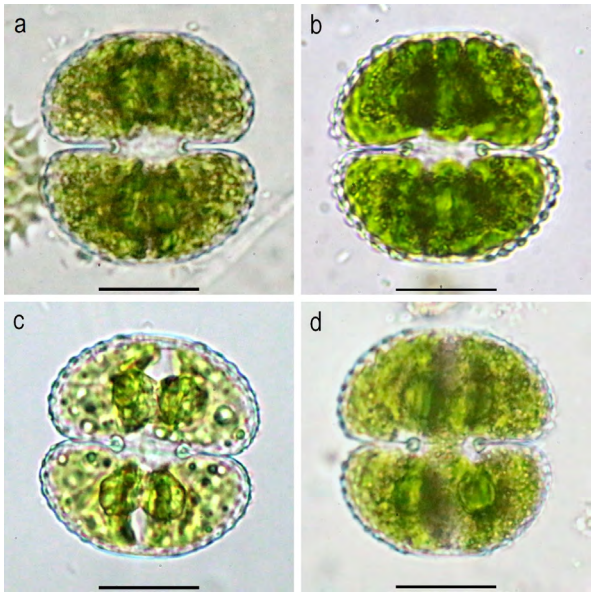

Figure 9a–d. Vegetative cells of *C. obscurum*. a. Cell with one pyrenoid from location 11; b. Cell with one pyrenoid from location 9; c. Cell with a large pyrenoid from location 13; d. Cell with two pyrenoids from location 13. Scale bar 20µm. Photos © Michiel Schreijer.

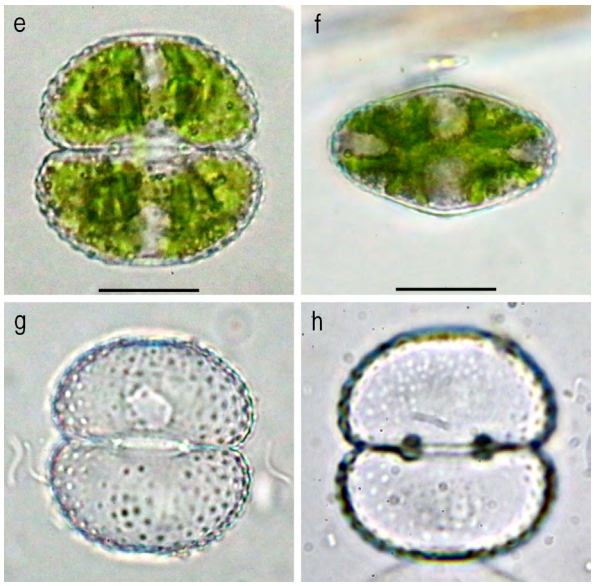

Figure 9e–h. Vegetative cells. e. Cell with two pyrenoids from location 11; f. Apical view; same cell as fig. 9e; g. Empty cell from location 13; h. Empty cell from location 10c. Scale bar 20µm. Photos © Michiel Schreijer.

Ecological conditions in Zwanenwater

In Zwanenwater *Cosmarium obscurum* is mainly found in mesotrophic to very slightly eutrophic dune pools with a moderate nutrient concentration that may be slightly increased temporarily as a result of enrichment from the surrounding environment (pH: 5,9–7,6; EC: 130–705 µS/cm) (fig. 10a–b). This can be a direct result of contact with nutrient-rich water from the large dune lakes, but can also occur indirectly as a result of the presence of raw cow manure along the edges of the pools. This manure is produced by large grazers that are used to prevent the dune area from becoming overgrown. In one case, *C. obscurum* suddenly appeared in a dune

valley flooded by heavy rainfall where cow manure overflowed and slowly decomposed.

Concluding remarks

Research on desmids is traditionally carried out in weakly acidic, nutrient-poor to moderately nutrient-rich inland waters such as moorland pools, and smaller and larger hollows and pools in fen and bog areas (as long as they are not too acidic and oligotrophic). More recently, various ephemeral pools and puddles have also become known as sites of poorly known species (e.g., van Geest & Coesel, 2019; see also Van Westen, 2024). Dune lakes also form an unusual and long-ignored environment, but interesting desmid species can be found here too (Van Geest, 2021; see also Van Tooren et al., 2018, 2020), and Zwanenwater is no exception in this respect.

Acknowledgements

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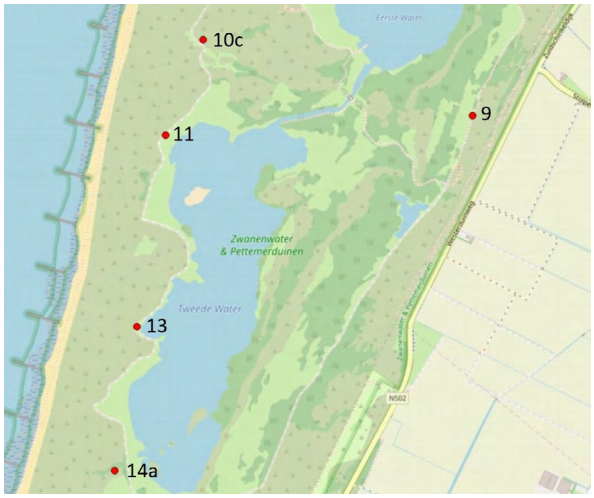

Figure 10 b. Sites of *C. obscurum* in nature reserve 'Zwanenwater', The Netherlands.

Figure 10a. Location of the largest population of *C. obscurum (Location 13).* Photo © Michiel Schreijer.