Cyanophyceae associated with mangrove trees at Inhaca Island, Mozambique

S.M.F. Silva*

Keywords: Bostrychietum, Cyanophyceae, epiphytes, Inhaca Island, mangrove, taxonomy

ABSTRACT

A survey of the Cyanophyceae associated with two of the five mangrove trees and their associated Bostrychieta at Inhaca Island, Mozambique, was undertaken. Sixteen taxa belonging to 12 genera were identified. Of these, six taxa were new records for Mozambique, three at generic and three at specific level. Thirteen taxa of Cyanophyceae were found growing on *Avicennia marina* (Forssk.) Vierh. and four on *Ceriops tagal* (Perr.) C.B. Robinson. *Chamaecalyx leibleiniae* (H. Reinsch) Komarek & Anagnostidis was the only Cyanophyceae to occur on both species of tree.

UITTREKSEL

'N Opname van Cyanophyceae wat geassosieer word met twee van die vyf manglietbome en hul geassosieerde Bostrychieta op Inhaca Eiland, Mosambiek, is gedoen. Sesien taksons wat aan 12 genera behoort, is geïdentifiseer. Ses van hierdie taksons was nuwe rekords vir Mosambiek, drie op genusvlak en drie op spesievlak. Daar is gevind dat dertien Cyanophyceae-taksons op *Avicennia marina* (Forssk.) Vierh. groei en vier op *Ceriops tagal* (Perr.) C.B. Robinson. *Chamaecalyx leibleiniae* (H. Reinsch) Komarek & Anagnostidis was die enigste Cyanophyceae wat op albei boomspesies voorgekom het.

INTRODUCTION

After a long period of neglect, some attention has recently been given to epiphytic Cyanophyceae associated with mangroves with respect to their abundance and importance within this particular habitat (Berjak et al. 1977; Dor 1984; Lambert et al. 1989).

The Cyanophyceae from southern African mangroves were studied in detail by Lambert et al. (1989). This report constitutes an important contribution to our knowledge of the ecology and taxonomy of the Cyanophyceae in that region. The northern limit of sampling by Lambert et al. (1989) was in the Kosi Estuary which borders Mozambique (Figure 1B). Inhaca Island is situated ± 180 km to the north, on the east coast of southern Africa, within the Indo-West-Pacific biogeographic zone of the degree squares 2532DD and 2632BB (see Edwards & Leistner 1971) (Figure 1A, B). It is of interest because of the well-zoned mangrove swamps, a feature not apparent in the swamps to the south (Berjak et al. 1977). The island is situated in the south of Mozambique, forming part of the barrier between the Indian Ocean and Maputo Bay (Figure 1). The largest stands of mangroves are located at the head of the northern and the southern bays (Figure 1C) (Macnae & Kalk 1969).

The mangrove vegetation on Inhaca Island is mainly composed of the following: *Avicennia marina* (Forssk.) Vierh., *Bruguiera gymnorrhiza* (L.) Lam., *Ceriops tagal* (Perr.) C.B. Robinson, *Lumnitzera racemosa* Willd., and *Rhizophora mucronata* Lam. *Ceriops tagal* occupies the central areas of all mangrove swamps on the island and macroscopic growth of algae on its trunks is generally very scarce. *Avicennia marina* is a dominant member of the mangrove community. The pneumatophores very often possess a covering of several species of Rhodophyceae which are collectively known as 'Bostrychietum', which is defined thus by the predominance of species such as *Bostrychia* spp., *Catenella* spp., *Caloglossa* sp. and *Murrayella* sp. (Post 1936; Macnae & Kalk 1962).
No research on the Cyanophyceae associated with the mangroves of Mozambique has yet been undertaken. The aim of this study was to identify those algae growing on mangrove trees as well as to contribute to our knowledge of their taxonomy and ecology in southern Africa.

MATERIALS AND METHODS

Two substrata which support the growth of benthic algae were considered for this study, viz.: the pneumatophores of Avicennia marina and the base of the trunks of Ceriops tagal. Sampling was carried out in the northern bay and at Saco during low tide. Twenty samples of the pneumatophores were collected at random, cutting them near the mud surface. In the case of C. tagal, trunk segments were removed. Macro-algal hosts within the Bostrychieta were noted. The number of samples analysed was not sufficient to indicate any marked changes in algal composition from the water’s edge to the upper limit of the pneumatophores.

Some material was preserved in 4% formalin, and some was allowed to dry in subdued lighting. All samples were deposited at the Herbarium of the Faculty of Biology (LMU), University Eduardo Mondlane in Maputo, Mozambique.

The system of classification used was Anagnostidis & Komarek (1985, 1988) and Komarek & Anagnostidis (1986, 1989).

RESULTS

Key to the species

1a Thallus unicellular or colonial:
2a Unicellular ................................................

Chamaealyx leibleiniae

2b Colonial:
3a Pseudoparenchymatous ..................... Xenococcus acervatus
3b Not pseudoparenchymatous. subspheric or elongate
4a Many cells per colony ....................... Aphanthece stagnina
4b Up to 4 cells per colony ..................

5a Cells 3.1—4.3 µm broad ...........................
5b Cells 31.8—38.1 µm broad ................... C. turgidus var. maximus
6b Filamentous or pseudofilamentous
7a Pseudofilaments .....................................
7b Pseudofilaments irradiating from pseudoparenchyma ....
8b Without heterocysts ..............................
9a Heterocysts intercalary only ..................

Nodularia sp.

9b Heterocysts terminal:
10a Heterocysts terminal only, cells 9.6—11.8 µm broad

Calothrix scopulorum

10b Heterocysts terminal and intercalary, cells 19.8—28.3 µm broad ..................... C. crustacea
11b Sheath present .................................
12a Trichomes regularly spirally coiled .......... Arthrospira platensis
12b Trichomes bent, not regularly spirally coiled .................. Oscillatoria peniculata

13a Many trichomes per sheath ................... Microcoleus chthonoplastes
13b Only one trichome per sheath

14a Sheath thick, lamellated, filaments 50.0—52.1 µm broad .............. Lyngbya majuscula
14b Sheath thin, unlamellated, filaments 6.2—20.6 µm broad

15a Filaments 17.1—18.7 µm broad ............. L. nigra
15b Filaments 19.0—20.6 µm broad ............... L. confervoides

145

CHROOCOCCALES

Microcystaceae

Aphanthece stagnina (C.K. Spreng.) A. Braun, In Rabinhorst: 66 (1865); Tilden: 32 (1910); Geitler: 164 (1932); Desikachary: 137 (1959); Humm & Wicks: 49 (1980) [=Coccolorhiza stagnina Drouet & Daily].

Thallus generally subspherical, ± 102.5 µm. Sheath colourless, lamellated, up to 15.6 µm thick. Cells oblong or polygonal by mutual compression, 3.1—5.6 x 2.8—3.4 µm, protoplasm homogeneous blue-green (Figure 2.1).

Specimens examined

MOZAMBIQUE —2632 (Bela Vista): Inhaca Island, near the northern bay, 07-09-1989, S. Silva & N. Cuamba 43 (LMU).


Chroococcaceae

Chroococcus minor (Kützing) Näg.: 47 (1849); Tilden: 9 (1910); Geitler: 240 (1932); Desikachary: 105 (1959).

Colony subspherical or elongate, groups of 3—4 cells. Sheath thin, colourless or yellowish lamellated. Cells generally hemispherical or subhemispherical, protoplasm homogeneous pale blue-green, 2.8—4.0 x 3.1—4.3 (—6.2) µm (Figure 2.2, 2.3, 2.4).

Specimens examined


Chroococcus turgidus (Kützing) Näg. var. maximus Nygaard: 201 (1926); Tilden: 5 (1910); Geitler: 229 (1932); Desikachary: 102 (1959).

Colony subspherical or elongate, groups of 2 cells. Sheath colourless, lamellated, ± 11.5 µm thick. Cells hemispherical, 17.7—30.3 x 31.8—38.1 µm, protoplasm granular dark green (Figure 2.5).

Specimens examined

MOZAMBIQUE —2632 (Bela Vista): Inhaca Island, near the northern bay, 07-09-1989, S. Silva & N. Cuamba 43 (LMU).


Chamaesiphonaceae

Sporangia single or gregarious, club-shaped, straight or bent, 22.5–46.8 x (8.4–)10.0–19.6 μm, protoplasm homogeneous pale blue-green. Sheath thin, colourless. Exocytes many, ± 9, 4.0–8.1 μm. (Figure 2.6, 2.7, 2.8).

Specimens examined


Distribution in Mozambique: first record for the occurrence of the species.

Oscillatoriales

Oscillatoriaceae

Oscillatoria jenensis G. Schmid: 572 (1921); Geitler: 949 (1932).

Trichomes bent, not constricted at the cross-walls, slightly attenuated or not at the ends. Cells 4–9 times broader than long. (1.5–)2.1–5.3 x 14.3–19.6 μm, cross-walls not granular, protoplasm homogeneous blue-green (Figure 2.14, 2.15).

Specimens examined

MOZAMBIQUE.—2632 (Bela Vista): Inhaca Island, near the northern bay, 07-09-1989, S. Silva & N. Cuamba 43 (LMU).

Distribution in Mozambique: first record for the occurrence of the species.

Lyngbya nigra C. Agardh ex Gomont: 145 (1892); Tilden: 119 (1910); Geitler: 1063 (1932); Desikachary: 317 (1959).

Filaments long, flexuous, 17.1–18.7 μm broad. Sheath thin, colourless, unlamellated. Trichome not constricted at the cross-walls, slightly attenuated or not. Cells 3–5 times broader than long, 2.5–4.6 x 13.4–15.0 μm, cross-walls not granular, protoplasm granular blue-green. Calyptra rounded (Figure 2.16).

Specimens examined

MOZAMBIQUE.—2632 (Bela Vista): Inhaca Island, near the northern bay, 07-09-1989, S. Silva & N. Cuamba 43 (LMU).

Distribution in Mozambique: first record for the occurrence of the species.

Lyngbya confervoides C. Agardh ex Gomont: 156 (1892); Tilden: 119 (1910); Geitler: 1061 (1932); Desikachary: 314 (1959); Humm & Wicks: 81 (1980) [=Microcoleus lyngbyaceous (Kützing) P.L. Crouan].

Filaments long, flexuous, 19.0–20.6 μm broad. Sheath thin, colourless, unlamellated. Trichome not constricted at the cross-walls, not attenuated at the ends. Cells 7–12 times broader than long, 1.2–2.1 x 14.0 μm, cross-walls not granular, protoplasm homogeneous dark green. Calyptra absent (Figure 2.17).

Specimens examined

MOZAMBIQUE.—2632 (Bela Vista): Inhaca Island, near the northern bay, 07-09-1989, S. Silva & N. Cuamba 43 (LMU).

Distribution in Mozambique: 2632 (Bela Vista) Inhaca Island, marine, on rocks, on Crassostrea sp. and mixed with Bostrychia spp. and Catenella sp. (Silva 1991).
Lyngbya majuscula Harv. ex Gomont: 151 (1892); Tilden: 123 (1910); Geitler: 1060 (1932); Desikachary: 313 (1959); Humm & Wicks: 81 (1980) [=Microcoleus lyngbyaceus (Kützing) P.L. Crouan].

Filaments long, flexuous, 50.0—52.1 μm broad. Sheath colourless, lamellated, ± 3.4 μm thick. Trichome not constricted at the cross-walls, not attenuated at the ends. Cells 9—10 times broader than long, 2.1—5.0—(10.9) × 39.0—450.0 μm, cross-walls not granular. Protoplasm homogeneous dark green. Calyptra absent (Figure 3.1).

Specimens examined

Distribution in Mozambique: first record for the occurrence of the genus.

Phormidiaceae

Arthrospira platensis (Nordst.) Gomont: 247 (1892); Geitler: 919 (1932) [=Spirulina platensis (Nordst.) Geitl.]; Desikachary: 190 (1959).

Trichomes constricted at the cross-walls, not attenuated at the ends. Spirals 75.0 μm distant from each other. Cells 3—4 times broader than long. 1.8—3.1 × 7.5—8.4 μm, protoplasm homogeneous blue-green (Figure 2.18, 2.19).

Specimens examined
MOZAMBIQUE.—2632 (Bela Vista): Inhaca Island, near the northern bay, 07-09-1989, S. Silva & N. Cuamba 43 (LMU).


Distribution in Mozambique: 247 (1892); Tilden: 264 (1910); Geitler: 600 (1932); Desikachary: 523 (1959); Humm & Wicks: 151 (1980).

Thallus caespitose, dark-green. Filaments bent, ± 1400.0 × 200—35.3 μm, slightly swollen at the base, not attenuated into a hair. Sheath colourless or yellowish, lamellated, ± 6.5 μm thick. Trichome constricted at the cross-walls. Cells generally 3 times broader than long or subquadratic, 3.7—10.9 × 11.5—13.1 μm, protoplasm homogeneous blue-green. Heterocysts colourless, depressed spherical or cylindrical, 13.7—15.6 × 11.2—16.8 μm. Akinetes not observed (Figure 3.4).

Specimens examined
MOZAMBIQUE.—2632 (Bela Vista): Inhaca Island, near the northern bay, 07-09-1989, S. Silva & N. Cuamba 43 (LMU).

Rivulariaceae

Calothrix crustacea Thur. ex Born. & Flah.: 353 (1886); Tilden: 264 (1910); Geitler: 601 (1932); Desikachary: 524 (1959); Humm & Wicks: 84 (1980).

Thallus caespitose, dark-green. Filaments bent, ± 35.0 × 20.0—35.3 μm, slightly swollen at the base, not attenuated into a hair. Sheath colourless or yellowish, lamellated, ± 6.5 μm thick. Trichome constricted at the cross-walls. Cells generally 0.7—2.0 times longer than broad, (1.5—)3.4—10.9 × 19.6—28.1 μm, protoplasm granular blue-green. Heterocysts 1-basal, 1—2-intercalar, protoplasm yellowish, (6.8—)15.3—35.3 × (12.1—)20.3—27.8 μm. Hormogonia not observed (Figure 3.5, 3.6, 3.7).

Specimens examined


Calothrix scopulorum (F. Weber & D. Mohr) C. Agardh ex Born. & Flah.: 359 (1886); Tilden: 258 (1910); Geitler: 601 (1932); Desikachary: 524 (1959); Humm & Wicks: 84 (1980) [=Calothrix crustacea Schousb. & Thur.].

Filaments single, bent, ± 1200.0 × 15.9—17.8 μm, slightly swollen at the base, not tapering into a hair. Sheath colourless, unlamellated, ± 2.8 μm thick. Trichome not constricted at the cross-walls. Cells 2—6 times broader than long, 2.1—4.3 × 9.6—11.8 μm, protoplasm granular blue-green. Heterocysts 1-basal, protoplasm yellowish, 18.4 × 9.6 μm. Hormogonia 350 × 96 μm (Figure 3.8).

Specimens examined
MOZAMBIQUE.—2632 (Bela Vista): Inhaca Island, near the northern bay, 07-09-1989, S. Silva & N. Cuamba 26 (LMU).


DISCUSSION

The Cyanophyceae on mangrove trees at Inhaca Island were found frequently associated with several species of red algae in the so-called 'Bostrychietum' on pneumatophores of Avicennia marina. These Cyanophyceae were also found on the base of trunks of Ceriops tagal where the number of taxa was lower than that observed on

NOSTOCALES

Nostocaceae

Nodularia sp.

Filaments single, straight or bent, 16.2—20.0 μm broad. Sheath thin, colourless, unlamellated. Trichome constricted at the cross-walls. Cells generally 3 times broader than long or subquadratic, 3.7—10.9 × 11.5—13.1 μm, protoplasm homogeneous blue-green. Heterocysts colourless, depressed spherical or cylindrical, 13.7—15.6 × 11.2—16.8 μm. Akinetes not observed (Figure 3.4).

Specimens examined

Nodularia sp. (Silva 1991).
pneumatophores (Table 1). This observation can be
explained in that the 'Bostrychietum' offers a suitable
micro-habitat for the development of Cyanophyceae where
they are less susceptible to extreme environmental condi­
tions such as desiccation, high light intensity and high
temperature conditions than on the base of C. tagal.
Besides, C. tagal occurs fairly high up the shore where
tidal inundations are less frequent.

Sixteen taxa of Cyanophyceae were identified, which in­
cluded 12 genera (Aphanotoche, Arthrospira, Calothrix,
Chamaecalyx, Chroococcus, Hydrococcus, Lyngbya,
Microcoleus, Nodularia, Oscillatoria, Stichosiphon
and Xenococcus) and 14 species (Aphanotoche stagnina
(C.K. Sprengel) A. Braun, Arthrospira platensis (Nordst.),
Gomont, Chroococcus minor (Kützing) Nägeli, C. turgi­
dus (Kützing) Nägeli var. maximus Nygaard, Calothrix
crustacea Thun. ex Born. & Flah., C. scopulorum (F. Weber & D. Moehr) C. Agardh ex Born. & Flah.,
Chamaecalyx leibleiniae (H. Reinsch) Komarek & Anag­
nostidis, Hydrococcus rivialis Kützing, Lyngbya con­fervoides C. Agardh ex Gomont, L. majuscula Harv. ex
Gomont, L. nigra C. Agardh ex Gomont, Microcoleus
chthonoplastes Thun. ex Gomont, Oscillatoria jenensis G.
Schmid and Xenococcus acervatus Setch. & N.L. Gardner.
In addition, Stichosiphon sp. probably constitutes a new
species and Nodularia sp. could not be identified further
due to the lack of reproductive material. Arthrospira
platenis, Hydrococcus rivialis and Stichosiphon sp. are
recorded for the first time at the generic level and Lyngbya
nigra, Oscillatoria jenensis and Xenococcus acervatus are
first records at the specific level for Mozambique.

Of the identified species, 75% were found growing
exclusively on Avicennia marina and 18% only on Cer­iops
tagal. On A. marina, eight taxa were not associated with
macroalgae (Aphanotoche stagnina, Chroococcus turgi­
dus var. maximus, Arthrospira platensis, Lyngbya nigra,
Aphanotoche stagnina, Chroococcus turgidus var. maximus, Arthrospira platensis, Lyngbya nigra.

### TABLE 1 — Mangrove substrata upon which the species of Cyanophyceae
were found

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Avicennia marina</th>
<th>Ceriops tagal</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>+</td>
<td>C</td>
<td>G</td>
</tr>
<tr>
<td>+</td>
<td>M</td>
<td>Ce</td>
</tr>
<tr>
<td>+</td>
<td>C</td>
<td>Cy</td>
</tr>
<tr>
<td>+</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

L. confervoides, L. majuscula, Nodularia sp. and Calo­
thrix scopulorum, but four were present on at least two
different genera of macroalgae (Chamaecalyx leibleiniae,
Stichosiphon sp., Hydrococcus rivialis and Xenococcus
acervatus). Microcoleus chthonoplastes was found associ­
ated with almost all species of the red algae present on
Avicennia marina. C. leibleiniae was the only epiphytic
Cyanophyceae present on both mangrove trees considered
in this survey. Only Chamaecalyx leibleiniae, Chroococcus
minor, Oscillatoria jenensis and Calothrix crustacea were
growing on Ceriops tagal. Chamaecalyx leibleiniae was
found associated with Caloglossa sp. and Chroococcus
minor with Calothrix crustacea. O. jenensis and C.
crustacea were epiphytic only on the bark of Ceriops
tagal, and never on macroalgae (Table 1).

Lambert et al. (1989) found 27 species of Cyanophyceae
(Table 2) on mangroves on the south-east coast of South
Africa, of which five are also present at Inhaca Island,
namely Calothrix scopulorum, Hydrococcus rivialaris,
TABLE 3.—Substrata upon which common species of Cyanophyceae were found growing on mangrove swamps from the southern coast of South Africa and Inhaca Island

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Substrata</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calothrix scopularis</td>
<td>M A B R B C G M U E Rh</td>
</tr>
<tr>
<td>Hydrococcus variabilis</td>
<td>M A B R B C G M U E Rh</td>
</tr>
<tr>
<td>Lyngbya confluens</td>
<td>* + * + + + *</td>
</tr>
<tr>
<td>Microcoleus chthonoplastes</td>
<td>* + * + + + + *</td>
</tr>
<tr>
<td>Xanococcus acervatus</td>
<td>+ + + + + + + +</td>
</tr>
</tbody>
</table>

* according to Lambert et al. 1989; + Inhaca Island; A, Avicennia marina; B, Brugueira gymnorrhiza; B, Bostrychia spp.; C, Caloglossa sp.; E, Enteromorpha sp.; G, Gelidium sp.; M, mud; Mu, Murravea sp.; R, Rhizophora mucronata; Rh, Rhizoclonium sp.

Lyngbya confluens, Microcoleus chthonoplastes and Xanococcus acervatus. Substrata upon which these common species were found show some similarity in both regions (Table 3). This flora consists mainly of non-heterocystous forms (88.2%), which compares well with the number found in southern Africa (85.2%; according to Lambert et al. 1989).

The results obtained in this survey show the diversity of species of Cyanophyceae associated with Avicennia marina and Ceriops tagal in mangroves at Inhaca Island, as follows: seven species of Chroococcales (one Microcystaceae, two Chroococcaceae, two Chamaesiphonaceae, one Hydrocoleaceae and one Xenococcaceae), six species of Oscillatoriales (four Oscillatoriaceae and two Phormidiaceae) and three species of Nostocales (one Nostocaceae and two Rivulariaceae).

ACKNOWLEDGEMENTS

I wish to thank Prof. R.N. Pienaar for the correction of the manuscript. Prof. M. Kalk and Dr A. Critchley for their helpful criticisms and Mr N.J.B. Cuanba for his collaboration with sampling.

REFERENCES


Verdoorn (1961) cited the type specimen of her new species *Aloe soutpansbergensis* in the protologue as Crundall s.n. in PRE 29005. A diligent search, undertaken in the National Herbarium, Pretoria, in connection with our revision of the southern African species of *Aloe*, failed to reveal a specimen with this number.

A specimen, Crundall s.n. in PRE 27035, was found among the sheets of *A. soutpansbergensis*, however. It was collected in 1942, the year in which Verdoorn stated that her species was discovered, and was marked 'Figured for Flowering Plants of South Africa'. One would expect this annotation on the missing specimen, as the protologue was published in that journal and, of course, included a coloured illustration. Furthermore, the position of the leaves and flowers on the specimen (Figure 1) closely matches the published plate (Figure 2). Is it possible that by some error the specimen on which the plate was based, was registered twice, but the second number was not attached to the specimen?

The PRE register suggests that this was indeed the case, as the same details are recorded under both no. 27035 and 29005. Complicating the issue is another Crundall specimen of the same species from the same place, registered as no. 37735. This, however, was not figured and seems to be somewhat later than the other two.

We believe that the original painting of the plant holds the key to this puzzle. The outer cover bears the expected