Marine Cyanophytes from the Western Cape, South Africa: Chroococcales

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Received 9 May 1998; revised 2 October 1998

Forty taxa of marine Chroococcales (Cyanophyceae) belonging to six families (Microcystaceae, Chroococcaceae, Chamaesiphonaceae, Dermocarpellaceae, Xenococcaceae and Hydrococcaceae) and 18 genera (*Aphanocapsa*, *Aphanothece*, *Chamaecalyx*, *Chroococcidiopsis*, *Chroococcus*, *Cyanocystis*, *Cyanosarcina*, *Gloeocapsa*, *Hydrococcus*, *Hyella*, *Merismopedia*, *Microcrocis*, *Myxosarcina*, *Pleurocapsa*, *Stanieria*, *Stichosiphon*, *Synechococcus* and *Synechocystis*) have been recorded for the Western Cape, South Africa. Twenty taxa are new records for South Africa; five at the generic level, (*Cyanocystis*, *Synechococcus*, *Microcrocis*, *Synechocystis* and *Stichosiphon*), fourteen at the specific level (*Aphanothece stagnina*, *Aphanocapsa sesciacensis*, *Merismopedia affixa*, *M. litorale*, *Gloeocapsa crepidinium*, G. cf. *gelatinosa*, *Cyanosarcina* cf. *chroococcoides*, *Stanieria sphaerica*, *Chamaecalyx* cf. *fucicola*, *C.* cf. *suffultus*, *C.* cf. *swirenkoi*, *Pleurocapsa crepidinium*, *P.* cf *minor* and *P.* cf. *minuta*) and one at the varietal level (*Chroococcus turgidus* var. *maximus*). Morphological and size variability have been recorded and discussed.

Keywords: Marine, Cyanophyceae, Chroococcales, Western Cape.

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Introduction

In South Africa, reports on the Chroococcales, particularly from marine habitats, are scanty and the majority of the taxa referred in literature (Barton 1893, 1896, 1897; Delf & Mitchell 1921; Drouet & Daily 1956) are usually as part of species lists. To date, only five species of Chroococcales, belonging to four genera (*Cyanocystis*, referred as *Dermocarpa*, *Entophysalis*, *Hyella* and *Merismopedia*) have been reported from South Africa. This paper is part of a large survey of the marine Cyanophyceae from the Western Cape (Silva & Pienaar 1997, 1998a) and it aims to extend our knowledge on the marine Cyanophyceae from South Africa.

Materials and Methods

Sixty seven benthonic samples from twelve locations described (Silva & Pienaar 1998a) in the Western Cape, South Africa, have been analysed. Enrichment cultures were prepared using Provasoli's Enriched Seawater medium (PES) (McLachlan 1973) and subjected to an irradiance of 20 $\mu mol.m^{-2}.sec^{-1}$, a temperature of 20°C and an alternating 16L:8D cycle. Wild and cultured material was studied using a Zeiss photomicroscope equipped with bright field, Nomarski interference and phase contrast optics. A camera lucida was used for detailed drawings of specimens. Each of the sixty samples collected were observed every four weeks over a period of six months to monitor the development of other cyanophytes. In some instances a dilute solution of 3% hydrochloric acid was used to remove the calcium carbonate substrate into which some cyanophytes were attached or into which they burrowed. The range of morphological variability of each species has been illustrated. The system of classification adopted for this study was Komarek and Anagnostidis (1986).

Results

A total of forty taxa of marine Chroococcales have been described (Tables 1 and 2).

Genus *Aphanothece* Näg.

A. microspora (Menegh.) Rabenh., *Fl. Eur. Algar.* 2: 64. 1865. (Figure 1).

Colonies usually sub-sphaerical, up to 10.3 µm diam., 1–10 cells in a colony; mucilaginous envelopes colourless, homogeneous; cells cylindrical, 2.1–2.5(–3.1) µm wide, 3.1–5.3 µm long., up to 2 times longer than wide; protoplast pale blue-green, homogeneous.

Distribution in South Africa - KWAZULU-NATAL: Durban, on *Jania* sp.; Isipingo, on rocks (Silva 1994). WESTERN CAPE: Valkenberg Vlei (Fristch 1918).

The Western Cape specimens are slightly shorter than those described by Geitler (1932) which are two to three times longer than wide.

A. nidulans P. Richt., *Bot. Notiser.*, 128. 1884. (Figures 2–5)

Colonies usually amorphous, mucilaginous envelopes firm or diffluent, colourless, homogeneous; cells closely packed or not, cylindrical, (0.9–)1.0–1.5 µm wide, (1.8–)2.5–3.1 µm long, up to 2 times longer than wide, protoplast blue-green, homogeneous.

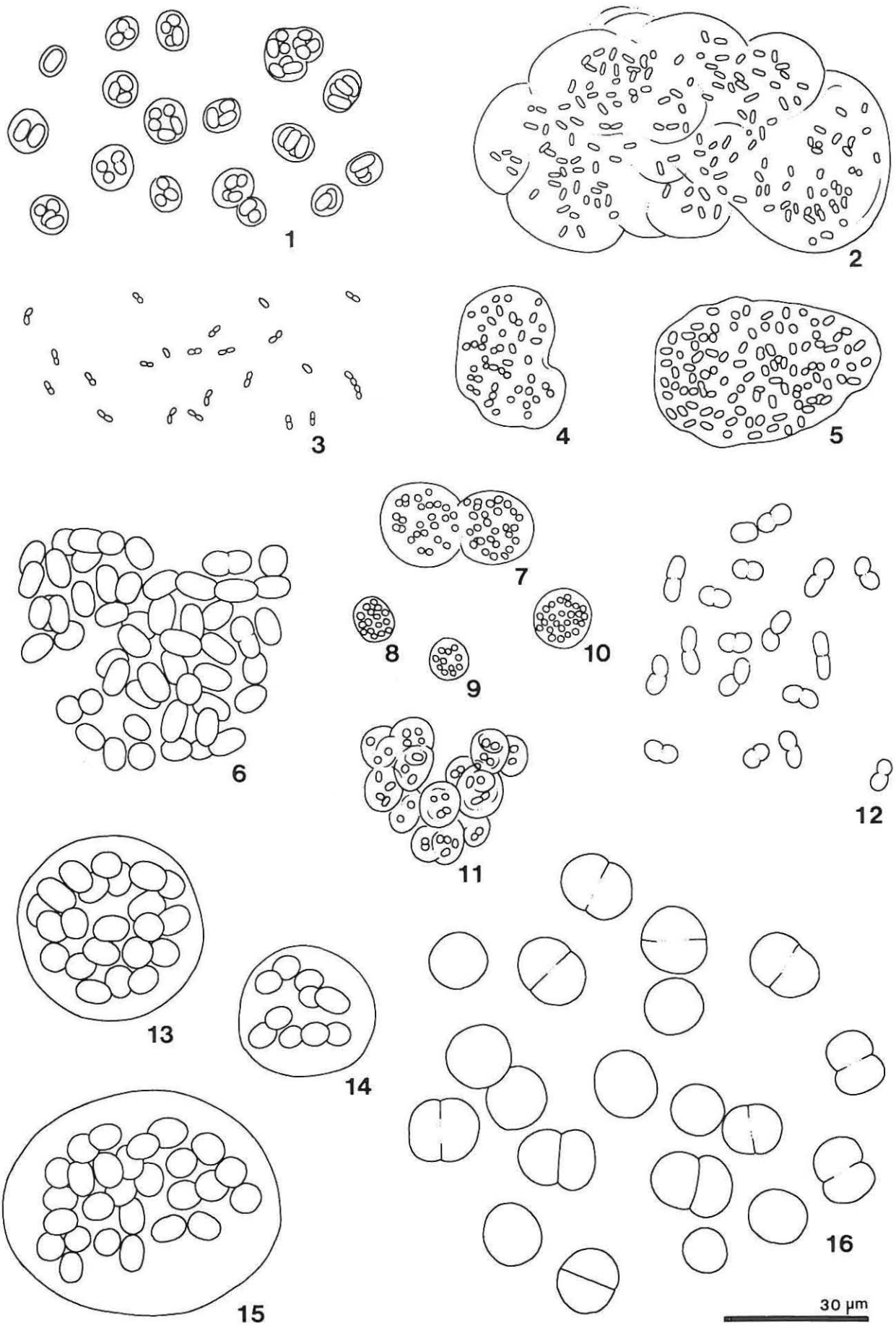
Distribution in South Africa - NORTHERN PROVINCE: Belfast Pan (Fritsch & Rich 1938).

Two populations of *Aphanothece nidulans* were found in the study area. One was observed at Plettenberg Bay, on a moist concrete wall, and the other population was found growing on rocks in Lambert's Bay. The two populations differ in the aspect of the mucilaginous envelopes. In the first the cells were surrounded by firm mucilaginous envelopes (Figures 2 and 4–5) and in the other one the envelope was diffluent (Figure 3). Besides, the cells were more closely packed in the colonies when compared with the illustrations given by Geitler (1932) and Desikachary (1959).

A. cf. *stagnina* (Spreng.) A. Braun, in Rabenh., *Fl. Eur. Algar.* 2. 66. 1865. (Figure 6)

Colonies amorphous, mucilaginous envelopes colourless, homogeneous, usually not evident; cells cylindrical, 4.6–5.3 µm wide, 6.5–8.4 µm long, up to 2 times longer than wide; protoplast blue-green, homogeneous.

Distribution in South Africa - First record for the occurrence of the species.



Figures 1–16 1: *Aphanothece microspora* (colonies of varying cell number). **2–5**: *Aphanothece nidulans* (2, 4–5: firm mucilaginous envelopes; 3: diffluent mucilaginous envelopes was not represented). **6**: *A. stagnina* (mucilaginous envelopes not represented). **7–11**: *Aphanocapsa concharum*. **12**: *Synechococcus curtus*. **13–15**: *Aphanocapsa litoralis*. **16**: *A. seisciacensis* (mucilaginous envelopes not represented).

Our specimens of *Aphanothece* cf. *stagnina* are slightly smaller than *A. stagnina* reported by Desikachary (1959) who refers to cells up to 11.0 µm long, although the ratio cell length/width is the same. According to the literature (Geitler 1932), the type species was described from freshwater habitats.

Genus *Synechococcus* Näg.

S. curtus Setch., *in* Collins *et al., Phyc. Bor.-Am.* 28: 1351. 1907. (Figure 12)

Cell cylindrical, straight, 3.1–3.4 µm wide, 4.6–5.9 µm long., up to 1½ times longer than wide; protoplast blue-green, homogeneous.

Distribution in South Africa - First record for the occurrence of the genus.

Komárek (1976), in his review of the genus *Synechococcus* Näg, refers to the presence of mucilage connecting the cells. This characteristic was not observed in the Western Cape material (Figure 12).

Genus *Aphanocapsa* Näg.

A. concharum Hansg., *Neue Süßw. Meeresalg*, 19. 1890. (Figures 7–11)

Colonies sub-sphaerical or amorphous, mucilaginous envelopes colourless, homogeneous; cells sub-sphaerical, 1.2–1.5 µm diam.; protoplast blue-green, homogeneous.

Distribution in South Africa - KWAZULU-NATAL - Isipingo, on rocks and *Crassostea* sp. (Silva 1994)

A. litoralis Hansg., *Prodr. Alg. Fl. Böhm.* 2: 158. 1892. (Figures 13–15)

Colonies sub-sphaerical or elliptical, up to 68.4 µm diam., mucilaginous envelopes colourless, homogeneous; cells sub-sphaerical, 4.0–6.0 µm diam.; protoplast blue-green, homogeneous.

Distribution in South Africa - KWAZULU-NATAL: Port Edward, rocks (Silva 1994).

A. sesciacensis Frémy, *Bull. Mus. nat. D'hist. nat.*, 383. 1928. (Figure 16)

Colonies amorphous, mucilaginous envelopes colourless, homogeneous, not evident; cells sub-sphaerical (8.7–)10.0–13.4 µm diam.; protoplast olive-green yellowish, homogeneous.

Distribution in South Africa - First record for the occurrence of the species.

Aphanocapsa sp. (Figures 17–18)

Colonies amorphous, mucilaginous envelopes colourless, homogeneous, not evident; cells sub-sphaerical, 2.5–3.7(–4.1) µm diam.; protoplast blue-green or yellowish-green, homogeneous.

Three populations of *Aphanocapsa* sp. were found: one on *Bostrychia* spp., one on *Calothrix pilosa* (Harv.) Born. et Flah. and one on rocks. The mucilaginous envelope is always very delicate and a dilute solution of methylene blue was added to highlight the entire colony (Figures 17–18). Further culture studies are necessary to confirm the precise taxonomic position of this organism.

Genus *Merismopedia* Meyen

M. affixa P. Richt., *Ber. Naturf. Ges. Leipzig*, 152. 1894. (Figure 19)

Colonies square, mucilaginous envelopes colourless, homogenous, not evident; cells sub-sphaerical to elliptical, 4, 8 or 16 cells in a colony, 1.8–2.1 µm wide, 1.8–2.8 llm long; protoplast blue-green, homogeneous.

Distribution in South Africa - First record for the occurrence of the species.

The populations of *Merismopedia affixa* were found on sand grains and also as epiphytes on *Calothrix crustacea* Thur. ex Born. et Flah. There was no morphological variation due to the habitat. Most of the colonies found consisted of up to 16 cells (Figure 19). Geitler (1932) reported colonies with a maximum number of 32 cells.

M. glauca (Ehrenb.) Näg., *Gatt. einzell. Alg.* 55. 1849. (Figures 20–21)

Colonies square, mucilaginous envelopes usually not evident; cells sub-sphaerical to oblong, up to 100 cells in a colony, 3.7–4.6 µm wide, 5.0–5.6 µm long; protoplast blue-green, homogeneous.

Distribution in South Africa - EASTERN CAPE: Quingolo, Mganduli district, in pools; On *Typha* in exposed stream; floating in stream (Fritsch & Stephens 1921). FREE STATE: Modder River (Fritsch 1918). KWAZULU-NATAL: Edenvale (Fritsch & Rich 1924). NORTHERN CAPE: Griqualand West (Fritsch & Rich 1930); Little Namaqualand and Cape region between Ceres and Karoopoort (West 1912). NORTH-WEST: Brakpan (Rich 1932; Nygaard 1932). NORTHERN PROVINCE: Belfast Pan (Fritsch & Rich 1938). Without precise location: Wille, in 1903, (according to Fritsch & Stephens 1921).

Colonies of *Merismopedia glauca* consisted of up to 100 cells (Figures 20–21). Geitler (1932) reports colonies with a maximum number of 64 cells. However, in the literature larger colonies with up to 150 cells have already been reported (Kaas 1985).

M. litorale (Oerst.) Rabenh., *Fl. Eur. Alg.* 2: 57. 1865. (Figures 22–23)

Colonies usually square, mucilaginous envelopes colourless, homogeneous; cells sub-sphaerical to elliptical, up to 55 cells in a colony, 6.0–6.5 µm wide, 6.2–8.4 µm long; protoplast violet, homogeneous.

Distribution in South Africa - First record for the occurrence of the species.

The studied specimens agree with the description in Geitler (1932), except that he reported colonies with a maximum of 32 cells.

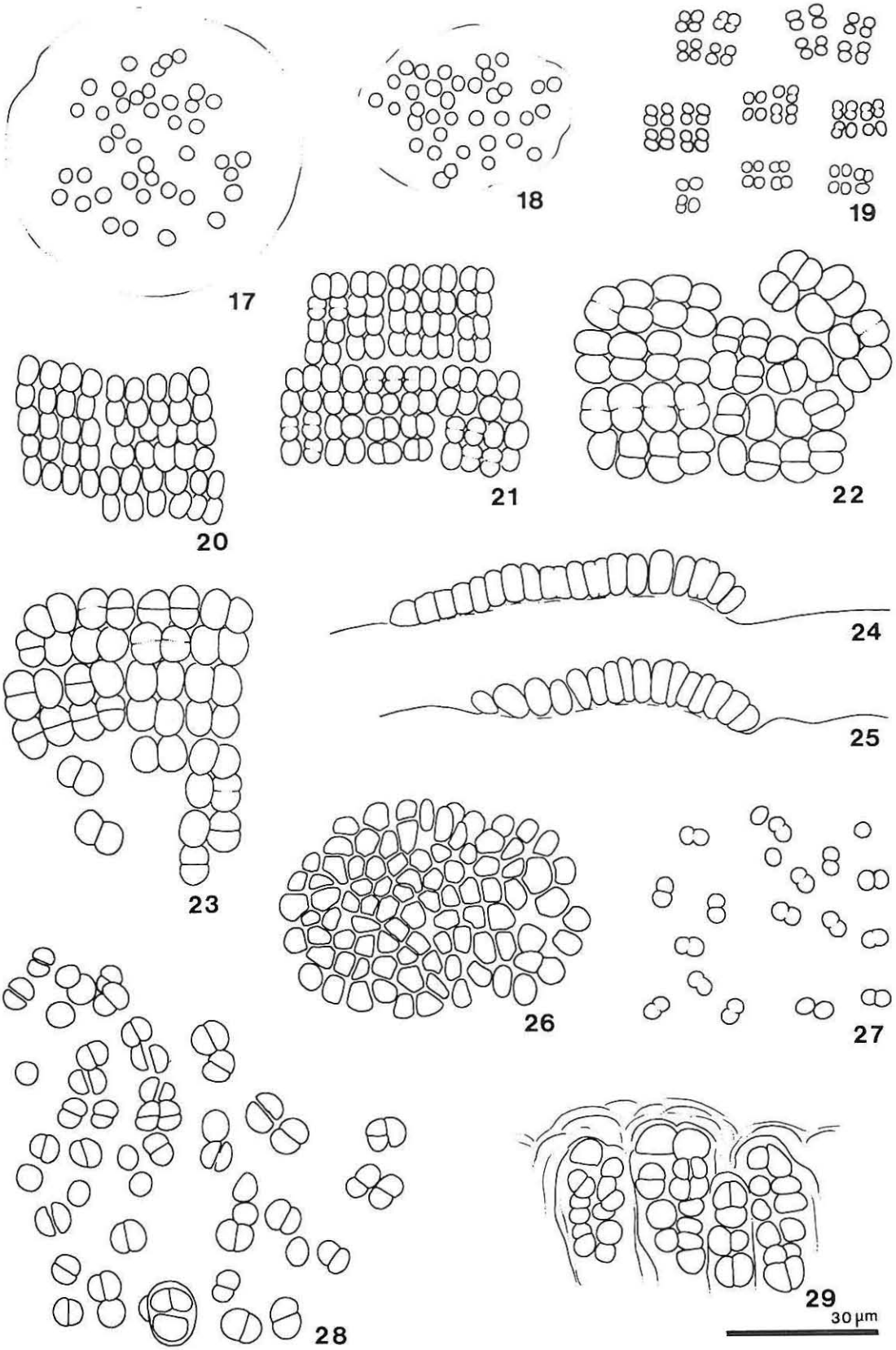
Genus *Microcrocis* P. Richt.

M. sabulicola (Lagerh.) Geitl., in Engler & Prantl, *Nat. Pflanzenfam.* Ib, 56. 1942. (Figures 24–26).
Syn.: *Holopedia sabulicola* (Lagerh.) Kirchn., in Engler-Prantl, *Nat. Pflanzenf.* I: 57. 1900.

Colonies slightly curved, mucilaginous envelopes colourless, homogeneous; cells isodiametric (front view), oblong or elliptical (side view), closely packed, usually polygonal in large clusters, 2.5–4.6 µm wide, 4.6–8.4 µm long; protoplast blue-green, homogeneous.

Distribution in South Africa - First record for the occurrence of the genus.

The cells of *Microcrocis sabulicola* from South Africa are slightly longer (Figures 24–25) than the Danish specimens



Figures 17–29 **17–18**: *Aphanocapsa* sp. **19**: *Merismopedia affixa* (colonies of varying cell number). **20–21**: *M. glauca* (part of colonies). **22–23**: *M. litorale* (part of colonies). **24–26**: *Microcrocis sabulicola* (24–25: side view; 26: front view). **27**: *Synechocystis aquatilis* f. *salina* **28–29**: *Gloeocapsa crepidinium* (28: surface view, mucilaginous envelope not represented; 29: side view).

reported by Kaas (1985) and Geitler ((1932) as *Holopedia sabulicola*). Both authors reported cell lengths ranging from 3.0–6.0 µm.

Genus *Synechocystis* Sauv.

S. aquatilis Sauv. f. *salina* Kom., *Arch. Protistenk.* 118: 132. 1976. (Figure 27)
Syn.: *S. salina* Wisl., *Acta Soc. Bot. Polon.* 2: 111. 1924.

Cells single or in groups of two, sub-sphaerical, 2.8–3.7 µm diam.; protoplast blue-green, homogeneous.

Distribution in South Africa - First record for the occurrence of the genus.

Genus *Gloeocapsa* Kütz.

G. crepidinium Thuret, in Born. et Thur., *Notes algolog.* 1: 1. 1876. (Figures 28–29)

Colonies macroscopic, green, lobed, outer mucilaginous envelopes firm, colourless; cells sub-sphaerical, oblong to hemi-sphaerical, 3.7–7.5(–8.4) µm wide, 2.8–4.3(–6.5) µm long. Individual envelopes yellow, usually surrounding small groups of cells, seldom lamellated, protoplast bluegreen, homogeneous.

Distribution in South Africa - First record for the occurrence of the species.

Developmental and culture studies on *Gloeocapsa* Kütz. have been reported in literature (Golubic 1965; Nielsen 1973; Komárek 1993) due to the morphological variation within the species. In our samples the individuals of *Gloeocapsa crepidinium* developed firm mucilaginous envelopes. This characteristic makes the study of the organisms very difficult, especially in the identification of the planes of cell division. In side view (Figure 29) the cells are in groups surrounded by a common mucilaginous envelope. In plan view (Figure 28) the cells seems to be apart from the others.

G. cf. *gelatinosa* Kütz., *Phyc. gen.* 174. 1843. (Figure 30)

Colonies usually amorphous, rarely oblong, mucilaginous envelopes colourless, homogeneous; cells sphaerical, 2.5–4.6 µm diam. with envelopes 5.3–8.7 µm diam. protoplast blue-green, homogeneous.

Distribution in South Africa - First record for the occurrence of the species.

The specimens we found are morphologically similar to *Gloeocapsa gelatinosa*, but differ in their habitat. The type species was described from thermal habitats (Geitler 1932; Dor 1967).

Genus *Chroococcus* Näg.

C. cf. *distans* (G.M. Smith) Komárková- Legnerová & Cronberg, *Algol. Stud.* 72: 26. 1994. (Figure 32)
Basyon.: *Chroococcus* cf. *limneticus* Lemm. var. *distans* G.M. Smith, Phytopl. Lakes Wisc. 1: 30. 1920.

Colonies usually amorphous, rarely sub-sphaerical, mucilaginous envelopes colourless, homogeneous, usually not evident; individual envelopes evident or not; cells sub-sphaerical to hemi-sphaerical, (2.5–)3.7–4.6(–6.5) µm wide, 4.0–6.5 µm long; protoplast blue-green, homogeneous.

Distribution in South Africa - NORTHERN PROVINCE: Belfast Pan (Fritsch & Rich 1938).

The specimens of *Chroococcus* Näg. from South Africa resemble *C. distans* but differ in their habitat and the slightly smaller cell size (Geitler 1932; Hindak & Moustaka 1988; Compère 1991). The number of cells per colony was not included in the description of the type species due to the mucilaginous envelopes not being very distinct.

C. cf. *minor* (Kütz.) Näg., *Gatt. einzell. Alg.*, 47. 1849. (Figure 31)

Colonies usually sub-sphaerical, aggregated, 5.9–11.8 µm diam., mucilaginous envelopes colourless, homogeneous; cells hemi-sphaerical, usually up to 4 cells in a colony, 2.1–3.4(–4.0) µm wide, 1.5–2.1(–3.7) µm long; protoplast blue-green, homogeneous.

Distribution in South Africa - EASTERN CAPE: In Pools of Buffalo River, King William's Town (Fritsch & Stephens 1921). NORTHERN CAPE: Karoo, Little Namaqualand- and Great Namaqualand (West 1912). NORTHERN PROVINCE: Belfast Pan (Fritsch & Rich 1938). WESTERN CAPE: Stellenbosch (Hodgetts 1926).

Although this species has been proposed based on freshwater material (Geitler 1932), it has already been reported in the literature for marine habitats (D'Hont & Coppejans 1988).

C. cf. *minutus* (Kütz.) Näg., *Gatt. einzell. Alg.*, 46. 1849. (Figures 33–40)

Colonies sub-sphaerical or elliptical, 12.8–20.9 µm wide, 17.5–25.0 µm long., mucilaginous envelopes colourless, slightly lamellated; cells hemi-sphaerical, up to 2–3(–4) cells in a colony, 9.0–13.4(–15.0) µm wide, 6.5–9.3 µm long; protoplast blue-green, finely granular.

Distribution in South Africa - EASTERN CAPE: Kentani, Qolora River (Fritsch & Stephens 1921). WESTERN CAPE: Stellenbosch flats (Hodgetts 1926); Table Mountain (Fritsch 1918). NORTHERN CAPE: Griqualand West (Fritsch & Rich 1930); Great Namaqualand (West 1912). Without precise location: Wille, in 1903, according to Fritsch (1918).

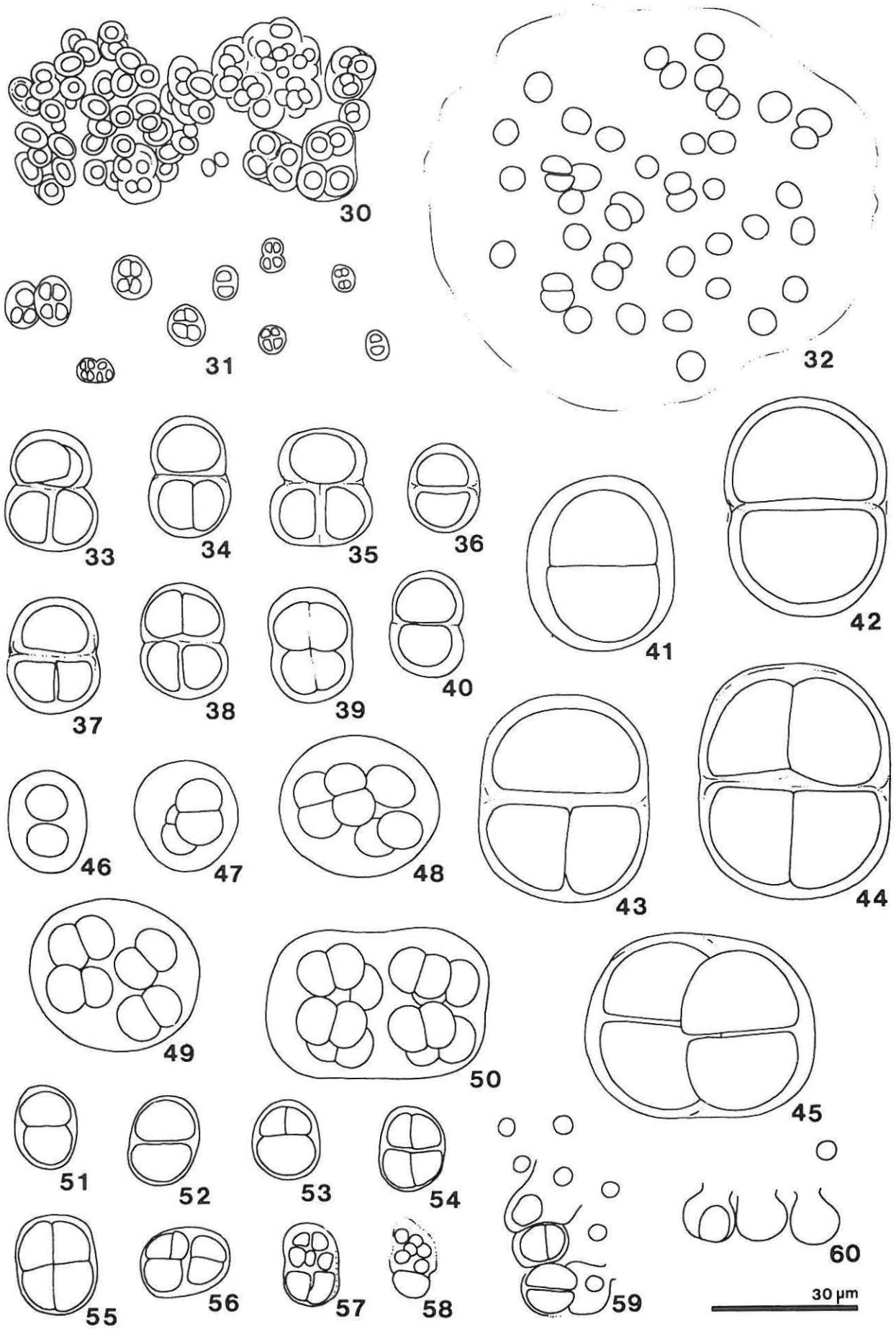
The material of *Chroococcus minutus* from the Western Cape is similar to the ones reported in the literature (Geitler 1932; Kovácik 1988) but it differs in the habitat and the slightly wider cells. The studied specimens are slightly wider than those reported by Geitler (1932) who reported cell width excluding the mucilaginous envelope ranging from 4.0 up to 10.0 µm, without the mucilaginous envelopes. The difficulty in the identification of this species has already been reported in the literature (Komárek & Novelo 1994). These authors stated that the simple morphology of this species has sometimes led to misidentification. They also commented that specimens from aerophytic, thermal and saline waters probably do not belong to this particular species as it was originally described from freshwater habitats.

C. cf. *turgidus* (Kütz.) Näg. var. *maximus* Nyg., *Vidensk. Medd. Dansk nat. Fören. Kjabenh.* 82: 201. 1926. (Figures 41–45).

Colonies sub-sphaerical or oblong, 21.2–40.0 µm wide, 22.1–48.7(–62.8) µm long, mucilaginous envelopes colourless, usually not lamellated; cells hemi-sphaerical, 2–4 cells in a colony, 19.6–35.9(–39.6) µm wide, 11.2–21.2(–30.3) µm long.; protoplast green, olive-green or brownish, granular.

Distribution in South Africa - First record for the occurrence of the variety.

Our material was found on a variety of substrata; namely Abalone shells, rock, sand and concrete wall. According to Geitler (1932) this organism is planktonic. In Southern Africa, Rino (1972) reported this variety growing mixed with freshwater aquatic plants.



Figures 30–60 **30**: *Gloeocapsa* cf. *gelatinosa*. **31**: *Chroococcus minor* (colonies or varying cell number). **32**: *C.* cf. *distans*. **33–40:** *C.* cf. *minutus*. **41–45**: *C. turgidus* var. *maximus* (colonies of varying cell number). Figs. 46-50: Chroococcus sp. (colonies of varying cell number). **51–60**: *Chroococcidiopsis* sp 2 (51–56: cells prior to the formation of nanocytes; 57–58: nanocytes within the mother cell wall; 59–60: release ofthe nanocytes).

Chroococcus sp. (Figures 46–50)

Colonies sub-sphaerical to oblong, 16.2–32.5(–47.1) µm diam., mucilaginous envelopes colourless, homogeneous; cells sub-sphaerical to hemi-sphaerical, arranged in groups of 2–8, rarely 16 cells, 8.4–9.6 µm wide, 5.6–7.8 µm long; protoplast blue-green, homogeneous.

The Western Cape *Chroococcus* resembles some known planktonic species (*C. distans* and *C. limneticus* Lemm.). They differ from them (Senna 1992; Komárková-Legnerová & Cronberg 1994) by the larger size of the cells (Figures 46–50). However, cultural studies need to be undertaken to decide the precise taxonomic position of this organism.

Genus *Chroococcidiopsis* Geitl.

Chroococcidiopsis sp 1 (Figures 61–68)

Cells solitary or in clusters, surrounded by colourless, homogeneous mucilaginous envelopes, usually not evident; cells sub-sphaerical to hemi-sphaerical, 7.1–16.5 µm wide, 6.5–14.0 µm long; protoplast brownish, homogeneous; reproduction takes place by the production of up to 30 nanocytes, developed by the division of one or more daughter cells and released through the rupturing of the mother cell wall; nanocytes subsphaerical, 2.1–3.4 µm diam.

Our material does not agree with any of the described species of *Chroococcidiopsis* Geitl., and it differs in the habitat, cell size and the colour of the protoplasm. Further culture studies are still necessary to decide the precise taxonomic position of this organism.

Chroococcidiopsis sp 2 (Figures 51–60)

Cells solitary or in clusters, surrounded by colourless, homogeneous mucilaginous envelopes; cells sub-sphaerical or hemi-sphaerical, 5.6–12.5 µm wide, 4.6–7.8 µm long; protoplast olive-green, granular; reproduction takes place by the production of up to 8 nanocytes, developed by the division of one or more daughter cells, released through a rupture of the mother cell wall; nanocytes sub-sphaerical, 2.8–3.7(–4.6) µm diam.

The specimens resemble *Chroococcidiopsis thermalis* Geitl. but two main characteristics distinguish our specimens from the type species. *C. thermalis* occurs in thermal habitats (Komárek & Hindak 1975) and the cells of *Chroococcidiopsis thermalis* are reported to be slightly narrower (up to 10.0 µm) than those found in South Africa (Figures 51–60).

Genus *Cyanosarcina* Kovác.

C. cf. *chroococcoides* (Geitl.) Kovác., *Arch. Hydrobiol. Suppl.* 80, 1–4: 177. 1988. (Figures 69–72).
Syn.: *Myxosarcina chroococcoides* Geitl., *Arch Protistenk.* 60: 443. 1927.

Colonies sub-sphaerical or irregular, mucilaginous envelopes colourless, homogeneous; cells usually closely packed, hemi-sphaerical, sometimes polygonal, 5.0–9.0 µm wide, 3.1–7.1 µm long; protoplast brownish, rarely pink, homogeneous.

Distribution in South Africa - First record for the occurrence of the species.

Our samples of *Cyanosarcina chroococcoides* morphologically resemble those specimens of Geitler (1932) and Hoffmann (1986), but differ in their habitat.

Cyanosarcina sp. (Figures 83–87)

Colonies sub-sphaerical or oblong, up to 30.6 µm diam., mucilaginous envelopes colourless, homogeneous; cells usually closely packed, hemi-sphaerical, polygonal in older colonies, 3.1–11.5 µm wide, (2.5–)4.0–7.1 µm long.; protoplast olive-green or dark blue-green, homogeneous; nanocytes not observed.

These specimens are temporarily placed within the genus *Cyanosarcina* (Kovácik, 1988) due to the lack of nanocytes in both the wild and cultured material.

Genus *Myxosarcina* Printz

M. cf. *concinna* Printz, *K. Norske Vidensk. Selsk. Skrift.*, 35. 1920. (Figures 73–82)

Colonies sub-sphaerical, oblong or sometimes irregular, up to 50.0 µm diam., mucilaginous envelopes colourless, homogenous, usually not evident; cells usually sub-sphaerical or hemi-sphaerical, polygonal in older colonies, 2.8–8.4(–9.6) µm wide, 2.1–7.1 µm long; protoplast brownish, rarely blue-green, homogeneous; nanocytes sub-sphaerical, numerous, 1.5 µm diam.

Distribution in South Africa - KWAZULU-NATAL: Isipingo, on *Bostrychia* sp., *Ceramium* sp., *Cladophora* sp. and on rocks (Silva 1994).

Myxosarcina Printz from the Western Cape differs from *M. concinna* in the habitat in which occurs. The type species was described from subaerial samples (Geitler 1932). Our specimens were found on both shells and rocks, at three different localities.

Genus *Cyanocystis* Borzi

C. prasina (Reinsch) Kom. et Anagn., *Arch. Hydrobiol. Suppl.* 73,2: 203. 1986. (Figures 88–91)
Syn.: *Dermocarpa prasina* (Reinsch) Born. et Thur., *Notes Algolog* 2: 73–77. 1880.

Cells in hemi-sphaerical clusters, pyriforme, ellipsoidal or sub-sphaerical, 6.2–14.0 µm wide, 20.0–23.7 µm long; protoplast blue-green, violet or brownish, homogeneous; reproduction takes place by the production of up to 8 nanocytes, developed by the division of the entire cell, released through a rupture of the mother cell wall; nanocytes sub-sphaerical, 1.8–3.4 µm diam.

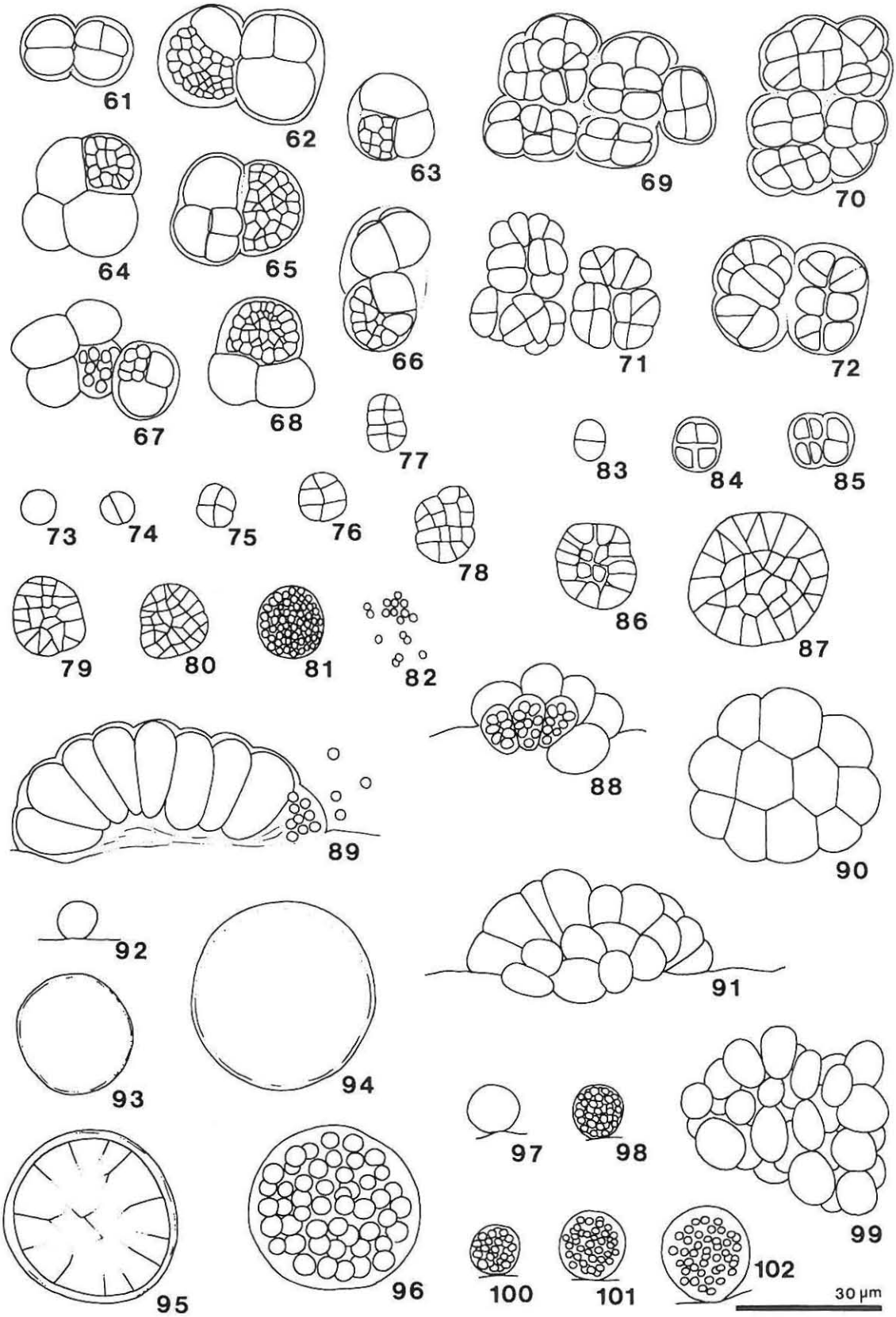
Distribution in South Africa - WESTERN CAPE: Knysna, on *Cladophora rupestris* (Barton 1893, Delf & Mitchell 1921, both as *Dermocarpa prasina*)

The specimens described from the Western Cape are not as large as those reported in the literature (Geitler 1932), which range from 4.0–24.0 µm wide and 15.0–30.0 µm long. Two populations from the Western Cape were studied (Table 2) and both were found as epiphytes on rhodophytes and resemble the specimens reported by in D'Hont and Coppejans (1988) and Ardré (1960). This is the first report of the genus *Cyanocystis* in South Africa.

Genus *Stanieria* Kom. et Anagn.

S. cf. *cyanosphaera* (Kom. et Hind.) Kom. et Anagn., *Arch. Hydrobiol. Suppl.* 73, 2: 208. 1986 (Figures 92–96).
Syn: *Chroococcidiopsis cyanosphaera* Kom. et Hind., *Algol. Stud.* 13: 320. 1975.

Cells single or in clusters, sub-sphaerical, up to 42.1 µm diam.; protoplast olive-green, brown or violet, homogeneous; nanocytes sphaerical, numerous, 3.0–3.7 µm diam., released by the rupture of the mother cell wall.



Figures 61–102 **61–68**: *Chroococcidiopsis* sp 1 (61: cells prior to the formation of nanocytes, 62–68: nanocytes within the mother cell wall). **69–72**: *Cyanosarcina* cf. *chroococcoides*. **73–82**: *Myxosarcina* cf. *concinna* (73: cell before the first cell division; 74–80: different stages of development prior to the formation of nanocytes; 81: nanocytes within the mother cell wall; 82: nanocytes after release). **83–87**: *Cyanosarcina* sp. (Different stages of development). **88–91**: *Cyanocystis prasina* (88–89, 91: side view of the cells; 90: surface view). **92–96**: *Stanieria* cf. *cyanosphaera* (92: side view of a cell on the substrate - not to scale, 93–94: cell prior to the formation of nanocytes; 95: beginning of the formation of nanocytes; 96: nanocytes whithin the mother cell wall). **97–102**: *S. sublitoralis* (97: side view, cell prior to the formation of nanocytes; 98, 100–102: nanocytes within the mother cell wall; 99: surface view of the cell on the substrate).

Table 1 Localities and habitat of marine Chroococcales (Cyanophyceae) from the Western Cape, South Africa

Aphanocapsa concharum	Lambert's Bay	rock
	Plettenberg Bay	concrete wall
A. litoralis	Kleinbaai	Abalone shell
	Plettenberg Bay	sand and concrete wall
A. sesciacensis	Lambert's Bay	rock
Aphanocapsa sp.	Hermanus	*Calothrix pilosa*
	Lambert's Bay	rock
	Plettenberg Bay	*Bostrychia* sp.
Aphanothece microspora	Knysna	rocks
A. nidulans	Fisherhaven	sand
	Lambert's Bay	rock
	Plettenberg Bay	concrete wall
A. cf. *stagnina*	Plettenberg Bay	sand
Chamaecalyx cf. *fucicola*	Kleinbaai	Abalone shell
C. cf. *sufultus*	Cape Agulhas	rock
C. cf. *swirenkoi*	Stanford Bay	rock
Chroococcidiopsis sp. 1	Knysna	rocks
Chroococcidiopsis sp. 2	Hermanus	rock
Chroococcus cf. *minor*	Knysna	rock
C. cf. *minutus*	Fisherhaven	sand
C. cf. *turgidus* var. *maximus*	Kleinbaai	Abalone shell and rock
	Knysna	rock
	Lambert's Bay	rock
	Plettenberg Bay	sand and concrete wall
	Stanford Bay	rock
C. cf.*distans*	Lambert's Bay	*Porphyra* sp.
	Plettenberg Bay	concrete wall
Chroococcus sp.	Plettenberg Bay	sand
Cyanocystis prasina	Cape Agulhas	rhodopyhte
	Knysna	rhodophyte
	Natures Valley	rhodophyte
Cyanosarcina cf. *chroococcoides*	Lambert's Bay	rock
Cyanosarcina sp.	Cape Agulhas	shell
	Hemanus	glass
	Knysna	rock
Gloeocapsa crepidinium	Hermanus	rock
	Knysna	rock
	Plettenberg Bay	concrete wall
Gloeocapsa cf. *gelatinosa*	Knysna	rock
	Plettenberg Bay	concrete wall
Hydrococcus rivularis	Knysna	*Bostrychia* sp.
	Plettenberg Bay	*Bostrychia* sp.
Hyella sp. 1		*Codium stephensiae* and
	Kleinbaai	Abalone shell
	Stanford Bay	rock
	Plettenberg Bay	rocks
Hyella sp. 2	Romensbaai	rock
	Stanford Bay	rock
H. immanis	Lambert's Bay	*Porphyra* sp.
Merismopedia affixa	Fisherhaven	sand
	Lambert's Bay	*Calothrix crustacea*

Table 1 Continued

M. glauca	Plettenberg Bay	sand
M. litorale	Knysna	rock
Microcrocis sabulicola	Cape Agulhas	rhodophyte
	Nature's Valley	rhodophyte
	Plettenberg Bay	rhodophyte
Myxosarcina cf. *concinna*	Cape Agulhas	shells
	Hermanus	rock
	Romensbaai	rock
Pleurocapsa crepidinium	Lambert's Bay	*Porphyra* sp.
P. minuta	Fisherhaven	sand
	Kleinbaai	rock
	Romensbaai	Abalone shell
P. cf. *minor*	Hermanus	stones
	Lambert's Bay	rock
	Stanford Bay	rock and Abalone shell
Stanieria cf. *cyanosphaera*	Cape Agulhas	rock
	Kleinbaai	sand and rock
	Knysna	rock
	Lambert's Bay	rock
	Nature's Valley	rock
	Plettenberg Bay	rock
	Stanford Bay	rock
S. sphaerica	Knysna	rock
	Plettenberg Bay	rhodophytes
S. sublitoralis	Hermanus	rock
	Nature's Valley	rock
	Plettenberg Bay	concrete wall
Stichosiphon mangle	Lambert's Bay	*Bostrychia* sp.
	Plettenbeg Bay	*Bostrychia* sp.
Synechococcus curtus	Fisherhaven	rock
Synechocystis aquatilis f. *salina*	Plettenberg Bay	rock

Distribution in South Africa - KWAZULU-NATAL: Isipingo, on *Centroceras* sp., on *Codium* sp., on *Crassostrea* sp., on *Gymnogongrus* sp. and on rocks (Silva 1994).

The specimens of *Stanieria cyanosphaera* agree with the description of the type species (Komárek & Hindák 1975), with the exception of the colour of the protoplast and the habitat.

S. sphaerica (Setch. et Gardn.) Anagn. et Pantaz., *Algol. Stud.* 64: 147. 1991. (Figures 103–109)
Syn.: *Dermocarpa sphaerica* Setch. et Gardn., in Gardn. *Univ. Cal. Publ.*, 457. 1918. *Cyanocystis sphaerica* (Setch. et Gardn.) Kom. et Anagn., *Arch. Hydrobiol./Suppl. 73;* 203. 1986.

Cells single or in clusters, sub-sphaerical, rarely polygonal when in clusters, 7.5–12.8 µm diam.; protoplast blue-green or brownish, homogeneous; nanocytes numerous, 1.5–3.1 µm diam., released by the rupture of the mother cell wall.

Distribution in South Africa - First record for the occurrence of the species.

Stanieria sphaerica was found both as an epilith and as an epiphyte on intertidal rhodophytes. No morphological variability was observed in populations from different habitats.

S. sublitoralis (Lindst.) Anagn. et Pantaz., *Algol. Stud.* 64: 145. 1991. (Figures 97–102)
Syn.: *Dermocarpa sublitoralis* Lindst., *Fl. Mar. Cyanophyc. Schwed. Westküste,* 30. 1943.

Cells single or in clusters, sub-sphaerical, rarely polygonal when in clusters, 9.3–14.0(–19.0) µm diam.; protoplast pale violet, homogeneous; nanocytes sub-sphaerical, numerous, 1.5–2.5 µm diam., released by the rupture of the mother cell wall.

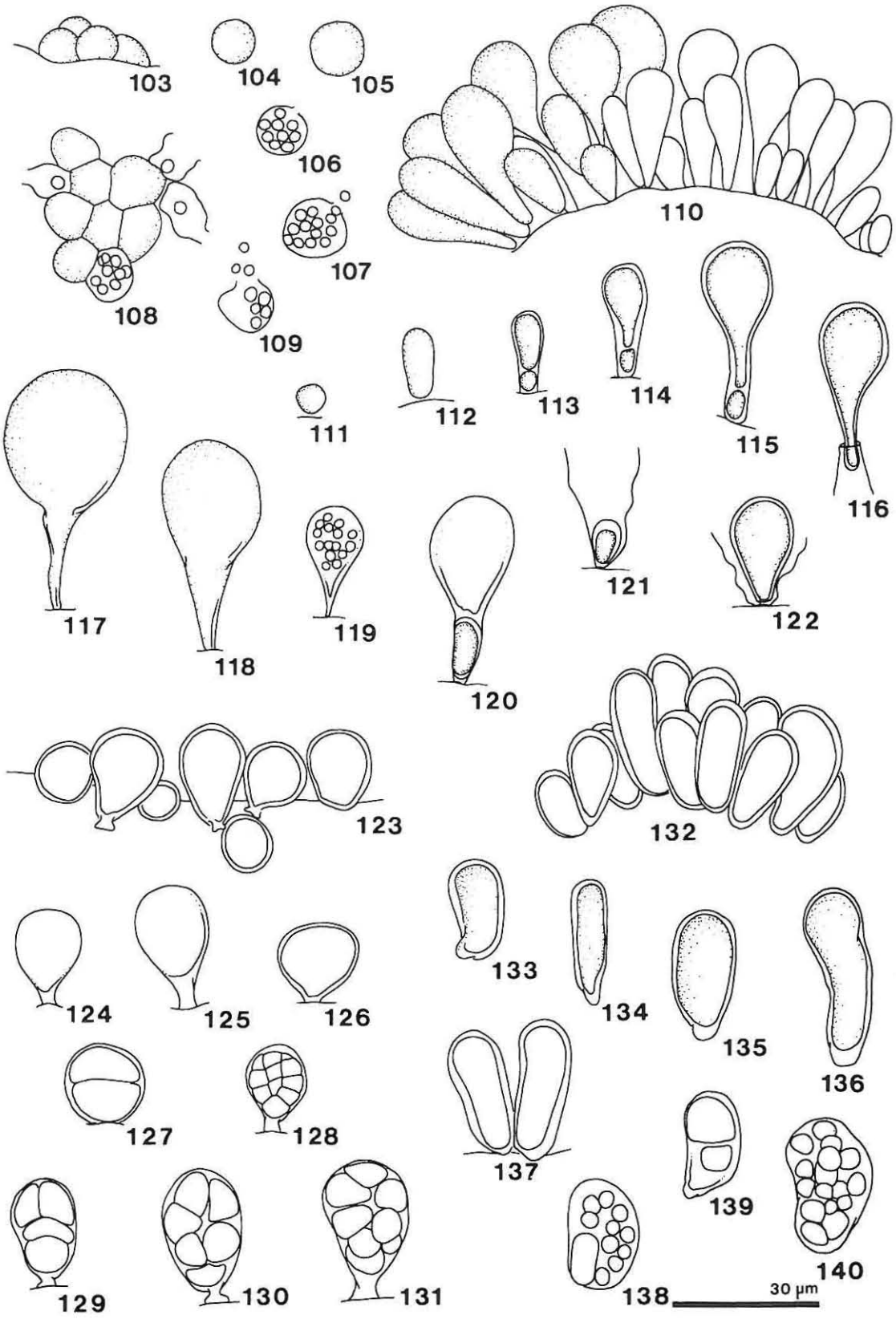
Distribution in South Africa - KWAZULU-NATAL: Isipingo, on *Codium* sp., *Bostrychia* sp. and on rocks; Palm Beach and Umdloti, on *Gelidium* sp. (Silva 1994).

Genus *Chamaecalyx* Kom. et Anagn.

C. cf. *fucicola* (Sauna.) Kom. et Anagn., *Arch. Hydrobiol. Suppl.* 73, 2: 199. 1986. (Figures 110–122)
Syn.: *Dermocarpa fulcicola* Saund., *Proc. Wash. Acad. Sci.* 3: 397. 1901.

Cells in hemi-sphaerical clusters, heteropolar, club-shaped, rarely stalked, straight or slightly bent, 12.5–25.3 µm wide at the apex, 3.1–5.3 µm wide at the base, 25.0–50.0 µm long.; protoplast violet, homogeneous; exocytes numerous, sub-sphaerical, 1.5 µm diam.; sterile basal portion club-shaped or oblong, 2.5–3.7(–5.3) µm wide, 4.0–6.8 µm long.

Distribution in South Africa - First record for the occurrence of the species.



Figures 103–140 **103–109**: *Stanieria sphaerica* (103: side view of cell on the substrate; 104–105: cells prior to the formation of nanocytes; 106–108: nanocytes within the mother cell wall; 109: release of nanocytes). **110–122**: *Chamaecalyx* cf. *fucicola* (111–112: initial stages of development; 113–116: heteropolar cells; 119: exocytes within the mother cell wall, sterile basal part not represented; 120–122: empty mother cell walls, sterile basal part represented). **123–131**: *C.* cf. *suffultus* (123–126: side view of the cells prior to the formation of exocytes; 127–128: beginning of the formation of exocytes; 128–131: exocytes within the mother cell wall). **132–140**: *C.* cf. *swirenkoi* (132–137: cells prior to the formation of exocytes; 139: beginning of the formation of exocytes; 138–140: exocytes within the mother cell wall).

Geitler (1932) reported much longer cells (40.0–120.0 µm) for this species (as *Dermocarpa clavata*) than the ones found in the Western Cape.

C. cf. *suffultus* (Setch. et Gardn.) Kom. et Anagn., *Arch. Hydrobiol. Suppl.* 73, 2: 199. 1986. (Figures 123–131)
Syn.: *Dermocarpa suffulta* Setch. et Gardn., *Univ. Cal. Publ. Bot.* 6: 440. 1918.

Cells single of in clusters, heteropolar, pear-shaped, usually with a short stalk, up to 4.0 µm long, usually straight, heteropolar, 9.6–17.5 µm wide at the apex, 7.5–9.3 µm at the base, 13.7–27.5 µm long; protoplast violet, homogeneous; exocytes ca. 8, polygonal before released, 5.0–8.7 µm diam.; sterile basal portion subsphaerical, hemi-sphaerical to polygonal, 7.8–9.0 µm wide, 4.0–7.8 µm long.

Distribution in South Africa - First record for the occurrence of the species.

The South African specimens of *Chamaecalyx* Kom. et Anagn. agree with the description of the type species of *Chamaecalyx suffultus*, except by possessing slightly longer cells (Geitler 1932: as *Dermocarpa suffulta*, up to 20.0 µm).

C. cf. *swirenkoi* (Širš.) Kom. et Anagn., *Arch Hydrobiol. Suppl.* 73, 2; 199. 1986. (Figures 132–140)
Syn.: *Dermocarpa swirenkoi* Širš., *Vizn. Dnipropetr. Gidrobiol. St.* 1 195. 1929. *Dermocarpa clavata* Geitl., *Rabenh. 's Krypt.-Fl.* 14:406. 1932.

Cells usually single or in clusters, heteropolar, oblong, with a very short stalk, up to 2.0 µm long, straight or slightly bent, heteropolar, 8.1–16.5 µm wide at the apex, 5.9–10.0 µm wide at the base, 14.6–37.5 µm long; protoplast olive-green, granular; exocytes ca. 12–16, sub-sphaerical, 3.1–3.7(–4.0) µm diam.; sterile basal portions hemi-sphaerical to polygonal, 5.9–10.9 µm wide, 5.3–5.6 µm long.

Distribution in South Africa - First record for the occurrence of the species.

Several developmental stages of *Chamaecalyx swirenkoi* reported by Hindák (1983; as *Dermocarpa swirenkoi*) were found in the wild material studied (Figures 132 and 139–140).

Genus *Stichosiphon* Geitl.

S. mangle Branco, Silva et Sant'Anna, *Taxon* 44, 393. 1995. (Figures 141–146)

Pseudofilaments solitary, elongated, straight or curved, 1.5–2.1 µm wide at the base, 2.5–3.7 µm in the middle, up to 52.5 µm long, mucilaginous envelopes thin, colourless, usually not evident when young; cells disc-shaped, up to 33½ times wider than long, 1.5–3.1 µm wide, 0.9–1.8 µm long; protoplast pale blue-green, homogeneous; apical cells hemi-sphaerical; exocytes numerous, ca. 35, usually biseriate, sub-sphaerical, 1.5–1.8 µm diam., released in groups, by the rupture of the mucilaginous envelopes at the apex of pseudofilaments.

Distribution in South Africa - First record for the occurrence of the genus.

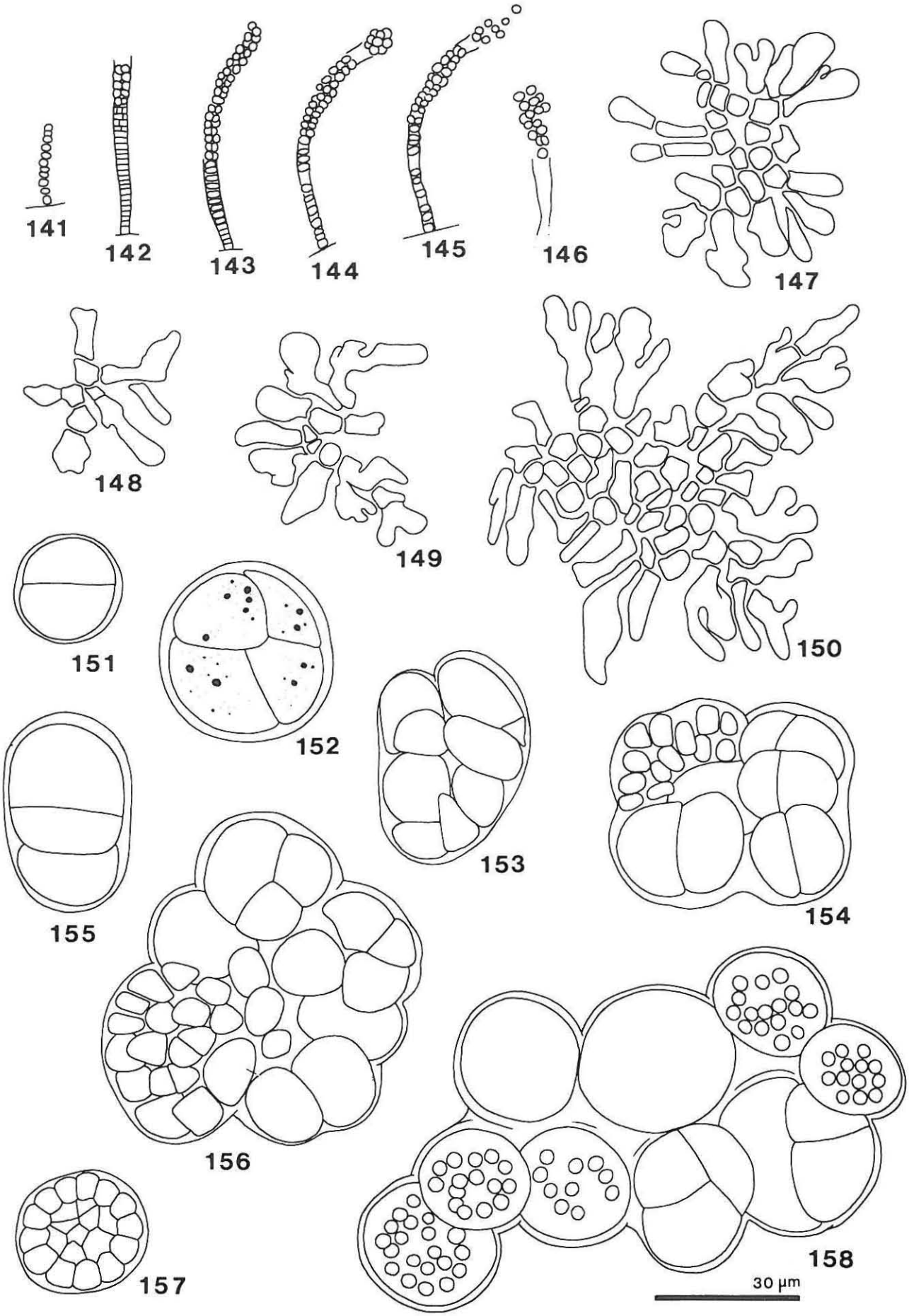
The specimens were found at two different locations in the Western Cape, both as epiphytes on *Bostrychia* sp. This agrees with the habitat of previously described specimens (Silva 1991, as *Stichosiphon* sp.; Branco *et al.* 1994, 1996).

Genus *Hydrococcus* Kutz.

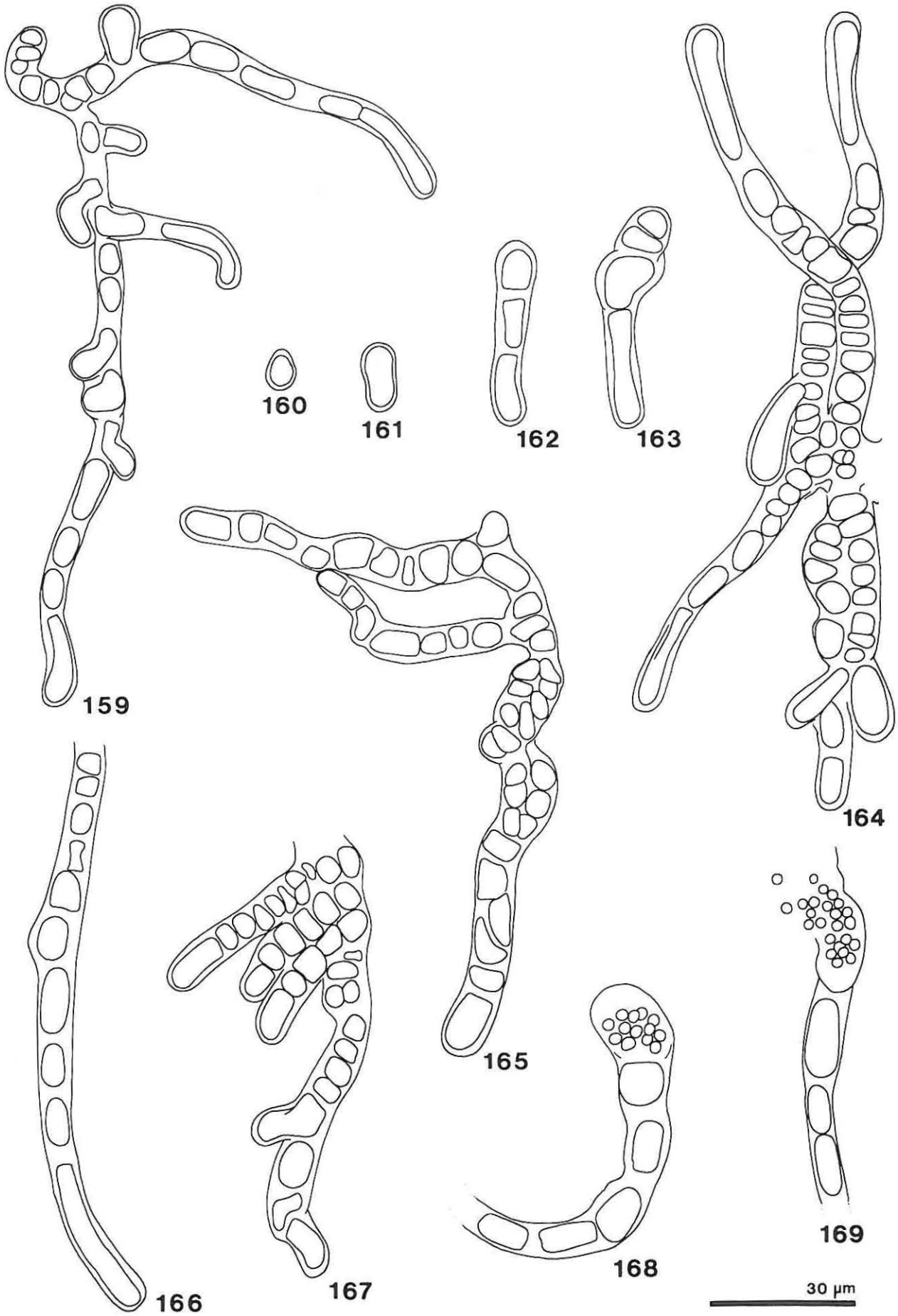
H. rivularis Kutz., *Linnaea* 380. 1833. (Figures 147–150)

Table 2 Taxa of *Chroococcales* (Cyanophyceae) from the Western Cape, South Africa

Microcystaceae Elenk.
Aphanothece microspora (Menegh.) Rabenh.
A. nidulans P. Richt.
A. stagnina (Spreng.) A. Br.
Synechococcus curtus Setch. in Collins *et al.*
Aphanocapsa concharum Hansgirg
A. litoralis Hansg.
A. seisciacensis Frémy
Aphanocapsa sp.
Merismopedia affixa P. Richt.
M. glauca (Ehr.) Kütz.
M. litorale (Oersted.) Rabenh.
Microcrocis sabulicola (Lagerh.) Geitl.
Synechocystis aquatilis Sauv. f. *salina* Kom.
Chroococcaceae Näg.
Gloeocapsa crepidinium Thur.
G. cf. *gelatinosa* Kütz.
Chroococcus cf. *distans* (G.M. Smith) Komárková-Legnerová & Cronberg
C. cf. *minor* (Kütz.) Näg.
C. cf. *minutus* (Kütz.) Näg.
C. cf. *turgidus* (Kütz.) Näg. var. *maximus* Nyg.
Chroococcus sp.
Cyanosarcina cf. *chroococcoides* (Geitl.) Kov.
Cyanosarcina sp.
Chamaesiphonaceae Borzi
Chamaecalyx cf. *fucicola* (Saund.) Kom. et Anagn.
C. cf. *suffultus* (Setch. et Gardn.) Kom. et Anagn.
C. cf. *swirenkoi* (Širš.) Kom. et Anagn.
Stichosiphon mangle Branco, Silva et Sant'Anna
Dermocarpellaceae Ginsb.-Ardré ex Christ.
Cyanocystis prasina (Reinsch.) Kom. et Anagn.
Stanieria cf. *cyanosphaera* (Kom. et Hind.) Kom. et Anagn.
S. sublitoralis (Lindst.) Anagn. et Pantaz.
S. sphaerica (Setch. et Gardn.) Kom. et Anagn.
Xenococcaceae Erceg.
Chroococcidiopsis sp. 1
Chroococcidiopsis sp. 2
Myxosarcina cf. *concinna* Printz
Hydrococcaceae Kütz.
Hydrococcus rivularis Kütz.
Hyella immanis Al-Thukair et Golubic
Hyella sp. 1
Hyella sp. 2
Pleurocapsa crepidinium Coll.
P. cf. *minor* Hansg. *em.* Geitl.
P. minuta Geitl.



Figures 141–158 **141–146**: *Stichosiphon mangle* (141: pseudofilament prior to the formation of exocytes; 142: pseudofilaments bearing exocytes; 143–146: release ofexocytes). **147–150**: *Hydrococcus rivularis* (surface view of pseudofilaments). **151–158**: *Hyella immanis* (151–153, 155: ceils prior to the formation of nanocytes; 154, 157–158: nanocytes within the mother cell wall).



Figures 159–169 *Hyella* sp. 1 (159, 164–167: pseudofilaments of varying stages of development; 160–163: beginning of development of pseudofilaments; 168: nanocytes within the mother cell wall, 169: release of nanocytes).

Thallus discoidal, pseudoparenchymatous; pseudofilaments usually branched, radially arranged; mucilaginous envelopes thin, colourless, homogeneous, usually not evident; cells square or polygonal, usually as wide as long, rarely longer, 3.1–5.0 µm wide, 3.4–7.1 µm long; protoplast blue-green, homogeneous; apical cells variable, cylindrical or bifid, up to 6½ times longer than wide, 3.4–7.1 µm wide, 9.3–26.2 µm long.

Distribution in South Africa - KWAZULU-NATAL: Kosi Bay, Richards Bay, Mlalazi, Beachwood estuaries (Lambert *et al.* 1989). EASTERN CAPE: Mnzamba, Mntafufu, Mngazana, Mtata, Xora, Mbashe, Nxaxo, Kobonqaba, Kwelera and Nahoon estuaries (Lambert *et al.* 1989).

In southern Africa, *Hydrococcus rivularis* has already been reported as epiphyte of *Bostrychia* sp., collected in a mangrove area at Inhaca Island, Mozambique (Silva 1991)

Genus *Hyella* Born. et Flah.

H. immanis Al-Thuk. et Golub., *J. Phycol* 27(6): 768. 1991. (Figures 151–158)

Thallus composed of cocoid cells at the substrate surface and radiating pseudofilaments; branching not observed; pseudofilaments rare, uniseriate, up to 22.8 µm wide; mucilaginous envelopes thin, not lamellated, colourless; cells usually square, polygonal or hemi-sphaerical, 11.5–23.7(–37.8) µm wide, 9.6–21.5 µm long; protoplast olive-green or brown, homogeneous or granular; nanocytes sub-sphaerical, 2.1–3.1 µm diam.

Distribution in South Africa - Lambert's Bay, Port Alfred and Sodwana Bay (Silva & Pienaar 1998b).

This species was recently described by Al-Thukair and Golubic (1991) based on material collected along the Saudi Arabian coast. Our specimens of *Hyella immanis* match the original description by Al-Thokair and Golubic (1991), but pseudofilaments were rarely observed in the wild material.

Hyella sp 1. (Figures 159–169)

Thallus composed of coccoid cells and radiating pseudofilaments; branching frequent, initiated by protrusion of the proximal or distal end of an intercalary cell, rarely by the slippage of an intercalary cell; pseudofilaments usually flexnous, uniseriate, biseriate proximally, 5.0–9.6 µm wide, mucilaginous envelopes thin, not lamellated, colourless; intercalary cells oblong to cylindrical, sub-sphaeric, square or polygonal proximally, up to 4 times longer than wide, 4.0–5.9 µm wide, (2.8–)3.7–20.0 µm long; protoplast blue-green, violet or olive green, homogeneous or finely granular; apical cells clavate or cylindrical, up to 9 times longer than wide, (3.1–)3.4–5.0(–6.8) µm wide, 11.8–45.3 µm long; nanocytes sub-sphaerical, polygonal before released, 1.5–2.1(–2.8) µm diam.

These specimens of *Hyella* were found at three different localities associated with cultures of *Codium stephensiae*, Abalone shells and rocks and were very abundant. Unialgal cultures of this organism have been obtained and developmental studies are being carried out to determine the specific identification of these organisms.

Hyella sp 2. (Figures 170–180)

Thallus composed of coccoid cells and radiating pseudofilaments; branching frequent, initiated by the protrusion of an intercalary cell; pseudofilaments usually straight, uniseriate, up to 15.6 µm wide; mucilaginous envelopes thin, not lamellated, colourless; intercalary cells square to oblong, up to 2 times longer than wide, 5.9–11.8 µm wide, (3.7–)5.0–14.0(–20.6) µm long; protoplast olive-green or brownish, granular; apical cells usually cylindrical or clavate, rarely bifid, up to 8 times longer than wide, (5.0–)5.9–11.2 µm wide, 10.3–71.9 µm long; nanocytes sub-sphaerical, polygonal before released, 2.8–3.1 µm diam.

Genus *Pleurocapsa* Thur. ex Hauck

P. crepidinium Collins, *Rhodora* 136. 1901. (Figures 181–186)

Cells usually in irregular clusters, colonial or pseudofilamentous organization, pseudofilaments usually not evident, mucilaginous envelopes thin, colourless, homogeneous; cells sub-sphaerical, hemi-sphaerical or polygonal, 5.9–11.2 µm wide, (4.3–)5.0–12.5 µm long, protoplast blue-green, homogeneous; nanocytes sub-sphaerical, up to 9 in the mother cell, 2.5–3.1 µm diam.
Distribution in South Africa - First record for the occurrence of the species.

In culture, pseudofilaments of *Pleurocapsa crepidinium* are restricted to part of its life cycle (Figures 183–185). Older cultures usually display both filamentous and colonial organtzation.

P. cf. *minor* Hansg. *em.* Geitl., *Arch. f. Protist.* 51: 347. 1925. (Figures 187–192)

Cells usually in irregular clusters, colonial or pseudofilamentous organization; pseudofilaments distinct, uniseriate, 9.3–12.1 µm wide, up to 52.1 µm long, mucilaginous envelopes thick, up to 3.1 µm wide, colourless in young cells, otherwise yellow, homogeneous; cells sub-sphaerical, hemi-sphaerical, polygonal, oblong or transversally elliptical, 3.4–9.6 µm wide, 4.6–7.1 µm long; protoplast brown, olive-green or pink, homogeneous or granular; nanocytes sub-sphaerical, 1.5–2.1 µm diam.

Distribution in South Africa - First record for the occurrence of the species.

Characteristics of the apical cell were not included in the description due to its absence from the studied material. Pseudofilaments were often found in the wild material but probably due to the age of the sampled specimens, the mucilaginous envelopes were usually found empty at the apex of the pseudofilaments (Figures 187–188). According to Geitler (1932) the type species was described from a freshwater habitat.

P. minuta Geitl., *Rabenh. 's Krypt.-Fl.* 14: 355. 1932. (Figures 193–197)

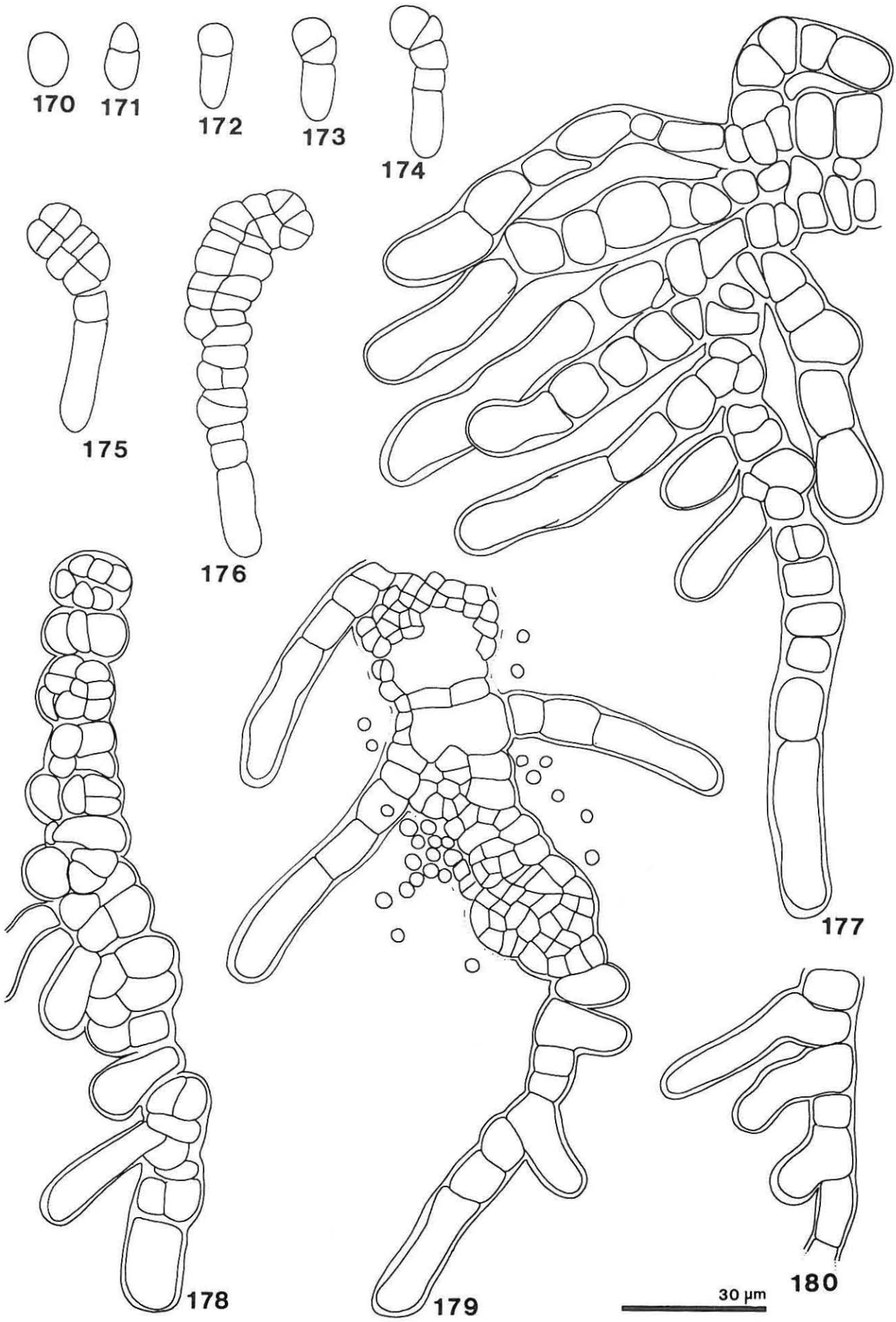
Cells in clusters, almost entirely in pseudofilamentous forms, pseudofilaments very distinct, parallel, close to one another, uniseriate, rarely biseriate, 6.5–9.6 µm wide, up to 56.5 µm long, mucilaginous envelopes thick, up to 3.1 µm wide, colourless, homogeneous; intercalary cells sub-sphaerical, square, oblong or transversally elliptical, (2.8–)4.0–7.8 µm wide, (1.8–)2.5–7.1 µm long, protoplast olive-green or blue-green, homogeneous; apical cells up to 2 times longer than wide, (3.7–)4.3–7.1 µm wide, (3.7–)4.6–12.1 µm long.; nanocytes not observed.

Distribution in South Africa - First record for the occurrence of the species.

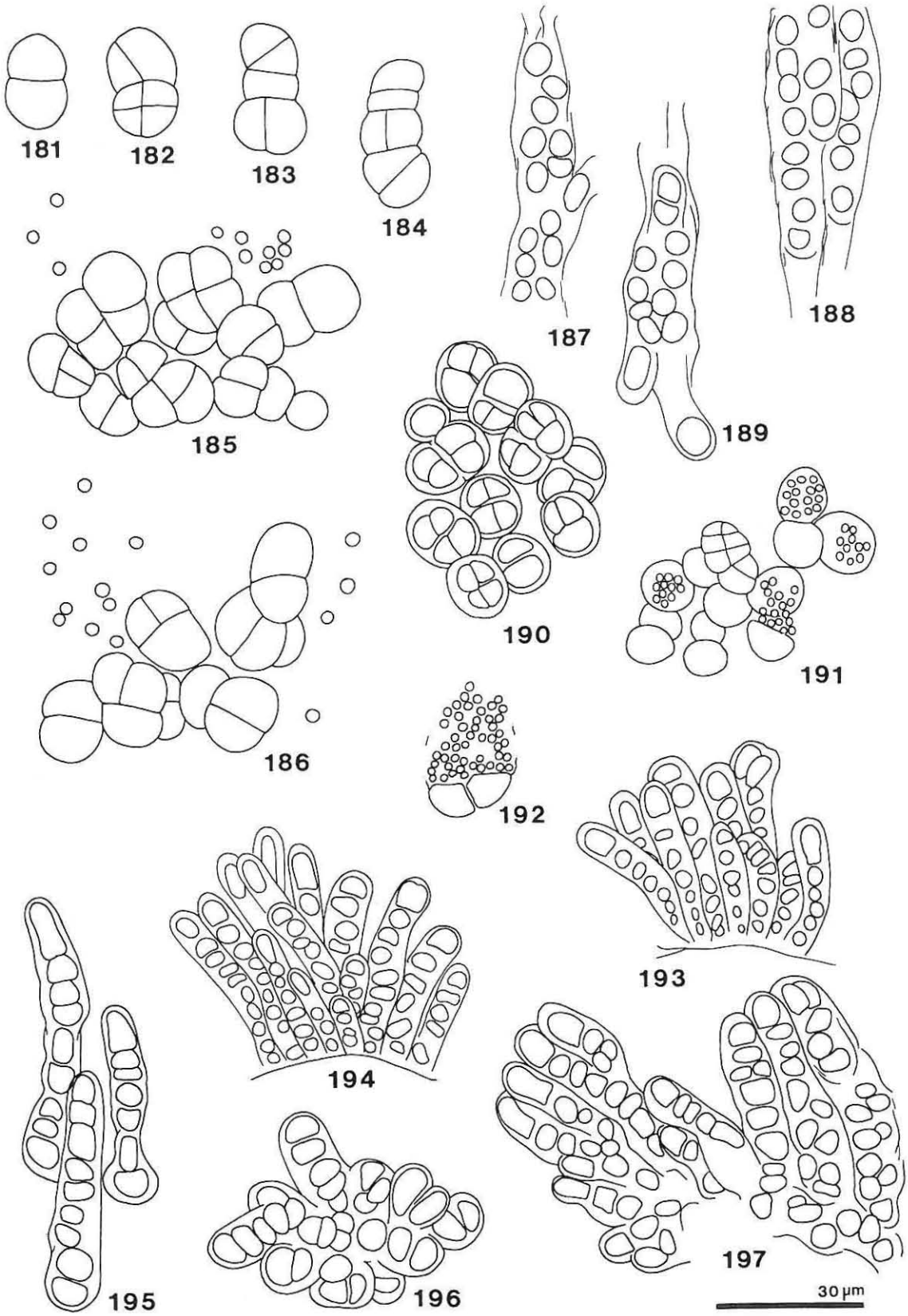
Pleurocapsa minuta from three different locations were studied. The specimens were found on sand, rocks and Abalone shells Specimens growing on rocks and on sand have slightly smaller size of cells than those growing on shells (Figures 193-194).

Morphological and size variability in the species was common. In addition, some specimens were very similar to the type description but came from very different habitats. As a result, the species name has been assigned with some hesitation.

Six of the studied taxa did not fit into the known species



Figures 170–180 *Hyella* sp. 2 (170–176: beginning of development of pseudofilaments; 177–178, 180: pseudofilaments showing lateral branching; 179: release of nanocytes).



Figures 181–197 **181-186**: *Pleurocapsa crepidinium* (181–184: beginning of the formation of pseudofilaments; 185–186: release of nanocytes). **187–192**: *P.* cf. *minor* (187–188: pseudofilaments; 190: colonies of varying cell number; 191: nanocytes within the mother cell wall; 192: release of nanocytes). **192–197**: *P. minuta* (pseudofilaments).

described to date, so no specific name was assigned to them. Cultural studies and additional systematic sampling needs to be carried out before new taxa can be proposed.

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