

Desmids of Bonaire and Curaçao

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Abstract

To our knowledge, no targeted research has ever been conducted into the occurrence of desmids on the Caribbean islands. In the beginning of 2023, the first author examined as many waters as possible on Bonaire and Curaçao for the presence of desmids. The research was promoted by an extremely wet rainy period, which resulted in much more freshwater basins on the islands than in previous years. In total, approximately 35-40 taxa were found, including many small forms of the genus *Cosmarium*. Some of these forms could not be identified with the pertaining literature and may have to be described as new species. In practice, most species were found in normally completely dried-out reservoirs behind dams that now contain water precisely because of this abundant rainfall.

Samenvatting

Er is voor zover ons bekend nog nooit gericht onderzoek gedaan naar de aanwezigheid van sialgen op de Caribische eilanden. De eerste auteur heeft begin 2023 zo veel mogelijk wateren geïnventariseerd op het voorkomen van sialgen op Bonaire en Curaçao. Het onderzoek werd bevorderd door een extreem natte regenperiode waardoor veel meer zoet water aanwezig was op de eilanden dan in eerdere jaren. In totaal werden circa 35-40 taxa aangetroffen, waaronder veel kleine soorten van het genus *Cosmarium*. Aan een deel van deze soorten kon vooralsnog geen naam worden gegeven en zij zullen mogelijk als nieuw moeten worden beschreven. In de praktijk werden de meeste soorten aangetroffen in normaliter geheel uitgedroogde wateren achter dammen die juist door deze overvloedige regenval nu water bevatten.

Keywords: Bonaire, Carribean, Curaçao, desmids, Desmidiaceae, distribution

Introduction



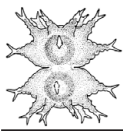
Photo 1. Dam Grandi (Bonaire). Several species were found only in this large temporarily pond.

Photo © Bart van Tooren.

Curaçao and Bonaire are arid islands in the tropical Caribbean with an annual rainfall of 400-600 mm. Precipitation mainly falls in the rainy season (October - December); in the dry season precipitation may stay away for a long time. Therefore, permanent freshwater basins are scarce on the islands. This may be the reason why no specific research has ever been conducted into the occurrence of desmids on Curaçao and Bonaire. Even more, to our knowledge so far on none of the Caribbean Islands research has been done into their desmid flora. During an inventory by the first author in January/February 2023 an attempt was made to investigate the present occurrence of desmids on both islands.

As freshwater is a necessity for life, during a long time efforts have been made to promote the presence of permanent freshwater basins on the islands. Broadly speaking, several types of freshwater sites can be distinguished:

1. *Freshwater springs*. There are some natural freshwater springs on both islands. On Bonaire, Pos Bronswinkel in National Park Slagbaai is a well-known spring, on Curaçao this applies to the freshwater spring Roi Rincon near the airport. In the past, these springs were mainly located in open areas, but nowadays most of the springs are surrounded by increasingly dense forests. As a result, their character has changed considerably.
2. *Man made wells*. Dozens of wells have been dug out on both islands. In the past, they were essential for obtaining freshwater, but due to the preparation of drinking water from seawater, many wells fell into disuse and do not contain water any longer. Moreover, they are frequently located in private gardens and in that case they are more or less inaccessible.
3. *Freshwater reservoirs behind dams*. Especially at the beginning of the 20th century many dams were constructed, creating freshwater ponds or lakes. They can be very large, such as Muizenberg on Curaçao. Dam Grandi (photo 1) is a well-known freshwater lake on Bonaire. In recent decades, many of these dams were no longer maintained, causing the water bodies behind them to dry up more or less permanently. Only a few of these lakes still contain fresh water more or less permanently, but only in the wettest years, although nowadays dams are more and more actively maintained.
4. *Temporary puddles and pools*. During periods of heavy precipitation, temporary pools can form, e.g. on the limestone plateaus but also elsewhere.



Finally, it should not be left unmentioned that in a karst landscape like on these islands there is much more freshwater underground, accessible via caves. These locations were not included in the study as they are dark and therefore do not contain aquatic plants. In practice, most samples were collected in the temporary waters behind dams.

Methods

In total 34 samples were collected on the islands, 26 on Bonaire (including Klein Bonaire) and 8 on Curaçao. On Bonaire 15 locations were sampled, 6 on Curaçao. An attempt was made to sample most locations where desmids could be expected, but samples were also collected at locations where nothing was expected in advance. Collection was done with a plankton net (mesh size 30 µm). It was possible to squeeze out stoneworts (Characeae) at some locations, but at most locations there were few or no aquatic plants present and plankton samples had to be used for examination only, sometimes supplemented with some squeezed out detritus. There was no possibility to view the samples directly after collection and therefore all samples were preserved almost immediately in formalin. A SEM preparation was made of several samples in order to facilitate the identification of some desmids or to serve in the description of new species.

Identification was initially done with Prescott's standard work for American desmids (Prescott et al., 1972-1981), supported by Dillard (1991, 1993), but also Coesel & Meesters (2023) was regularly used.

The nomenclature of the species follows Coesel & Meesters (2023). For the taxa not present in this work, Prescott et al. (1972-1981) is followed. All samples are in the collection of the first author and will later be offered to Naturalis Biodiversity Center (L).

Results

The rainy season of 2022-2023 was very wet, implicating there was much more fresh water present during the research conducted in January/February 2023 than in other years. There were even large water bodies of which the local people said there had not been water for many years. Almost all these waters had a completely bare bottom, without aquatic plants. Only at a few locations was the water column partly filled with Characeae, *Chara zeylanica* var. *elegans* and *C. leptosperma* (Van Tooren & Bruinsma, 2024).

Figures 1 and 2 show the locations where desmids have been recorded. On Bonaire, desmids were found in 8 of the 15 locations sampled. On Curaçao, desmids were found in all 6 locations that were sampled. The average number of desmids on each location on Curaçao was much lower than on Bonaire.

Approximately 35-40 taxa desmids were ultimately found. Almost all species were found on Bonaire, while on Curaçao only 17 species were found. *Closterium submoniliferum* was the only taxon that was found on Curaçao only. Most of these 35-40 taxa belong to the genera *Closterium* and *Cosmarium*. Species of other genera were rare. Of several species of *Closterium* and the ornamented *Cosmariums* only one or a few cells were found, but larger numbers of the small smooth-walled *Cosmariums* were sometimes present, although never abundant.

Desmids were found almost only in reservoirs behind dams, the only exception was a ditch in Kralendijk with many water plants. The freshwater springs are shaded nowadays and contain no desmids. The same was true for temporarily pools but we investigated only a few examples. There was actually no distinction in species numbers between the ponds with or without stoneworts. The site with the highest number of species, Kaminda Lagun, did not differ in any respect from the other



Photo 2. Kaminda Lagun (Bonaire), de location where the highest number of species of desmids has been found.

Photo © Bart van Tooren.

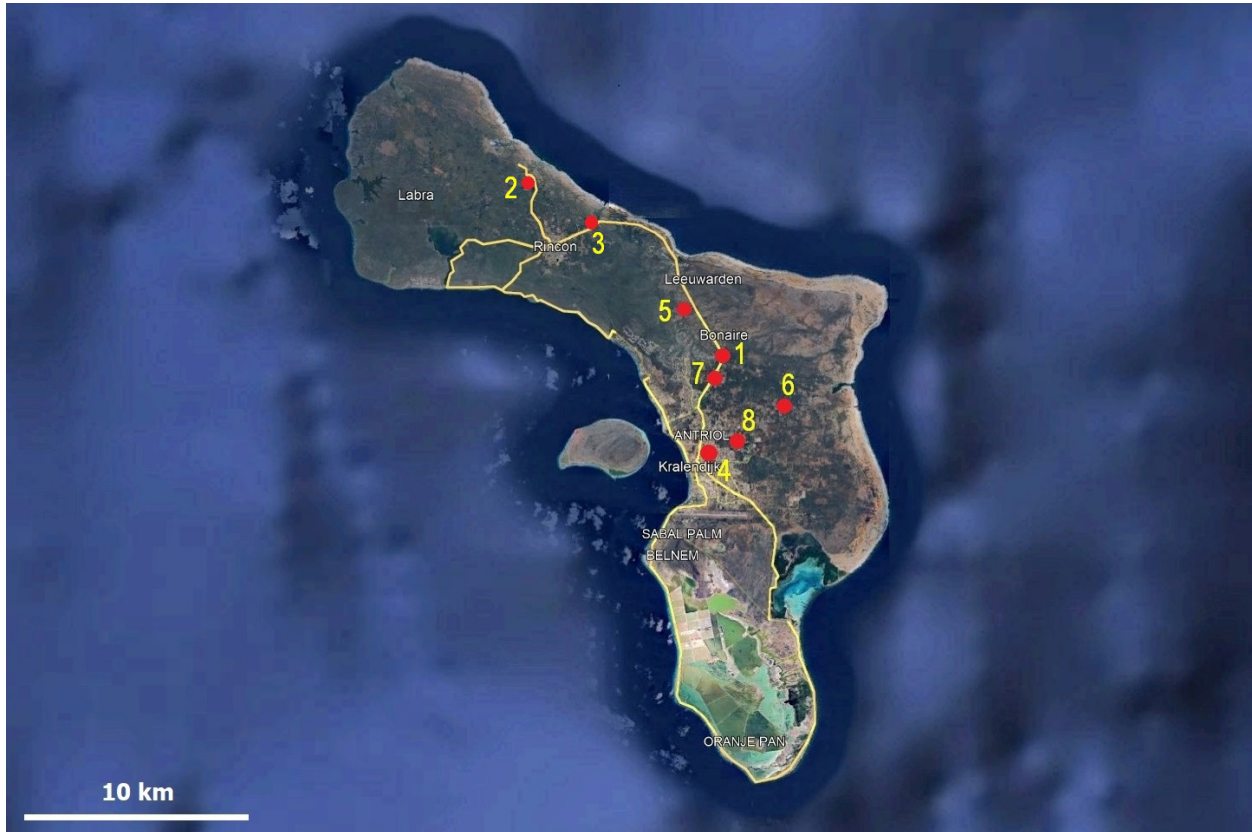
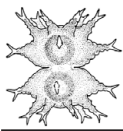


Figure 1. Locations with desmids on Bonaire.; 1 = Pos Gurubu (two ponds); 2 = Dam Grandi; 3 = pond north east of Rincon; 4 = two ponds near Kaya Gavilan, Kralendijk; 5 = small pond in Terra Barra; 6 = pond near Kaminda Lagun; 7 = ditch along Kaya Hulanda in Kralendijk; 8 = northern pond in water purification area near Kay Papa Cornes. Source © Google Earth.



Figure 2. Locations with desmids on Curaçao. 9 = pond opposite supermarket along the start of the road to Bullenbaai in Willemstad; 10= several locations in Malpuis estate, north and south of main road; 10 = small pond east of Soto; 11 = pond east of Soto; 12 pond north of Soto; 13 = Muizenberg. Source © Google Earth.



sites sampled. It was a bare pool of water through which even a now flooded path for cars ran (photo 2). Two samples were collected on the island of Klein Bonaire. No desmids were found here.

Almost all species that were reliably identified are also known from Europe, and are common there in mostly fairly trivial nutrient-rich environments. Only a few species are not known from Europe.

Annotated list of species

Identification proved to be problematic for most of the small smooth-walled *Cosmarium*s. These resemble trivial European species in many respects, but we cannot rule out that some of the forms will have to be described as new species. This also applies to the ornamented *Cosmarium*s, whose morphology does generally not show a 100% similarity with known taxa. Unfortunately, the ornamentation of the cells of these *Cosmarium* species could not always be studied in detail, especially due to the fact that frequently only one or a few cells were observed.

In the list of species we only present the species for which we are quite certain about the identification, as well as a number of species whose identity is still unclear but which have been found in somewhat larger numbers. One or more images of all these species are also included. The other species, of which often only one or a few cells have been found and whose correct name is still unclear, are mentioned for the sake of completeness, but no image of them is included in this contribution. Further research in the coming years may provide more clarity about their identity.

After each species name is indicated where the species is depicted.

***Closterium* cf. *acerosum* (1a, 1l).** A rather common species on both islands. The cells are sometimes rather long (up to 930 µm), although within the length given for *Cl. acerosum* var. *elongatum*. The cell wall is faintly striated and occasionally pseudo-girdlebands are visible. However, in contrast with typical *Cl. acerosum* the pyrenoids appear to be scattered throughout the chloroplast; compare the poorly known *Cl. pritchardianum* var. *africanum*. With some doubt we prefer the name *Cl. acerosum*.

***Closterium moniliferum* (1b).** A rather common, characteristic species on both islands.

***Closterium pseudolunula* (1c).** A rather common species on Bonaire, also found in one location on Curaçao.

***Closterium* spec. 1 (1f, 1g).** A rather common form in one location on Bonaire (a water purification plant). The recurved top is very characteristic. The general cell shape corresponds rather well with *Cl. leibleinii* var. *recurvatum* as figured in Prescott (1975). However, this species has a slightly narrower, rounded apex with a clear pore and is generally much less wide at this length. The apex of our specimens is more like that of *Cl. moniliferum*, but last mentioned species is larger. A feature complicating determination is that *Cl. moniliferum*, rather common on these islands, sometimes also shows

a weak recurvature of the apex (see the image of *Cl. moniliferum*).

***Closterium* spec. 2 (1h, 1i, 1j, 1k).** A very common and variable form on both islands. We have presented some figures that show the morphological range. The cells often appear a bit too curved to classify them as *Cl. tumidulum*, and then more closely resemble *Cl. venus*. Růžička (1977) also describes an intermediate form between *Cl. venus* and *Cl. tumidulum* and the present material may include more than one species. It is still difficult to assign names to the different forms.

***Closterium submoniliferum* (1d, 1e).** A common species on Curaçao, not found on Bonaire.

***Closterium* spp. indet.** On several localities several cells were found that belong to other *Closterium* species, but their identification is still impossible. A few cells possibly belong to *Cl. cf. acutum* var. *variabile* (Kaya Gavilan and the water purification plant on Bonaire). In the material from Kaya Gavilan (Kralendijk) in addition one cell was found that probably belongs to *Cl. cornu* and in Dam Grandi (Bonaire) one cell that was rather similar to *Cl. limneticum*. Also in Dam Grandi one large cell was found that may belong to *Cl. baillyanum*. Finally, in Dam Grandi a few cells were observed that possibly belong to *Cl. strigosum* var. *elegans*.

***Cosmarium* cf. *biretum* (3b).** Only found in Kaminda Lagoon (Bonaire). *C. biretum* is a variable species; according to Prescott et al. (1981), based on the dimensions of the present material (42-46 X 40-42 µm) it should rather be assigned to its var. *minus*. However, this is a very poorly known form published without figure and therefore we provisionally list our form as cf. *biretum* here.

***Cosmarium boitierense* var. *inambitosum* (2a, 2b, 2j).** Found on several localities on Bonaire. The SEM-picture clearly shows the distinct median protuberance on either semicell.

***Cosmarium* cf. *quadrum* (3c, 3d).** This species was recorded from several locations on Bonaire, although always in very low numbers. The cells seem closely related to *C. quadrum* but have a slightly widened apex, in contrast to the "typical" form that have parallel sides and very broadly rounded apical angles. Scott & Grönblad (1957) described a similar form from Florida as *C. quadrum* var. *sublatum* f. *dilatatum*, but that form has slightly fewer vertical rows of granules.

***Cosmarium regnellii* (2c, 2d).** A rather common species on both islands. In our samples too, *C. regnellii* appeared to be a very variable form, most probably representing a species complex with a problematic taxonomy. We found various transitional forms, e.g. cells that look like *C. meneghinii*.

***Cosmarium* spec. 1 (2e, 2f).** One of the most common species on both islands, and a small but characteristic one, but its identity is still not clear.

***Cosmarium* spec. 2 (2l, 2m).** There is some resemblance of this species with smaller forms of *C. septentrionale*. It was found on several localities on both islands. Unfortunately, the cell wall ornamentation was not visible

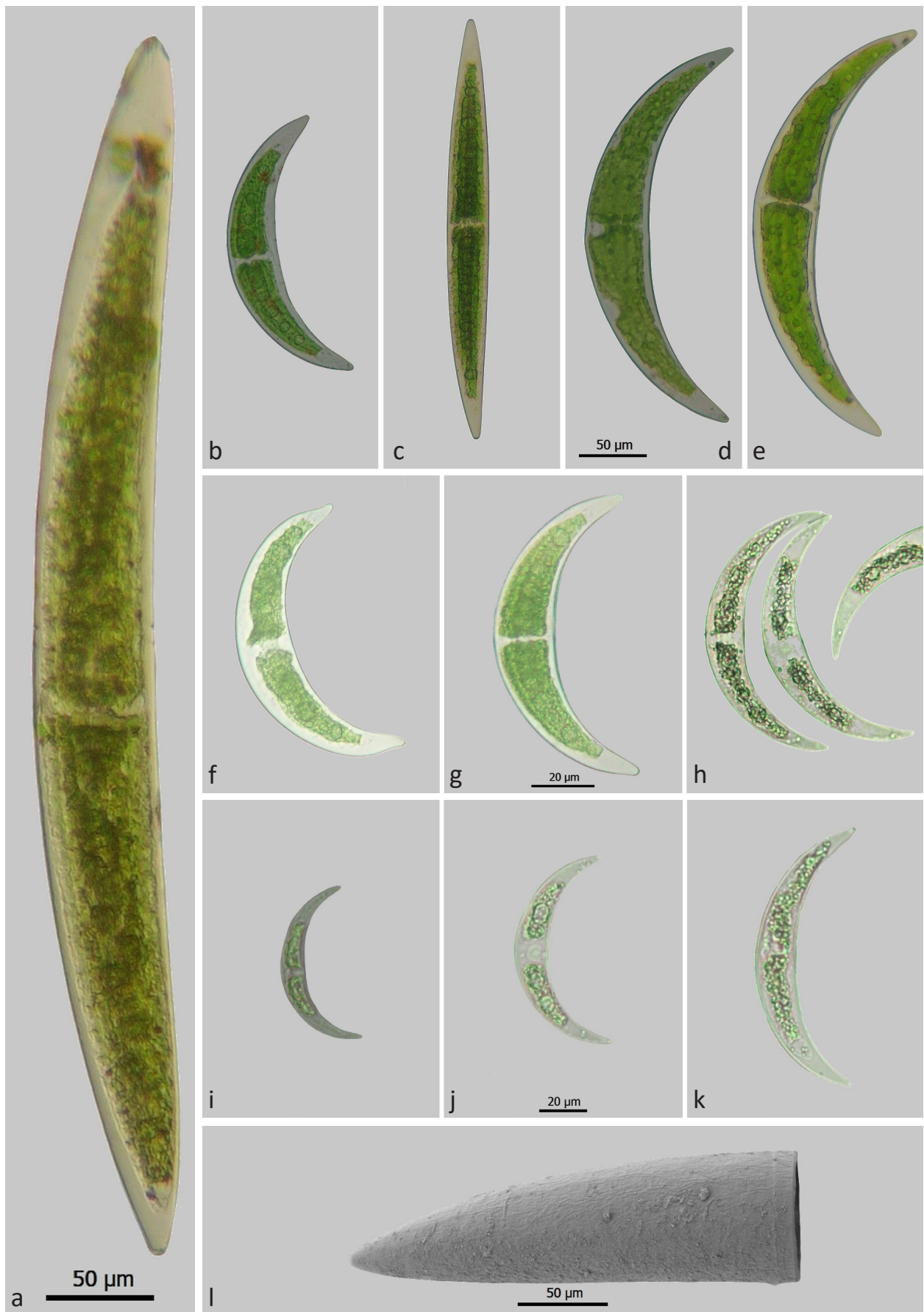
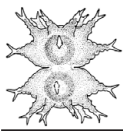


Plate 1: a) *Closterium* cf. *acerosum* (6B); b) *Closterium moniliferum* (9C); c) *Closterium pseudolunula* (8B); d) and e) *Closterium submoniliferum* (13C); f) and g) *Closterium* spec. 1 (8B); h) *Closterium* spec. 2 (11C); i) *Closterium* spec. 2 (4B); j) *Closterium* spec. 2 (3B); k) *Closterium* spec. 2 (6B); l) *Closterium* cf. *acerosum* SEM-photo (6B). The numbers behind the names refer to the locations on Bonaire (B) and Curaçao (C), see figures 1 and 2.

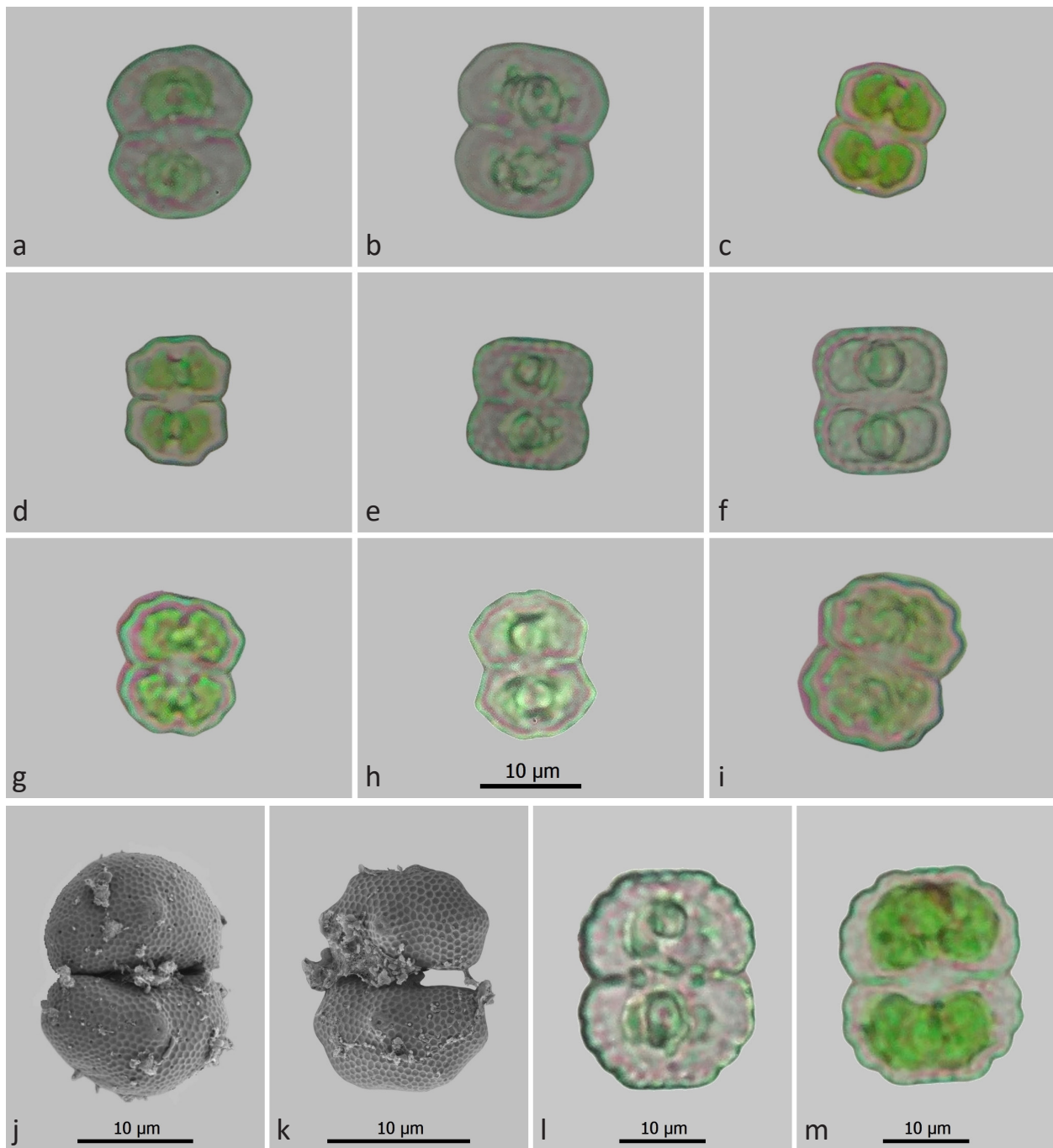
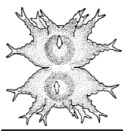
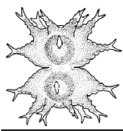


Plate 2: a) *Cosmarium boitierense* var. *inambitosum* (1B); b) *Cosmarium boitierense* var. *inambitosum* (2B); c) and d) *Cosmarium regnellii* (5B); e) *Cosmarium* spec. 1 (4B); f) *Cosmarium* spec. 1 (2B); g) and i) *Cosmarium* spec. 3 (1B); h) *Cosmarium* spec. 3 (4B); k) *Cosmarium* spec. 3 (6B); j) *Cosmarium boitierense* var. *inambitosum* SEM-photo (6B); k) *Cosmarium* spec. SEM-photo (6B); l) *Cosmarium* spec. 2 (6B); m) *Cosmarium* spec. 2 (9C). The numbers behind the names refer to the locations on Bonaire (B) and Curaçao (C), see figures 1 and 2.



(no empty cells were found) and it is not clear to which species the cells may belong.

Cosmarium spec. 3 (2g, 2h, 2i, 2k). This form belongs to the most common desmid species on Bonaire and Curaçao. At first impression it could be associated with *C. meneghini* but that species has the lateral sides nearly parallel and not as divergent as in the present material. In addition, *C. meneghini* generally has no cell wall undulation between lateral and apical angles. Our material is also reminiscent of smaller forms associated with *C. orthogonum*, but at present we are unable to identify it with certainty. Moreover, the large variability shown suggests that possibly two or even three different species should be distinguished.

Cosmarium turpinii (3e, 3f, 3g). The cells of this species are found on only one locality, Kaminda Lagun on Bonaire. However, there is a lot of variation within the cells. Several cells show probably the nominate form but also several cells have a strongly trapeziform, like *Cosmarium turpinii var. podolicum*. The strongly trapeziform semicells of this last taxon are ornamented with prominent, single grains that are nowhere doubled. Probably it is an undescribed species.

Cosmarium spp. indet. We found several additional species that unfortunately could not be satisfactorily identified. Especially small, smooth-walled forms were problematic. The most common forms are illustrated with micrographs (see above under *Cosmarium spec. 3*). In addition, cells were observed that possibly belong to *C. calculus*, *C. granatum*, *C. laeve*, *C. impressulum var. impressulum*, *C. impressulum var. suborthogonum*, *C. quadratulum* and *C. subgranatum var. borgei*. However, transitional forms made a reliable determination even more problematic. Also problematic was the identification of some ornamented cells, mostly with a cell-length of 30-50 µm. Although a few forms were frequently observed we were not able to identify them.

Euastrum hypochondrum (3h, 3i). This characteristic species, known from North and South America and Africa, was found in Kaminda Lagun and Dam Grandi on Bonaire.

Euastrum spinulosum (3i, 3m). Most curiously, *E. spinulosum* was described from Europe (Italy; see Delponte, 1876) but it primarily has a tropical distribution. Although the species can also be found throughout Europe, it becomes increasingly rare northwards (Růžička, 1981). We found the species on several localities on both islands. It is not clear to which variety the present form belongs. The American *E. spinulosum var. lindae* is characterized by a central ornamentation of small, densely disposed spines, a feature not present here. There is some similarity to the image of subsp. *africanum* in Nordstedt (1880), which Růžička (1981) considers to belong to the nominate variety. Both *Euastrum* species reported here are part of a group related forms with interesting evolutionary lines and biogeography (see Coesel, 2000).

Gonatozygon monotaenium (3a). A few cells in Kaya Gavilan (Bonaire).

Penium margaritaceum (3j, 3n). A few cells in Kaminda Lagun (Bonaire). The cells are comparatively short for *P. margaritaceum* (Růžička, 1977).

Pleurotaenium. Only one semicell was found in dam Grandi (Bonaire). It most likely represents *P. ehrenbergii* although judging from the length of the semicell, the cell was rather long (no image presented).

Staurastrum spec. (3k, 3o). This taxon was rather common on both islands. Superficially it looks like *Staurastrum bieneanum* but there are series of small granules on the cell wall encircling the arms (compare the problematic *St. bieneanum var. ellipticum*, described from Novaya Zemlia by Wille, 1879 and considered related to *St. lapponicum* by Coesel & Meesters, 2013). We have no name for this taxon, although the form is very characteristic.

Discussion

Optimal habitats for the presence of many species of desmids are not present on Bonaire and Curaçao. So, a total number of 35-40 desmid taxa was more than expected in advance. At most locations, only a few species were found, mainly in low densities. This illustrates that the environment is not very suitable for desmids, mainly due to its temporary nature, but also due to the ubiquitous high lime content and the absence of (submerged) aquatic plants. The most species-rich location was Kaminda Lagun at Bonaire with 24 species. However, we have no explanation for the fact that this location was more rich in species than other locations. In general, on the locations on Bonaire more species were found than on the locations on Curaçao. In the largest waterbody, Muizenberg on Curaçao, only two species were found. The absence of aquatic plants and the less calcareous water are the most probably reasons.

At first glance, almost all recorded species are species with a large distribution area and mainly occurring in environments that are more or less trivial for desmids, in this case relatively calcareous and ephemeral habitats. This raises the question why it proved so difficult to adequately determine a number of taxa. A first obvious explanation is that for many species there was little material available. In general, the density of cells was very low. Only one or at most a few cells were found from almost half of the taxa. This also meant that sometimes no or hardly any cells of the ornamented *Cosmariums* were found where the ornamentation was clearly visible due to the absence of cell contents.

There may be another reason for the problems in identification of the small smooth-walled *Cosmariums*. It cannot be ruled out that, partly due to the relatively isolated islands and the harsh environments for desmids, the species present undergo a fairly rapid evolution, which makes identification as a well-known taxon diffi-

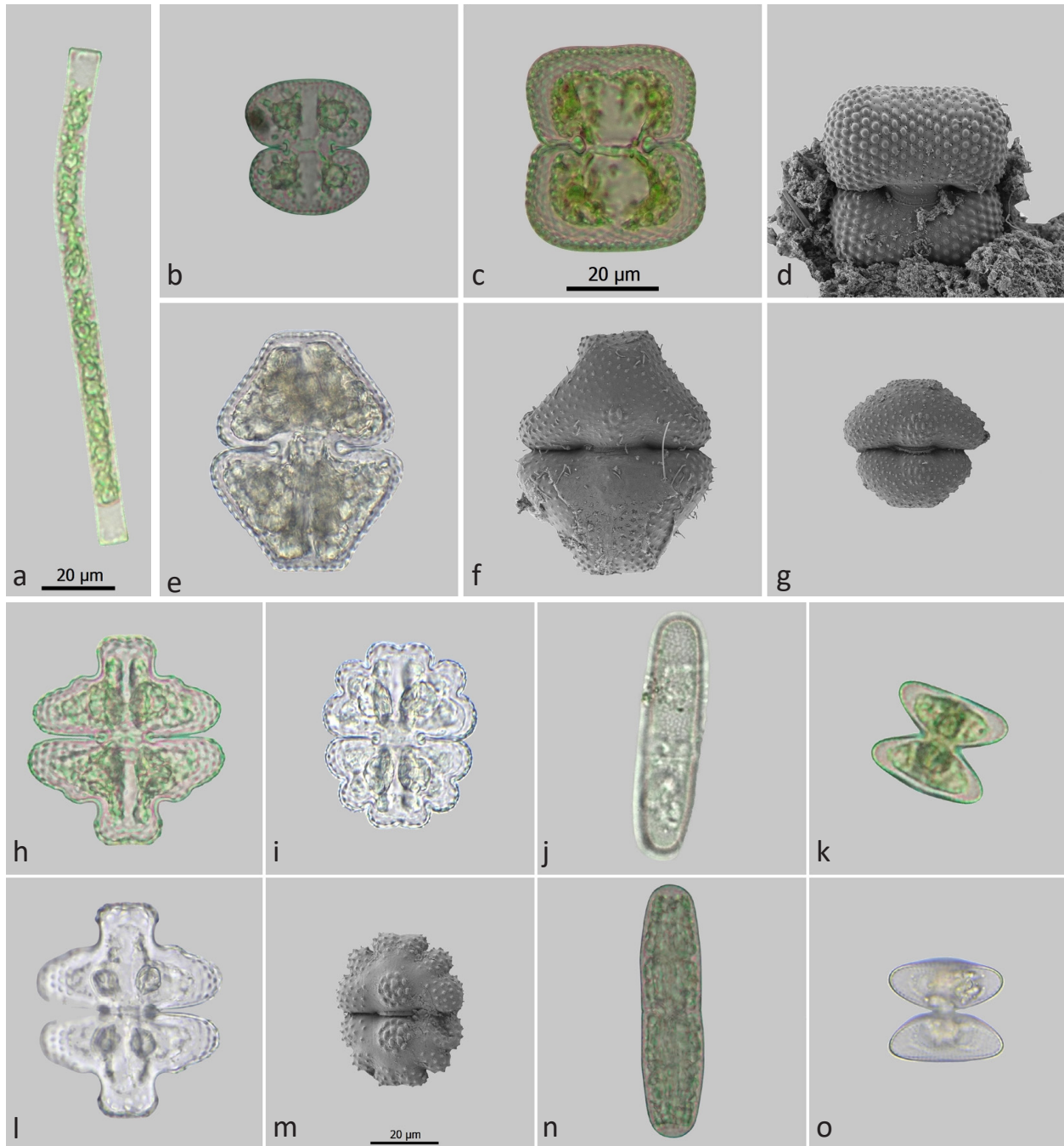
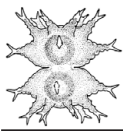
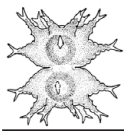


Plate 3: a) *Gonatozygon monotaenium* (4B); b) *Cosmarium biretum* (6B); c) *Cosmarium* cf. *quadrum* (5B); d) *Cosmarium* cf. *quadrum* (6B); e), f) and g) *Cosmarium turpinii* (6B); h) and l) *Euastrum hypochondrum* (6B); i) and m) *Euastrum spinulosum* (6B); j) and n) *Penium margaritaceum* (6B); k) and o) *Staurastrum* spec. (6B). Photos d, f, g and m are SEM-photos. The numbers behind the names refer to the locations on Bonaire (B) and Curaçao (C), see figures 1 and 2.



cult, but at the same time the differences do not appear to be so great that the description of new species is justified. In addition, the desmid flora from this part of the world, including the adjacent parts of Venezuela, for example, is very poorly known. This especially applies to the small *Cosmarium* species found here, the taxonomy of which is already a major problem even in thoroughly investigated parts of Western Europe.

This research will hopefully provide an incentive to conduct more research into desmids on these islands, making more rich and representative material available.

Acknowledgements

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