Phytotaxa 359 (1): 001–166
http://www.mapress.com/j/pt/

Monograph

ISSN 1179-3155 (print edition)
PHYTOTAXA
ISSN 1179-3163 (online edition)

https://doi.org/10.11646/phytotaxa.359.1.1

PHYTOTAXA

359

Freshwater Cyanobacteria of North-Eastern Australia: 3. Nostocales

GLENN B. MCGREGOR
Queensland Department of Environment and Science, GPO Box 2454, Brisbane, Qld, 4001, Australia.
Email: glenn.mcgregor@qld.gov.au

Magnolia Press
Auckland, New Zealand

Accepted by Karolina Fucíková: 3 May 2018; published: 9 Jul. 2018

GLENN B. MCGREGOR
Freshwater Cyanobacteria of North-Eastern Australia: 3. Nostocales
(*Phytotaxa* 359)
166 pp.; 30 cm.
9 July 2018
ISBN 978-1-77670-408-8 (paperback)
ISBN 978-1-77670-409-5 (Online edition)

FIRST PUBLISHED IN 2018 BY
Magnolia Press
P.O. Box 41-383
Auckland 1346
New Zealand
e-mail: magnolia@mapress.com
http://www.mapress.com/j/pt/

ISSN 1179-3155 (print edition)
ISSN 1179-3163 (online edition)

CONTENTS

ABSTRACT

This is the first detailed account of the Nostocales of north-eastern Australia, and the third and final volume in the series documenting the freshwater cyanobacterial flora of this region. This monophyletic group comprises filamentous cyanobacteria which produce heterocytes and akinetes. Amongst the cyanobacteria, this group is perhaps the most morphologically diverse, occurring as single filaments, unstructured aggregations, or colonies of various arrangements, which may exhibit false-, true-, or no-branching. This volume provides keys, morphological and ecological data, and photomicrographs for 35 genera, and 93 species from nine families to enable the identification of natural populations based on stable and recognizable characters observable by light microscopy. Distributional data are based on extensive surveys incompassing 358 sites which represent the major freshwater habitats of the region including rivers and streams, palustrine and lacustrine wetlands, thermal springs, and artificial reservoirs, as well as a review of the Australian phycological literature.

INTRODUCTION

This is the third and final volume in the series documenting the freshwater cyanobacterial flora of north-eastern Australia. Thirty five genera, and 93 species from nine families of the Order Nostocales are presented. This monophyletic group comprises filamentous cyanobacteria which produce heterocytes and akinetes. Amongst the cyanobacteria, this group is amongst the most morphologically diverse, occurring as single filaments, unstructured aggregations, or colonies of various arrangements, which may exhibit false-, true-, or no-branching.

Within the aquatic domain, they occupy a wide variety of habitats, in a range of forms, including macroscopic benthic mats, floating metaphytic aggregations amongst submerged and emergent aquatic vegetation, and they are often the dominant component of phytoplankton communities in lakes and reservoirs. In Australia, as elsewhere, some heterocytous species commonly form blooms, impacting water quality, recreational amenity, and aquatic ecosystem health. Noteworthy are *Raphidiopsis raciborksii*, *Dolichospermum circinale*, and *Chrysosporum ovalisporum*. All three species produce potent cyanotoxins, have widespread distributions in Australia, and over past decades, have been associated with recurrent blooms in major water supply reservoirs, ornamental lakes, and farm dams. Cyanotoxin production has also been associated with benthic species including *Nostoc linckia* (Gaget *et al.* 2017) and *Iningainema pulvinus* (McGregor & Sendall 2017). However, most species are not problematic, rather due to their ability to access nitrogen not often accessible to other algae, heterocystous cyanobacteria are important contributors to ecosystem primary productivity across a range of habitats including lakes (Cottingham *et al.* 2015), rivers (Townsend & Douglas 2017), and tropical floodplain wetlands (Adame *et al.* 2017).

This volume includes keys, morphological and ecological data, and photomicrographs to enable the identification of natural populations of heterocystous cyanobacteria based on mostly stable and recognisable characters observable with the aid of light microscopy. Distributional data are based on extensive surveys carried out by the author at lakes, reservoirs, streams, rivers and wetlands throughout north-eastern Australia, and a review of the Australian phycological literature, along with observations and samples provided by colleagues in laboratories throughout Australia. It is very likely that the total diversity of freshwater Nostocales from north-eastern Australia has been underestimated by this work. Many collections contained vegetative material which lacked akinetes and/or heterocytes making identification impossible. Additionally, cryptic diversity within the character poor cyanobacteria, has been shown to be a challenge to further recognition of new taxa based soley on morphology (Dvořák *et al.* 2015).

Nevertheless, this phenotypic and ecological characterisation of natural populations provides a basis to further ecological, toxicological, and systematic research. As such, this volume will aid the widespread recognition of heterocystous cyanobacterial diversity from different regions and habitats and is the first methodological step towards a comprehensive polyphasic evaluation of Australia's cyanobacterial flora.

Study area

North-eastern Australia includes all of Queensland and approximately the northern third of the Northern Territory. It incorporates six of Australia's twelve major drainage divisions and covers an area of approximately 2.1 million square kilometres (Fig. 1). The area extends through more than 18 degrees of latitude; hence there is a considerable breadth of climate, flow regimes, landforms, and aquatic ecosystems. A comprehensive field sampling program at 358 sites targeted representative freshwater biotopes across the study region has been undertaken over the past 20 years (Fig. 1, Appendix 1). For the purposes of this account freshwater is defined as all habitats not influenced by marine or saline conditions (after Skinner & Entwisle, 2001). However, some intertidal salt marshes, estuaries, and habitats that are subject to occasional marine spray were included in this volume. In these cases, details of the specific habitat attributes are provided. In each of the biotopes studied, cyanobacteria from all possible habitats were sampled, including the plankton, benthos, epiphyton and metaphyton. A comprehensive account of the freshwater biotopes of north-eastern Australia sampled as part of this study is provided in volumes one and two (McGregor 2007, 2013).

Sampling and specimens

Phytoplankton:—Two approaches were used for sampling planktonic cyanobacteria, a quantitative depth-integrated whole water method, and a qualitative surface plankton net tow method. The depth-integrated, site composite collection method after (Hötzel & Croome 1999) was mainly used in lentic systems with a minimum depth of more than 5 m (i.e. large lakes, reservoirs, and weirs). Water samples were collected using an integrated tube sampler through the water column from the surface to 5 m, which generally represents the photic depth in most Queensland reservoirs (McGregor & Everding 1998). For all other biotopes from which planktonic cyanobacteria were sampled, a 20 cm diameter plankton net with a 10 μm mesh was used. Samples were preserved in situ using either 3–4 % calcium-buffered formaldehyde or Lugol's iodine solution to a final concentration of 1%, or alternatively taken live to the laboratory for observation and analysis. Collections have been lodged in the Queensland Herbarium, Brisbane (BRI).

Benthic, epiphytic and metaphytic cyanobacteria:—Subsamples (approx. 1 cm^2) of mats, crusts, filaments and other thalli represented at a site were collected by repeated scraping and/or cutting with a sharpened blade. Different substrata sampled in this manner included rocks, sand and gravel beds, woody debris, buoys and mooring fixtures. Macrophytes were sampled by both squeezing plants and collecting the liquor or by roughly dragging a 20 cm diameter plankton net with a 10 μm mesh through macrophyte beds. Samples were preserved in the manner described above.

Cultures:—Subsamples of live material collected in the field were grown as either multi-species or unispecific, non-axenic cultures in a range of liquid or solidified media, with or without nitrogen, at 23°C, 16/8 hour light and dark photoperiod to facilitate the observation of taxonomically important morphological features or developmental stages that are often absent at the time of collection, or locally rare species that were under-represented in subsamples.

Light microscopy:—Preserved and live material was examined using bright-field, phase contrast, and differential interference contrast illumination systems with either an Olympus BX51 or BX53 compound microscope to a maximum magnification of 1000 ×. Photomicrographs and illustrations were obtained using either an Olympus SC100 or DP72 digital microscope camera. Cell measurements were made from digital images using Olympus cellSens software or Digimizer V 4.2 (http://digimizer.com). Identifications were generally achieved, and descriptions were compiled from features observable using light microscopy. However, additional ultrastructural features seen with the aid of transmission electron microscopy are provided for some species. All illustrations and photomicrographs were prepared by the author unless otherwise indicated.

SYSTEMATIC ACCOUNT

Cyanobacterial classification developed under the botanical system, as traditionally they were recognised as algae, and identified as such. Therefore, their nomenclature was covered by the provisions of the International Code for Nomenclature for Algae, Fungi and Plants (ICN) (formerly the International Code of Botanical Nomenclature). However, since the 1970s, following the recognition of cyanobacteria as prokaryotes, there has been several attempts to harmonise cyanobacterial nomenclature between the botanical code, and the International Code of Nomenclature of Prokaryotes (ICNP). This has yet to be adequately resolved; for a summary of the complex outstanding issues see Oren & Ventura (2017).

The modern classification system of cyanobacteria combines traditional approaches using morphological, ultrastructural, and ecological traits, with phylogenetic information derived through the analysis of various genomic regions, using contemporary molecular techniques (Komárek 2016). Identification of cyanobacteria using this system remains challenging due to cryptic diversity, lack of morphological variability, and frequent convergent evolutionary events (Dvořak *et al.* 2015). Nevertheless, the application of molecular techniques in resolving phylogenetic relationships between strains has rapidly increased over the past decade. As a result, the number of new and revised taxa has significantly expanded. It is expected that, over time, with the application of these techniques to Australian material, many of the genera presented here will be split into new monophyletic taxa representing coherent evolutionary lineages, each with corresponding morphological and ecological attributes.

The families, genera, and species of the Nostocales considered in this volume follow those recognised by Komárek (2013) and Komárek *et al.* (2014) (Table 1). Genera are listed alphabetically under each family, and the species in alphabetically under each genus. An attempt has been made, wherever possible, to emphasises in plates, the morphological features that aid the identification of genera and species. The ecology of individual species is based on field collections, or from ecological data in the literature the region or elsewhere. Australian distributions were obtained from Day *et al.* (1995), Atlas of Living Australia (http://www.ala.org.au), and a review of the relevant literature.

TABLE 1. Freshwater Nostocales recorded from north-eastern Australia.

Aphanizomenaceae
Anabaenopsis
A. arnoldii
A. circularis
A. ekenkinii
A. tanganyikae
Aphanizomenon
A. gracile
Chrysosporum
C. bergii
C. ovalisporum
Cuspidothrix
C. issatschenkoi
Dolichospermum
D. affine
D. circinale
D. crassum
D. flosaque
D. helicoideum
D. perturbatum
D. planktonicum
D. smithii
D. spiroides
Nodularia
N. harveyana
N. spumigena
N. willei
Raphidiopsis

.....continue on the next page

TABLE 1. (Continued)

R. curvata
R. mediterranea
R. raciborskii
Sphaerospermopsis
S. aphanizomenoides
S. eucompacta
S. reniformis

Gloeotrichiaceae
Gloeotrichia
G. raciborskii
G. natans

Hapalosiphonaceae
Fischerella
F. sp. A
Hapalosiphon
H. hibernicus
H. pumilus
H. welwitschia
Mastigocladus
M. laminosus
Nostochopsis
N. lobatus

Nostocaceae
Anabaena
A. cylindrica
A. inaequalis
A. oscillaroides
A. torulosa
A. wallumensis
A. cf. *alatospora*
A. cf. *augstumalis*
A. cf. *oblonga*
A. cf. *willei*
A. sp. A
Aulosira
A. laxa
A. cf. *epiphytica*
A. sp. A
Cronbergia
C. siamensis
Cylindrospermum
C. licheniforme
C. stagnale
C. sp. A
Macrospermum
M. volzii
Nostoc
N. commune
N. linckia
N. sphaericum
N. verrucosum
N. sp. A
N. sp. B
Wollea
W. ambigua

.....continue on the next page

TABLE 1. (Continued)

W. bharadwajae
W. saccata

Rivulariaceae
Calothrix
C. atricha
C. brevissima
C. cf. *fusca*
C. sp. A
C. sp. B
C. sp. C
C. sp. D
Camptylonemopsis
C. cf. *pulneyensis*
Fortiea
F sp. A
Microchaete
M. tenera
M. cf. *investiens*
M. sp. A
M. sp. B
M. sp. C
Rivularia
R. aquatica
R. beccariana

Scytonemataceae
Ewamiania
E. thermalis
Iningainema
I. pulvinus
Heteroscytonema
H. crispum
Scytonema
S. coactile
S. mirabile
S. subtile
S. tolypothrichoides
S. cf. *sanpaulense*
S. sp. A
Scytonematopsis
S. kashyapii

Stigonematales
Stigonema
S. eliskae
S. informe
S. ocellatum

Symphonemataceae
Symphonema
S. kaboorum

Tolypothrichaceae
Coleodesmium
C. sp. A
Tolypothrix
T. lanata

KEY TO FAMILIES

1. Filamentous, heterocystous, isopolar, with free uniseriate trichomes enveloped by fine mucilaginous envelopes or sheaths. Filaments ± straight, flexuous, or ± irregularly screw-like coiled, without branching; all vegetative cells capable of cell division. Vegetative cells spherical, barrel-shaped to cylindrical, apical cells rounded, conical, acutely pointed or cylindrical and bluntly rounded, with or without aerotopes. Heterocytes terminal or intercalary. Akinetes often several times larger than vegetative cells, formed from one vegetative cell or from the fusion of several vegetative cells, positioned adjacent or remote from heterocytes..... .....**1. APHANIZOMENONACEAE**
(Genera included in this volume: *Anabaenopsis*, *Aphanizomenon*, *Chrysosporum*, *Cuspidothrix*, *Dolichospermum*, *Nodularia*, *Raphidiopsis*, *Sphaerospermopsis*)

2. Thallus spherical, hemispherical, or irregularly shaped, mucilaginous, sometimes hollow, often macroscopic. Trichomes heteropolar with basal heterocytes and sub-terminal akinetes ..... **2. GLOEOTRICHIACEAE**
(Genera included in this volume: *Gloeotrichia*)

3. Thallose, composed of true-branched filaments of trichomes and sheaths. Trichomes unseriate, divicariate, but not morphologically divided into main trichomes and branches, often constricted at the cross walls, moniliform, but usually ± cylindrical, true-branched with T-, V, and Y-type branching. Branches cylindrical or less frequently narrowed towards the apices, rarely attenuated to hair-like cells. Vegetative cells cylindrical, barrel-shaped or irregularly rounded; apical cells rounded. Heterocytes intercalary, barrel-shaped or spheroidal, sometimes absent.....**3. HAPALOSIPHONACEAE**
(Genera included in this volume: *Hapalosiphon*, *Mastigocladus*, *Nostochopsis*, *Fischerella*)

4. Filamentous, heterocystous, isolpolar, with free uniseriate trichomes enveloped by fine or firm mucilaginous envelopes or sheaths. Filaments ± straight, flexuous, or ± irregularly screw-like coiled, without branching; all vegetative cells capable of cell division. Vegetative cells spherical, barrel-shaped to cylindrical, apical cells rounded, conical, acutely pointed or cylindrical and bluntly rounded. Heterocytes terminally on both ends, or intercalary. Akinetes often several times larger than vegetative cells, formed from one vegetative cell or from the fusion of several vegetative cells, positioned adjacent or remote from heterocytes.....**4. NOSTOCACEAE**
(Genera included in this volume: *Anabaena*, *Aulosira, Cronbergia*, *Cylindrospermum*, *Macrospermum*, *Nostoc*, *Wollea*)

5. Thallose, usually attached to the substratum, flat, prostrate, crustaceous, bushy or gelatinous, spherical, rarely occurring as solitary filaments. Filaments heteropolar, uniseriate, apical parts typically ending in terminal hair-like cells, constricted or unconstricted at the cross walls, with gelatinous sheaths. Vegetative cells cylindrical or barrel-shaped, terminal cells often elongated, narrowed and cylindrical. Heterocytes basal, sometimes intercalary, single or up to several in series. Akinetes known from several genera, usually developing above the basal heterocytes, solitary or in series ..... **5. RIVULARIACEAE**
(Genera included in this volume: *Calothrix*, *Camptylonemopsis*, *Fortiea*, *Microchaete*, *Rivularia*)

6. Filamentous, with obligatory false branching. Thallus prostrate, forming flat or woolly mats, sometimes occurring as solitary filaments amongst other algae. Trichomes monoseriate, isopolar, cylindrical or widened or narrowed at both ends, rarely forming hairs, usually with distinct meristematic zone. Sheaths usually thick, firm or gelatinous, often lamellated, sometimes funnel-like and widened at the ends, colourless or variously coloured. Heterocytes intercalary, mostly occurring singly. Akinetes absent...**6. SCYTONEMATACEAE**
(Genera included in this volume: *Ewamiania*, *Heteroscytonema, Iningainema*, *Scytonema*, *Scytonematopsis*)

7. Thallose, filamentous, solitary or forming cushion-like clumps or tufty colonies, with true branching. Trichomes bi- or multiseriate, uniseriate in young trichomes and at ends of branches, sometimes very thick, irregularly laterally true branched with T- and V-type branching, irregularly coiled, sometimes narrowed towards the ends, apical cell sometimes larger than adjacent cells. Sheaths thin or thick, often wide, lamellated and usually yellowish-brown in colour. Vegetative cells globose, barrel-shaped or roundly irregular, usually connected to each other by a pit connection. Heterocytes intercalary, solitary, rarely lateral. Akinetes not known ..... **7. STIGONEMATALES**
(Genera included in this volume: *Stigonema*)

8. Thallose; thallus pulvinate or woolly, with multiple densely coiled, or parallel arranged filaments, sometimes joined into erect fascicles. Filaments irregularly branched, not distinctly morphologically diversified in basal sections and branches. Trichomes uniseriate, isopolar, with vegetative cells usually longer than wide, cylindrical, not constricted or slightly constricted at cross walls, not attenuated towards the ends, with rounded terminal cells. Branching of two types, true or reverse Y-type, and false, scytonematoid; branching initiates remote from the heterocytes. Sheaths firm, homogeneous or slightly lamellated, yellow-brown in colour in mature parts. Heterocytes intercalary, cylindrical, solitary.....**8. SYMPHONEMATACEAE**
(Genera included in this volume: *Symphonema*)

9. Filaments polarized with mainly basal, uniporous heterocytes. Single false-branching common, double branching occurring sporadically. Sheath thick or thin, but always present, sometimes yellow to yellow brown in colour. Vegetative cells isodiametric or shorter or longer than wide. Trichomes not or very slightly attenuated toward the ends ..... **9. TOLYPOTHRICHACEAE**
(Genera included in this volume: *Coleodesmium*, *Tolypothrix*).

1. APHANIZOMENONACEAE

Aphanizomenonaceae Elenkin (1938: 845)
Type: *Aphanizomenon* Morren ex Bornet & Flahault (1888: 180)

Filamentous, heterocytous, isopolar, with free uniseriate trichomes enveloped by fine mucilaginous envelopes or sheaths. Filaments ± straight, flexuous, or ± irregularly screw-like coiled, without branching; all vegetative cells capable of cell division. Vegetative cells spherical, barrel-shaped to cylindrical, apical cells rounded, conical, acutely pointed or cylindrical and bluntly rounded, with or without aerotopes. Heterocytes terminal or intercalary. Akinetes often several times larger than vegetative cells, formed from one vegetative cell or from the fusion of several vegetative cells, positioned adjacent or remote from heterocytes.

A cosmopolitan family of 11 genera and more than 155 species; Common constituents of the plankton of lakes and reservoirs. Eight genera and 26 species are recorded from north-eastern Australia.

KEY TO GENERA

1. Trichomes always without heterocytes.....RAPHIDIOPSIS
- Trichomes capable of producing heterocytes 2
2. Heterocytes terminal.....RAPHIDIOPSIS (in part, ex. *Cylindrospermopsis*)
- Heterocytes intercalary.....3
3. Heterocytes develop in pairs which, following trichome breakage, are in the terminal position ..... ANABAENOPSIS
- Heterocytes solitary 4
4. Apical cells generally differentiated, elongated, tapered, or hyaline 5
- Apical cells generally undifferentiated.....6
5. Apical cells elongated, attenuated and acuminate..... CUSPIDOTHRIX
- Apical cells conical, or tapered and elongated, often hyaline ..... CHRYSOSPORUM
6. Vegetative cells always distinctly shorter than broad..... NODULARIA
- Vegetative cells ± isodiametric or longer than wide.....7
7. Akinetes spherical, always developing either side of the heterocytes..... SPHAEROSPERMOPSIS
- Akinetes adjacent to or remote from heterocytes.....8
8. Akinetes long cylindrical, often with a collar-like extension at either end which extends over the adjacent vegetative cells ....APHANIZOMENON (in part *A. gracile*)
- Akinetes oval to cylindrical..... DOLICHOSPERMUM

ANABAENOPSIS

Anabaenopsis Miller (1923: 125)
Type: *A. elenkinii* Miller (1923: 125)

Filamentous; trichomes solitary or sometimes arranged in tangled clusters; planktonic; circinate, sigmoidal or spirally coiled, seldom straight; without sheaths but producing diffluent, colourless, homogeneous mucilage; trichomes metameric with heterocytes developing intercalary in pairs at regular distances from one another. Trichomes often disintegrate soon after heterocyte formation at the position between heterocyte pairs. Vegetative cells short to long barrel-shaped or cylindrical, shorter up to several times longer than wide, pale blue-green, with aerotopes. Heterocytes terminal or intercalary, spherical or widely oval, rarely ovoid or elongated, rounded conical, usually slightly greater than vegetative cells. Akinetes spherical to broadly ovate, solitary or in series, intercalary, arising paraheterocytically, generally in the centre of trichomes.

A widely distributed genus of 32 species known from freshwater lakes and reservoirs, rivers and estuaries, more commonly throughout tropical and subtropical regons. Here four species are described from north-eastern Australia. Bibliography: Jeeji-Bai *et al.* (1977), Hindák (1988), Iteman *et al.* (2002), Komárek (2005), Rajaniemi *et al.* (2005), Santos *et al.* (2011), Aguilera *et al.* (2016).

1. Filaments > 8 µm broad..... *A. arnoldii*
- Filaments < 8 µm broad.....2
2. Filaments not or only slightly constricted at the cross walls..... *A. tanganyikae*
- Filaments clearly constricted at the cross walls 3
3. Vegetative cells cylindrical, 4.5–10.5 µm long × (2.5–) 4–6 µm broad ..... *A. circularis*
- Vegetative cells barrel-shaped to long ellipsoid, 4.0–7.5 (–9) µm long × 4–6 (–8) µm broad..... *A. elenkinii*

Anabaenopsis arnoldii Aptekar (1926: 54) Fig. 2 A–D.

Filaments planktonic; trichomes solitary or clustered in small colonies, ± irregularly screw-like coiled, coils 25–60 μm in diameter, constricted at the cross walls, with wide, colourless, diffluent mucilage. Vegetative cells spherical or widely barrel-shaped, distinctly compressed at the poles, grey-blue to yellow-green in colour, with aerotopes, (4–) 8–10 μm broad. Heterocytes spherical to widely oval, 5–11 μm long × 5.0–10.5 μm broad. Akinetes solitary or in pairs, widely elliptical, with colourless epispore, 10–19 (–22) long × 8–14 (–19) μm.

Specimens examined:—Carbrook Lakes.

Other records:—South Australia: Pelican Point at Lake Alexandrina, Campbell Park at Lake Albert, Gumeracha Weir, River Torrens, Baker (1991); Victoria: Ling & Tyler (2000); Northern Territory: Magela Ck, Thomasson (1986).

Observations:—Known from brackish coastal lagoons and occasionally estuaries. Associated with blooms of *N. spumigena* in Carbrook Lakes, south-east Queensland (McGregor *et al.* 2012).

Anabaenopsis circularis (G.S.West) Wołoszyńska & Miller in Miller (1923: 125) Fig. 3 G–H.
Basionym: *Anabaena flosaquae* var. *circularis* G.S.West (1907: 170)

Filaments planktonic; trichomes solitary, arcuate or irregularly screw-like coiled, short, constricted at the cross walls. Vegetative cells cylindrical, 1.4–4 × longer than wide, with aerotopes, 4.5–10.5 μm long × (2.5–) 4–6 μm broad. Heterocytes spherical to oval, 3–7 μm in diameter. Akinetes solitary or in pairs, widely oval to oblong-ovate, with colourless or yellowish epispore, 8.0–12.0 μm long × 4.0–7.0 μm broad.

Specimens examined:—Ben Anderson Barrage, Bjelke-Petersen Dam, Boondooma Dam, Bucca Weir, Callide Dam, Coolmunda Dam, Dumbleton Weir, Eden Bann Weir, Jones Weir, Kirar Weir, Leslie Dam, Ned Churchward Weir, Neville Hewitt Weir, Paradise Dam, Tartrus Weir, Tinaroo Falls Dam.

Other records:—Western Australia: Hyde Park, Lee *et al.* (2014).

Observations:—Known mainly from tropical regions or warmer areas of the temperate zone. Differs from *A. elenkinii* by virtue of narrower vegetative cells.

Anabaenopsis elenkinii Miller (1923: 125) Fig. 4 A–D.

Filaments planktonic; trichomes solitary, shortly circinate to irregularly screw-like coiled, coils 15–35 (–50) μm in diameter, constricted at the cross walls. Vegetative cells barrel-shaped to long ellipsoid, isodiametric to 1.2–4 × longer than wide, with aerotopes, 4.0–7.5 (–9) μm long × 4–6 (–8) μm broad. Heterocytes spherical to slightly ovate, 3–7 (–10) μm in diameter. Akinetes solitary or in series, ovate to oblong-ovate, with colourless or yellowish epispore, 8.0–15.0 μm long × (5.5–) 8.0–11.0 μm broad.

Specimens examined:—Warrego R. at Allan Tannock Weir, Atkinson Dam, Beardmore Dam, Fitzroy R. at Bingegang Weir, Fitzroy R. at Moura Weir, Fitzroy R. at Bedford Weir, Fitzroy R. at Giru Weir, Fitzroy R. at Glebe Weir, Fitzroy R. at Tartrus Weir, Fitzroy R. at Theodore Weir, Fitzroy R. at Eden Bann Weir, Fitzroy R. at Neville Hewitt Weir, Burnett R. at Claude Wharton Weir, Burnett R. at Ben Anderson Barrage, Burnett R. at Kirar Weir, Burnett R. at Ned Churchward Weir, Burnett R. at Jones Weir, Bill Gunn Dam, Bjelke-Petersen Dam, Boondooma Dam, Bowen R. at Bowen R. Weir, Kolan R. at Bucca Weir, Burdekin Falls Dam, Callide Dam, Cania Dam, Condamine R. at Chinchilla Weir, Coolmunda Dam, Pioneer R. at Mirani Weir, Pioneer R. at Marian Weir, Pioneer R. at Dumbleton Weir, East Leichhardt Dam, Eungella Dam, Fairbairn Dam, Fred Haigh Dam, Gattonvalue offstream storage, Glenlyon Dam, Condamine R. at Jack Taylor Weir, Julius Dam, Kinchant Dam, Lake Clarendon, Maroon Dam, Mary R. at Mary R. Barrage, Moogerah Dam, Moura offstream storage, Paradise Dam, Peter Faust Dam, Tinaroo Falls Dam, Wuruma Dam.

Other records:—South Australia: Bundaleer Res., Howards Dam, Kangaroo Is., Kimba Farm Dam, Eyre Penin., Strathalbyn Res., Kersbrook and Mount Barker farm dams, Mount Lofty Ranges, Pinnaroo and Frances farm dams; New South Wales: Namoi R. near Walgett; Victoria: Edenhope Res., Kerang and Shepparton farm dams, Baker (1991); Western Australia: Swan Coastal Plain Wetlands, Kemp (2009); Northern Territory: Ling & Tyler (2000).

Observations:—Widespread species throughout the warmer areas of the temperate zone, common in the plankton of mesotrophic reservoirs and weir pools throughout Australia; not typically a bloom forming species. Compare with *A. circularis* which typically has narrower vegetative cells.

Anabaenopsis tanganyikae (G.S.West) Wołoszyńska & Miller in Miller (1923: 125) Fig. 3 A–F.
Basionym: *Anabaena tanganyikae* G.S.West (1907: 171)

Filaments planktonic; trichomes solitary, arcuate or loosely screw-like coiled, not or only slightly constricted at the cross walls. Vegetative cells cylindrical 1.2–3.5 × longer than wide, facultatively with aerotopes, 4–10 (–12) μm long × 2.5–4.0 μm broad. Heterocytes spherical to broadly oval, 3.5–8.0 μm × 3.0–5.5 μm, intercalary in pairs. Akinetes solitary or in series, widely oval to cylindrical, with colourless epispore, 7–15 μm long × 4.0–7.5 μm broad.

Specimens examined:—Bill Gunn Dam, Borumba Dam, Burdekin Falls Dam, Callide Dam, Kirar Weir, Wuruma Dam.

Other records:—South Australia: River Murray at Milang, Goolwa, Lake Alexandrina at Pelican Point, Lake Albert at Meningie, Howards Dam, Baker (1991).

Observations:—Pan-tropical distribution, occasionally reported from warmer areas of the temperate zone; uncommon in Australia, known from mesotrophic reservoirs along the Queensland coast, and weir pools of the southern Murray-Darling Basin.

APHANIZOMENON

Aphanizomenon Morren ex Bornet & Flahault (1888: 180)
Type: *A. flosaquae* Ralfs ex Bornet & Flahault (1886: 241)

Filaments planktonic, solitary, in a few species joined into fascicle-like, microscopic or macroscopic colonies with trichomes oriented in parallel; trichomes straight or slightly bent, cylindrical or sharply or continually tapered towards the ends, ± constricted at the cross walls, sometimes with diffluent and colourless mucilage trichomes uniseriate, trichomes sub-symmetric, with intercalary heterocytes, which are sub-symmetrically localized in fully developed trichomes. Vegetative cells cylindrical or barrel-shaped, isodiametric or slightly shorter or longer than wide, pale blue-green or blue-green, with aerotopes, several species facultatively develop aerotopes. Heterocytes few (1–3 per trichome), intercalary, barrel-shaped or cylindrical with rounded or obtuse ends. Akinetes typically oval to long, cylindrical with rounded ends, developing paraheterocytically, solitary or in short rows, close to heterocytes or slightly distant from them, usually in an asymmetrical position. Reproduction by trichome dissociation and by akinetes.

A widely distributed genus of 19 species known from freshwater lakes and reservoirs and rivers. One species is known from north-eastern Australia. The traditional genus *Aphanizomenon* is heterogeneous (Komárek & Mareš 2012). Over the past decade, several species traditionally belonging to *Aphanizomenon* have been transferred to new genera based on updated phylogenetic information (*Cuspidothrix*, *Chrysosporum*, *Sphaerospermopsis*). Bibliography: Baker (1991), Baker & Fabbro (2002), Li *et al.* (2000, 2003), Rajaniemi *et al.* (2005a, 2005b), Komárek & Komárková (2006), Komárek & Mareš (2012), Zapomělová *et al.* (2012), Cirés & Ballot (2016), Komárek (2016).

Aphanizomenon gracile (Lemmermann) Lemmermann (1907: 193) Fig. 5 A–H.
Basionym: *Aphanizomenon flosaquae* var. *gracile* Lemmermann (1898: 204)

Filaments planktonic; trichomes solitary, not forming fascicles, isopolar, sub-symmetrical, straight or slightly flexuous, constricted at the cross walls. Vegetative cells isodiametric to short cylindrical, 2.8–6.5 (–9) μm long × 2.5–5.5 μm broad, with aerotopes; apical cells rounded or club-shaped, sometimes slightly elongated and narrowed. Heterocytes intercalary, solitary, ovate to sub-cylindrical, 3.5–7.5 μm long × 3.0–5.0 μm broad. Akinetes solitary, long cylindrical, often with a collar-like extension at either end which extends over the adjacent vegetative cells, 7.5–15.0 (–42) μm long × (2.5–) 4.0–6.5 (–8.0) μm broad.

Specimens examined:—Atkinson Dam, Ben Anderson Barrage, Bill Gunn Dam, Bjelke-Petersen Dam, Boondooma Dam, Borumba Dam, Cania Dam, Claude Wharton Weir, Coolmunda Dam, Eden Bann Weir, Eungella Dam, Giru Weir, Glen Niven Dam, Glenlyon Dam, Ibis Dam, Kinchant Dam, Kirar Weir, Lake Clarendon, Leslie Dam, Mirani Weir, Moogerah Dam, Paradise Dam, Peter Faust Dam, Tartrus Weir, Teemburra Dam, Tinaroo Falls Dam, Wuruma Dam, Wyndham Dam.

Other records:—Queensland: Ling & Tyler (2000); South Australia: River Murray at Murtho, Morgan, Swan Reach in Lake Alexandrina, Lake Albert at Narrung and Meningie, Warren Res., Strathalbyn Res., Dawesley farm dam, Mount Lofty Ranges, Bundaleer Res., Barcoota Res., Baker (1991); Victoria: Violet Ck Res., Lance Ck Res.,

Lake Whitton, Sea L. Storage, Baker (1991), Ling & Tyler (2000); New South Wales: River Murray at Yarrawonga, Euston, Redcliffs, Merbein, Sullivan *et al.* (1988), Hume Dam, Humpage *et al.* (2013); Northern Territory: Magela Ck, Thomasson (1986); Western Australia, Chelodina Wetlands, Lee *et al.* (2014).

Observations:—Widespread species, known from the plankton of mesotropic lakes and reservoirs throughout the temperate zone (Komárek 2013). In Australia is has been widely reported, however it is not typically a bloom forming species and has not been associated with cyanotoxin production. Trichomes lacking akinetes may be confused with *Sphaerospermopsis aphanizomenoides*.

CHRYSOSPORUM

Chrysosporum Zapomělová, Skácelová, Pumann, Kopp & Janeček (2012: 359)
Type: *C. ovalisporum* (Forti) Zapomělová, Skácelová, Pumann, Kopp & Janeček (2012: 359)

Filaments planktonic; trichomes solitary, straight or slightly flexuous, constricted at the cross walls. Apical cells conical, or tapered and elongated, often hyaline. Vegetative cells cylindrical, compressed during division, with aerotopes. Heterocytes intercalary, solitary, spherical, or slightly elongated. Akinetes widely ovoid, with brownish or yellow-brown epispore, remote from heterocytes.

A widely distributed genus of three species, all known from the plankton of freshwater lakes, reservoirs and rivers. Here two species are described from north-eastern Australia. Bibliography: Baker (1991), Stüken *et al.* (2006, 2009), Komárek & Mareš (2012), Zapomělová *et al.* (2012), Sukenik *et al.* (2012), Komárek (2016).

1. Vegetative cells barrel-shaped, 4–8 µm broad, apical cells conically narrowed and tapered ..... *C. bergii*
- Vegetative cells cylindrical, 2.5–4.5 µm broad, apical cells elongated, narrowed and hyaline ..... *C. ovalisporum*

Chrysosporum bergii (Ostenfeld) Zapomělová, Skácelová, Pumann, Kopp & Janeček (2012: 359) Fig. 6 A–E.
Basionym: *Anabaena bergii* Ostenfeld (1908: 142)

Filaments planktonic; trichomes solitary, straight or slightly flexuous, narrowed towards the ends, constricted at the cross walls, with indistinct mucilaginous envelope. Vegetative cells barrel-shaped, ± spherical, 4–8 µm broad, with aerotopes; apical cells conically narrowed, tapered and hyaline. Heterocytes solitary, intercalary, spherical to ovate, 5–10 µm broad. Akinetes broadly ovate with dark brown epispore, intercalary, remote from the heterocytes, (12–) 20–24 µm long × 10–20 µm broad.

Specimens examined:—Condamine R. at Allan Tannock Weir, Boondooma Dam, Borumba Dam, Callide Dam, Cania Dam, Eungella Dam, Fred Haigh Dam, Glenlyon Dam, Julius Dam, Lake Clarendon, Maroon Dam, Paradise Dam, Peter Faust Dam, Fitzroy R. at Tartrus Weir, Teemburra Dam, Tinaroo Falls Dam.

Other records:—South Australia: Beetaloo Res., Baker (1991), Thornden Park Res., Humpage *et al.* (2013); New South Wales: Baker & Fabbro (2002); Victoria: Western Australia: Swan Coastal Plain Wetlands, Kemp (2009), Baldwin Park, Lee *et al.* (2014); Northern Territory: Palm Valley Ck, Humpage *et al.* (2013).

Observations:—Widely distributed throughout eastern Australia, however not often associated with bloom events.

Chrysosporum ovalisporum (Forti) Zapomělová, Skácelová, Pumann, Kopp & Janeček (2012: 359) Fig. 7 A–G.
Basionym: *Anabaena ovalisporum* Forti 1911

Filaments planktonic; trichomes solitary, straight or slightly flexuous, narrowed towards the ends, constricted at the cross walls. Vegetative cells cylindrical, isodiametric up to 3 × as long as broad, 2.5–4.5 µm broad, with aerotopes; apical cells elongated and narrowed, tapered and hyaline. Heterocytes solitary, intercalary, spherical to sub-spherical, 5.0–8.5 µm broad. Akinetes broadly ovate with yellow-brown epispore, intercalary, remote from the heterocytes, 18–27 µm long × 10–15 µm broad.

Specimens examined:—Atkinson Dam, Bill Gunn Dam, Boondooma Dam, Borumba Dam, Bucca Weir, Burdekin Falls Dam, Callide Dam, Cania Dam, Coolmunda Dam, Crookes Dam, Pioneer R. at Dumbleton Weir, Fitzroy R. at Eden Bann Weir, Eungella Dam, Fred Haigh Dam, Haughton R. at Giru Weir, Glenlyon Dam, Julius Dam, Kinchant Dam, Burnett R. at Kirar Weir, Burnett R. at Ned Churchward Weir, Lake Clarendon, Leslie Dam, Maroon Dam, Mary R. at Mary R. Barrage, Moogerah Dam, Paradise Dam, Peter Faust Dam, Teemburra Dam, Tinaroo Falls Dam, Wuruma Dam.

Other records:—Queensland: Hervey Bay, Shaw *et al.* (1999); New South Wales: Cobaki L., Everson *et al.* (2009), Angourie Blue Pool, Humpage *et al.* (2013); South Australia: Baker & Fabbro (2002), Thornden Park Res., Humpage *et al.* (2013); Western Australia: Swan Coastal Plain Wetlands, Kemp (2009), Baldwin Park, Lee *et al.* (2014), Ling & Tyler (2000).

Observations:—Reported throughout Europe, typically from waters with higher conductivities. Widespread distribution throughout Australia, where it is known to produce the cyanotoxins cylindrospermopsin and deoxy-cylindrospermopsin (Shaw *et al.* 1999, Everson *et al.* 2009). This species was the main constituent of a major bloom in the Murray R., New South Wales in 2016 where it affected Lakes Hume and Mulwala, and 400 km further downstream (Willis 2016).

CUSPIDOTHRIX

Cuspidothrix Rajaniemi, Komárek, Willame, Hrouzek, Kaštovská, Hoffmann & Sivonen (2005: 388)
Type: *C. issatschenkoi* (Usachev) Rajaniemi, Komárek, Willame, Hrouzek, Kaštovskà, Hoffmann & Sivonen (2005: 388)

Filaments planktonic; trichomes solitary, short to long, straight or curved, cylindrical, slightly constricted or unconstricted at cross walls, up to 6 µm wide, clearly narrowed and pointed at the ends. Vegetative cells cylindrical, isodiametric or longer than wide, cell content finely granular and/or with facultative aerotopes; apical cells elongated, attenuated and acuminate, mainly colourless and hyaline. Heterocytes intercalary, solitary, cylindrical or elliptical. Akinetes intercalary, solitary or rarely in twos, elongated ± cylindrical, remote from the heterocytes.

A widely distributed genus of five species known from the plankton of freshwater lakes, reservoirs and rivers. One species is known from north-eastern Australia. Bibliography: Baker (1991), Baker & Fabbro (2002), Rajaniemi *et al.* (2005a), Komárek & Komárková (2006), Komárek & Mareš (2012), Komárek (2016).

Cuspidothrix issatschenkoi (Usachev) Rajaniemi, Komárek, Willame, Hrouzek, Kaštovskà, Hoffmann & Sivonen (2005: 388) Fig. 8 A–E.
Basionym: *Anabaena issatschenkoi* Usachev (1938: 109)

Filaments planktonic; trichomes solitary or slightly flexuous, cylindrical, continually narrowed towards both ends, not or slightly constricted at the cross walls. Vegetative cells long cylindrical, with aerotopes, 4–8 (–15) µm long × 2.5–4.0 µm broad; apical cells narrowed, hair-like, often hyaline. Heterocytes solitary, sub-cylindrical 6–11 µm long × 2.5–4.0 µm broad. Akinetes cylindrical with rounded ends, solitary or in series, remote from the heterocytes, 6–20 µm long × 2.5–4.5 µm broad.

Specimens examined:—Condamine R. at Jack Taylor Weir, Warrego R. at Allan Tannock Weir, Atkinson Dam, Beardmore Dam, Fitzroy R. at Bedford Weir, Burnett R. at Ben Anderson Barrage, Burnett R. at Claude Wharton Weir, Burnett R. at Kirar Weir, Burnett R. at Ned Churchward Weir, Bill Gunn Dam, Fitzroy R. at Bingegang Weir, Fitzroy R. at Eden Bann Weir, Fitzroy R. at Glebe Weir, Fitzroy R. at Moura Weir, Fitzroy R. at Tartrus Weir, Fitzroy R. at Theodore Weir, Fitzroy R. at Neville Hewitt Weir, Bjelke-Petersen Dam, Boondooma Dam, Borumba Dam, Bowen R. at Bowen R. Weir, Kolan R. at Bucca Weir, Burdekin Falls Dam, Callide Dam, Cania Dam, Condamine R. at Chinchilla Weir, Coolmunda Dam, Pioneer R. at Dumbleton Weir, Pioneer R. at Marian Weir, Pioneer R. at Mirani Weir, Eungella Dam, Fairbairn Dam, Fred Haigh Dam, Gattonvalue offstream storage, Haughton R. at Giru Weir, Glenlyon Dam, Jones Weir, Julius Dam, Kinchant Dam, Lake Clarendon, Leslie Dam, Mary R. at. Mary R. Barrage, Moogerah Dam, Paradise Dam, Peter Faust Dam, Teemburra Dam, Tinaroo Falls Dam, Wuruma Dam.

Other records:—South Australia: Warren Res., Lake Alexandrina at Mannum, Lake Albert at Narrung, Campbell Park and Meningie, Baker (1991); New South Wales: River Murray at Lake Victoria, Baker (1991), Hume Dam, Humpage *et al.* (2013); Victoria: River Murray at Bonyaricall Ck, Baker (1991); Northern Territory: Ling & Tyler (2000).

Observations:—Common throughout the temperate zone including Europe, Asia, North America and New Zealand; recorded from lakes and reservoirs throughout eastern Australia.

DOLICHOSPERMUM

Dolichospermum (Ralfs ex Bornet & Flahault) Wacklin, Hoffmann & Komárek (2009: 60)
Type: *D. flosaquae* (Brébisson ex Bornet & Flahault) Wacklin, Hoffmann & Komárek (2009: 60)

Filaments planktonic, solitary or aggregated into floccose masses; trichomes isopolar, metameric with respect to the position of heterocytes, straight, flexuous, circinate, spirally coiled or irregularly twisted, constricted at the cross walls, without firm sheaths, generally with fine diffluent mucilage. Vegetative cells spherical, ellipsoidal, barrel-shaped, quadrate or cylindrical, with aerotopes. Apical cells undifferentiated, morphologically similar to the vegetative cells. Heterocytes intercalary, solitary, exceptionally in pairs; developing from vegetative cells in ± metameric position. Akinetes spherical to cylindrical in shape, developing paraheterocytically, rarely adjacent to heterocytes, generally separated from them by one or more cells, solitary or in series. Mature akinetes usually three or more times larger than vegetative cells.

A widely distributed genus of 45 species known from the plankton of freshwater lakes, reservoirs, rivers and estuaries. Here nine species are described from north-eastern Australia. Planktonic species with aerotopes, previously considered within the genus *Anabaena* have recently been transferred to *Dolichospermum* (Wacklin *et al.* 2009). It is likely that more revisions will be made in the future. Bibliography: Baker (1991), Li & Watanabe (2000, 2001), Fergusson & Saint (2000), Lyra *et al.* (2001), Baker & Fabbro (2002), Gugger *et al.* (2002a, 2002b), Rajaniemi *et al.* (2005a, 2005b), Zapomělová *et al.* (2007, 2010), Komárek & Zapomělová (2007, 2008), Wacklin *et al.* (2009), Andreja *et al.* (2015), Komárek (2016), Li *et al.* (2016a, 2016b).

1. Filaments straight or slightly flexuous 2
- Filaments regularly or irregularly coiled 4
2. Filaments < 6 µm broad ..... *D. affine*
- Filaments > 6 µm broad 3
3. Akinetes spherical to broadly ovate ..... *D. smithii*
- Akinetes oblong-ovate or oblong with conical ends ..... *D. planktonicum*
4. Filaments regularly screw-like coiled 5
- Filaments irregularly coiled 7
5. Akinetes oval to cylindrical 6
- Akinetes cylindrical reniform ..... *D. perturbatum*
6. Vegetative cells globose, 8.0–12.0 µm in diameter ..... *D. crassum*
- Vegetative cells spherical, (4.0–) 7.0–9.0 µm long × 6.0–8.5 µm broad ..... *D. spiroides*
7. Vegetative cells > 5 µm in diameter ..... *D. circinale*
- Vegetative cells < 5 µm in diameter 8
8. Akinetes cylindrical, slightly arcuate, solitary or up to two in series, adjacent to or remote from the heterocytes ..... *D. helicoideum*
- Akinetes cylindrical reniform, solitary or in pairs, remote from the heterocytes ..... *D. flosaquae*

Dolichospermum affine (Lemmermann) Wacklin, Hoffmann & Komárek (2009: 61) Fig. 9 A–D.

Basionym: *Anabaena affinis* Lemmermann (1897: 261)

Filaments solitary, planktonic; trichomes straight or slightly flexuous, constricted at the cross walls, not attenuated towards the ends; mucilage fine, colourless, up to 20 µm wide. Vegetative cells spherical or slightly barrel-shaped, compressed at the poles, clearly constricted at the cross walls, (2.5–) 4.5–7.5 µm long × 4.5–6.0 µm broad, with aerotopes; apical cells rounded to shortly conical. Heterocytes intercalary, solitary, spherical, 5.0–7.5 µm in diameter. Akinetes intercalary, solitary or rarely in pairs, ovate to oblong with rounded ends, adjacent to or remote from the heterocytes, (6–) 11–22 (–30) µm long × (4.5–) 9.0 – 13.0 µm broad.

Specimens examined:—Atkinson Dam, Bill Gunn Dam, Burnett R., Ned Churchward Weir.

Other records:—South Australia: Warren Res., Strathalbyn Res., Mount Lofty Ranges, Baker (1991), Ling & Tyler (2000); Victoria: Baker & Fabbro (2002).

Observations:—A widespread species, recorded throughout Europe, Asia, North and South America and New Zealand (as *Anabaena affinis* Lemmermann). Australian populations are not known to form fascicles of parallel arranged trichomes as variously reported from Europe.

Dolichospermum circinale (Rabenhorst ex Bornet & Flahault) Wacklin, Hoffmann & Komárek (2009: 61) Fig. 10 A–C.

Basionym: *Anabaena circinalis* Rabenhorst ex Bornet & Flahault (1886: 230)

Filaments solitary or entangled into small clusters, planktonic; trichomes circinate or irregularly open screw-like coiled, > 50 µm in diameter, constricted at the cross walls, not attenuated towards the ends; often associated with a broad, colourless mucilage. Vegetative cells spherical or compressed at the poles, blue-green in colour, with aerotopes, 7.0–8.5 (–11.0) µm in diameter; apical cells undifferentiated. Heterocytes spherical, 8.5–11.0 µm in diameter. Akinetes

intercalary, solitary or in series, cylindrical, slightly curved and remote from the heterocytes, 20.0–28.0 μm long × 11.5–16.0 μm broad.

Specimens examined:—Atkinson Dam, Baroon Pocket Dam, Beardmore Dam, Fitzroy R. at Bedford Weir, Fitzroy R. at Bingegang Weir, Fitzroy R. at Eden Bann Weir, Fitzroy R. at Glebe Weir, Fitzroy R. at Moura Weir, Fitzroy R. at Neville Hewitt Weir, Fitzroy R. at Tartrus Weir, Fitzroy R. at Theodore Weir, Burnett R. at Ben Anderson Barrage, Burnett R. at Kirar Weir, Burnett R. at Ned Churchward Weir, Bill Gunn Dam, Bjelke-Petersen Dam, Bowen R. at Bowen R. Weir, Callide Dam, Cania Dam, Condamine R. at Jack Taylor Weir, Condamine R. at Chinchilla Weir, Burnett R. at Claude Wharton Weir, Coolmunda Dam, Crookes Dam, Pioneer R. at Dumbleton Weir, Pioneer R. at Mirani Weir, Eungella Dam, Fairbairn Dam, Glen Niven Dam, Glenlyon Dam, Kinchant Dam, Lake Clarendon, Lake MacDonald, Leslie Dam, Maroon Dam, Mary R. at Mary R. Barrage, Moogerah Dam, Moura offstream storage, Paradise Dam, Peter Faust Dam, Six Mile Ck at Bajool Weir, Teemburra Dam, Wuruma Dam, Wivenhoe Dam, Warrego R. at Allan Tannock Weir.

Other records:—New South Wales: Prospect Res., Cannon *et al.* (1970), Bowen & Smalls (1980), Lismore R., May (1970), Braidwood Lagoon, May (1972), Lake Uranagong near Finlay, May & McBarron (1973), Burrinjuck Dam, May (1978), Carcoar Dam, Glenbawn Dam, May (1981), River Murray at Torrumbarry and Euston, Sullivan *et al.* (1988), Chaffey Dam, May (1989), Baker (1991), Toonumbar Dam near Lismore, Baker (1991), Lake Cargelligo near Griffith, Baker (1991), Namoi R. near Walgett, Baker (1991), Hawkesbury R. at Sackville, Baker (1991); Western Australia: farm dams in south-west, Aplin (1983), Hyde Park, (Lee *et al.* 2014); South Australia: Gumeracha Weir, R. Torrens, South Para Res., Hope Valley Res., Little Para Res., Happy Valley Res., Myponga Res., Hindmarsh Valley Res., Strathalbyn Res., Warren Res., Baker (1991); Victoria: Barkers Ck Res., Lake Cup Cup near Donald, Dock L. and Green L. near Horsham, Hepburn Lagoon near Ballarat, Hopetoun Res. near Warracknabeal, Kybram near Shepparton, Lance Ck Res. and Wonthaggi-Inverlock Res., Violet Town Res. near Benalla, Tallarook near Seymour, Baker (1991); Northern Territory: Kangaroo Ck, Humpage *et al.* (2013).

Observations:—Cosmopolitan species; known from every Australian state where it is a common bloom forming species in lakes, reservoirs, and farm dams. Australian populations can produce paralytic shellfish poisons (Humpage *et al.* 1994), and taste and odour compounds geosmin and 2-methylisoborneol (Hayes & Burch 1989). It was the dominant species in a major bloom in the Barwon-Darling River in November and December 1991, which affected almost 1000 km of the system (Bowling & Baker 1996).

Dolichospermum crassum (Lemmermann) Wacklin, Hoffmann & Komárek (2009: 61) Fig. 11 A–E.

Basionym: *Anabaena spiroides* var. *crassa* Lemmermann (1898: 155)

Filaments solitary, planktonic; trichomes regularly screw-like coiled, coils 40–90 μm in diameter, constricted at the cross walls, not attenuated towards the ends; often with a broad, colourless mucilage. Vegetative cells globose, compressed at the poles, dark blue-green in colour, with aerotopes, 8.0–12.0 μm in diameter; apical cells undifferentiated. Heterocytes spherical or slightly compressed at the poles, 9.0–15.0 μm in diameter. Akinetes intercalary, solitary or in pairs, oval to cylindrical, slightly curved and remote from the heterocytes, 14.0–40.0 μm long × 13.5–25.0 μm broad.

Specimens examined:—Atkinson Dam, Bill Gunn Dam, Fitzroy R. at Eden Bann Weir, Haughton R. at Giru Weir, Lake Clarendon, Paradise Dam.

Other records:—Queensland: Indooroopilly, McLeod (1975); New South Wales: River Murray at Murtho, Murbko, Swan Reach, Mannum, Wood's Point, Hawkesbury R. near Sackville, Baker (1991), Hume Dam, Humpage *et al.* (2013); South Australia: Lake Alexandrina at Goolwa, Baker (1991), Gumeracha Weir-River Torrens, Farm dam at Angaston, Baker (1991); Victoria: Wonthaggi-Inverloch Res., Green L., Dock L., Baker (1991), Ling & Tyler (2000); Northern Territory: Kangaroo Ck, Humpage *et al.* (2013).

Observations:—Uncommon, recorded from Europe, Asia, South America and New Zealand. Australian populations reported from mesotrophic dams and weir pools.

Dolichospermum flosaquae (Brébisson ex Bornet & Flahault) Wacklin, Hoffmann & Komárek (2009: 60) Fig. 12 A–D.

Basionym: *Anabaena flosaquae* Brébisson ex Bornet & Flauhault (1886: 228)

Filaments solitary or entangled into small clusters, planktonic; trichomes irregularly screw-like coiled and twisted, constricted at the cross walls, not attenuated towards the ends; often associated with an indistinct, colourless mucilage. Vegetative cells spherical and compressed at the poles, (3.0–) 4.0–5.5 μm in diameter, blue-green in colour, with

aerotopes; apical cells undifferentiated. Heterocytes spherical 5.0–10.0 µm in diameter. Akinetes intercalary, solitary or in pairs, cylindrical reniform, remote from the heterocytes, 15.0–24.0 µm long × (4.0–) 7.0–14.0 µm broad.

Specimens examined:—Atkinson Dam, Beardmore Dam, Fitzroy R. at Bedford Weir, Fitzroy R. at Eden Bann Weir, Fitzroy R. at Glebe Weir, Fitzroy R. at Moura Weir, Fitzroy R. at Neville Hewitt Weir, Fitzroy R. at Theodore Weir, Fitzroy R. at Bingegang Weir, Burnett R. at Ben Anderson Barrage, Burnett R. at Charles Lloyd Jones Weir, Burnett R. at Claude Wharton Weir, Burnett R. at Jones Weir, Burnett R. at Kirar Weir, Burnett R. at Ned Churchward Weir, Bill Gunn Dam, Bjelke-Petersen Dam, Boondooma Dam, Borumba Dam, Bowen R. at Bowen R. Weir, Kolan R. at Bucca Weir, Burdekin Falls Dam, Callide Dam, Cania Dam, Coolmunda Dam, Corella Dam, Pioneer R. at Dumbleton Weir, Pioneer R. at Marian Weir, Pioneer R. at Mirani Weir, Eungella Dam, Fairbairn Dam, Fred Haigh Dam, Gattonvale offstream storage, Haughton R. at Giru Weir, Glenlyon Dam, Julius Dam, Kinchant Dam, Lake Clarendon, Leslie Dam, Maroon Dam, Mary R. at Mary R. Barrage, Moogerah Dam, Moura offstream storage, Paradise Dam, Peter Faust Dam, Fitzroy R. at Tartrus Weir, Teemburra Dam, Tinaroo Falls Dam, Warrego R. at Thurulgoona, Wuruma Dam.

Other records:—Queensland: SE Queensland, McLeod (1975); New South Wales: Lake Victoria, Baker (1991), Namoi R. near Walgett, Baker (1991); Victoria: River Murray at Bonyarical Ck, Baker (1991), Yan Yean Res., Hardy (1907), Dartmouth Dam, Powling (1980); South Australia: River Murray at Waikerie, Murbko, Swan Reach, Punyelroo, Baker (1991), Ling & Tyler (2000); Western Australia: Vasse R., Lee *et al.* (2014); Northern Territory: Alligator Rivers region, Ling & Tyler (1986).

Observations:—Cosmopolitan. Widespread and common throughout Australia where it sometimes forms blooms in mesotrophic reservoirs and farm dams. Australian populations have not been associated with the production of cyanotoxins.

Dolichospermum helicoideum (Bernard) Wacklin, Hoffmann & Komárek (2009) Fig. 13 A–F.

Trichomes planktonic, solitary, ± regularly spirally coiled, without mucilaginous sheath, constricted at the cross walls; coils 25–40 µm in diameter. Vegetative cells barrel-shaped, isodiametric or up to 1.8 × longer than broad, 3.6–6.0 µm long × 3.0–3.8 µm broad, with aerotopes; apical cells sometimes slightly narrowed and elongated. Heterocytes solitary, spherical to ellipsoidal, 4.2–5.2 µm long, 3.9 × 4.4 µm broad. Akinetes cylindrical, slightly arcuate, up to 3.3 × longer than broad, 9.4–18.2 µm long × 3.7–5.9 µm broad, single or up to two in series, adjacent to or remote from the heterocytes.

Specimens examined:—Ben Anderson Barrage, Bjelke-Petersen Dam, Boondooma Dam, Bowen R. Weir, Bucca Weir, Callide Dam, Cania Dam, Coolmunda Dam, Eungella Dam, Glenlyon Dam, Kirar Weir, Ned Churchward Weir, Paradise Dam, Wuruma Dam.

Other records:—Queensland: central Queensland as *Anabaena flos-aquae* f. *lemmermannii*, Fabbro & Duivenvoorden (1993).

Observations:—Known from tropical areas of south-east Asia and South and Central America. In Australia, it is commonly misreported as *D. flosaquae*, however *D. helicoideum* differs by the elongated cylindrical shape of akinetes, which may be either remote or adjacent to the heterocyte.

Dolichospermum perturbatum (Hill) Wacklin, Hoffmann & Komárek (2009) Fig. 14 A–C.
Basionym: *Anabaena perturbata* Hill (1976: 67)

Filaments solitary or clustered into microscopic aggregations, planktonic; trichomes regularly spirally coiled, coils 30–40 µm in diameter, constricted at the cross walls, not attenuated towards the ends; often with a broad, colourless mucilage. Vegetative cells spherical or slightly longer than broad, 7.0–9.0 µm in diameter, blue-green in colour, with aerotopes; apical cells undifferentiated. Heterocytes spherical, 7.0–10.0 µm in diameter. Akinetes intercalary, solitary, cylindrical and reniform, remote from the heterocytes, 13.0–19.0 µm long × 9.5–15.0 µm broad.

Specimens examined:—Atkinson Dam, Moogerah Dam.

Other records:—Baker (1991), Baker & Fabbro (2002).

Observations:—Cosmopolitan species, known from the plankton of reservoirs and weir pools throughout Australia.

Dolichospermum planctonicum (Brunnthaler) Wacklin, Hoffmann & Komárek (2009) Fig. 15 A–C.
Basionym: *Anabaena planctonica* Brunnthaler (1903: 292)

Filaments solitary, planktonic; trichomes straight or flexuous, constricted at the cross walls, not attenuated towards the ends; often associated with a broad, hyaline mucilage. Vegetative cells spherical or depressed globose, dark blue-green in colour, with aerotopes, 5.5–12.0 μm long × 8.0–15.0 μm broad; apical cells undifferentiated. Heterocytes solitary, spherical, 9.0–15.0 μm in diameter. Akinetes intercalary, solitary or up to 3 in series, oblong-ovate or oblong with conical ends, remote from heterocytes, 15.0–38.0 μm long × 9.0–20.0 μm broad.

Specimens examined:—Bjelke-Petersen Dam, Bowen R. at Bowen R. Weir, Burnett R. at Jones Weir, Burnett R. at Kirar Weir, Kinchant Dam, Mary R. at Mary R. Barrage, Pioneer R. at Mirani Weir.

Other records:—New South Wales: Prospect Res., Cannon *et al.* (1970), Bowen & Smalls (1980), River Murray at Swan Hill, Sullivan *et al.* (1988), Namoi R. near Walgett, Baker (1991), Ling & Tyler (2000); Victoria: Wonthaggi-Inverloch Res., Baker (1991); South Australia: Warren Res., Hindmash Valley Res., Baker (1991); Northern Territory: Magela Ck, Thomasson (1986).

Observations:—Cosmopolitan species, may be mistaken for *D. smithii* which differ by the shape of mature akinetes.

Dolichospermum smithii (Komárek) Wacklin, Hoffmann & Komárek (2009) Fig. 16 A–E.
Basionym: *Anabaena solitaria* f. *smithii* Komárek (1958)

Filaments solitary, planktonic; trichomes straight or flexuous, constricted at the cross walls, not attenuated towards the ends; often associated with a broad, hyaline mucilage. Vegetative cells spherical or depressed globose, dark blue-green in colour, with aerotopes, 8.5–12.0 μm in diameter; apical cells undifferentiated. Heterocytes solitary, spherical, 9.0–15.0 μm in diameter. Akinetes intercalary, solitary or up to 3 in series, spherical to broadly ovate, remote from the heterocytes, 15.0–28.0 μm in diameter.

Specimens examined:—Burdekin Falls Dam, Burnett R. at Claude Wharton Weir, Burnett R. at Kirar Weir, Burnett R. at Ned Churchward Weir, Coolmunda Dam, Fairbairn Dam, Fitzroy R. at Eden Bann Weir, Fitzroy R. at Tartrus Weir, Julius Dam, Kinchant Dam, Lake Clarendon, Mary R. at Mary R. Barrage, Pioneer R. at Dumbleton Weir, Pioneer R. at Marian Weir.

Other records:—South Australia: River Murray at Murtho, Wood's Point, Warren Res., Baker (1991).

Observations:—Cosmopolitan species, can be confused with *D. planktonica* which differ by the shape of mature akinetes.

Dolichospermum spiroides (Klebhan) Wacklin, Hoffmann & Komárek (2009) Fig. 17 A–D.
Basionym: *Anabaena spiroides* Klebahn (1895: 25)

Filaments solitary, planktonic; trichomes regularly screw-like coiled, coils 20–60 μm in diameter, constricted at the cross walls, not attenuated towards the ends; often with a broad, colourless mucilage. Vegetative cells spherical, compressed at the poles, dark blue-green in colour, (4.0–) 7.0–9.0 μm long × 6.0–8.5 μm broad, with aerotopes; apical cells undifferentiated. Heterocytes spherical, 7.0–10.0 μm in diameter. Akinetes intercalary, solitary or in series, oval to cylindrical with rounded ends, remote from the heterocytes, (11–) 15.0–21.0 μm long × 9.5–15.0 μm broad.

Specimens examined:—Atkinson Dam, Bokhara R. near Kirrima, Balonne R. at Weribone, Beardmore Dam, Bill Gunn Dam, Bjelke-Petersen Dam, Boondooma Dam, Bowen R. at Bowen R. Weir, Burdekin Falls Dam, Burnett R. at Ben Anderson Barrage, Burnett R. at Claude Wharton Weir, Burnett R. at Jones Weir, Burnett R. at Kirar Weir, Burnett R. at Ned Churchward Weir, Callide Dam, Cania Dam, Condamine R. at Chinchilla Weir, Coolmunda Dam, Culgoa R. at Woolerbilla, East Leichhardt Dam, Eungella Dam, Fairbairn Dam, Fitzroy R. at Bedford Weir, Fitzroy R. at Bingegang Weir, Fitzroy R. at Eden Bann Weir, Fitzroy R. at Glebe Weir, Fitzroy R. at Moura Weir, Fitzroy R. at Neville Hewitt Weir, Fitzroy R. at Tartrus Weir, Fitzroy R. at Theodore Weir, Fred Haigh Dam, Glenlyon Dam, Kinchant Dam, Kolan R. at Bucca Weir, Lake Clarendon, Leslie Dam, Maranoa R. at Woodlands, Maranoa R. at Jillambie Rd, Mary R. at Mary R. Barrage, Moogerah Dam, Moura offstream storage, Paradise Dam, Peter Faust Dam, Pioneer R. at Dumbleton Weir, Pioneer R. at Marian Weir, Pioneer R. at Mirani Weir, Six Mile Ck. at Bajool Weir, Teemburra Dam, Wuruma Dam.

Other records:—New South Wales: Lake Hume, Walker & Hillman (1977, 1982), Murrumbidgee R. at Balranald, Sullivan *et al.* (1988), River Murray at Murtho, Morgan, Swan Reach, Mannum, Woods Point, Hawkesbury R. at Sackville, Baker (1991), Murray R. at Moama, Humpage *et al.* (2013); Victoria: River Murray from Heywoods to Redcliffs, Sullivan *et al.* (1988); South Australia: Lake Alexandrina at Goolwa, Baker (1991).

Observations:—Cosmopolitan species, widespread, records from the plankton of reservoirs and weir pools throughout Australia.

NODULARIA

Nodularia Mertens ex Bornet & Flahault (1886: 243)
Type: *N. spumigena* Mertens ex Bornet & Flahault (1888: 245)

Filamentous; filaments solitary or in groups or clusters, rarely in mats, isopolar, unbranched, straight, curved, coiled or irregularly spirally coiled with fine, diffluent mucilage, opened at both ends. Trichomes uniseriate, cylindrical, rarely short and slightly attenuated at the ends of mature trichomes, constricted at the cross walls, metameric, with heterocytes regularly spaced. Vegetative cells shortly barrel-shaped, generally broader than long, aerotopes present in planktonic species. Cell content yellowish, pale olive-green or blue-green in colour. Heterocytes generally the same shape as vegetative cells, sometimes slightly smaller or larger. Akinetes shortly barrel-shaped, shorter than wide, or spherical, developing apoheterocytically. Cells divide crosswise to the trichome axis, growing to their original size before the next division, all cells capable of division, without meristematic zones. Reproduction by hormogonia, dissociation of trichomes, and by akinete production.

A widely distributed genus of 22 species including planktonic and benthic species, known from freshwater lakes and reservoirs, rivers, estuaries and inland saline lakes. Here three species are described from north-eastern Australia. Bibliography: Šmarda *et al.* (1988), Komárek *et al.* (1993), Bolch *et al.* (1999), Vigna *et al.* (2001), Lyra *et al.* (2005), Krüger *et al.* (2009), Hašler *et al.* (2011), Řeháková *et al.* (2014).

1. Trichomes planktonic, with aerotopes ..... *N. spumigena*
- Trichomes benthic or periphytic, without aerotopes 2
2. Vegetative cells 1.5–2.8 µm long × 4.0–5.5 µm wide ..... *N. harveyana*
- Vegetative cells 2.0–4.8 µm long × 8.2–11.5 µm wide ..... *N. willei*

Nodularia harveyana Thuret ex Bornet & Flahault (1886: 243) Fig. 18 F–I.

Filaments solitary or forming fine mats on the substratum, straight or flexuous 4–6 µm wide. Trichomes cylindrical, slightly constricted at the cross walls, not attenuated towards the ends; sheath fine, colourless, diffluent. Vegetative cells shortly barrel-shaped, always shorter than broad, 1.5–2.8 µm long × 4.0–5.5 µm wide, without aerotopes. Heterocytes barrel-shaped to rectangular-rounded, 3–5 (–8) µm long × 4–6 (–9) µm wide. Akinetes compressed sub-spherical to almost spherical, 4–8 µm long × 6–7 µm wide, single or multiple in series.

Specimens examined:—Home Beach Swamp, North Stradbroke Is., L. Cathie, Port Macquarie.

Other records:—Queensland: Mt Alford, A.B. Cribb 1976 (BRI 0701382), Bribie Is., A.B. Cribb 1975 (BRI 0701383), Dunwich, North Stradbroke Is., R.L. Specht 1974 (BRI 0701384).

Observations:—Cosmopolitan. Benthic or periphytic species, typically found growing in sandy substratum in the estuarine reaches of rivers and streams, or inland saline/brackish water bodies. Observed from shallow groundwater fed coastal wetlands, located behind frontal dunes, which receive periodic seawater inundation.

Nodularia spumigena Mertens ex Bornet & Flahault (1888: 245) Fig. 19 A–E.

Filaments planktonic; trichomes solitary, straight or slightly flexuous to irregularly coiled. Trichomes cylindrical, constricted at the cross walls; sheath thick, fine, diffluent and indistinct. Vegetative cells discoid to shortly barrel-shaped, distinctly compressed, 2.0–4.5 µm long × 7.0–12.0 µm broad, with aerotopes. Heterocytes sub-spherical or discoid, 4.5–6.0 µm long × 7.5–11.5 µm broad, at regular intervals along the trichome. Akinetes sub-spherical to almost spherical, 6.5–10.5 µm long × 9.0–13.0 µm broad, single or multiple in series, mature epispore yellow-brown in colour.

Specimens examined:—Carbrook Lakes, Monterey Keys.

Other records:— Victoria: Ling & Tyler (2000); South Australia: Lake Alexandrina, Francis (1878), Geddes (1984), Lake Albert, Strathalbyn Res., shallow swamp at Naracoorte, Baker (1991); Western Australia: Peel-Harvey Estuary, Huber (1984), Lake Yangebup, Kemp (2009); Tasmania: Ling & Tyler (2000).

Observations:—Wide distribution throughout temperate and subtropical areas. Australian populations produce the cyanotoxin nodularin (Heresztyn & Nicholson 1997). This species has also been frequently reported as forming nuisance coastal blooms including in the Peel-Harvey Estuary, Western Australia (Huber 1986) and as a persistent bloom in a cable ski park lake in SE Queensland (McGregor *et al.* 2012, Stewart *et al.* 2012).

Nodularia willei Gardner (1927) Fig. 18 A–E.

Filaments solitary amongst other algae or grouped into irregular clusters or mats, straight or slightly flexuous, 8.5–12.0 µm broad. Trichomes cylindrical, slightly constricted at the cross walls, not attenuated towards the ends. Sheath fine, colourless, indistinct, open at both ends. Vegetative cells short barrel-shaped, always shorter than wide, 2.0–4.8 µm long × 8.2–11.5 µm broad, without aerotopes. Heterocytes intercalary, solitary, compressed, 4.5–6.0 µm long × 8.2–11.0 µm broad. Akinetes sub-spherical, compressed, solitary or commonly multiple in series, 5.5–8.3 µm long × 9.5–13.2 µm broad, with brownish granular contents.

Specimens examined:—Emu Ck at Grieves Rd, Marongi Ck at Turtle Ck Rd, Reedy Ck at Mt. Byron Rd, Running Ck at Biggenden Rd Crossing, Sandy Ck at Wivenhoe-Somerset Rd Crossing, Sheepstation Ck at Kilcoy-Murgon Rd, Wallaby Ck at Himstedts Rd.

Observations:—Growing on the benthos and amongst aquatic macrophytes and filamentous algae in shallow streams of the Mary and Brisbane catchments, south-east Queensland. A pantropical species, originally described from Central America. Australian material is consistent with the original description by Gardner (1927). Compare with *N. moravica* Hindák, Šmarda & Komárek 2003 which has similar morphology, but is known from wetlands in central Europe.

RAPHIDIOPSIS

Raphidiopsis (Fritsch & Rich) Anguilera, Berrendero Gómez, Kaštovský, Echenique & Salerno (2018: 144)
Type: *R. curvata* Fritsch & Rich (1929: 91)

Filamentous, planktonic; trichomes solitary, without sheaths or gelatinous envelopes, straight, waved or screw-like coiled, isopolar, uniseriate, with or without heterocytes. When heterocytes are present, they are in the terminal position, oval, ovoid or conical, sometimes slightly curved and drop-like, developing at one or both ends of the trichome. Trichomes without heterocytes usually attenuated toward both ends, but without hair-like, elongated apical cells, ± constricted at the cross walls, sometimes indistinct. Vegetative cells barrel-shaped, always longer than broad, sometimes slightly elongated towards the trichome ends, facultatively with aerotopes; apical cells conical-rounded or sharply pointed. Akinetes intercalary, barrel-shaped, oval or cylindrical, single or multiple in series, developing towards the middle of trichomes.

A widely distributed genus of 19 species known from freshwater lakes, reservoirs and rivers. Here three species are described from north-eastern Australia. Bibliography: Seenayya & Suba Raju (1972), Baker (1991), Komárek & Kling (1991), Fabbro & Duivenvoorden (1996), Padisák (1997), McGregor & Fabbro (2000), Komárek & Komárková (2003), Li *et al.* (2008), Moustaka-Gouni *et al.* (2009), Stüken *et al.* (2006, 2009), Kling (2009), Moustaka-Gouni *et al.* (2009), McGregor *et al.* (2011), Piccini *et al.* (2011), Komárek & Mareš (2012), Moreira *et al.* (2015), Antunes *et al.* (2015), Komárek (2016), Li *et al.* (2017), Komárek (2016), Aguilera *et al.* (2018).

1. Trichomes always lacking heterocytes 2
- Trichomes with terminal heterocytes ..... *R. raciborskii*
2. Trichomes c-shaped curved, sigmoidally or irregularly circular ..... *R. curvata*
- Trichomes straight or slightly bent ..... *R. mediterannea*

Raphidiopsis curvata Fritsch & Rich (1929: 91) Fig. 20 G.

Filaments planktonic; trichomes solitary or rarely in small floccose clusters, c-shaped curved, sigmoidally coiled or irregularly circular, not constricted at the cross walls. Vegetative cells cylindrical, 1.5–2.5 × longer than broad, 2–4.5 µm broad, blue-green, with aerotopes. Apical cells elongated and sharply pointed. Akinetes intercalary, barrel-shaped or bluntly cylindrical oval, sometimes slightly curved, single or multiple in series, 10–16 µm long × 3.5–5.5 µm broad, with smooth, colourless epispore.

Specimens examined:—Lake Clarendon, Eungella Dam, Wuruma Dam.

Other records:—Queensland: SE Queensland, McLeod (1975).

Observations:—Cosmopolitan. Uncommon species, rarely reported from reservoirs and weir pools. Differs from *R. mediterranea* by the curved shape of the trichome.

Raphidiopsis mediterranea Skuja (1937: 23) Fig. 20 A–F.

Filaments planktonic; trichomes straight or slightly bent, narrowed and sharply pointed at both ends, solitary or aggregated into fasciculated, parallel arranged clusters, not constricted at the cross walls. Vegetative cells cylindrical, 2–5 × longer than broad, 1.0–3.5 μm broad, blue-green in colour, with aerotopes. Apical cells elongated and sharply pointed. Akinetes intercalary, barrel-shaped or bluntly cylindrical oval, single or 2–4 in series, with smooth, colourless or brownish epispore.

Specimens examined:—Lake Clarendon, Bill Gunn Dam, Wuruma Dam, Atkinson Dam, Borumba Dam, Cania Dam, Wyndham Dam, Bjelke-Petersen Dam, Peter Faust Dam, Fitzroy R. at Moura Weir, Fitzroy R. at Eden Bann Weir, Fitzroy R. at Neville Hewitt Weir, Fitzroy R. at Bingegang Weir, Fred Haigh Dam, Coolmunda Dam, Pioneer R. at Marian Weir, Pioneer R. at Dumbleton Weir, Pioneer R. at Mirani Weir, Teemburra Dam, Fairbairn Dam, Fitzroy R. at Tartrus Weir, Julius Dam, Moogerah Dam, Leslie Dam, Kinchant Dam, Callide Dam, Tinaroo Falls Dam, Burnett R. at Ben Anderson Barrage, Burnett R. at Kirar Weir, Burnett R. at Jones Weir, Tinaroo Falls Dam, Ibis Dam, Warrego R. at Allan Tannock Weir, Eungella Dam.

Other records:—Baker & Fabbro (2002).

Observations:—A widely distributed species, although generally considered more common throughout the tropics. In Australia, it has been infrequently reported from the plankton of mesotrophic reservoirs. The low frequency at which it has been reported is not surprising given its morphological similarity to *R. raciborskii* (McGregor & Fabbro 2000). In *R. raciborskii* heterocytes are solitary, terminal, and develop at one or both ends of the trichome, whereas in *R. mediterannea* heterocytes are lacking. Given that heterocytes are not always expressed in *R. raciborskii* populations, distinction from *R. mediterannea* is often based on differential apical cell morphology alone. Morphological similarities between these two species therefore, may result in misidentifications (Mohamed 2006, Alster *et al.* 2010). Australian populations of *R. mediterannea* produce the cyanotoxins cylindrospermopsin and deoxy-cylindrospermopsin (McGregor *et al.* 2011).

Raphidiopsis raciborskii (Wołoszyńska) Anguilera, Berrendero Gómez, Kaštovský, Echenique & Salerno (2018: 144) Fig. 21 A–H.

Basionym: *Anabaena raciborskii* Wołoszyńska (1912: 684)

Trichomes solitary, straight, coiled or sigmoidal, often slightly attenuated towards the apices. Vegetative cells quadrate to cylindrical, not or slightly constricted at the cross walls which are often indistinct, 2.0–8.5 μm long × 2.0–4.5 μm broad, with aerotopes. Heterocytes long ovoid or conical, sometimes slightly curved, terminal at one or both ends of the trichome, 3.5–11 μm long × 2.5–4.0 μm broad. Akinetes oblong-ovate to cylindrical and rounded at the ends with curved margins in coiled trichomes, 7.5–16.0 μm long × (2.5–) 3.5–4.5 μm broad, solitary or in series, typically remote from the heterocytes.

Specimens examined:—Atkinson Dam, Beardmore Dam, Bill Gunn Dam, Bjelke-Petersen Dam, Boondooma Dam, Borumba Dam, Bowen R. Weir, Burdekin Falls Dam, Burnett R. at Ben Anderson Barrage, Burnett R. at Jones Weir, Burnett R. at Kirar Weir, Burnett R. at Ned Churchward Weir, Callide Dam, Cania Dam, Condamine R. at Chinchilla Weir, Coolmunda Dam, Copperfield Dam, Corella Dam, Crookes Dam, East Leichhardt Dam, Dowse Lagoon, Eungella Dam, Fairbairn Dam, Fitzroy R. at Bedford Weir, Fitzroy R. at Bingegang Weir, Fitzroy R. at Claude Wharton Weir, Fitzroy R. at Eden Bann Weir, Fitzroy R. at Glebe Weir, Fitzroy R. at Moura Weir, Fitzroy R. at Neville Hewitt Weir, Fitzroy R. at Tartrus Weir, Fitzroy R. at Theodore Weir, Fred Haigh Dam, Gattonvale offstream storage, Glen Niven Dam, Glenlyon Dam, Haughton R. at Giru Weir, Julius Dam, Kinchant Dam, Kolan R. at Bucca Weir, L. Clarendon, Lake Moondarra, Leslie Dam, Marian Weir, Maroon Dam, Mary R. Barrage, Moogerah Dam, Moura offstream storage, Paradise Dam, Peter Faust Dam, Pioneer R. at Dumbleton Weir, Pioneer R. at Mirani Weir, Six Mile Ck at Bajool Weir, Somerset Dam, Stag Ck Weir, Teemburra Dam, Tinaroo Falls Dam, Warrego R. at Allan Tannock Weir, Wivenhoe Dam, Wuruma Dam, Wyndham Dam.

Other records:—Queensland: Palm Is., Hawkins *et al.* (1985), Ling & Tyler (2000); New South Wales: River Murray at Heywoods, Yarrawonga, Torrumbarry, Swan Hill and Euston, Sullivan *et al.* (1988); Victoria: Bonyaricall Ck, U/S Robinvale, Swan Reach, L. Alexandrina at Goolwa, Baker (1991); South Australia: Big Bend Lagoon, Murray R., Baker (1991); Northern Territory: Ling & Tyler (2000).

Observations:—Pantropical species, widely distributed throughout tropical regions and warmer areas of the temperate zone where it has more recently been considered an invasive species (Antunes *et al.* 2015, Moreira *et al.* 2015). Reported from lakes, reservoirs and rivers in every mainland state of Australia (as *Cylindrospermopsis*

raciborskii, Baker & Fabbro 2002). Australian populations produce the cyanotoxins cylindrospermopsin and deoxy-cylindrospermopsin (Hawkins *et al.* 1997, Saker & Eaglesham 1999). Three morphological forms of *R. raciborskii* are known from Australia including straight, coiled, and sigmoid/irregular. This morphological plasticity may lead to identification difficulties, as many similarities exist between these morphotypes and other species of *Raphidiopsis* with terminal heterocytes such as *R. philippinensis* (Taylor) Anguilera, Berrendero Gómez, Kaštovský, Echenique & Salerno and *R. catemaco* (Komárková-Legnerová & Tavera) Anguilera, Berrendero Gómez, Kaštovský, Echenique & Salerno. This variability appears intrinsic to *R. raciborskii* and does not reflect interspecific differences between morphotypes.

SPHAEROSPERMOPSIS

Sphaerospermopsis Zapomělová, Jezberová, Hrouzek, Hisem, Řeháková & Komárková (2010: 415)
Type: *S. reniformis* (Lemmermann) Zapomělová, Jezberová, Hrouzek, Hisem, Řeháková & Komárková (2010: 415)

Filaments planktonic; trichomes solitary, coiled or straight, constricted at the cross walls, with or without mucilaginous sheaths. Apical cells elongated and tapered in straight species, or undifferentiated in coiled species. Vegetative cells spherical or barrel-shaped, compressed during division, with aerotopes. Heterocytes intercalary, solitary, spherical. Akinetes spherical or widely oval, adjacent to either side of the heterocytes.

A widely distributed genus of seven species known from freshwater lakes and reservoirs, rivers and estuaries. Here three species are described from north-eastern Australia. Bibliography: Zapomělová *et al.* (2009, 2010), Werner *et al.* (2012), Li *et al.* (2015, 2016).

1. Trichomes straight ..... *S. aphanizomenoides*
- Trichomes coiled 2
2. Coils (7.0–) 8.5–15.8 µm in diameter ..... *S. eucompacta*
- Coil diameter 12–24 µm in diameter ..... *S. reniformis*

Sphaerospermopsis aphanizomenoides (Forti) Zapomělová, Jezberová, Hrouzek, Hisem, Řeháková & Komárková (2010: 415) Fig. 22 A–H.
Basionym: *Anabaena aphanizomenoides* Forti (1911: 4)

Filaments planktonic; trichomes straight or slightly flexuous, slightly attenuated towards the ends, constricted at the cross walls. Vegetative cells quadrate or sub-spherical, isodiametric or 1–2 × longer than broad, 3.0–6.0 (–10) µm long × 3.0–5.5 (–7.0) µm broad, with aerotopes; apical cells slightly narrowed and shortly rounded or elongated and club-shaped. Heterocytes spherical or ovate, intercalary, solitary, 4.0–7.5 µm in diameter. Akinetes spherical to widely oval, 6.5–14.6 µm long × 6.5–14.0 µm broad, solitary or in pairs, adjacent either side of the heterocytes, epispore smooth, colourless.

Specimens examined:—Atkinson Dam, Beardmore Dam, Bill Gunn Dam, Bjelke-Petersen Dam, Boondooma Dam, Borumba Dam, Bowen R. at Bowen R. Weir, Burdekin Falls Dam, Burnett R. at Ben Anderson Barrage, Burnett R. at Claude Wharton Weir, Burnett R. at Jones Weir, Burnett R. at Kirar Weir, Burnett R. at Ned Churchward Weir, Callide Dam, Cania Dam, Condamine R. at Chinchilla Weir, Coolmunda Dam, Corella Dam, Crookes Dam, Eungella Dam, Fairbairn Dam, Fitzroy R. at Bedford Weir, Fitzroy R. at Bingegang Weir, Fitzroy R. at Eden Bann Weir, Fitzroy R. at Glebe Weir, Fitzroy R. at Moura Weir, Fitzroy R. at Neville Hewitt Weir, Fitzroy R. at Tartrus Weir, Fitzroy R. at Theodore Weir, Fred Haigh Dam, Gattonvale offstream storage, Glen Niven Dam, Glenlyon Dam, Haughton R. at Giru Weir, Horn Is. Dam, Ibis Dam, Julius Dam, Jumna Dam, Kinchant Dam, Kolan R. at Bucca Weir, Lake Clarendon, Leslie Dam, Loudon Dam, Maroon Dam, Mary R. at Mary R. Barrage, Moogerah Dam, Moura offstream storage, Paradise Dam, Peter Faust Dam, Pioneer R. at Dumbleton Weir, Pioneer R. at Marian Weir, Pioneer R. at Mirani Weir, Six Mile Ck at Bajool Weir, Teemburra Dam, Tinaroo Falls Dam, Warrego R. at Allan Tannock Weir, Wuruma Dam, Wyndham Dam.

Other records:—New South Wales: Lake Victoria, Baker (1991), Clarie Hall Res., River Murray at Tocumwal, Humpage *et al.* (2013); Victoria: River Murray at Torrumbarry, Sullivan *et al.* (1988), River Murray at Merbein, Baker (1991); South Australia: Lake Alexandrina, Lake Albert, Baker (1991), Ling & Tyler (2000); Western Australia: Vasse R., Lee *et al.* (2014).

Observations:—Widespread species throughout Australia, known from every mainland state. Australian

populations closely resemble European populations (after Hindák 2000). There has been wide variability reported in the vegetative cell dimensions of this species (see Stüken *et al.* 2009, Zapomělová *et al.* 2009), however the shape and position of akinetes adjacent to the heterocytes is generally a conserved feature.

Sphaerospermopsis eucompacta (Li & Watanabe) Li & Li in Li *et al.* (2015: 300) Fig. 23 A–G.
Basionym: *Anabaena eucompacta* Li & Watanabe (1999: 93)

Trichomes planktonic, solitary and regularly tightly coiled, without mucilaginous sheaths; coils (7.0–) 8.5–15.8 μm in diameter, distance between coils 4.2–8.7 μm. Vegetative cells spherical or slightly elongate, 2.4 –4.7 (–6.0) μm long × 2.8–4.2 μm broad, with aerotopes. Heterocytes spherical, 3.8–4.7 μm in diameter. Akinetes spherical to broadly ovoid, 6.3–8.8 μm long × 5.3–7.6 μm broad, adjacent to the heterocytes on one or both sides.

Specimens examined:—Moura offstream storage, Gattonvale offstream storage, Lake Clarendon, Bill Gunn Dam, Fitzroy R. at Moura Weir, Fitzroy R. at Neville Hewitt Weir, Fitzroy R. at Bedford Weir, Fitzroy R. at Theodore Weir, Fairbairn Dam, Wuruma Dam, Coolmunda Dam, Moogerah Dam, Burnett R. at Ben Anderson Barrage, Burnett R. at Ned Churchward Weir, Burnett R. at Claude Wharton Weir, Callide Dam, Kolan R. at Bucca Weir, Eungella Dam, Bjelke-Petersen Dam, Paradise Dam, Glenlyon Dam, Cania Dam, Teemburra Dam, Pioneer R. at Dumbleton Weir, Kinchant Dam.

Other records:—South Australia: River Murray, Swan Reach (as *Anabaena spiroides* f. *spiroides*), Baker (1991).

Observations:—This species is similar to *Dolichospermum compactum* (Nygaard) Wacklin, Hoffmann & Komárek (2009) with respect to the narrow, tightly coiled trichomes, however it differs by the position of the akinetes which are remote from the heterocytes (a feature often difficult to resolve with LM in such tightly compact coils). *S. crassa* X. Li & R. Li (2016) is distinguished from *S. eucompacta* by larger vegetative cells and heterocyte diameter. *S. eucompacta* was originally described from the plankton of L. Yatsuru, Japan. Australian populations are known from mesotrophic weir pools throughout north-eastern Australia and the lower River Murray, South Australia.

Sphaerospermopsis reniformis (Lemmermann) Zapomělová, Jezberová, Hrouzek, Hisem, Řeháková & Komárková (2010: 415) Fig. 24 A–C.
Basionym: *Anabaena reniformis* Lemmermann (1898: 155)

Filaments planktonic; trichomes irregularly spirally coiled, constricted at the cross walls. Vegetative cells barrel-shaped or sub-spherical, compressed at the poles, 4.0–6.0 (–8) μm long × 3.5–5.5 μm broad, with aerotopes; apical cells undifferentiated. Heterocytes spherical or ovate, intercalary, solitary, 4.0–7.0 μm in diameter. Akinetes spherical, 7.0–10.5 (–12.5) μm in diameter, solitary or in pairs, adjacent either side of the heterocytes, epispore smooth, colourless.

Specimens examined:—Atkinson Dam, Beardmore Dam, Bill Gunn Dam, Bjelke-Petersen Dam, Boondooma Dam, Borumba Dam, Bowen R. at Bowen R. Weir, Burdekin Falls Dam, Burnett R. at Ben Anderson Barrage, Burnett R. at Claude Wharton Weir, Burnett R. at Jones Weir, Burnett R. at Kirar Weir, Burnett R. at Ned Churchward Weir, Callide Dam, Cania Dam, Condamine R. at Chinchilla Weir, Coolmunda Dam, Corella Dam, Crookes Dam, Eungella Dam, Fairbairn Dam, Fitzroy R. at Bedford Weir, Fitzroy R. at Bingegang Weir, Fitzroy R. at Eden Bann Weir, Fitzroy R. at Glebe Weir, Fitzroy R. at Moura Weir, Fitzroy R. at Neville Hewitt Weir, Fitzroy R. at Tartrus Weir, Fitzroy R. at Theodore Weir, Fred Haigh Dam, Gattonvale offstream storage, Glen Niven Dam, Glenlyon Dam, Haughton R. at Giru Weir, Hinze Dam, Horn Is. Dam, Ibis Dam, Julius Dam, Jumna Dam, Kinchant Dam, Kolan R. at Bucca Weir, Lake Clarendon, Leslie Dam, Loudon Dam, Maroon Dam, Mary R. at Mary R. Barrage, Moogerah Dam, Moura offstream storage, Paradise Dam, Peter Faust Dam, Pioneer R. at Dumbleton Weir, Pioneer R. at Marian Weir, Pioneer R. at Mirani Weir, Six Mile Ck at Bajool Weir, Teemburra Dam, Tinaroo Falls Dam, Warrego R. at Allan Tannock Weir, Wuruma Dam, Wivenhoe Dam, Wyndham Dam.

Other records:—South Australia: River Murray at Swan Reach, Farm dam, Mount Barker, Baker (1991) (as *Anabaena spiroides* morphotype 2); Victoria: Iraak Ck downstream of Nangiloc, Humpage *et al.* (2013).

Observations:—Common and widespread species known from the plankton of reservoirs and weir pools throughout Australia. Shape and position of the akinete adjacent either side of the heterocyte is a distinctive morphological feature.

2. GLOEOTRICHACEAE

Gloeotrichiaceae Komárek, Kaštovský, Mareš & Johansen (2014: 315)
Type: *Gloeotrichia* Agardh ex Bornet & Flahault (1886: 365)

Thallus spherical, hemispherical, or irregularly shaped, mucilaginous, sometimes hollow, often macroscopic. Trichomes heteropolar with basal heterocytes and sub-terminal akinetes.

GLOEOTRICHIA

Gloeotrichia Agardh ex Bornet & Flahault (1886: 365)
Type: *G. pisum* Thuret ex Bornet & Flahault (1886: 366)

Filamentous, colonial; trichomes heteropolar with basal heterocytes and apical, hair-like ends with their own sheaths, radially united into gelatinous, globose or hemispherical colonies, which are microscopic up to several centimetres in diameter, olive-green, yellow-green, brown or dark blue-blackish in colour. Colonies enveloped by fine mucilage; trichomes always oriented with heterocytes towards the colony centre. Trichomes rarely falsely branched; branches rapidly separate from the mother trichome but remain parallel and radially located within the colonial mucilage forming their own gelatinous sheaths. Colonies planktonic or attached to the substratum. Trichomes uniseriate, rarely with intercalary heterocytes, constricted or unconstricted at the cross walls, straight or irregularly coiled. Sheaths always present, but sometimes gelatinized within the mucilage of colonies, especially near the apical parts of trichomes. Basal heterocytes oval or cylindrical. Vegetative cells in several planktonic species contain aerotopes. Cell division perpendicular to the long axis of the trichome, usually in a meristematic zone. Reproduction by dissociation of trichomes within colonies, and by the formation of hormogonia, differentiating after the separation of the apical hair through the formation of necridic cells, sometimes liberated from old colonies.

A worldwide genus with 28 species currently taxonomically accepted; most are known from benthic or metaphytic habitats, two species are planktonic and produce aerotopes. Five species are known from Australian freshwaters. Here two species are described from north-eastern Australia. Bibliography: Komárek (2013), Komárek et al (2014).

1. Trichomes 7–10 µm broad in the basal area..... *G. raciborskii*
- Trichomes 4–7 µm broad in the basal area..... *G. natans*

Gloeotrichia natans Rabenhorst ex Bornet & Flahault (1886: 369) Fig. 25 A–F.

Thallus composed of gelatinous, irregularly spherical colonies, olive-green to brown in colour, 4–10 cm in diameter, attached to the substratum or less commonly free-floating. Filaments long, radially arranged within colonies, gradually tapered towards the ends, ± constricted at the cross walls. Sheath vase-like, widened, initially colourless, later yellow to yellow-brown in colour, layered and opened at the end. Vegetative cells initially shorter than broad to isodiametric, elongated towards the ends, up to 3 × longer than broad, 6.3–16.0 µm long × 4.0–7.0 µm broad. Heterocytes basal, single, ± spherical, 8.0–12.5 µm long × 9.0–12.0 µm broad. Akinetes cylindrical, slightly arcuate when mature, up to 5 × longer than broad, 25–55 µm long × 10–15 µm broad, with brown coloured exospore.

Specimens examined:—Cattle Ck at Gargett, Little Yabba Ck at Maleny Kenilworth Rd Crossing.

Other records:—Queensland: Canarvon Ck, A.B. Cribb 1964 (BRI 0700772), Bailey (1895), SE Queensland, McLeod (1975); Victoria: Bailey (1895), Entwisle (1994), Möbius (1895), Schmidle (1896).

Observations:—Known from coastal streams in south-east and northern Queensland. Observed forming olive-green to brownish gelatinous colonies on granitic cobbles and boulders, and large woody debris.

Gloeotrichia raciborskii Wołoszyńska (1912: 687) Fig. 26 A–E.

Thallus gelatinous, olive-green to brown in colour, colonies small spherical, attached to macrophytes or the substratum, later free floating, irregularly globose, up to 3–5 cm in diameter. Filaments long, > 800 µm, tapered from a spherical basal heterocyte, radially arranged from the colony centre. Trichomes clearly constricted at the cross walls, 7–10 µm wide in the basal area, narrowing to long, hair-like cells 2–6 µm broad. Vegetative cells barrel-shaped, slightly shorter or longer than broad. Heterocytes spherical, basal, 10–14 µm in diameter. Akinetes cylindrical, long ellipsoidal with

widely rounded ends, arising from several vegetative cells, 10–60 µm long × (12–) 14–25 µm broad, with colourless to dull-brown coloured exospore.

Specimens examined:—Einasleigh R. at the Beach, Blacks Ck at Whitefords.

Other records:—Queensland: Baker & Fabbro (1992).

Observations:—Colonies growing on sandy substrate amongst submerged aquatic vegetation, or sometimes free-floating in the littoral areas or backwaters of tropical streams and rivers. A variable species, with several subspecific taxa described.

Other species known from Australia: *G. echinulata* P.G. Richter, Victoria, Entwisle (1994); *G. pisum* Thuret ex Bornet & Flahault, SE Queensland, McLeod (1975); *G. raciborskii f. lillienfeldiana* (Wołoszyńska) Geitler, Ling & Tyler (2000).

3. HAPALOSIPHONACEAE

Hapalosiphonaceae Elenkin (1916: 278, 280)
Type: *Hapalosiphon* Nägeli ex Bornet & Flahault (1886: 53)

Filamentous, thallose; composed of true-branched filaments, with all filaments and branches morphologically similar. Trichomes unseriate, divicariate, but not morphologically divided into main trichomes and branches, often constricted at the cross walls, moniliform, but usually ± cylindrical, true-branched with T-, V, and Y-type branching. Branches cylindrical, or less frequently narrowed towards the ends, rarely attenuated to hair-like cells. Vegetative cells cylindrical, barrel-shaped or irregularly rounded; apical cells rounded. Heterocytes intercalary, barrel-shaped or spheroidal. Akinetes absent. Reproduction by production of hormogonia.

A cosmopolitan family of 13 genera; four genera and six species are known from freshwater habitats of north-eastern Australia.

KEY TO GENERA

1. Trichomes from thermal habitats ..... MASTIGOCLADUS
- Trichomes not from thermal habitats 2
2. Heterocytes attached to the main axis or laterally on the ends of short, 1–3 celled branches ..... NOSTOCHOPSIS
- Heterocytes intercalary .....
3. Heterocytes sub-spherical in basal trichomes, cylindrical in branches ..... FISCHERELLA
- Heterocytes cylindrical, undifferentiated in branches ..... HAPALOSIPHON

FISCHERELLA

Fischerella (Bornet & Flahault) Gomont (1895:49)
Type: *F. thermalis* Gomont (1895: 52)

Filamentous, thallose; thallus prostrate, felt-like, rarely in compact mats, composed of creeping, uni- or multiseriate filaments forming erect uniseriate branches. Creeping trichomes usually moniliform, enveloped by thick, waved, sometimes slightly lamellated and coloured sheaths; vegetative cells usually barrel-shaped, sometimes enveloped by their own gelatinous sheaths; erect, T-type branching developing usually unilaterally after lengthwise cell division in basal trichomes, usually cylindrical, with cylindrical and often elongated cells and thin, mainly colourless sheaths. Vegetative cells often with slightly granular contents. Heterocytes intercalary, sub-spherical in basal trichomes, cylindrical in branches. Akinetes develop occasionally and irregularly in basal trichomes. Reproduction by uniseriate hormogonia which separate from the ends of branches; typically, hormogonia are morphologically distinct from the main branches, with aerotopes.

A worldwide genus with 19 species that are currently accepted taxonomically; most are known from moist soils, or growing subaerophytically on walls and terrestrial vegetation, few are known from aquatic habitats.

Two species are known from Australian freshwaters. Here one species is described from north-eastern Australia. Bibliography: Gugger & Hoffmann (2004), Fiore *et al.* (2009), Komárek *et al.* (2014).

***Fischerella* sp. A.** Fig. 27 A–F.

Thallus mucilaginous; main filaments cylindrical, uni- or multiseriate, flexuous, entangled, 13–22 µm wide. Branches erect, cylindrical, sometimes with tolypotrichoid false-branching, 7–12 µm wide. Sheaths initially fine, colourless, later thickened, firm, coloured and lamellate, open at the ends. Vegetative cells of main filaments cylindrical to shortly barrel-shaped, 0.7–1.1 × longer than wide, 6.5–13.5 µm long × 6.3–15.5 µm wide; cells of branches elongated cylindrical with rounded ends, 3–8 × longer than wide, 11.2–29.5 µm long × 4.5–6.0 µm wide. Heterocytes single or sometimes two in series, sub-spherical to elongated cylindrical with bluntly rounded ends, in main filaments, 10.0–22.5 µm long × 6.5–11.5 µm wide, in branches 7.3–38.0 µm long × 4.8–8.5 µm wide.

Specimens examined:—Pascoe R. at Crossing Spring #1.

Observations:—Metaphytic, floating on the surface and attached to trailing terrestrial, and submerged aquatic vegetation, as irregular clumps 3–8 cm in diameter. A species of *Fischerella* isolated from an ephemeral creek near Townsville, northern Queensland has been reported producing the hepatotoxins microcystins (Cirés *et al.* 2014).

Other species known from Australia: *F. musicola* (Thuret) Gomont (1895), SE Queensland, McLeod (1975), *F.* sp., Queensland (Cirés *et al.* 2014).

HAPALOSIPHON

Hapalosiphon Nägeli ex Bornet & Flahault (1886: 53)
Type: *H. pumilus* Kirchner ex Bornet & Flahault (1887: 61)

Filamentous thallose; thallus composed of irregular filamentous clusters, attached to the substratum, epiphytic on aquatic plants, or free floating in the metaphyton. Filaments irregularly arcuate, with uniseriate trichomes; with true, T-type branching, morphologically undifferentiated between the main and lateral trichomes, rarely with branches that are slightly narrower. Sheaths thin, colourless, rarely indistinctly layered. Heterocytes intercalary, uncommon in lateral branches. Vegetative cells cylindrical or barrel-shaped, distinctly constricted at the cross walls, sometimes with finely and sparsely granular contents. Heterocytes intercalary, cylindrical. Reproduction by hormogonia with aerotopes, separating from trichomes at the ends of lateral branches through the formation of necridic cells.

A cosmopolitan genus comprising 28 species; three are described here from freshwater habitats of north-eastern Australia. Most species grow in standing waters amongst aquatic macrophytes and in the metaphyton of littoral areas of lakes and lacustrine wetlands. Several species prefer moors and peaty waters, one species occurs in thermal waters, two species grow subaerophytically. Bibliography: Siva & Sant'Anna (1990), Hindák (2012), Komárek (2013), Komárek *et al.* (2014).

1. Cells of the main filament and branches usually of the same dimensions ..... *H. hibernicus*
- Cells of the main filament usually larger than the branches 2
2. Filaments flexuous to irregularly coiled (6–) 8–20 µm wide ..... *H. pumilus*
- Filaments flexuous, 5.5–9.0 µm wide ..... *H. welwitschia*

Hapalosiphon hibernicus West & G.S.West (1896: 163) Fig 28. A–D.

Filaments solitary, or in small clusters amongst other algae, blue-green to olive-green in colour; richly branched, flexuous to irregularly coiled (5–) 7.5–9.0 µm wide. Branches erect, vertically divaricate, usually of the same diameter as the main filament. Sheaths thin, colourless to slightly yellow-brown in colour, sometimes thickened in mature filaments. Trichomes cylindrical, clearly constricted at the cross walls, particularly in older filaments, branches less so. Vegetative cells cylindrical, ± isodiametric or up to 4 × longer than broad, 6.5–17.3 µm long × 3.5–7.5 µm wide; apical cells rounded. Heterocytes cylindrical, up to 2 × longer than broad, 7.5–9.0 µm long × 3.5–6.5 µm wide.

Specimens examined:—Little R. at Gulf Development Rd.

Other records:—Victoria: Darling (1982), Entwisle (1994).

Observations:—Observed growing amongst filamentous algae and submerged aquatic vegetation in the littoral zone of an acidic tropical coastal river. Known from clear water, peaty habitats throughout the temperate zone (Komárek 2013).

Hapalosiphon pumilus Kirchner ex Bornet & Flahault (1887: 61) Figs. 29 A–E, 30 A–E.

Thallus composed of clusters of densely entangled blue-green to olive-green coloured filaments. Filaments richly branched, flexuous to irregularly coiled (6–) 8–20 µm wide. Branches vertically divicariate, erect, often slightly narrower than the main filament. Sheaths fine, colourless to yellow-brown in colour, and thickened in mature filaments. Trichomes cylindrical, clearly constricted at the cross walls, particularly in older filaments, branches less so; cells towards the apices of branches usually very short. Vegetative cells barrel-shaped and ± isodiametric in older filaments; in branches, cylindrical and up to 2–4 × longer than wide, 6.9–12.5 (–28) µm long × 5.7–12.0 µm wide. Heterocytes isodiametric to elongated cylindrical, 7.5–18.2 (–30) µm long × 4.2–7.4 (–13) µm wide. Reproduction by the production of 14–50 celled hormogonia which arise at the ends of branches and typically contain aerotopes.

Specimens examined:—Archer R. wetland #1, Freshwater L., Great Sandy Natl Park, Cooloola Section, Boomerang L., Great Sandy Natl Park, Fraser Is. Section, Cockatoo Ck at Heathlands, Honey Eater L., Moreton Is. Natl Park, Moon Point Fens, Great Sandy Natl Park, Fraser Is. Section, Blue L., Eighteen Mile Swamp, Naree Budjong Djara National Park, North Stradbroke Is., Rainbow Beach Fens, Great Sandy Natl Park, Cooloola Section, Saucepan Spring at Eliot Ck, Swallow Lagoon, Naree Budjong Djara Natl Park, North Stradbroke Is., Tortoise Lagoon, Naree Budjong Djara Natl Park, North Stradbroke Is., Welsby Lagoon, North Stradbroke Island.

Other records:—Queensland: Bailey (1893), Bailey (1895), Cribb (1976, 1974), McLeod (1975); New South Wales: Playfair (1917); Northern Territory: Scott & Prescott (1958), Thomasson (1986).

Observations:—Common in the littoral areas of wallum lakes and peaty wetlands, where it forms conspicuous colonies on the benthos, or attached to aquatic vegetation. Masses of hormogonia have been observed in the plankton of wallum lakes during spring and early summer.

Hapalosiphon welwitschii West & G.S.West (1897: 242) Fig. 31 A–D.

Thallus caespitose, with filaments densely entangled, blue-green to olive-green in colour. Filaments flexuous, 5.5–9.0 µm wide. Branches short, erect, slightly narrower than the main filament, and narrowed towards the ends. Sheaths thin, colourless. Trichomes cylindrical, clearly constricted at the cross walls, particularly in older filaments. Vegetative cells rounded barrel-shaped, ± isodiametric; in branches cylindrical, up to 2 × longer than wide, 5.0–9.5 (–15) µm long × 5.5–9.0 (–12.0) µm wide. Heterocytes isodiametric to elongated cylindrical 7.5–12.5 µm long × 5.5–9.6 µm wide.

Specimens examined:—Christmas Ck at Stinson Memorial Park.

Other records:—Queensland: McLeod (1975), Entwisle (1994).

Observations:—Growing on granitic rocks in a small shallow coastal stream amongst colonies of *Nostoc* and *Nostochopsis lobatus*.

Other species known from Australia: *H. baronii* West & G.S.West (1895: 85); *H. delicatulus* West & G.S.West (1902: 203); *H. fontinalis* , Bowen Ck, Hinchinbrook Is., Queensland, A.B. Cribb, 1979 (BRI 0700783), Rainbow Ck, Blackdown Tableland, Queensland, A.B. Cribb, 1974 (BRI 0700784), Mimosa Ck, Blackdown Tableland, Queensland, A.B. Cribb, 1974 (BRI 0700785); *H. intricatus* West & G.S.West (1894: 271), Lake Jennings Fraser Is., Queensland, A.B. Cribb, 1971 (BRI 0700781); *H. lutecolus* West & G.S West (1897: 241).

MASTIGOCLADUS

Mastigocladus Cohn ex Kirchner (1898: 81)
Type: *M. laminosus* Cohn ex Kirchner (1898: 39)

Thallus a soft, spongy mat, sometimes embedded with calcite crystals, smooth or gelatinous on the surface, to compact, occasionally layered, blue-green or olive-green in colour, composed of densely tangled filaments. Trichomes uniseriate, irregularly coiled, with thin, distinct, colourless sheaths, diffluent in old stages; true branching of T- or reverse Y-type, often unilateral, in some stages branching is rare or almost absent; branches usually continually tapering to the ends. Heterocytes intercalary, solitary or rarely in pairs. Akinetes uncommon, solitary in mature parts of the trichome. Cells divide crosswise or lengthwise before branching. Reproduction by hormogonia or by dissociation of trichomes.

Mastigocladus currently contains one species, *M. laminosus*, a true branching taxon from thermal springs. Bibliography: Castenholz (1996), Miller *et al.* (2006, 2007), Kaštovský & Johansen (2008).

Mastigocladus laminosus Cohn ex Kirchner (1898: 39) Fig. 32 A–D.

Thallus membranous, leathery, spongy or firm, often layered, blue-green to olive green in colour. Filaments densely entangled, contorted or irregularly flexuous with thin, distinct, gelatinous sheaths, T-, V-, or Y-type true branched, 4–8 (–10) µm wide; branches usually narrower than the main filaments. Trichomes usually divicariate at right angles, constricted in mature parts, cylindrical and sometimes unconstricted in branches. Vegetative cells barrel-shaped and of irregular lengths along the main filaments, cylindrical in branches and often distinctly longer than wide; apical cells cylindrical and rounded. Heterocytes intercalary, spherical, ellipsoidal or cylindrical, 6.5 (–7) µm wide × 9 µm long, solitary or in pairs.

Specimens examined:—Nettle Ck at Innot Hot Springs, Talaroo Thermal Springs.

Other records:—Queensland: Bedkira Bore, J.W. Cribb, 1978 (BRI 0701247), Townsville, Cires *et al.* (2014).

Observations:—Thermophilic species, recorded from almost all hot spring sites throughout the world below an upper temperature limit of about 58 °C (Castenholz 1996, McGregor & Rasmussen 2007).

NOSTOCHOPSIS

Nostochopsis Wood ex Bornet & Flahault (1886: 80)
Type: *N. lobatus* H.C.Wood ex Bornet & Flahault (1886: 80)

Thallose, attached to the substratum, macroscopic, forming an expanded gelatinous mass, which may be irregularly spherical, sometimes forming large, bulbous colonies, initially hollow, later free-floating, and composed of radially arranged erect filaments. Filaments with diffluent, mucilaginous sheaths; trichomes long, irregularly true-branched, cylindrical, sometimes irregularly narrowed. Sheaths gelatinous and confluent, colourless or slightly yellow-brown in colour. Vegetative cells barrel-shaped; heterocytes intercalary, terminal at the ends of short branches or lateral on the main trichome. Akinetes not known. Reproduction by disintegration of thallus and by the production of hormogonia which develop on the ends of branches. Eight species currently described, one known from Australia. Bibliography: Gugger & Hoffmann (2004), Moreno *et al.* (2012), Komárek (2013).

Nostochopsis lobatus H.C.Wood ex Bornet & Flahault (1886: 80) Figs. 33 A–D, 34 A–B.

Thallus spherical, sub-spherical or irregularly lobed, either solid throughout or hollow, 3–30 cm in diameter, blue-green to yellow-brown in colour; mucilage homogeneous, colourless or yellow-brown, diffluent at the ends. Filaments cylindrical, radially arranged, laterally branched, often slightly widened and club-shaped at the ends. Vegetative cells of the main axis 5.5–8.0 µm long × 3.5–5.5 µm broad; lateral branches generally smaller, 5–7 µm long × 2–3 µm broad. Heterocytes spherical or sub-spherical, 6.0–7.5 µm long × 5.5–7.0 µm broad, attached to the main axis or laterally on the ends of short 1–3 celled branches.

Specimens examined:—Mary R. at Gympie, Reedy Ck at Mount Byron Rd, South Pine R. at Carter Court, Christmas Ck at Stinson Memorial Park.

Other records:—Queensland: Reynolds Ck, A.B. Cribb, 1949 (BRI 0701824), Burham R. at Sapling Pocket, A.B. Cribb, 1981 (BRI 0701825), Upper Millstream Falls, A.B. Cribb, 1973 (BRI 0701827), Mt Crosby Weir on spillway, A.B. Cribb, 1971 (BRI 0701828), Canarvon Gorge, A.B. Cribb, 1969 (BRI 0701829), Obi Obi Ck, A.B. Cribb, 1969 (BRI 0701831), Carney's Ck, A.B. Cribb, 1963 (BRI 0701833), Gap Ck, Cunningham's Gap, A.B. Cribb, 1964 (BRI 0701835), Cedar Ck Falls, Conway Natl Park, Proserpine, Entwistle, 1993 (MEL), Murray Falls, Cardwell, Entwisle, 1993 (MEL), Millstream Falls, A.B. Cribb, 1973 (BRI 0701827), SE Queensland, McLeod (1975); New South Wales: MacDonald R., Walcha Rd, Entwisle, 1970 (NSW).

Observations:—Originally described from temperature streams in north-eastern United States. Recorded in Australia from central northern New South, through to north-eastern Queensland, but is probably more widespread. Observed here growing on granitic rocks in some small shallow coastal streams amongst colonies of *Nostoc*.

4. NOSTOCACEAE

Nostocaceae Agardh ex Kirchner (1898: 101)
Type: *Nostoc* Vaucher ex Bornet & Flahault (1886: 181)

Filamentous, heterocystous, isopolar, with free localised uniseriate trichomes enveloped by fine or firm mucilaginous envelopes or sheaths. Filaments ± straight, flexuous, or ± irregularly screw-like coiled, without branching. Trichomes isopolar, cylindrical or moniliform, constricted or unconstricted at the cross walls, sometimes narrowed towards the apices, usually without meristematic zones, all vegetative cells capable of cell division. Vegetative cells spherical, barrel-shaped to cylindrical, apical cells rounded, conical, acutely pointed or cylindrical and bluntly rounded. Heterocytes terminally on both ends, or intercalary. Akinetes often several times larger than vegetative cells, formed from one vegetative cell or from the fusion of several vegetative cells, positioned adjacent or remote from heterocytes. Reproduction by formation of hormogonia, or by akinete germination.

A cosmopolitan family of 18 genera, including more than 400 species; seven genera are described here from north-eastern Australia, mostly from benthic or metaphytic habitats.

KEY TO GENERA

1. Heterocytes always develop in the terminal position 2
- Heterocytes intercalary 3
2. Akinetes always adjacent to terminal heterocytes ..... CYLINDROSPERMUM
- Akinetes adjacent to or remote from heterocytes, filaments typically short ..... CRONBERGIA
3. Trichomes enveloped by firm sheath ..... AULOSIRA
- Trichomes not enveloped by firm sheaths 4
4. Trichomes arranged into gelatinous, amorphous, globose or irregularly lobed, colonies 5
- Trichomes single, or in unstructured mats or clusters 6
5. Colonies irregularly cylindrical or subspherical, sometimes tube-like. ..... WOLLEA
- Colonies globose or irregularly lobed, when mature, smooth or warty on the surface, usually with a distinct and firm integument on the surface ..... NOSTOC
6. Akinetes spherical, oval or cylindrical, solitary or in series, adjacent to, or near heterocytes. ..... ANABAENA
- Akinetes widely oval, large, solitary, with smooth or sculptured exospore, rarely in pairs, always adjacent to outer heterocytes. ..... MACROSPERMUM

ANABAENA

Anabaena Bory de Saint-Vincent ex Bornet & Flahault (1886: 224)
Type: *A. oscillarioides* Bory de Saint-Vincent ex Bornet & Flahault (1886: 233)

Filamentous; trichomes solitary or aggregated into macroscopic mats on the substrate, straight or variously coiled and twisted, constricted at the cross walls, always without firm sheaths, sometimes with hyaline, colourless, diffluent mucilage; trichomes often moniliform, isopolar, metameric with heterocytes developing solitary and intercalary, which are generally regularly spaced. Vegetative cells cylindrical, barrel-shaped or spherical, shorter or longer than wide, pale or bright blue-green or olive-green in colour, without aerotopes, sometimes with granular contents; apical cells may be slightly elongated, conical, conical rounded or spherical. Heterocytes spherical, widely oval or cylindrical, sometimes elongated, usually slightly larger than vegetative cells. Akinetes spherical, oval or cylindrical, solitary or many in series, intercalary, developing paraheterocytically, adjacent to or near the heterocytes. Cells divide cross-wise and grow to the original size before the next division; without meristematic zones. Reproduction by trichome fragmentation and by akinete production.

A widely distributed genus of 150 species known from freshwater lakes and reservoirs, rivers and estuaries. Here 10 species are described from north-eastern Australia. Many traditional *Anabaena* species which produce aerotopes, and are typically planktonic, were transferred to *Dolichospermum* (Wacklin *et al.* 2009). Bibliography: Willame *et al.* (2006), Wacklin *et al.* (2009), Komárek (2013), Komárek *et al.* (2014), Kust *et al.* (2015), Kozlíková-Zapomělová *et al.* (2016).

1. Akinetes always remote from heterocytes 2
- Akinetes either remote from, or adjacent to heterocytes 5
2. Apical cells bluntly rounded, and generally undifferentiated 3
- Apical cells conically rounded 4
3. Akinetes cylindrical with bluntly rounded ends, 15.5–17.0 µm long × 5.0–6.5 µm wide, exospore undifferentiated ..... *A.* sp. A
- Akinetes rounded cylindrical, 15.5–24.0 µm long × 7.0–11.5 µm wide, exospore radially striated ..... *A.* cf. *alatospora*
4. Vegetative cells isodiametric or up to 2 × longer than broad, akinetes cylindrical, sometimes concave towards the centre ..... *A.* cf. *oblonga*
- Vegetative cells isodiametric or shorter than broad, akinetes uniformly cylindrical ..... *A. inaequalis*
5. Filaments straight or only slightly flexuous 6
- Filaments flexuous to irregularly coiled and contorted 8
6. Heterocytes cylindrical, L:B ratio 1.4–2.1 ..... *A.* cf. *willei*
- Heterocytes spherical to ovate 7
7. Akinetes widely cylindrical, flatly rounded at the ends ..... *A. torulosa*
- Akinetes oblong-ovate to cylindrical with rounded ends ..... *A. oscillarioides*
8. Apical cell conically rounded ..... *A. cylindrica*
- Apical cell bluntly rounded and generally undifferentiated 9
9. Akinetes rounded cylindrical, exospore covered with long flexuous hair-like processes ..... *A. wallumensis*
- Akinetes long cylindrical with rounded ends, exospore smooth ..... *A.* cf. *augustumalis*

Anabaena* cf. *alatospora Gonzalves & Kamat (1959) Fig. 35 A–C.

Filaments single or entangled in loose mucilaginous clusters dispersed amongst aquatic plants and other algae. Trichomes flexuous, irregularly twisted, deeply constricted at the cross walls. Vegetative cells spherical to barrel-shaped, up to 1.6 × longer than wide, 3.0–5.0 µm long × 3.5–5.0 µm wide, with granulated blue-green contents; apical cells rounded and undifferentiated. Heterocytes intercalary, sub-spherical to cylindrical, up to 1.7 × longer than wide, 6.0–9.5 µm long × 3.5–6.0 µm wide. Akinetes solitary, intercalary, always remote from the heterocytes, rounded cylindrical, 15.5–24.0 µm long × 7.0–11.5 wide, endospore pale yellow-brown, exospore radially striated.

Specimens examined:—Amity Swamp, North Stradbroke Is., Rainbow Beach Fens at Great Sandy Natl Park, Cooloola Section.

Observations:—Growing amongst other algae and aquatic plants, in shallow, acidic, coastal wetlands and in the littoral area of perched lakes. *A. alatospora* was originally described from puddles in Mysore State, India where it formed mucilaginous mats, not singly dispersed or in small mucilaginous clusters as was observed for the material described here. However, the radially striated exospore is a distinctive common feature.

Anabaena* cf. *augstumalis Schmidle (1900: 174) Fig. 36 E–F.

Filaments benthic, epiphytic, solitary, or clustered together into small mats. Trichomes flexuous, with fine, indistinct mucilage, cylindrical, constricted at the cross walls, not attenuated towards the ends. Vegetative cells barrel-shaped to shortly cylindrical, isodiametric, or up to 1.6 × longer than broad, (3.2–) 4–5 µm long × 3–4 µm broad, without aerotopes; apical cells rounded. Heterocytes spherical to oval, intercalary, solitary, (5.0–) 6.0–8.7 µm long × 4.3–6.0 µm broad. Akinetes long cylindrical with rounded ends, solitary or in pairs, remote from or adjacent to heterocytes, 18–28 µm long × 6–10 µm broad.

Specimens examined:—Brown L., North Stradbroke Is.

Other records:—Northern Territory, Thomasson (1986).

Observations:—Uncommon, observed as part of the periphyhton attached to the emergent sedge, *Lepironia articulata* (Retz.) Domin, in the littoral zone of an acidic perched lake. *A. augustumalis* is known from similar peaty habitats throughout the temperate zone. Several varieties have been described including forms with smaller and larger cell dimensions. It has been designated *cf.* here as the Brown L. material observed differs from typical *A. augustumalis* by its smaller vegetative cell size, being closer in dimensions to *A. augustumalis* var. *longispora* Tarnavschi & Mitroiu (1956).

Anabaena cylindrica Lemmermann (1896: 186) Fig. 36 A–B.

Filaments aggregated into fine mucilaginous mats. Trichomes flexuous to irregularly coiled, and variously entangled, constricted at the cross walls, not attenuated towards the ends. Vegetative cells isodiametric or up to 1.5 × longer than wide, 3.9–5.6 µm long × 3.4–4.6 µm wide; apical cells conically rounded. Heterocytes intercalary, spherical to

cylindrical, 6.5–8.1 (–10.0) µm long × 4.3–5.5 µm wide. Akinetes cylindrical with rounded ends, solitary or up to five in series, located either side of the heterocytes, 2.5–4.5 × longer than wide, 16–25 (–31) µm long × 5.5–7.0 µm wide, exospore smooth, colourless.

Specimens examined:—Eurong Beach stream at Great Sandy Natl Park, Fraser Is. Section.

Other records:—New South Wales, Victoria: Sullivan *et al.* (1988).

Observations:—Growing along the edges of shallow coastal sandy streams and soaks. Widely distributed throughout the temperate zone where it has been observed as either periphytic on aquatic plants, or as part of the metaphyton (Komárek 2013).

Anabaena inaequalis Bornet & Flahault (1886: 231) Fig. 37 A–B.

Filaments benthic, jointed into prostrate mats, less commonly tychoplanktonic; trichomes straight or slightly flexuous, sometimes in parallel fascicles, constricted at the cross walls, not attenuated towards the ends. Vegetative cells shortly barrel-shaped, isodiametric or shorter or longer than wide, (2.0–) 5.5–8.5 µm long × 4.0–5.5 µm wide, ± aerotopes; apical cells rounded to rounded conical. Heterocytes spherical to cylindrical ellipsoidal, intercalary, solitary, 5.5–8.0 (–10.5) µm long × 4.5–5.5 µm broad. Akinetes cylindrical, as broad, or slightly broader than vegetative cells, solitary or rarely in series, remote from heterocytes, 5.5–11.0 (–22) µm long × 5–8 µm broad, with smooth, colourless exospore.

Specimens examined:—Atkinson Dam, Balonne R. at Kurray, Balonne R. at St George, Bjelke-Petersen Dam, Borumba Dam, Burnett R. at Jones Weir, Burnett R. at Kirar Weir, Burnett R. at Ned Churchward Weir, California Ck at Gavin Way, Culgoa R. at Cubbie, Culgoa R. at Whyenbah, Fitzroy R. at Glebe Weir, Moogerah Dam, Home Beach Swamp at North Stradbroke Is., Sheepstation Ck at Kilcoy-Murgon Rd, Wuruma Dam.

Other records:—New South Wales: Braidwood Lagoon, Braidwood, V. May, 1968 (NSW 616150), River Murray at Heywoods, Torrumbarry, Swan Hill, Euston, Sullivan *et al.* (1988); Victoria: Watermeadow, Portland Aerodrome, S. Skinner, 2001 (NSW 627309), Yan Yean Res., Hardy (1907); South Australia: River Murray at Murtho, Blanchetown, Lake Alexandrina at Goolwa, Warren Res., Baker (1991).

Observations:—Australian populations have been reported from the benthos, mostly associated with soft fine sediments, and less commonly from the plankton of lakes and reservoirs. Baker (1991) describes *A. inaequalis* from the plankton, with or without aerotopes, not joined together into colonial fascicles, but lacking mucilage.

Anabaena* cf. *oblonga Wildeman (1897: 50) Fig. 38 A–E.

Filaments aggregated into fine mucilaginous mats, which can form into macroscopic columnar structures that rise from the benthos, sometimes detaching and freely floating in the water column. Trichomes flexuous to irregularly coiled and variously entangled, constricted at the cross walls, not attenuated towards the ends. Vegetative cells isodiametric or up to 2 × longer than wide, 4.3–7.7 µm long × 3–5 µm wide; apical cells conically rounded. Heterocytes intercalary, oval to cylindrical, 6.5–9.6 µm long × 4.2–5.5 µm wide. Akinetes cylindrical with bluntly rounded ends, sometimes slightly concave towards the centre, solitary or up to three in series, remote from heterocytes, 2.7–4.7 × longer than wide, 14–30 µm long × 4.4–6.3 µm wide, exospore smooth, colourless.

Specimens examined:—Walsh R. at Wrotham.

Observations:—Forming extensive mats and columnar structures in the benthos of shallow, off- stream pools on sand and gravel substrates. The observed material has akinetes which are slightly longer and narrower than typical *A. oblonga*, a tropical species originally described from Indonesia, but also known from Cuba and Argentina (Komárek 2013).

Anabaena oscillarioides Bory de Saint-Vincent ex Bornet & Flahault (1886: 233) Fig. 36 C–D, G–H.

Filaments benthic, sometimes tycoplanktonic; trichomes solitary, straight or flexuous, cylindrical, distinctly constricted at the cross walls. Vegetative cells short barrel-shaped, ± isodiametric, 2.0–6.5 µm long × 4.0–5.5 (–6.5) µm broad, blue-green in colour; apical cells rounded or slightly conical. Heterocytes solitary, spherical to ovate, 5–10 µm long × 5–8 µm broad. Akinetes solitary, or up to two in series, cylindrical to oblong-ovate with rounded ends, (5–) 10–20 (–40) µm long × 6–10 µm broad, with a smooth, brownish-green exospore, adjacent to the heterocytes.

Specimens examined:—Atkinson Dam, Balonne R. near Brookdale, Balonne R. at Whenbah Bridge, Bill Gunn Dam, Bowen R. Weir, Burnett R. at Jones Weir, Burnett R. at Kirar Weir, Condamine R. at Chinchilla Weir Pondage, Condamine R. at Sunnyside, Cooper Ck at Tanbar Waterhole at Tanbar, Einasleigh R. at Talaroo, Fitzroy R. at Bingegang

Weir, Lake Clarendon, Mary R. at Mary R. Barrage, Mary R. at Moy Pocket, Six Mile Ck at Bajool Weir, Tinaroo Falls Dam, Warrego R. at Red Waterhole at Binya, Yabba Ck at Bella Ck Rd.

Other records:—Queensland: Cribb (1986), SE Queensland, McLeod (1975), Grimes (1988); Victoria: Entwisle (1989), River Murray at Merbein, Murtho and Ross Lagoon, Baker (1991); New South Wales: Noble & Happey-Wood (1987), Playfair (1915, 1917), Namoi R. near Walgett, Baker (1991); South Australia: Strathalbyn Res., Bundaleer Res., Baroota Res., Baker (1991), River Murray at Wilkadene, Murtho Park, Humpage *et al.* (2013); Northern Territory: Scott & Prescott (1958), Ling & Tyler (2000).

Observations:—Typically known as a benthic species, however it has been reported as tycoplanktonic or in the plankton of weir pools, particularly in southern Australia (Baker 1991).

Anabaena torulosa Lagerheim ex Bornet & Flahault (1886: 236) Fig. 37 C–F.

Filaments benthic, often tycoplanktonic; trichomes solitary, growing amongst other algae or forming prostrate mats, straight or flexuous, cylindrical, distinctly constricted at the cross walls. Vegetative cells barrel-shaped, ± isodiametric, (2.0–) 3.5–5.0 µm long × 4–7 (–8) µm broad, blue-green in colour; apical cells conical. Heterocytes solitary, spherical to ovate, 6–10 µm long × 6–8 µm broad. Akinetes solitary or in series, widely cylindrical, flatly rounded at the ends, (5.5–) 14–24 (–28) µm long × (5–) 7–12 µm broad, epispore smooth, brownish-green in colour, adjacent to and on either side of the heterocytes.

Specimens examined:—Bill Gunn Dam, Burnett R. at Ned Churchward Weir, Fairbairn Dam, Paradise Dam, Sandy Ck at Wivenhoe-Somerset Rd Crossing, Sheepstation Ck at Kilcoy-Murgon Rd.

Other records:—Queensland: SE Queensland, McLeod (1975); South Australia, River Murray at Ross Lagoon, Warren Res., Strathalbyn Res., Bundaleer Res., Baker (1991), Ling & Tyler (2000).

Observations:—Growing on the benthos in shallow littoral areas of lakes and backwaters of streams, usually on fine, unconsolidated sediments. Considered a cosmopolitan species with a wide distribution (Komárek 2013).

Anabaena wallumensis G. B. McGregor *sp. nov.* Fig. 39 A–D.

Filaments entangled in loose mucilaginous clusters, dispersed among other cyanobacteria and microalgae in periphytic mats. Trichomes flexuous, ± irregularly coiled, deeply constricted at cross walls, not attenuated towards ends, 3.1–5.0 µm wide, with a sub-symmetric structure, one heterocyte occurring every (10–) 24–40 (–52) vegetative cells. Vegetative cells barrel-shaped, isodiametric or up to 1.7 × longer than wide, (3.1–) 4.0–5.0 µm long × 5.6–7.5 (–8.5) µm wide, with granulated blue-green contents; apical cells rounded and undifferentiated. Heterocytes intercalary, sub-spherical to cylindrical, 1.5 × longer than wide, 4.5–7.0 µm long × 6.0–8.5 (–10) µm wide, occasionally in pairs. Akinetes rounded cylindrical, solitary and always adjacent to heterocytes, 2.2–2.7 × longer than wide, 7.5–11 µm long × 18–22 (–27) µm wide, endospore pale golden brown, exospore covered with flexuous hair-like processes, up to 6.3 µm in length.

Holotype:—Preserved specimen deposited in the Queensland Herbarium (BRI), accession number AQ826841. Type locality: Moon Point Fens, Fraser Is. (25°12’48.84” S, 153°3’36.43” E). Etymology: the specific epithet refers to the indigenous Kabi word for the wallum banksia (*Banksia aemula* R. Brown) which is used to describe coastal shrub and heathlands on deep, nutrient-poor, acidic sandy soils.

Specimens examined:—Boomerang Lakes, Lake Jennings, Moon Point Fens at Great Sandy Natl Park, Fraser Is. Section, Rainbow Beach Fens at Great Sandy Natl Park, Cooloola Section.

Observations:—*A. wallumensis* is morphological similar to a number of benthic species known from tropical and subtropical marshy habitats, which have large cylindrical akinetes adjacent to intercalary heterocytes (*A. fuscovaginata*, *A. iyengarii*, *A. oblonga*, *A. orientalis*). However, in *A. wallumensis*, the mature exospore is densely covered in distinctive, flexuous hair-like processes. The material was observed growing in the metaphyton of several shallow peaty wetlands amongst emergent sedges, and in the littoral areas of acidic perched lakes in SE Queensland.

Anabaena* cf. *willei Gardner (1927: 60) Fig. 40 A–H.

Filaments single, growing amongst other algae, or in fine, unstructured mats on the benthos. Trichomes straight, not or slightly attenuated towards the ends, constricted at the cross walls. Vegetative cells cylindrical to barrel-shaped, 0.6–1.3 × longer than wide, 3.5–8.0 µm long × 4.3–5.5 (–6.5) µm wide, contents homogeneous, blue-green in colour; apical cells conical. Heterocytes intercalary, cylindrical 9.3–14.1 µm long × 5.9–7.6 µm wide. Akinetes cylindrical

with bluntly rounded ends, adjacent to, or remote from heterocytes, solitary or up to five in series, 2–3 × longer than wide, 10–20 µm long × 5.0–8.5 µm wide, with smooth exospore.

Specimens examined:—Palmer R. at NESP Red.

Observations:—The material from north Queensland, as compared to the original description of *A. willei* from Puerto Rico, was slightly wider and had akinetes which lacked coloured exospores. The observed material formed fine, flat, mucilaginous mats on sandy and silty substrates in the littoral areas and backwaters of a tropical river.

***Anabaena sp.* A** Fig. 41 A–E.

Filaments single, dispersed among submerged aquatic plants and other algae. Trichomes straight or slightly flexuous, not attenuated towards the ends, constricted at the cross walls. Vegetative cells barrel-shaped to cylindrical, up to 2 × longer than wide, 5.1–10.0 µm long × 4.8–6.5 µm broad, olive-green in colour, often distinctly vacuolate; apical cells bluntly rounded. Heterocytes intercalary, single or rarely in pairs, cylindrical, up to 2.5 × longer than wide, 10.0–14.5 µm long × 5.4–8.0 µm wide. Akinetes solitary, intercalary, always remote from the heterocytes, cylindrical with bluntly rounded ends, 15.5–17.0 µm long × 5.0–6.5 wide, endospore pale yellow-green in colour.

Specimens examined:—Rainbow Beach Fens at Great Sandy Natl Park, Cooloola Section, L. Jennings at Great Sandy Natl Park, Fraser Is. Section.

Observations:—Growing amongst other algae and aquatic plants, in shallow, acidic, coastal wetlands and in the littoral area of perched lakes. Compare with *A. saaremaaensis* Skuja, also known from swamps, peaty pools and marshes with emergent aquatic plants. This species, originally described from Estonia, lacks vacuolated cells, and usually forms expanded mucilaginous mats rather than being found as single filaments.

Other species known from Australia: *A. subcylindrica*, Stony Ck, Blackdown Tableland, Queensland, A.B. Cribb, 1974 (BRI 0700211), *A. oryzae*, Corowa-Mulwala Rd, W of Corowa, New South Wales, S. Skinner, 2001 (NSW 910253).

AULOSIRA

Aulosira Kirchner ex Bornet & Flahault (1886: 256)
Type: *A. laxa* Kirchner ex Bornet & Flahault (1886: 256)

Filaments solitary or together in loose irregular clusters, rarely in mats, or growing epiphytically, with firm, distinct, colourless sheaths enveloping one or rarely two trichomes, open at the ends. Trichomes cylindrical, uniseriate, isopolar, constricted to almost unconstricted at the cross-walls, metameric, straight to slightly flexuous. Vegetative cells cylindrical or barrel-shaped, ± isodiametric to longer than wide, blue-green, pale grey blue, olive-green or reddish in colour; aerotopes only known from one species, often with prominent granules; terminal cells undifferentiated. Heterocytes solitary, intercalary, spherical, oval or cylindrical. Akinetes develop apoheterocytically, elongated, oval to cylindrical.

A widely distributed, but poorly known genus of 30 species. The majority are metaphytic or benthic, known from shallow freshwater habitats or growing on soils; one species is marine. Here three species are described from north-eastern Australia; one further species is known from elsewhere in Australia. Bibliography: Lukešová *et al.* (2009), Komárek (2013), Komárek *et al.* (2014), Hindáková & Hindák (2017).

1. Vegetative cells shorter than wide 2
- Vegetative cells isodiametric, up to 2 × longer than broad ..... *A.* sp. A
2. Akinetes either adjacent to or remote from heterocytes. ..... *A. laxa*
- Akinetes always remote from heterocytes ..... *A.* cf. *epiphytica*

Aulosira* cf. *epiphytica (Gardner) Hindáková & Hindák (2017: 495) Fig. 42 A–F.
Basionym: *Nodularia epiphytica* Gardner 1927

Filaments solitary, or in ± irregular parallel arrangements, straight or slightly flexuous, attached to the substrate along the entire length, 5.9–6.8 µm wide. Sheath fine, firm, colourless, not lamellated, open at the ends. Trichome cylindrical, distinctly constricted at the cross walls, not attenuated towards the ends. Vegetative cells barrel-shaped, pale blue-green to olive-green in colour, 4.1–6.6 µm long × 4.7–5.5 µm wide; apical cell round to shortly conical. Heterocytes

intercalary, oval to shortly cylindrical, 4.8–7.7 µm wide × 4.6–6.3 µm long. Akinetes long cylindrical, solitary or two in series, remote from heterocytes, 4.6–6.8 µm wide × 8.8–15.5 µm long.

Specimens examined:—Atkinson Dam.

Observations:—Growing attached to the substrate and amongst submerged aquatic plants in the littoral area of a subtropical reservoir. Gardner (1927) originally described *A. epiphytica* (as *Nodularia epiphytica*) from tropical habitats in Puerto Rico, where it was observed growing attached to aquatic plants. Hindáková & Hindák (2017) studied epiphytic material attached to filamentous algae from the littoral area of irrigation channels in Southern Slovakia, and transferred this species to *Aulosira.* This material from SE Queensland was only observed from the benthos of an artificial lake, not epiphytically as in previous observations from elsewhere.

Aulosira laxa Kirchner ex Bornet & Flahault (1886: 256) Fig. 43 A–C.

Filaments solitary or loosely entangled in mats, straight or flexuous, 8–10 (–11.5) wide. Sheaths fine, firm, colourless, sometimes diffluent, not lamellated. Trichomes ± cylindrical, constricted at the cross walls, not attenuated towards the apex. Vegetative cells barrel-shaped, shorter than wide, blue-green in colour, (3.5–) 4.2–5.3 µm long × 7.0–8.2 µm wide. Heterocytes intercalary, solitary, ± spherical to cylindrical, 7.0–8.5 µm wide. Akinetes solitary or in short series, cylindrical, remote or adjacent to the heterocytes, 15–25 µm long × 5–8 µm wide, with smooth colourless exospore.

Specimens examined:—Toogoom Lagoon, Northshore.

Observations:—Growing amongst other algae and submerged aquatic plants in a shallow eutrophic urban lagoon.

***Aulosira* sp. A.** Fig. 43 D–H.

Filaments solitary or mixed loosely in mats with other algae, straight or flexuous, 5.4–7.0 wide. Sheaths fine, firm, colourless, not lamellated. Trichomes cylindrical, constricted at the cross walls, not attenuated towards the apex. Vegetative cells barrel-shaped, isodiametric up to 2 × longer than broad, 6.0–11.0 µm long × 3.6–5.2 µm wide, blue-green in colour. Heterocytes intercalary, solitary, ± spherical to cylindrical, 3.6–5.8 µm wide × 6.0–11.3 (–14.9) µm long. Akinetes solitary or in short series, adjacent to or remote from heterocytes, cylindrical with bluntly rounded ends, up to 2 × longer than broad, 6.3–11.6 µm long × 4.7–6.8 µm wide, with smooth colourless exospore.

Specimens examined:—Palmer R. at Gum Ck.

Observations:—Forming unconsolidated mats on rocky substrates in a tropical river. Akinetes were common, and often in series.

Other species known from Australia: *Aulosira* sp., New South Wales, Noble & Happey-Wood (1987).

CRONBERGIA

Cronbergia Komárek, Zapomělová & Hindák (2010: 329)
Type: *C. siamensis* (Aarikanonda) Komárek, Zapomělová & Hindák (2010: 329)

Filamentous planktonic or amongst other algae in fine mucilaginous masses; trichomes isopolar, uniserial, unbranched, solitary, without sheaths, straight or slightly flexuous, short (up to 80–120 µm long), distinctly constricted at the cross-walls. Cells spherical, barrel-shaped or slightly elongate. Heterocytes terminal, spherical, ovoid or slightly oval, intercalary. Akinetes solitary or in short rows, or in the centre of short trichomes in series, oval or oval-cylindrical, slightly distant from heterocytes. Bibliography: Komárek (2010), Hindák (2000, 2001), Cronberg (2003), Komárek (2013), Komárek *et al.* (2014), Genuário *et al.* (2018).

Cronbergia siamensis (Antarikanonda) Komárek, Zapomělová & Hindák (2010: 329) Fig. 35 D.
Basionym: *Anabaena siamensis* Antarikanonda (1985: 345)

Filamentous; trichomes solitary amongst other algae or parallely aggregated into bright blue-green, mucilaginous mats, straight, short, up to 30–70 µm long, distinctly constricted at the cross walls. Vegetative cells cylindrical, isodiametric or longer than broad, without aerotopes, 2–5 µm long × 2–4 µm broad. Heterocytes spherical or subspherical, terminal at both ends of the trichome, 2–4 µm broad. Akinetes oval to subspherical, solitary or up to 3 or more in series, remote from heterocytes, 5–10 µm in diameter.

Specimens examined:—Rainbow Beach Fens, Great Sandy Natl Park, Cooloola Sect.

Observations:—Growing in the metaphyton of several shallow, peaty wetland pools amongst other algae and emergent vegetation. This material is consistent with the original description of *C. siamensis* from paddy fields in Thailand. However, trichomes were mostly singly dispersed amongst other algae, and did not form coherent thalli. Genuário *et al.* (2018) has recently shown that this species is phylogenetically aligned with the genus *Cylindrospermum* rather than *Cronbergia*.

CYLINDROSPERMUM

Cylindrospermum Kützing ex Bornet & Flahault (1886: 249)
Type: *C. majus* Kützing ex Bornet & Flahault (1888: 252)

Filaments forming a fine or compact, expanded mucilaginous mat on submerged substrates, straight, slightly curved or irregularly coiled, cylindrical along their entire length or slightly narrowed towards the middle, without sheaths, but with very fine, colourless, homogeneous, diffluent mucilage, symmetrical, constricted at the cross walls. Vegetative cells cylindrical, isodiametric or longer than wide, rarely barrel-shaped or almost spherical, without aerotopes, sometimes with dispersed granules and visible chromatoplasm, pale or bright blue-green. Heterocytes terminal, arising from apical cells, ovoid, oval or conical, developing at both ends of trichomes, rarely only at the one end. Akinetes develop adjacent to heterocytes, at both ends of the trichome, usually ovate, ellipsoidal or sub-cylindrical, solitary or up to 7 in series, sometimes with sculptured outer cell wall. Cells divide crosswise and grow into the original size before the next division. Without meristematic zones, all cells capable of dividing. Reproduction by trichome fragmentation into hormogonia and by akinete production.

A widely distributed genus of 49 species known from freshwater lakes and streams and wetlands, growing in benthos, on aquatic plants and submerged woody and stony substrates. Here three species are described from north-eastern Australia; a further eight species are known from elsewhere in Australia. Bibliography: Komárek (1989), Skinner & Entwisle (2001), Komárek (2013), Komárek *et al.* (2014), Johansen *et al.* (2014).

1. Filaments < 3.5 µm broad..... *C.* sp. A
- Filaments > 3.5 µm broad.....2
2. Akinetes elliptical to broadly ovate.....*C. licheniforme*
- Akinetes cylindrical to cylindrical-oval, rounded at the ends ..... *C. stagnale*

Cylindrospermum licheniforme Kützing ex Bornet & Flahault (1886: 253) Fig. 44 A–F.

Thallus mucilaginous, flat, amorphous, pale blue-green to brown in colour. Trichomes flexuous, constricted at the cross walls. Vegetative cells cylindrical barrel-shaped, isodiametric or slightly longer than wide, 4.5–7.0 µm long × 3.5–7.0 µm broad, without aerotopes. Heterocytes elongate conical or ovoid, 7–12 µm long × 7–8 µm broad, adjacent to akinetes. Akinetes elliptical to broadly ovate, 20–43 µm long × 10–14 µm broad, with smooth reddish-brown exospore.

Specimens examined:—Balonne R. at Weribone, Condamine R. at Cotswold, Condamine R. at Leslie Reserve, Condamine R. at Sunnyside, Condamine R. at Yarramalong, Coopers Ck Yorakah Waterhole at Tanbar, Culgoa R. at Woolerbilla, Little Yabba Ck at Maleny Kenilworth Rd Crossing, Narran R. at Dirrandandi-Hebel Rd, Thomson R. Waterloo Waterhole at Noonbah, Yabba Ck at Stirling's Crossing, Wenlock R. at Moreton.

Other records:—Queensland: Bailey (1895), Bailey (1913), McLeod (1975), Möbius (1895); New South Wales: Paterson R., Pound Crossing Bridge, Singleton-Gresford Rd, Entwisle, 1991 (MEL).

Observations:—Forming thin, unstructured mucilaginous mats on the substrate, or attached to submerged aquatic plants. Known from throughout temperate and subtropical areas. Komárek (2013) considers *C. licheniforme* to be a temperate species and populations from tropical countries most likely to be *C. goetzei*, a species which Playfair (1918) described as intermingled with *C. stagnale* from Lismore, New South Wales.

Cylindrospermum stagnale (Kützing) ex Bornet & Flahault (1888: 250) Fig. 43 I–L.

Thallus mucilaginous, flat, amorphous, blue-green to greyish green in colour. Trichomes flexuous, constricted at the cross walls. Vegetative cells isodiametric or up to 2 × longer than wide, 4.5–7.0 µm long × 3.5–5.0 µm broad, without

aerotopes. Heterocytes elongate conical or ovoid, 7–16 µm long × 5–8 µm broad, adjacent to akinetes. Akinetes cylindrical to broadly oval, rounded at the ends, 20–45 µm long × 10–15 µm broad, with smooth reddish-brown exospore.

Specimens examined:—Babinda Ck at the Boulders, Soda Springs, Yabba Ck at Stirling's Crossing.

Other records:—Queensland: Mt Crosby, Queensland, A.B. Cribb, 1963 (BRI 0700614); New South Wales: Irrigation channel, Griffith-Leeton Rd, S. Skinner, 2001 (NSW 627239), Deer Park R., Waterfall Way, Dorrigo-Ebor Rd, S. Skinner, 2000 (NSW 481099), Zoom Ck, N of Walcha, S. Skinner, 2000 (NSW 446041).

Observations:—Cosmopolitan species, growing amongst other algae, and attached to aquatic vegetation and woody debris (Komárek 2013); in northern Australia, more commonly encountered in cooler high-altitude streams.

***Cylindrospermum* sp. A** Fig. 45 A–G.

Trichomes flexuous, solitary, amongst other algae, not typically aggregated into defined mats or strata, distinctly and deeply constricted at the cross walls, pale blue-green in colour. Vegetative cells short barrel-shaped, 1.4–2.4 µm long × 2.2–2.8 µm wide. Heterocytes conically rounded, 3–4 µm long × 2–2.4 µm wide. Mature akinetes not observed.

Specimens examined:—Amity Swamp, North Stradbroke Is., Rainbow Beach Fens, Great Sandy Natl Park, Cooloola Section.

Observations:—Growing in the metaphyton of shallow, peaty wetlands amongst other algae and emergent vegetation from several locations in SE Queensland. Mature akinetes were not observed. Compare with *C. breve* Welsh (after Komárek 1989, Komárek *et al.* 2017).

Other species known from Australia: *C. majus*, One Mile Ck, Ipswich, Queensland, A.B. Cribb, 1948 (BRI 0700612); *C. punctatum*, Mimosa Ck, Blackdown Tableland, Queensland, A.B. Cribb, 1974 (BRI 0700613). *C. alatosporum*, Northern Territory, Thomasson (1986); *C. ecballiisporum*, Northern Territory, Thomasson (1986); *C. goetzei*, Lismore, New South Wales, Playfair (1918); *C. minutissimum*, SE Queensland, McLeod (1975); *C. punctatum* Queensland, Cribb (1976); *C. rectangulare* Northern Territory, Playfair (1915, 1917, 1918); *C. indentatum,* Queensland, Ling & Tyler (2000).

MACROSPERMUM

Macrospermum Komarék (2008: 81)
Type: *M. volzii* (Lemmermann) Komárek (2008: 81)

Filaments planktonic, solitary or in irregular clusters, or in fine macroscopic mats on the benthos; trichomes with symmetric or subsymmetric structure, composed of two subapical heterocytes and a third ± central heterocyte in mature trichomes; straight or irregularly coiled, with fine, colourless, diffluent mucilage, uniseriate, unbranched, ± cylindrical, constricted at the cross walls, sometimes narrowed towards ends with distinct central parts. Vegetative cells cylindrical to slightly barrel-shaped, ± isodiametric or distinctly longer than wide, with blue-green homogeneous contents, facultatively with aerotopes; apical cells rounded, conical, or narrowed and bluntly pointed. Heterocytes solitary, intercalary, cylindrical, usually wider than the vegetative cells. Akinetes widely oval, large, solitary, with smooth or sculptured exospore, rarely in pairs, always adjacent to outer heterocytes.

A genus of four species, all known from tropical regions, which can be recognised by their distinctive large akinetes which are always adjacent to one side of intercalary heterocytes. This genus has yet to be evaluated by molecular methods. Here one species is described from north-eastern Australia. Bibliography: Komárek (2008, 2013), Dwivedi *et al.* (2010).

Macrospermum volzii (Lemmermann) Komárek (2008: 81) Figs. 46 A–E, 47 A–B.
Basionym: *Anabaena volzii* Lemmerman (1905: 153)

Filaments flexuous to irregularly coiled, forming fine microscopic mats, later macroscopic, spreading, occasionally in columnar formations; with fine, colourless, diffluent mucilage, constricted at the cross walls. Vegetative cells isodiametric, cylindrical, up to 2 × longer than broad, 4.5–14 µm long × 4.0–5.8 µm wide; contents homogenous, without aerotopes; apical cells conically narrowed, bluntly pointed or rounded. Heterocytes intercalary, cylindrical, 2–3 × longer than broad. Akinetes generally single, adjacent to heterocytes, mostly on one side, elliptical, 1.5–2.5 × longer than broad, with smooth brown epispore, (20–) 32–48 µm long × (13–) 15–20 µm broad.

Specimens examined:—Palmer R. at NESP Purple.

Observations:—Growing in mucilaginous colonies on sandy substrates in the littoral areas and backwaters of a tropical river and associated floodplain waterholes. Pantropical distribution including Asia, and Central and South America. Compare with *M. unisporum* (Gardner) Komárek, which differs little from *M. volzii* in terms of morphology and ecology.

Other records:—Queensland, Baker & Fabbro (2002).

NOSTOC

Nostoc Vaucher ex Bornet & Flahault (1886: 181)

Type: *N. commune* Vaucher ex Bornet & Flahault (1888: 203)

Thallus micro- to macroscopic, gelatinous, amorphous, globose or irregularly lobed, smooth or warty on the surface, filamentous or forming flat gelatinous colonies, usually with a distinct and firm surface integument. Filaments within colonies irregularly coiled and loosely or densely agglomerated, sometimes more concentrated in the peripheral area of the colony; sheaths around trichomes present, but visible usually only in the periphery of colony or in young colonies, wide, fine mucilaginous, confluent with colonial mucilage, sometimes yellowish-brown. Trichomes isopolar, the same width along the entire length, apical cells not morphologically differentiated from other vegetative cells. Vegetative cells cylindrical, barrel-shaped to almost spherical. Heterocytes solitary or in series, terminal or intercalary. Akinetes develop apoheterocytically, oval, single or commonly in series, slightly larger than vegetative cells.

A widely distributed genus of 101 species known from the benthos of freshwater lakes and reservoirs, rivers and estuaries, and many terrestrial habitats. Here six species are described from north-eastern Australia; a further three species are known from elsewhere in Australia. Bibliography: Skinner & Entwisle (2001), Hrouzek *et al.* (2013), Komárek (2013), Komárek *et al.* (2014), Joneson & O'Brien (2017).

1. Mature colonies typically macroscopic, spherical, flattened, or irregularly lobate 2
- Mature colonies typically microscopic, spherical to irregularly spherical, amorphous 4
2. Mature colonies thin, mucilaginous, amorphous ..... *N. linckia*
- Mature colonies spherical to irregularly lobate 3
3. Colonies initially spherical, when mature, irregularly flattened, on wetted soils ..... *N. commune*
- Colonies initially spherical, when mature irregularly lobate, in flowing streams ..... *N. verrucosum*
4. Vegetative cells cylindrical ..... *N.* sp. A
- Vegetative cells barrel-shaped, isodiametric or longer than broad 5
5. Vegetative cells 3.5–5.5 µm long × 4.1–4.8 µm wide, olive-green to yellow-brown in colour ..... *N. sphaericum*
- Vegetative cells 2.8–6.2 µm long × 2.8–3.6 µm wide, pinkish red in colour ..... *N.* sp. B

Nostoc commune Vaucher ex Bornet & Flahault (1888: 203) Fig. 48 A–D.

Colonies macroscopic, gelatinous, irregularly spherical when immature, later irregularly flattened or wavy, up to 15 cm in diameter, olive-green to yellow-green or brown in colour with firm periderm. Filaments flexuous, densely entangled, sheaths yellow-brown, sometimes lamellated. Vegetative cells shortly barrel-shaped to spherical, isodiametric or longer or shorter than wide, 3.0–5.5 (–7) µm long × 4.0–4.3 (–6) µm wide. Heterocytes subspherical, sometimes in series, both terminal and intercalary, 5.5–8.4 µm long × 5.0–8.0 µm wide. Akinetes 4–7 µm long × 5–6 µm wide with smooth colourless cell wall.

Specimens examined:—Atkinson Dam, Mary R. at Gympie.

Other records:—Queensland: Marlong Ck at Marlong Caves, Mt Moffat, A.B. Cribb, 1986 (BRI 0701396), Surveyors Gully, Lake Broadwater, A.B. Cribb, 1986 (BRI 0701397), Sundown Natl Park, A.B. Cribb, 1985 (BRI 0701398), Big Bend area of Burdekin R., A.B. Cribb, 1981 (BRI 0701400), Darluca near Landsborough, A.B. Cribb, 1975 (BRI 0701405), Mt Cordeaux, A.B. Cribb, 1951 (BRI 0701412), Scawfell Is., A.B. Cribb, 1994 (BRI 0715673), Cribb (1971), Cribb (1984), SE Queensland, McLeod (1975); Victoria: Darling (1982), Watts (1887); New South Wales: cemetery, corner of Sydney Rd and Great Western Hwy, St Marys, S. Skinner, 2015 (NSW 848499), The Toll House, South Ck, Windsor, S. Skinner, 2015 (NSW 848501), White Gum Lookout, Coonamble, T.J. Entwisle, 2000 (NSW 627469), May (1970). South Australia: Mt Lofty, J.B. Cleland, 1922 (AD 54527). Western Australia: Northern end of Lake Coogee, Beeliar Regional Park, C. Prideaux, 2013 (PERTH 8560862), Warren Beach, Northcliffe, B. Muir, 1972 (PERTH 7051980).

Observations:—Subaerophytic species, commonly found growing on edge of streams and wetlands on wet loamy substrates.

Nostoc linckia Bornet ex Bornet & Flahault (1886: 193) Fig. 49 A–D.

Thallus macroscopic, fine, thin, mucilaginous, blue-green to blackish-green in colour, initially attached to the substrate, later free floating as irregularly clusters. Filaments flexuous, densely entangled, constricted at the cross walls. Vegetative cells sub-globose to barrel-shaped, 3.0–5.8 µm in diameter. Heterocytes sub-spherical, 4.5–6.5 µm in diameter. Akinetes globose, 6–9 µm long × 4.5–7.0 µm broad, with smooth, colourless to brownish outer cell wall.

Specimens examined:—Fitzroy R., Endeavour R. at Jensen's Crossing, Einasleigh R. at Talaroo.

Other records:—Queensland: Reynolds Ck, A.B. Cribb, 1949 (BRI 0701421), Burnett Ck, Mt Barlow, A.B. Cribb, 1973 (BRI 0701422), Bailey (1895), Bailey (1913), SE Queensland, McLeod (1975); New South Wales: Barwon Valley Park, Belmont, Geelong, S. Skinner, 2003 (NSW 627347), Victoria: Entwisle (1994), Hardy (1906).

Observations:—Growing in shallow littoral areas and backwaters of streams and rivers. Often detaches from the substrate and becomes free floating in the water column. Australian strains have been associated with the production of the cyanotoxin microcystin (Gaget *et al.* 2017).

Nostoc sphaericum Vaucher ex Bornet & Flahault (1886: 208) Fig. 50 C–D.

Colonies ± spherical, with a firm, smooth periderm, olive-green to yellow-brown in colour, up to 3.5 cm in diameter, free-living or amongst other algae and aquatic vegetation. Individual sheaths usually only visible in mature colonies, where filaments may be surrounded by a distinct, often yellowed and slightly lamellated sheath. Vegetative cells ± barrel-shaped, isodiametric or slightly longer than broad, 3.5–5.5 µm long × 4.1–4.8 µm wide. Heterocytes spherical to oval, 5.5–7.9 µm long × 4–6 µm wide. Akinetes oval, 4.4–6.5 µm long × 4.4–6.6 µm wide, up to 5 in series.

Specimens examined:—Eurong Beach stream #1, Great Sandy Natl Park, Fraser Is. Section.

Observations:—Growing amongst filamentous algae in a shallow, coastal stream draining dune wetlands.

Other records:—Queensland: May (1978), McLeod (1975), Sonder (1880, 1881).

Nostoc verrucosum Vaucher ex Bornet & Flahault (1886: 216) Figs. 51 A–D, 52 A–B, 54 E.

Colonies gelatinous, initially irregularly spherical to ellipsoidal, when mature, folded, lobate and hollow, 3–10 cm in diameter, olive-green to brownish in colour, filaments densely entangled. Trichomes flexuous, ± indistinct sheaths, sometimes obvious around individual filaments in mature colonies, constricted at the cross walls. Vegetative cells shortly barrel-shaped, isodiametric or slightly shorter than wide, 2.5–3.7 µm long × 3.2–4.8 µm wide, dull blue-green in colour. Heterocytes sub-spherical, 4.2–6.2 µm in diameter. Akinetes sub-spherical, single or in series, 3.8–5.2 µm in diameter, with smooth colourless cell wall.

Specimens examined:—Cattle Ck at Gargett, Christmas Ck at Stinson Memorial Park, Isaac R. at Yatton.

Observations:—Forming conspicuous macroscopic colonies on granitic rocks in clear, flowing streams, frequently along with *Nostochopsis lobatus*. Mature colonies may elongate and break away from the surface, becoming free floating in the water column. Considered cosmopolitan (Komárek 2013).

Other records:—Queensland: D'Aguilar Range, Northbrook Ck, Mt Glorious-Dundas Rd, Entwisle, 1993 (MEL), New South Wales: Woodenbong Ck, Old Koreelah, Mt Barney, Entwisle, 1997 (MEL), Sherard Falls, Dorrigo Natl Park, Entwisle, 1997 (MEL), Junction of Peel R. and Wombramurra Ck, Entwisle, 1977 (NSW A3127), Peel R., May 1977, (NSW A3128), Peel R., May, 1977 (NSW A3129); Krui R., Collaroy, Entwisle, 1997 (MEL), Ashfield, S. Skinner, 2000 (NSW), Murray's ricefield, Griffith, May 1978 (NSW A3122).

***Nostoc* sp. A** Fig. 53 A–E.

Colonies gelatinous, irregularly spherical, 2–5 mm in diameter, firm, blue-green to olive-green in colour, filaments loosely entangled. Trichomes flexuous, ± indistinct sheaths, constricted at the cross walls. Vegetative cells cylindrical, 3–5 × longer than wide, 12.5–19.0 µm long × 3.5–5.0 µm wide. Heterocytes elongated spherical to cylindrical, 9.5–13.0 µm long × 5.2–6.5 µm wide. Akinetes ellipsoidal, single or in series, 6.5–12.8 µm long × 4.5–6.0 µm wide, with smooth colourless cell wall.

Specimens examined:—Emu Ck at Grieves Rd.

Observations:—Compare with *N. willei* Gardner, and *N. alatosporum* Sant'Anna *et al.*; both have distinctively elongated, cylindrical vegetative cells. Benthic, attached to sandy sediments, and growing amongst other algae.

***Nostoc* sp. B** Fig. 50 A–B.

Colonies gelatinous, irregularly spherical to ellipsoidal, 1–3 mm in diameter, firm, olive-green to brownish red in colour, filaments densely entangled. Trichomes flexuous, ± indistinct sheaths, constricted at the cross walls. Vegetative cells sub-globose to barrel-shaped, isodiametric up to 2 × longer than wide, 2.8–6.2 µm long × 2.8–3.6 µm wide, pinkish red in colour. Heterocytes sub-spherical, 3.9–6.0 µm in diameter. Akinetes spherical to ellipsoidal, single or in series, 5.6–7.5 µm long × 5.0–6.0 µm wide, with smooth colourless cell wall.

Specimens examined:—Brisbane R. at Colleges Crossing.

Observations:—Attached to stones and woody debris in the littoral area of a coastal subtropical river. The brownish red colour of the vegetative cells is distinctive for this species. Compare with *N. brittonii* Gardner.

Other species known from Australia: *N. borzioides*, Limestone Gorge, Gregory Natl Park, Northern Territory, Entwisle & Skinner, 1996 (MEL); *N. pruniforme*, Murray R., Murray Falls, Cardwell, Queensland, Entwisle, 1993 (MEL), Souita Falls, tributary of Beatrice R., Cardwell, Queensland, Entwisle,1993 (MEL); Rocky Springs, W of Eulo, Queensland, Ponder & Colman, 1984 (NSW), Ellenborough Falls, Ellenborough R., Elands, New South Wales, Entwisle, 1991 (MEL 2046775); Little Murray R., falls below bridge, Dorrigo, New South Wales, S. Skinner, 2000 (NSW), Findon Ck, 8.4 km from Old Grevillia, New South Wales, Entwisle, 1997 (MEL), Karuah R., upper part of Chichester S.F., Barrington Tops, New South Wales, Entwisle, 1991 (MEL), Polblue Ck, Horse Swamp Camping Area, New South Wales, Entwisle, 1999 (NSW), Apsley Falls, Apsley R., Oxley Wild Rivers Natl Park, New South Wales, Skinner, 2000 (NSW), Bergen Op Zoom Ck, 8 km NE of Walcha, New South Wales, Skinner, 2000 (NSW), Surveyor Ck, Walcha Road, New South Wales, May, 1968 (NSW A3132), Chaelundi Ck, Chaelundi Rest Area, Guy Fawkes R. Natl Park, New South Wales, Skinner, 2000 (NSW); Wollomombi R, bridge on Waterfall Way, New South Wales, Skinner, 2000 (NSW), Penrith Lakes, New South Wales, Skinner, 2000 (NSW), Blarney Ck, Wattagan Natl Park, New South Wales, Cherry, 2000 (NSW). South Coast: Chalkhills Ck, Rats Valley Rd, off Chalkhills Rd, Pambula, New South Wales, Entwisle, 1991 (MEL), Yowrie R., Yowrie, S. Skinner, 2000, Illawarbra Ck, Wandella S.F., Cobargo, New South Wales, Skinner, 2000, Sawpit Ck, Jindabyne-Mt. Kosciuzko Rd, New South Wales, Entwisle, 988 (MEL), Fiddlers Green Ck, Cann Valley Hwy, 34 km from Cann R. township, Victoria, Entwisle, 1991 (MEL); *N. gelatinosum*, Bullock Ck, Northern Tablelands, New South Wales, Skinner, 2000 (NSW).

WOLLEA

Wollea Bornet & Flahault (1886: 223)
Type: *W. saccata* Bornet & Flahault (1886: 233)

Filamentous, colonial; colonies macroscopic, gelatinous, smooth, irregularly cylindrical or subspherical, sometimes tube-like. Trichomes the same width along the entire length, straight or slightly curved, uniseriate, unbranched, not attenuated or widened at the ends, deeply constricted at the cross walls; apical cells rounded; irregular to parallelly and densely arranged in common, diffluent mucilage. Heterocytes intercalary, solitary. Akinetes arise paraheterocytically, either side of the heterocytes, in short series, spherical or oval. Vegetative cells divide crosswise by binary fission. Reproduction by production of hormogonia.

A genus of nine species known from freshwater lakes and reservoirs, rivers and estuaries. Here three species are described from north-eastern Australia. Bibliography: Desikachary (1959), Komárek (2013), Komárek *et al.* (2014), Kozlíková-Zapomělová *et al.* (2016).

1. Filaments solitary or in small clusters, not forming macroscopic colonies ..... *W. ambigua*
- Filaments arranged into mucilaginous macroscopic colonies 2
2. Colonies cylindrical, club-shaped when young, when mature variously branched, erect, tentacular, with tube-like projections ..... *W. bharadwajae*
- Colonies cylindrical, finger-like, not typically branched ..... *W. saccata*

Wollea ambigua (C.B.Rao) R.Y.Singh (1942) Fig. 54 A–C.
Basionym: *Anabaena ambigua* C.B.Rao (1937: 101)

Filaments solitary or several together in a parallel arrangement, enclosed in a firm, hyaline mucilaginous sheath up to 50 µm wide. Trichomes straight or flexuous, clearly constricted at the cross walls, ± narrowed towards the ends. Vegetative cells shortly barrel-shaped, 3.5–5.0 µm long × 4.5–7.0 µm wide; apical cells rounded. Heterocytes intercalary, spherical to slightly oval, solitary, 6.5–9.0 µm in diameter. Akinetes elongate-ellipsoidal, adjacent to the heterocytes, 13.0–16.5 µm long × 7.5–11.0 µm wide.

Specimens examined:—Balonne R. at St George, Balonne Minor R. at Cubbie, Bokhara R. near Kirrima, Condamine R. at Elbow Valley, Coopers Ck Tanbar Waterhole at Tanbar, Maranoa R. at Cashmere, Thomson R. Top Waterhole at Noonbah.

Observations:—Growing amongst other algae and aquatic macrophytes in the shallows and littoral areas of lowland rivers and associated waterholes.

Wollea bharadwajae R.N.Singh (1942: 593) Fig. 55 A–F.

Thallus macroscopic, cylindrical club-shaped when young, when mature a cluster of erect, tentacular, tube-like projections containing many trichomes, ± divaricated and variously branched, up to 8 cm long × 2.5 cm in diameter. Trichomes ± parallely arranged, straight or flexuous, clearly constricted at the cross walls, slightly narrowed towards the ends. Vegetative cells shortly barrel-shaped, 2.5–5.0 µm long × 3.5–5.0 µm broad; apical cells rounded and slightly conical. Heterocytes intercalary, spherical to barrel-shaped, 6.0–7.5 µm long × 5.8–7.0 µm broad. Akinetes spherical to sub-spherical, single or up to 3 in series, adjacent to the heterocytes, 10–13 µm long × 8–12 µm wide.

Specimens examined:—Balonne Minor R. near Miegunyah, Bokhara R. at Woolerbilla-Hebel Rd, Condamine R. at Chinchilla Weir, Narran R. at Dirrandandi-Hebel Rd.

Observations:—This species forms conspicuous, gelatinous, macroscopic colonies up to 15–20 cm in diameter, on the substratum of riverine waterholes in south-western Queensland; due to their size and complex shape, these colonies may be mistaken for prostrate aquatic macrophytes. Originally described from the benthos of ponds and paddy fields in India (Singh 1942).

Wollea saccata Bornet & Flahault (1886: 233) Fig. 54 D.

Thallus macroscopic, cylindrical, finger-like, mucilaginous, up to 10 cm long × 2–10 mm wide, comprised of ± parallel arranged trichomes. Trichomes cylindrical, clearly constricted at the cross walls, not or slightly attenuated towards the apices. Vegetative cells barrel-shaped, isodiametric to longer than broad, or elongate-cylindrical with rounded ends, blue-green in colour, 5–10 µm long × 4–6 µm wide; apical cells rounded. Heterocytes spherically ellipsoidal to cylindrical, slightly broader than vegetative cells, 6.5–10 µm long × 4–6 µm wide. Akinetes elongate-ellipsoidal to ovate, 3–5 in series, either side of the heterocyte, 15–22 µm long × 6–8 µm broad, with smooth exospore.

Specimens examined:—Thompson R. at Longreach.

Observations:—Growing on silty substrate in the shallow littoral zone of a subtropical riverine waterhole in small colonial clumps. Known from Europe and North America (Komárek 2013).

5. RIVULARIACEAE

Rivulariaceae Bornet & Flahault (1886: 338)
Type: *Rivularia* C.Agardh ex Bornet & Flahault (1886: 345)

Thallus macroscopic, usually attached to the substratum, flat, prostrate, crustaceous, bushy or gelatinous, spherical, ± encrusted, rarely occurring as solitary filaments. Filaments heteropolar, uniseriate, apical parts typically ending in terminal hair-like cells, constricted or unconstricted at the cross walls. Filaments with gelatinous sheaths, in some genera stratified at the ends and funnel-like widened, sometimes laterally confluent. Branching occurs in some genera; where present occurring as single false-branching, less typically geminate; branches grow in the same direction as the main filament. Vegetative cells cylindrical or barrel-shaped, terminal cells often elongated, narrowed and cylindrical. Heterocytes basal, sometimes intercalary, single or up to several in series. Akinetes known from several genera, usually developing above the basal heterocytes, solitary or in series. Reproduction by thallus disintegration, through branching, or production of hormogonia.

A cosmopolitan family of seven genera, five of which are known from Australia; four are described here from north-eastern Australia.

KEY TO GENERA

1. Filaments arranged in a common compact thallus, spherical or hemispherical ..... RIVULARIA
- Filaments not in a common thallus 2
2. Heterocytes intercalary ..... CAMPTYLONEMOPSIS
- Heterocytes basal and intercalary 3
3. Trichomes cylindrical or slightly widened at the base, narrowed in the middle part and clearly widened at the ends ..... FORTIEA
- Trichomes cylindrical along the whole length or slightly attenuated towards the ends ..... MICROCHAETE

CALOTHRIX

Calothrix C.Agardh ex Bornet & Flahault (1886: 345)
Type: *C. confervicola* C.Agardh ex Bornet & Flahault (1886: 349)

Filaments heteropolar, clearly differentiated into basal and apical parts, simple, solitary or in small groups, separated from one another, rarely occurring solitary, lateral false branches, generally oriented in the direction of the original growth. Trichomes with basal, spherical or hemispherical heterocytes, occasionally forming intercalary cylindrical heterocytes. Trichomes sometimes with widened basal parts, constricted or unconstricted at the cross walls, ending in a hair-like apical region composed from narrow, long, hyaline cells. Sheaths always present, usually firm, sometimes lamellated and yellow-brownish in colour or funnel-shaped widened at the ends. Vegetative cells cylindrical or barrel-shaped, aerotopes absent. Akinetes rarely in basal parts, however this has been reported in a few species. Cell division occurs perpendicularly to the long axis of trichomes. Trichomes dissociate at heterocytes and separately develop into new trichomes. Reproduction by motile hormogonia, which divide from the trichome, by the formation of necridic cells and liberate from the sheath after separation of the terminal hair; hormogonia of several species produce aerotopes.

As currently prescribed, the genus *Calothrix* is polyphyletic. Several genera, that are morphologically similar, and can only be confidently distinguished on molecular criteria, have been recently separated (*Calochaete* Hauer *et al.*, *Roholtiella* Bohunická *et al.*, *Macrochaete* Berrendero Gómez *et al.*); other future revisions are likely. Many *Calothrix* morphotypes were observed in collections from a variety of habitats throughout north-eastern Australia, however most were not able to be identified based soley on morphological criteria. Due to the uncertainty about the genus, four morphotypes have been given nominal designation here. Bibliography: Berrendero *et al.* (2008), Hauer *et al.* (2013), Komárek (2013), Komárek *et al.* (2014), Bohunická *et al.* (2015), Berrendero Gómez *et al.* (2016).

1. Mature trichomes tapering to fine, hair-like cells which are often hyaline 2
- Mature trichomes do not taper to fine, hair-like cells 3
2. Sheath lamellated, often funnel-like widened, colourless to yellow-brown in colour. ..... *C.* cf. *fusca*
- Sheath fine, hyaline, colourless. ..... *C.* sp. B
3. Vegetative cells pinkish-red to violet in colour ..... *C. atrichia*
- Vegetative cells blue-green to olive in colour 4
4. Trichomes cylindrical, not or slightly tapered towards the ends. ..... *C. brevissima*
- Trichomes clearly tapered towards the ends 5
5. Basal heterocytes 3.0–5.5 µm broad ..... *C.* sp. C
- Basal heterocytes > 10 µm broad 6
6. Filaments typically solitary, up to 220 µm long, vegetative cells 2.2–6.0 µm long × 7.5–14.5 µm broad ..... *C.* sp. A
- Filaments many together forming a dense erect turf, up to 2 mm in length, vegetative cells 3.5–4.6 µm long × 11.2–13.5 µm broad ..... *C.* sp. D

Calothrix atricha Frémy (1930: 261) Fig. 56 A–B.

Filaments solitary or in small clusters, unbranched, straight or flexuous, up to 200 µm long, gradually tapering towards the ends, 7.5–8.0 µm wide at the base, 4.0–4.5 µm wide towards the ends. Sheaths thin, colourless, not lamellated, open at the ends. Trichomes gradually tapering towards the ends, constricted at the cross walls. Vegetative cells at the base isodiametric or shorter than broad, 4.4–6.9 µm long × 6.0–7.5 µm broad, towards the ends barrel-shaped up to 2.3 × longer than broad, 4.5–10.0 µm long × 4.0–4.5 µm wide, pinkish-red to violet in colour; apical cells bluntly rounded. Heterocytes basal, solitary spherical to slightly conical, 5.0–7.0 µm long × 3.7–7.5 µm broad. Akinetes not observed.

Specimens observed:—Porcupine Ck at Porcupine Gorge Natl Park.

Observations:—Growing in small clusters amongst submerged aquatic plants and filamentous algae in the shallows of riverine waterholes. The violet colour of mature filaments is distinctive, and consistent with the description of dried *C. atricha* from stagnant waters in equatorial Africa.

Calothrix brevissima G.S.West (1907: 180) Fig. 57 A–C.

Filaments epiphytic, single or in small groups, short, up to 100 µm long, (5–) 6.0–7.5 µm wide, not or slightly tapered towards the ends. Sheath thin, firm, narrow, cylindrical or slightly tapered, colourless. Trichomes short, up to 110 µm long, cylindrical, straight or sometimes flexuous, slightly narrowed towards the ends, not or slightly constricted at the cross walls, blue-green to olive in colour, without terminal hairs. Vegetative cells mostly isodiametric to shorter than wide, shortly cylindrical to barrel-shaped, 3.5–5.5 µm wide; apical cells rounded. Heterocytes basal, solitary, hemispherical to spherical, 5.5–6.5 µm wide. Akinetes not observed.

Specimens observed:—Einasleigh R. at Talaroo.

Other records:—Queensland: SE Queensland, McLeod (1975).

Observations:—Epiphytic on filaments of *Scytonema* growing amongst aquatic macrophytes in a riverine waterhole. Compare with species from the genus *Microchaete*.

Calothrix* cf. *fusca Bornet & Flahault (1886: 364) Fig. 58 A–D.

Filaments solitary, or in small irregular groups, unbranched, up to 500 (–795) µm long, gradually tapering towards the ends. Sheath thin to thick, lamellated, often funnel-like widened, colourless to yellow-brown in colour. Trichomes continually narrowed towards the ends, 8.0–13.0 (–20.5) µm wide in the middle, usually constricted at the cross walls, ending in a fine, hair-like arrangement of hyaline cells. Vegetative cells at the base isodiametric or shorter than broad, 3.0–5.8 µm long × 6.0–10.5 µm wide, blue-green in colour; apical cells hyaline, 1.5–2 × longer than broad, 2.3–5.5 µm wide. Heterocytes basal, spherical to hemispherical 4.0–7.8 µm long × 5.5–8.5 µm wide. Akinetes not observed.

Specimens observed:—Rainbow Beach Fens, Great Sandy Natl Park, Cooloola Section, Amity Swamp, North Stradbroke Is.

Observations:—Growing in the metaphyton of acidic coastal wetlands amongst emergent sedges. *C. fusca* is considered cosmopolitan, more common in the northern temperate zone. Komárek (2013) considers material reported from various tropical and subtropical regions to be inconsistent with the original concept. Compare with *C. furfosa* Geitler from peaty pools in Indonesia.

***Calothrix* sp. A** Fig. 59 A, B, D, E, G.

Filaments endogloeic, in the mucilage of benthic colonial cyanobacteria, solitary, up to 220 µm long, gradually tapering towards the ends, up to 15 µm wide at the base, 7.5–9.0 µm wide in the middle, not or slightly constricted at the cross walls. Sheath fine, hyaline, colourless. Vegetative cells 0.2–0.5 × shorter than broad, 2.2–6.0 µm long × 7.5–14.5 µm broad, pale blue-green in colour; terminal cells conically rounded. Heterocytes basal, hemispherical, 7.3–11.0 µm long × 10.3–17.5 µm wide. Akinetes not observed.

Specimens observed:—Little Yabba Ck, Maleny Kenilworth Rd Crossing.

Observations:—Growing within the mucilage of *Cylindrospermum stagnale* colonies attached to granitic rocks in small coastal streams.

***Calothrix* sp. B** Fig. 59 C, F, H.

Filaments endogloeic, in the mucilage of benthic colonial cyanobacteria, solitary, up to 600 µm long, gradually tapering towards the ends to a fine hair-like cell. Sheath fine, hyaline, colourless. Vegetative cells at the base isodiametric or shorter than broad, up to 1.4 × longer than broad in the middle, 3.5–13.5 µm long × 5.2–12.0 µm wide, blue-green in colour; apical cells up to 3 × longer than broad, 1.5–2.7 µm wide. Heterocytes basal, hemispherical to conical, 7.5–10.5 µm long × 8.3–11.3 µm wide. Akinetes not observed.

Specimens observed:—Little Yabba Ck, Maleny Kenilworth Rd Crossing.

Observations:—Growing within the mucilage of *Cylindrospermum stagnale* colonies attached to granitic rocks in small coastal streams.

***Calothrix* sp. C** Fig. 60 B–I.

Filaments endogloeic in the mucilage of benthic colonial cyanobacteria, solitary or in irregular clusters, occasionally with single false-branching, up to 300 µm long, gradually tapering towards the ends, not or slightly constricted at the cross walls. Sheath fine, hyaline, colourless. Vegetative cells at the base isodiametric or up to 2.5 × longer than broad, 2.5–8.3 µm long × 2.0–6.5 µm wide, pale blue-green in colour; apical cells conically rounded. Heterocytes basal or intercalary; basal heterocytes spherical to conical, 3.0–6.0 µm long × 3.0–5.5 µm wide; intercalary heterocytes barrel-shaped, 4.5–7.0 µm long × 3.0–4.0 µm wide. Intercalary heterocytes may form in pairs, becoming terminal following breakage, or solitary giving rise to single false-branching or hormogonia. Akinetes not observed.

Specimens observed:—Yowah Spring #4.

Observations:—Epigloeic, growing within the mucilage of *Aphanocapsa* colonies in a shallow Great Artesian Basin spring. Similarities with species from *Calochaete* and *Roholtiella*.

***Calothrix* sp. D** Fig. 56 C–F.

Filaments in a dense, olive-green coloured turf. Filaments attached to the substrate, erect, straight to slightly flexuous, up to 2 mm in length, 14–25 µm wide at the base. Sheaths firm, widened, not coloured, or stratified, up to 5 µm wide, open at the ends. Trichomes blue- to olive-green in colour, slightly constricted at the cross walls, continuously narrowed towards the end, but not ending in a hair-like cell. Vegetative cells distinctly shorter than broad, 3.5–4.6 µm long × 11.2–13.5 µm wide. Heterocytes solitary, basal 7.1–21.3 µm long × 14.2–21.3 µm wide, intercalary, 8.5–16.3 µm long × 9.8–16.0 µm wide.

Specimens observed:—South Pine R. at Carter Court.

Observations:—Growing as a dense turf attached to large boulders and woody debris in the shallows of a subtropical river in SE Queensland.

Other species known from Australia: *C. castellii* Bornet & Flahault (1886: 369), Ling & Tyler (2000).

CAMPTYLONEMOPSIS

Camptylonemopsis Desikachary (1948: 49)
Type: *C. lahorensis* (S.L.Ghose) Desikachary (1948: 49)

Filaments heteropolar, solitary or in small groups, bent, attached to the substrate by their basal parts, filament ends grow upwards forming U-shaped arrangements. Trichomes uniseriate, with cells generally widened towards the apices. Vegetative cells barrel-shaped, usually longer and narrower in the central parts of the trichome, shorted and wider at the ends; apical cells widely rounded. Heterocytes intercalary, generally towards the central regions of the trichome, spherical or barrel-shaped. Akinetes barrel-shaped to long-oval or cylindrical, arising in the central regions of the trichome.

Most of the 13 currently recognised species are known from tropical environments; here one species is described from north-eastern Australia. Bibliography: Desikachary (1948), Komárek (2003), Komárek (2013), Komárek *et al.* (2014).

Camptylonemopsis* cf. *pulneyensis Fig. 61 A–H.

Filaments solitary or in small irregular clusters, amongst filamentous algae, crescent-shaped, 3.3–6.6 µm wide. Trichome cylindrical, narrowed towards the central region and widened towards the apices, clearly constricted at the cross walls. Sheath thin, firm, hyaline, not lamellated, open at the ends. Vegetative cells cylindrical, 1.2–3.1 × longer than broad in the central region, 0.3–1.3 × longer than broad towards the apices, 4.8–12.2 µm long × 2.3–4.4 µm wide; apical cell broadly rounded. Heterocytes intercalary, elongated cylindrical, 8.4–14.2 µm long × 3.3–4.4 µm broad. Akinetes intercalary, single or 2–3 in series, remote or adjacent to heterocytes, cylindrical with bluntly rounded ends, 8.5–10.5 µm long × 3.3–5.0 µm wide.

Specimens observed:—Palmer R. at Gum Ck.

Other records:—Victoria: Darling (1982), as *C.* cf. *pulneyensis.*

Observations:—*C. pulneyensis* was originally described growing amongst other algae in a pool in southern India;

akinetes were not reported. The observed material from northern Queensland is generally smaller in size, however similar in all other aspects. Description of *C.* cf. *pulneyensis* from an Australian alpine sphagnum bog is likely to be another species.

FORTIEA

Fortiea DeToni (1936: 3)
Type: *F. caucasica* (Elenkin) De Toni (1936: 3)

Filamentous; heteropolar, differentiated into a basal part with a terminal heterocyte and free apical end, cylindrical, simple, solitary or in small groups; filaments usually creeping along the substratum or amongst the periphyton. Sheaths firm, always one per trichome, colourless, sometimes thickened and lamellated. Trichomes cylindrical or slightly widened at the base, narrowed in the middle part and clearly widened at the ends, constricted or unconstricted at the cross walls, but usually constricted at the ends. Vegetative cells cylindrical or barrel-shaped, in the central parts of the trichome usually longer than wide, at the bases and at the apices isodiametric or shorter than wide; apical cells widely rounded or spherical. Akinetes, usually in rows and separated by heterocytes. Cell division crosswise, perpendicular to the long axes of trichomes; in old trichomes towards the apical meristematic zones. Trichomes dissociate at heterocytes. Reproduction by hormogonia, which separate from trichomes by necridic cells and by akinetes.

Most of the 13 described species are periphytic, growing among other algae and aquatic plants. Known from the tropics and warmer regions of the temperate zone. Here one species is described from north-eastern Australia Bibliography: Desikachary (1959), Komárek & Watanabe (1998), Komárek (2013), Bohunická *et al.* (2015).

***Fortiea* sp. A** Fig. 60 A.

Filaments single or rarely in irregular clusters, amongst filamentous algae, 4.2–5.6 µm wide. Trichomes cylindrical slightly narrowed towards the central areas, constricted at the cross walls; sheath thin, firm, hyaline, not lamellated, open at the ends. Vegetative cells cylindrical, 2.7–3.7 × longer than broad, elongated towards the central areas, 8.2–10.6 µm long × 2.8–3.2 µm wide; apical cells bluntly rounded. Heterocytes basal, spherical, 2.9–5.3 µm long × 2.8–6.2 µm wide. Akinetes not observed.

Specimens observed:—Palmer R. at Gum Ck.

Observations:—Growing amongst filamentous algae in the shallow benthic areas of tropical streams along with *Camptylonemopsis* cf. *pulneyensis*. Species from the genus *Fortiea* resemble several genera which grow attached, with either part or the entire filament, to the substrate including *Camptylonemopsis*, *Aulosira*, and *Microchaete*.

MICROCHAETE

Microchaete Thuret ex Bornet & Flahault (1886)
Type: *M. grisea* Thuret ex Bornet & Flahault (1887)

Filaments uniseriate, heteropolar, solitary or in small irregular groups, straight or slightly flexuous; attached by the base or creeping along the substratum or unattached and growing freely amongst other algae. Sheaths cylindrical, ± slightly narrowed or widened towards the ends, thin, firm, and usually colourless and unlamellated. False-branching typically lacking, occasionally with tolypotrichoid type false-branching. Trichomes cylindrical along the whole length or slightly attenuated towards the ends. Vegetative cells barrel-shaped to cylindrical, isodiametric or shorter or longer than broad, often shortened and rounded at the apex. Heterocytes basal, spherical to sub-spherical, less frequently intercalary. Akinetes known from a few species, solitary or in short rows adjacent to the trichome apex. Reproduction by the production of hormogonia or akinete germination.

As currently prescribed, the genus *Microchaete* is polyphyletic (Hauer *et al.* 2014). Many species share morphological similarity with species from *Calothrix* that do not have terminal hairs. Various morphotypes were observed from habitats across north-eastern Australia which do not correspond to currently described species; due to the uncertainty about the genus, three have been given nominal designations here. Bibliography: Komárek (2013), Hauer *et al.* (2014), Komárek *et al.* (2014).

1. Filaments amongst other algae or attached to rocky substratum 2
- Filaments epiphytic on filamentous algae or submerged vegetation 3
2. Vegetative cells 0.6–1.3 × longer than broad, 5.0–6.5 µm broad ..... *M.* sp. A
- Vegetative cells up to 1.6 × longer than broad, 3.8–5.6 µm broad ..... *M.* sp. B
3. Basal heterocytes < 6.8 µm broad ..... *M.* sp. C
- Basal heterocytes > 6.8 µm broad 4
4. Trichomes 6.0–7.5 µm wide ..... *M. tenera*
- Trichomes 7.7–10.4 µm wide ..... *M.* cf. *investiens*

Microchaete* cf. *investiens Frémy (1930: 283) Fig. 62 A–E.

Filaments solitary or in small groups, straight or slightly flexuous, 7.7–10.4 µm wide, initially attached to the substrate along its entire length, later only at the base, with the apical ends free. Trichomes cylindrical along the entire length, clearly constricted at the cross walls, brownish-green in colour. Sheath fine, not lamellated, colourless, open at the ends. Vegetative cells isodiametric to 2 × longer than broad, 7.8–11.0 µm long × 5.1–7.0 µm wide; apical cell conically rounded. Heterocytes solitary, basal spherical, 6.8–7.5 µm in diameter, intercalary cylindrical, 11.0–12.5 µm long × 7.1–11.2 µm wide. Akinetes not observed.

Specimens observed:—Little Yabba Ck, Maleny Kenilworth Rd Crossing.

Observations:—Growing attached to filaments of *Microseira wollei* and *Scytonema* in the littoral zone of a small, coastal stream. *M. investiens* is known from tropical areas, usually epiphytic on filamentous algae and aquatic plants; material from SE Queensland was slighty wider than previously reported for this species.

Microchaete tenera Thuret ex Bornet & Flahault (1886: 84) Fig. 63 A–F.

Filaments solitary or in small groups, flexuous, 6.0–7.5 (–8.5) µm wide, attached to the substratum along the basal region. Sheath thin, colourless, not lamellated. Trichomes cylindrical along the entire length, not or slightly constricted at the cross walls. Vegetative cells isodiametric up to 2 × longer than broad, 5.5–10.5 µm long × 4.5–5.5 (–6.9) µm wide; apical cells conically-rounded. Heterocytes basal and intercalary, basal heterocytes spherical to slightly conical, 6.0–9.0 µm long × 5.0–7.5 µm wide, intercalary heterocytes cylindrical, up to 4 × longer than broad, 10.0 –21.5 µm long × 5.0–6.5 µm wide. Akinetes not observed.

Specimens observed:—Fat Hen Ck at Kilkivan.

Other records:—Queensland: SE Queensland, McLeod (1975); New South Wales: Pond on the Broadway side of Victoria Park at Chippendale, S. Skinner, 2002 (NSW 910368); Victoria: Darling (1982).

Observations:—Epiphytic, growing attached to filaments of *Lyngbya* and intermixed with other filamentous algae and aquatic vegetation, in the shallows of a small subtropical stream.

***Microchaete* sp. A** Fig. 60 J–K.

Filaments solitary, amongst other algae, straight or slightly arcuate, uniformly 7.0–8.5 µm wide along the entire length. Sheaths thin, firm, colourless, not lamellated. Trichomes cylindrical, distinctly constricted at the cross walls. Vegetative cells sub-spherical to barrel-shaped, rounded at the ends, 0.6–1.3 × longer than broad, 3.5–7.5 µm long × 5.0–6.5 µm wide, pale blue-green in colour. Heterocytes basal, ± spherical, 4.5–5.0 µm in diameter. Akinetes not observed.

Specimens observed:—Fat Hen Ck at Kilkivan.

Observations:—Growing amongst other algae attached to rocky substratum in a clear, shallow lowland stream. The sub-spherical vegetative cells are a distinctive feature of this material.

***Microchaete* sp. B.** Fig. 64 A–F.

Filaments solitary, or more commonly clustered into small groups, flexuous, 4.2–5.3 µm wide, attached to the substratum along the basal region. Sheath fine, colourless, not lamellated, sometimes absent. Trichomes cylindrical along the entire length, not or slightly constricted at the cross walls. Vegetative cells isodiametric up to 1.6 × longer than broad, 3.1–7.2 µm long × 3.8–5.6 µm wide; apical cells conically-rounded. Heterocytes basal and intercalary, basal heterocytes spherical to slightly conical, 4.3–9.1 µm long × 4.3–5.3 µm wide, intercalary heterocytes cylindrical. Akinetes not observed.

Specimens observed:—Booloumba Ck at camping area #1.

Observations:—Growing amongst colonies of *Nostoc* in the littoral zone of shallow streams, on rocky substrate. The slightly conical shape of the terminal heterocytes is distinctive, and unlike other known *Microchaete* species.

***Microchaete* sp. C.** Fig. 65 A–F.

Filaments, epiphytic on filamentous algae, solitary or in small groups, flexuous, 5.3–6.2 µm wide, up to 200 µm long, attached to the substratum at the basal region. Sheath thin, colourless, not lamellated. Trichomes cylindrical along the entire length, constricted at the cross walls. Vegetative cells isodiametric up to 2 × longer than broad, 3.8–8.1 µm long × 3.7–5.6 µm wide; apical cells conically-rounded. Heterocytes basal and intercalary, basal heterocytes spherical to slightly conical, 3.6–6.8 µm long × 4.4–6.4 µm wide, intercalary heterocytes spherical. Akinetes not observed.

Specimens observed:—Einasleigh R. at Talaroo.

Observations:—Epiphytic, attached to filaments of *Scytonema* growing in shallow off stream waterholes. Compare with *M. tenera*; much of the observed material often lacked a definite sheath.

Other species known from Australia: *M. tenera* var. *tenuis*, Running Ck, Queensland, A.B. Cribb, 1991 (BRI 0701260); *M. grisea*, Carlisle Is., Heron Is., Queensland, A.B. Cribb, 1986, 1963 (BRI 0700728, BRI 0700729); *M. vitiensis*, Heron Is., Erskine Is., Queensland, A.B. Cribb, 1963, 1970 (BRI 0700730, BRI 0701261).

RIVULARIA

Rivularia Agardh ex Bornet & Flahault (1886: 345)
Type: *R. dura* Roth ex Bornet & Flahault (1886: 347)

Filamentous; filaments heteropolar, differentiated into basal and apical parts, simple, joined into firm, hemispherical or spherical, later often vast, flat, macroscopic, irregular strata, several centimetres in diameter; strata layered, with densely agglomerated trichomes oriented by their bases with heterocytes to the substratum and the apical hair-like parts towards the surface of the colony. Strata gelatinous to leathery, sometimes intensely incrusted by calcium carbonate. Trichomes generally cylindrical, constricted or unconstricted at the cross walls, dividing at intercalary heterocytes. Apical hairs composed of narrow, long, hyaline cells. Sheaths firm, sometimes lamellated, yellow-brown or colourless. Aerotopes and akinetes not produced. Cell division perpendicular to the long axis of the trichome, later in meristematic zones. Reproduction by dissociation of trichomes within colonies and heterocytes and by the production of hormogonia which are liberated following the separation of the apical hair through the production of necridic cells.

A world-wide genus with 49 species currently taxonomically accepted; most are periphytic or epiphytic. Here two species are described from north-eastern Australia; a further three species are known from elsewhere in Australia. Bibliography: Berrendero *et al.* (2008), Komárek (2013), Whitton & Mateo (2012), Komárek *et al.* (2014), León-Tejera *et al.* (2016), Shalygin *et al.* (2016).

1. Vegetative cells 5.0–9.8 µm long × 5.5–11.0 µm broad ..... *R. aquatica*
- Vegetative cells 8.0–19.0 µm long × 4.8–6.5 µm broad ..... *R. beccariana*

Rivularia aquatica De Wildeman (1897: 40) Fig. 66 A–E.

Colonies small, hemispherical to irregularly spherical, 1–3 cm in diameter, without calcareous encrustations, olive-green to yellow-brown in colour; sheaths thin or thick, colourless, not striated, narrowed towards the ends, sometimes indistinct. Trichomes gradually attenuated towards the end, constricted at the cross walls, attenuated into a long hair at the trichome apex. Vegetative cells cylindrical or long barrel-shaped, isodiametric or longer or shorter than broad 5.0–9.8 µm long × 5.5–11.0 µm broad. Heterocytes spherical, solitary or rarely in pairs, 10.0–12.0 (–14.0) µm in diameter.

Specimens observed:—Edgbaston Reserve.

Other records:—Queensland: Cattle Ck, Mackay-Eungella Rd, 1 km W of Gargett, T. Entwisle, 1993 (MEL).

Observations:—Growing on the substratum of shallow spring-fed wetlands, amongst colonies of *Iningianema pulvinus*; pantropical distribution (Komárek 2013).

Rivularia beccariana Bornet & Flahault (1886: 356) Fig. 67 A–F.

Colonies small, irregularly hemispherical up to 1 cm in diameter, without calcareous encrustations, olive- to blue-green in colour. Sheaths thin, colourless or yellow-brown, sometimes indistinctly lamellated, narrowed towards the ends. Trichomes gradually attenuated towards the end, not or slightly constricted at the cross walls, attenuated into a long flexuous hair at the trichome apex. Vegetative cells cylindrical or long barrel-shaped, isodiametric or longer or shorter than broad 8.0–19.0 µm long × 4.8–6.5 µm broad. Heterocytes spherical, solitary, 7.2–9.5 (–14) µm in diameter.

Specimens observed:—Fitzroy R. at Murray Lagoon.

Other records:—Queensland: SE Queensland, McLeod (1975), Stony Ck, Wallaman Falls Natl Park, A.B. Cribb, 1972 (BRI 0702310); New South Wales: Northern Tablelands, Severn R., Dundee, on *Vallisneria*, Skinner, 2000 (NSW). Central Coast, Dismal Swamp, Wollemi Natl Park, on *Myriophyllum* leaves, Coveny, 2000 (NSW). Victoria: Dandenong area, Devilbend Res., south of Mornington, Mackey, 1991 (MEL 2028556 and 2047042). Northern Territory: Nitmiluk Natl Park, Seventeen Mile Ck, near crossing on track from Katherine Gorge to Edith Falls, Entwisle, 1997 (MEL).

Observations:—Growing amongst littoral vegetation, and filamentous algae; widespread distribution, this epiphytic species, known from a variety of substrates (Komárek 2013), can be cryptic and is therefore likely to be under reported.

Other species known from Australia: *R. borealis* (Entwisle 1994), Victoria; *R. calcarea* (Entwisle 1994, Hardy 1906); *R. concentrica* Pambula R., Chalkhills Rd, off Wyndham–Pambula Rd, 8 km WNW of Pambula, New South Wales, Entwisle, 1991 (MEL), Wallagaraugh R., Newtons Crossing, picnic area, Allan Brooke Rd, New South Wales, Entwisle 1991 (MEL), Adams R above Adams Falls, Strathgordon, Tasmania, Entwisle, 1996 (MEL), Lisdillon Rivulet, Orford–Swansea Rd, 20 km from Swansea, Tasmania, Entwisle, 1996 (MEL).

6. SCYTONEMATACEAE

Scytonemataceae Rabenhorst ex Bornet & Flahault (1886: 85)
Type: *Scytonema* Agardh ex Bornet & Flahault (1886: 85)

Heterocystous, uniseriate, filamentous, with obligatory false branching. Thallus prostrate, forming flat or woolly mats, sometimes occurring as solitary filaments amongst other algae. Trichomes monoseriate, isopolar, cylindrical or widened or narrowed at both ends, rarely forming hairs, usually with distinct meristematic zone, less frequently combined with intercalary growth. Sheaths usually thick, firm or gelatinous, often lamellated, sometimes funnel-like and widened at the ends, colourless or variously coloured. Heterocytes intercalary, mostly occurring singly. Akinetes absent. Reproduction by the formation of hormogonia.

KEY TO GENERA

1. Filaments subaerophytic, from thermal habitats ..... EWAMIANIA
- Filaments not from thermal habitats 2
2. Filaments densely arranged, radiating from the centre of spherical to discoid colonies ..... ININGAINEMA
- Filaments solitary, or many together forming caespitose, woolly clusters or mats 3
3. Trichomes slightly narrowed towards the ends, sometimes with elongated, cylindrical, vacuolated apical and subapical cells ..... SCYTONEMATOPSIS
- Trichomes not narrowed towards the ends ..... HETEROSCYTONEMA, SCYTONEMA

EWAMIANIA

Ewamiania G.B. McGregor & B.C. Sendall (2017: 43)
Type: *E. thermalis* G.B. McGregor & B.C. Sendall (2017: 46)

Filaments densely arranged to form blackish-green hemispherical caespitose mats. Filaments isopolar, cylindrical, straight or flexuous, densely arranged and erect, often parallely fasciculate, with tolypotrichoid false-branching, rarely with scytonematoid false-branching. Vegetative cells short barrel-shaped or isodiametric, 0.5–1.2 × as long as wide,

slightly constricted at the cross walls, with granulated contents; terminal cells widely rounded. Sheath firm, relatively thick, lamellated, uncoloured to yellowish or yellow–brown in colour, cylindrical, closed at the apex. Heterocytes basal and intercalary, solitary, rarely up to 2(3) in series, developing particularly at the base of branches, spherical or ovoid. Akinetes not known. Reproduction by hormogonia, often with terminal heterocytes, not constricted at cross-walls, separated by necridic cells. A monospecific genus, with one species known from a thermal spring complex in tropical north-eastern Australia.

Ewamiania thermalis G.B. McGregor & B.C. Sendall (2017: 46) Figs. 68 A–K, 69 A–C.

Filaments densely arranged to form blackish-green hemispherical caespitose mats beginning as small 1–4 cm diameter circular tufts up to mats 4–6 cm wide by several metres long. Filaments isopolar, cylindrical, straight or flexuous, 15.5–40 μm in diameter, densely arranged and erect, often parallely fasciculate, up to 3 cm long, with tolypotrichoid false-branching, rarely with scytonematoid false-branching. Vegetative cells short barrel-shaped or isodiametric, 0.5–1.2 × as long as wide, 7.2–16.9 μm long, 10.4–14.5 μm wide, slightly constricted at the cross walls, with granulated contents; terminal cells widely rounded. Sheath firm, relatively thick, lamellated, uncoloured to yellowish or yellow–brown in colour, cylindrical, closed at the apex. Heterocytes basal and intercalary, solitary, rarely up to 2(3) in series, developing particularly at the base of branches, spherical or ovoid, 7.5–16.5 μm in diameter, 9.0–24.6 μm long. Akinetes not observed. Reproduction by up to 12-celled hormogonia, often with terminal heterocytes, not constricted at cross-walls, separated by necridic cells.

Specimens examined:—Talaroo thermal springs.

Observations:—A subaerophytic species known from a thermal spring complex in tropical, north-eastern Australia. Observed growing along the crests of travertine minidams just above the thermal waters discharging from the springs (48.5–62.7ºC) as well as along some of the shallow unconfined areas of vent-discharge aprons.

INGAINEMA

Iningainema G.B. McGregor & B.C. Sendall (2017: 17)
Type: *I. pulvinus* G.B. McGregor & B.C. Sendall (2017: 17)

Filaments densely arranged, radiating from the centre of irregularly spherical to discoid, blue-green to olive-green colonies. Filaments isopolar, uniseriate, cylindrical, straight or flexuous, main filament generally wider than the lateral filaments which gradually taper to a bluntly conical end; with single or geminate false-branching. Sheath firm, lamellated, uncoloured to yellowish or yellow-brown, closed at the apex. Vegetative cells isodiametric to shorter than broad, slightly constricted at the cross walls. Heterocytes basal and intercalary, solitary, spherical to compressed-ovoid. Akinetes absent. A monospecific genus, with one species known from a Great Artesian Basin spring complex in north-eastern Australia.

Iningainema pulvinus G.B. McGregor & B.C. Sendall (2017: 17) Figs. 70 A–E, 71 A–F, 72 A–B.

Filaments densely arranged, radiating from the centre of spherical to discoid, blue-green to olive-green colonies, 5–25 mm in diameter. Filaments isopolar, uniseriate, cylindrical, straight or flexuous, 20–39 μm in diameter, main filament generally wider than the lateral filaments which gradually taper to a bluntly conical end; with single or geminate false-branching. Sheath firm, lamellated, uncoloured to yellowish or yellow-brown, closed at the apex. Vegetative cells isodiametric to shorter than broad, slightly constricted at the cross walls, 3.3–8.2 μm long × 18.0–27.5 μm wide in the main filament, 3.5–5.0 μm long × 4.2–12.0 μm wide in lateral branches, with granular contents. Heterocytes basal and intercalary, solitary, spherical to compressed-ovoid, 6.3–9.5 μm long × 11.0–19.0 μm wide. Akinetes absent.

Specimens examined:—Edgbaston Reserve.

Observations:—Morphologically, *Iningainema* is most like *Scytonematopsis* Kiseleva and *Scytonema* Agardh ex Bornet & Flahault. All three genera have isopolar filaments enveloped by a firm, often layered and coloured sheath; false branching is typically geminate, less commonly singly (Komárek *et al.* 2013). In *Iningainema* and *Scytonematopsis*, filaments gradually narrow towards the apices. The false branching ontogeny in *Iningainema* is distinctive. It initiates via trichome fragmentation through the formation of a necridic cell, however rather than forming a lateral protrusion at the site of fragmentation, the trichome continues parallel growth within the sheath for a short distance, often leading

to trichome contortions and filament bulging, prior to lateral protrusion. Subsequently the filaments can be thickened or have a slight nodular appearance at the branching sites. This species is known to produce the hepatotoxin nodularin (McGregor & Sendall 2017).

HETEROSCYTONEMA

Heteroscytonema G.B. McGregor & Sendall (2018: 15)
Type: *H. crispum* (Bornet ex De Toni) G.B. McGregor & Sendall (2018: 15)

Filamentous, solitary, or many together forming a caespitose, woolly thallus, olive-green to blackish green in colour. Filaments straight to variously flexuous, sometimes slightly coiled, cylindrical, with solitary or geminate false-branching, initiated following the formation of necridic cells; sheath firm, lamellated, with a smooth exterior surface, colourless or yellowish-brown in mature filaments. Trichomes isopolar, not or slightly constricted at the cross walls. Vegetative cells discoid to short barrel-shaped, blue-green in colour; apical cells widely rounded. Heterocytes intercalary, discoid to subspherical, single or up to two in series. Reproduction by hormogonia, which develop at the ends of branches and liberate from the sheaths. Akinetes absent. Bibliography: Sendall & McGregor (2018)

Heteroscytonema crispum **(**Bornet ex De Toni) G.B. McGregor & Sendall (2018: 15) Fig. 73 A–F.
Basionym: *Scytonema crispum* (Bornet ex De Toni 1907: 498)

Filaments solitary or many together forming a caespitose, woolly thallus, olive-green to blackish green in colour. Filaments straight to variously flexuous, sometimes slightly coiled, 18–25 (–35) µm wide, cylindrical, with solitary or geminate false-branching; sheath firm, lamellated, with a smooth exterior surface, colourless or slightly yellowish-brown in mature filaments. Trichome the same width along the entire length, not or slightly constricted at the cross walls. Vegetative cells discoid to short barrel-shaped, 3.5–10.5 (–15) µm long × (12–) 16.5–25.0 (–30) µm wide; terminal cells widely rounded. Heterocytes discoid to subspherical, single or up to two in series, 9.0–20.5 (–37) µm long × 12.5–18.9 (–26) µm wide.

Specimens examined:—Awoonga Dam, Pool Ck at Talaroo, Fat Hen Ck at Kilkivan, Brisbane R. at Colleges Crossing, Brisbane R. at Savages Crossing, Emu Ck at Grieves Rd, Little Yabba Ck Maleny–Kenilworth Rd Crossing, Marongi Ck at Turtle Ck Rd, Reedy Ck at Mt. Byron Rd, Sandy Ck at Wivenhoe-Somerset Rd Crossing, Sheepstation Ck at Kilcoy-Murgon Rd, Wallaby Ck at Himstedts Rd.

Other records:—Queensland: Enoggera Res., Brisbane, A.B. Cribb, 1962 (BRI 0703039), Nandinya Falls, Palmerston Natl Park, A.B. Cribb, 1973 (BRI 0703040), Stony Ck, Wallaman Falls Natl Park, A.B. Cribb, 1972 (BRI 0703041), Canarvon Ck, Canarvon Gorge, A.B. Cribb, 1979 (BRI 0703042), Ipswich, A.B. Cribb, 1949 (BRI 0703046), Bailey (1913); New South Wales: South of Goathouse, c. 300 m down northern catchment of Dinner Run, Skinner, 2000 (NSW 448452); Western Australia: Dubaut Ck, Shark Bay, Huisman, 2009 (PERTH 8578451). Other records as *S. cinncinnatum*: Queensland: Mt Catharina, 10 km NE of Ingham, Skinner, 1984 (CANB 543263), Murray Falls, Murray R., 25 km NW of Cardwell, Entwisle, 993 (MEL); New South Wales: Coombadjha Ck, Washpool Natl Park, Skinner, 2000 (NSW), McCarrs Ck, Ku-Ring-Gai Chase Natl Park, Entwisle, 1999 (NSW), Waratah Gully Ck, 750 m E of Berowra Rly Stn, Entwisle, 2000 (NSW), Bridal Veil Falls, Govetts Leap, Blackheath, Entwisle, 1999 (NSW), Endrick R., 4 km NE of Nerriga, Entwisle, 1991 (NSW); Northern Territory: The Rocks Waterhole, Kakadu Natl Park, Entwisle, 1997 (MEL), Florence Falls, Litchfield Natl Park, Entwisle, 1997 (MEL), Walker Ck, Litchfield Natl Park, Entwisle, 1997 (MEL).

Observations:—Widespread and common species, known from riverine habitats throughout Australia. Considered synonymous with *S. cincinnatum* Thuret ex Bornet & Flahault. Strains from Australia, New Zealand, and Europe are known to produce saxitoxins, otherwise known as paralytic shellfish poisons (PSPs) (Sendall & McGregor 2018, Smith *et al.* 2011).

SCYTONEMA

Scytonema Agardh ex Bornet & Flahault (1886: 85)
Type: *S. hofmannii* Agardh ex Bornet & Flahault (1886: 99)

Filamentous, thallose; solitary branched filaments or forming mats on the substrate. Filaments free or in fascicles, sometimes densely coiled, prostrate or with erect branches, solitary or geminate falsely-branched. Branching initiates after trichome dissociation following the formation of necridic cells, typically between two adjacent heterocytes, usually not at heterocytes, loop-like lateral formations may occur after which the tops of the trichomes later divide. Trichomes isopolar, cylindrical, uniseriate, constricted at the cross walls; terminal parts of branches cylindrical or slightly widened, with rounded apical cell; middle parts of trichomes sometimes with elongated, cylindrical cells. Sheaths firm, limited, parallel or diverging, lamellated, usually yellow-brown, coloured by scytonemin, particularly in mature filaments. Cells pale or olive-green, usually with solitary, irregularly disposed granules or with granular content, rarely yellowish or pinkish coloured; apical cells sometimes vacuolate. Heterocytes intercalary, solitary, rarely in pairs, cylindrical or barrel-shaped. Akinetes not produced. Cells divide crosswise to the trichome axis, mainly in meristematic zones near the ends of branches. Reproduction by hormogonia, which develop at the ends of branches and liberate from the sheaths.

A worldwide genus with 126 species currently taxonomically accepted; most are aerophytic, subaerophytic or metaphytic. Six species are described here from north-eastern Australia, four other species are known from elsewhere in Australia. Bibliography: Skinner & Entwisle (2001), Komárek (2013a, 2013b), Komárek *et al.* (2014), Sendall & McGregor (2018).

1. Trichomes of the same width along the entire length....2
- Trichomes narrowed in the central parts, distinctly widened towards the ends....5
2. Vegetative cells isodiametric or shorter or longer than broad....3
- Vegetative cells always shorter or longer than broad....4
3. Vegetative cells 3.5–7.5 (–13.5) µm long × 8.0–11.0 (–13.5) µm wide....*S. coactile*
- Vegetative cells 3.5–8.0 µm long × 4.0–6.5 µm wide....*S. tolypothrichoides*
4. Vegetative cells shorter than broad, 3.3–8.7 µm long × 7.1–9.3 µm wide....*S.* cf. *sanpaulense*
- Vegetative cells longer than broad, 6.8–14.5 µm long × 7.9–10.5 µm wide....*S.* sp. A
5. Vegetative cells isodiametric to cylindrical, 6.5–16.0 µm long × 6.3–10.5 µm broad....*S. mirabile*
- Vegetative cells isodiametric to shortly barrel-shaped, 3.5 –5.5 µm long × (5.0–) 7.0–9.5 (–11.5) µm wide....*S. subtile*

Scytonema coactile Montagne ex Bornet & Flahault (1886: 90) Figs. 74 A–F.

Thallus caespitose, woolly, often forming irregularly spherical colonies 10–15 cm in diameter, dark blue-green to olive-green in colour. Filaments 16–24 µm wide, with geminate false-branching, branches generally the same diameter as the main filament. Sheaths firm, colourless or yellowish, often lamellated. Trichomes cylindrical, ± constricted at the cross walls. Vegetative cells isodiametric or longer or shorter than broad, 3.5–7.5 (–13.5) µm long × 8.0–11.0 (–13.5) µm wide; cells in the apical regions shorter than broad, 3.8–4.8 µm long × 11–12 µm wide, apical cells rounded. Heterocytes solitary, cylindrical, isodiametric or longer or shorter than broad, 6.4–10.5 (–19) µm long × 9.0–12.0 (–15) µm broad.

Specimens examined:—Blue L., Eighteen Mile Swamp, Naree Budjong Djara Natl Park, North Stradbroke Is.

Observations:—Metaphytic or attached to emergent sedges in the littoral zone of oligotrophic coastal wallum lakes and wetlands.

Scytonema mirabile Bornet (1889: 155) Fig. 75 A–L.

Thallus a felt-like blackish-green mat; filaments straight or variously flexuous, 10.5–21.0 µm broad, with solitary or geminate false-branching; sheaths wide, colourless to yellow or yellowish-brown in colour, with parallel layers. Trichomes cylindrical, widened towards the ends, towards the centre of the trichome not or slightly constricted at the cross walls, distinctly constricted towards the trichome apices. Vegetative cells isodiametric to cylindrical, 6.5–16.0 µm long × 6.3–10.5 µm broad, blue-green to olive-green in colour; apical cells widened, barrel-shaped, distinctly constricted at the cross walls, sometimes vacuolated, end cell hemispherical rounded, up to 16 µm wide. Heterocytes intercalary, isodiametric to cylindrical, 13.0–22.5 µm long × 8.1–10.7 µm broad.

Specimens examined:—Wallaby Ck at Talaroo, Einasleigh R. at Talaroo.

Other records:—Queensland: Skinner & Entwisle (2001), New South Wales: Adeline Falls, Lawson, Blue Mountains, S. Skinner & T.J. Entwisle, 2001 (NSW 627141), Swamp on road to Barokee Rest Area, Cathedral Rock Natl Park, Skinner, 2000 (NSW), Woronora R., Eckersley Ford, 11 km below Woronora Dam, Entwisle, 1999 (NSW), Mill Ck, 5 km E of Wisemans Ferry, Entwisle, 2000 (NSW), Playfair (1912), Playfair (1917); Victoria: River into Old R, 5 km W of Mt Castor, South West Natl Park, Entwisle, 1996 (MEL); Northern Territory: Wangi Falls, Litchfield Natl Park, Entwisle, 1997 (MEL).

Observations:—Growing amongst the metaphyton amongst aquatic plants in the littoral zone and in shallow offstream waterholes in tropical rivers.

Scytonema* cf. *sanpaulense Sant'Anna (1988: 530) Fig. 76 A–G.

Thallus flocculose, or forming irregular clusters amongst other algae. Filaments 11–12.4 μm wide, with geminate false-branching; branches the same morphology as the main filaments. Sheath, colourless and slightly parallely lamellated, often closed at the ends. Trichomes cylindrical, slightly constricted at the cross walls. Vegetative shorter than broad, 3.3–8.7 μm long × 7.1–9.3 μm wide; apical cells widely rounded. Heterocytes ± spherical, barrel-shaped to cylindrical, 10.2–18.2 μm long × 8.7–10.6 μm wide.

Specimens examined:—Maloney Springs.

Observations:—Growing amongst other filamentous algae and emergent aquatic plants in a shallow tropical wetland.

Scytonema subtile Möbius (1892: 448) Figs. 77 A–E, 78 A–F.

Filaments solitary amongst other algae, or forming small unstructured clusters, 14–17 (–21) μm wide, with geminate false-branching; branches narrowed at the base, widened towards the ends. Sheath wide, initially colourless, and later yellow to brown in colour, parallely lamellated. Trichomes cylindrical, narrowed in older parts not constricted at the cross walls, continually widened towards the ends and distinctly constricted. Vegetative cells long cylindrical in older parts of the filaments, 11.5–19.5 μm long × 1.8–5.0 (–6.5) μm wide, towards the ends shortened, isodiametric to shortly barrel-shaped, 3.5–5.5 μm long × (5.0–) 7.0–9.5 (–11.5) μm wide; apical cells widely rounded. Heterocytes ± spherical, barrel-shaped to cylindrical, 11.0–20.5 μm long × 6.0–7.5 (–12.0) μm wide.

Specimens examined:—Blue L., Naree Budjong Djara Natl Park, North Stradbroke Is., Crystal Ck at Bypass Rd.

Other records:—New South Wales: Central Coast: McCarrs Ck, Ku-Ring-Gai Chase Natl Park, Entwisle, 2000 (NSW); Brisbane Waters Natl Park, Coveny, 2000 (NSW); Sydney International Rowing Course, Penrith Lakes, S. Skinner, 2000 (NSW); Gap Ck Falls, Olney S.F., Cherry, 2000 (NSW). Northern Territory: billabong 25 km SW of Bullita Outstation, Gregory Natl Park, C.A. Coles, 1996 (MEL 2277156A).

Observations:—Metaphytic or attached to submerged and emergent aquatic plants in the littoral zone of subtropical wallum lakes, acidic tropical streams and waterholes (Komárek 2013).

Scytonema tolypothrichoides Kützing ex Bornet & Flahault (1886: 100) Fig. 79 A–E.

Thallus flocculose, or forming small unstructured tuft-like clusters, rarely occurring as solitary filaments amongst other algae. Filaments 10–18 μm wide, with geminate false-branching; branches the same morphology as the main filaments. Sheath wide, colourless and slightly parallely lamellated with divergent layers towards the ends. Trichomes cylindrical, not constricted at the cross walls, ± widened towards the ends. Vegetative cylindrical, isodiametric or slightly longer or shorter than broad, 3.5–8.0 μm long × 4.0–6.5 μm wide, towards the ends shortened, isodiametric to shortly barrel-shaped; apical cells widely rounded. Heterocytes ± spherical, barrel-shaped to cylindrical, 5.0–11.5 μm long.

Specimens examined:—Maloney Springs

Other records:—Queensland: SE Queensland, McLeod (1975).

Observations:—Growing in small clusters amongst other algae in the shallows of tropical springs and shallow wetlands.

***Scytonema* sp. A** Fig. 80 A–C.

Thallus an expanded rusty brown film, occasionally turfed across the surface. Filaments 17–23 μm wide, with geminate false-branching, branches generally the same diameter as the main filament. Sheaths firm, thickened and lamellated, yellow to yellow-brown in colour. Trichomes cylindrical, ± constricted at the cross walls. Vegetative cells in the main filaments isodiametric or longer than broad, 6.8–14.5 μm long × 7.9–10.5 μm wide; cells in the apical regions shorter than broad, 3.5–6.3 μm long × 11.5–12.5 μm wide, apical cells rounded. Heterocytes solitary, cylindrical, isodiametric or slightly longer than broad, 10.1–11.0 μm long × 8.6–11.5 μm broad.

Specimens examined:—Coomera R. d/s Yarrabilgong Falls, Lamington Natl Park.

Observations:—Forming greenish-brown coloured crustose films on dripping rock walls and granitic bolders adjacent to clear high altitude streams in subtropical SE Queensland.

Other species known from Australia: Queensland: *S. flexuosum*, Sonder (1880, 1881), *S. hofmannii*, Cribb (1976, 1984, 1986, 1987, 1988), Entwisle (1989, 1990, 1994), May (1970), *S. myochrous*, McLeod (1975), Nordstedt (1888), Playfair (1917); Northern Territory: *S. stuposum*, Nordstedt (1888), Playfair (1917).

SCYTONEMATOPSIS

Scytonematopsis Kiseleva (1930: 174)
Type: *S. woronichinii* Kiseleva (1930: 174)

Filamentous, thallose; composed of solitary branched filaments which form clusters or mats on the substratum, or amongst other algae. Filaments free or densely coiled, creeping on the substratum, or joined to the substratum by middle parts and free ends of branches, sparsely or commonly falsely branched, usually with two, rarely one, branches. Branching initiates after trichome dissociation through the formation of necridic cells, rarely after loop-formation, not at heterocytes. Trichomes isopolar, ends of young trichomes and branches cylindrical with rounded terminal cells, later distinctly narrowed, sometimes with elongated, cylindrical, vacuolated apical and subapical cells; trichomes constricted or unconstricted at the cross walls. Sheaths firm, limited, hyaline or parallel lamellated, often yellowish-brown in colour in mature filaments. Vegetative cells shorter or longer than wide, pale or olive-green, rarely pinkish or bright blue-green, often elongated and vacuolated towards the ends, without aerotopes. Heterocytes intercalary, usually solitary, cylindrical or barrel-shaped, of different length. Cells divide crosswise to the trichome axis. Reproduction by hormogonia, which separate from the filament through the formation of necridic cells, liberated from the sheath, germinating at both ends.

A worldwide genus with 15 species currently taxonomically accepted; most are periphytic or metaphytic. Here one species is described from north-eastern Australia; one other species is known from elsewhere in Australia. Bibliography: Vaccarino & Johansen (2011), Komárek (2013).

Scytonematopsis kashyapii (Bharadwaja) Geitler (1935: 445) Fig. 81 A–J.
Basionym: *Spelaeopogon kashyapii* Bharadwaja (1928: 69)

Thallus a tufted woolly prostrate mat; filaments rarely solitary, straight or flexuous, narrowed towards the ends with solitary or geminate false-branching; sheaths conspicuous, hyaline, firm and colourless. Trichomes slightly constricted at the cross walls. Vegetative cells barrel-shaped to long-cylindrical, 1.5–4.5 × longer than broad, 9.3–19.0 µm long × 4.3–6.5 µm broad; terminal cells slightly conical. Heterocytes intercalary, single or two in series, ellipsoidal to cylindrical, 9.6–24.0 µm long × 5.0–9.5 µm broad.

Specimens examined:—Pool Ck at Talaroo.

Observations:—Originally described growing on aquatic plants in pools and a small lake in India, also known from Indonesia. The material observed from Talaroo is consistent with the original description both in terms of the morphology and habitat.

Other species known from Australia: Queensland: *S. pilosa* (Harvey ex Bornet & Flahault) I.Umezaki & M.Watanabe (1994: 311), Clump Point, East of Tully (AD-A 64880).

7. STIGONEMATACEAE

Stigonemataceae (Bornet & Flahault) Borzì (1892: 43)
Type: *Stigonema* Agardh ex Bornet & Flahault (1886: 62)

Thallose, filamentous, with true branching. Filaments and branches generally undifferentiated, sometimes narrowed towards filament apices. Filaments torulous or moniliform, encased in a firm, lamellated and often coloured sheath. Trichomes mono- to polyseriate, composed of sphaeroid or irregularly rounded vegetative cells. Heterocytes intercalary or lateral, often terminal in hormogonia or immature filaments. Akinetes known from several species, but not well characterised. Reproduction by disintegration of thallus and production of hormogonia.

STIGONEMA

Stigonema Agardh ex Bornet & Flahault (1886: 62)
Type: *S. mamillosum* Agardh ex Bornet & Flahault (1887: 77)

Thallus woolly or crusty, filamentous, solitary or forming cushion-like clumps or tufty colonies, with true branching. Trichomes bi- or multiseriate, uniseriate in young trichomes and at ends of branches, sometimes very thick, irregularly laterally true branched with T- and V-type branching, irregularly coiled, sometimes narrowed towards the ends, apical cell sometimes larger than adjacent cells. Sheaths thin or thick, often wide, lamellated and usually yellowish-brown in colour. Vegetative cells globose, barrel-shaped or roundly irregular, usually connected to each other by a pit connection, which may not be apparent in mature trichomes; cell content blue-green or olive-green, usually with prominent solitary granules. Heterocytes intercalary, solitary, rarely lateral. Akinetes not known. Cells divide in all planes, but crosswise fission is the most common form of division. Meristematic zones may occur in some trichome sections, in which hormogonia arise. Reproduction by hormogonia, which liberate from the ends of trichomes and branches, morphologically different from trichomes; hormogonia vary from two- to many-celled.

A world-wide genus with 66 species currently taxonomically accepted; most are aerophytic or subaerophytic, growing on the bark of trees or wet rocks; a few species are aquatic growing periphytically or epiphytically on the substrate or amongst aquatic plants. Here three species are described from north-eastern Australia; a further species is known from elsewhere in Australia. Bibliography: Skinner & Entwisle (2001), Gugger & Hoffmann (2004), Komárek (2013), Sant'Anna *et al.* (2013), Komárek *et al.* (2014), Mareš *et al.* (2015).

1. Filaments growing freely amongst other algae, not attached to the substrate ..... *S. eliskae*
- Filaments attached to the substrate 2
2. Filaments 35–75 µm in diameter, erect, fasciculate ..... *S. informe*
- Filaments 18–35 (–50) µm broad, irregularly branched ..... *S. ocellatum*

Stigonema eliskae Komárek & Komárková (2017: 24) Fig. 82 A–F.

Filaments solitary or in loose agglomerations amongst other algae, not forming sessile colonies; isopolar, uni- to 3–4 × multiseriate, 20–35 (–45) µm broad, rarely laterally branched, branches typically short and of the same morphology as the main filaments. Sheath firm, uncoloured, not lamellated. Vegetative cells irregularly spherical, 7.5–15 (–18.5) µm in diameter, olive-green to yellow-brown in colour. Heterocytes lateral, subspherical to hemispherical, 5–15 µm in diameter. Reproduction by fragmentation and the production of hormogonia from the apices of lateral branches.

Specimens examined:—Amity Swamp, Tortoise Lagoon, Naree Budjong Djara Natl Park, North Stradbroke Is., Freshwater L., Great Sandy Natl Park, Cooloola Section.

Observations:—Growing amongst the *Hapalosiphon*-dominated metaphyton in the littoral zone of wallum lakes and streams. Not known to form sessile mats or attached to the substrate (Komárek & Komárková 2017).

Stigonema informe Kützing ex Bornet & Flahault (1886: 75) Fig. 83 A–B.

Thallus short, tufted, expanded and crusty, dark olive-green to brown in colour. Filaments multiseriate or uniseriate, 35–75 µm in diameter, erect, fasciculate; sheath firm, gelatinous, lamellated, uncoloured to yellow-brown in colour. Trichomes 4–6 times multiseriate in the main branches, less so in lateral branches. Vegetative cells compressed globose, or subquadrate, 9–15 (–18) µm in diameter. Heterocytes common, lateral, similar size to vegetative cells. Hormogonia uniseriate, developing at the ends of narrow branches, up to 18 µm wide.

Specimens examined:—Coomera R. at Lamington Natl Park, Binna Burra Section.

Other records:—Queensland: Tributary of Sanamore Lagoon, Cape York, A.B. Cribb, 1985, (BRI 1043.3), Hermit Ck, near Benthams Falls, E.A. Brown, 2001 (NSW 884756), McLeod (1975); New South Wales: Lord Howe Is., Brown 2000, Conn & Downs, 2000, McCarrs Ck, Kur Ring-Gai Chase Natl Park, Entwisle, 2000, Adeline Falls, Lawson, Blue Mountains, Entwisle, 2001, (NSW 491960); Tasmania: Uno Gully, Meetus Falls Road, Entwisle, 1996, (MEL 2033635A).

Observations:—Growing amongst *Scytonema* and other filamentous cyanobacteria on granitic boulders in the splash zone of clear high-altitude streams.

Stigonema ocellatum Thuret ex Bornet & Flahault (1886: 69) Figs. 84 A–D, 85 A–E.

Filaments solitary, growing amongst other algae or aquatic plants, forming cushion-like clusters or tufts, olive-green to brownish in colour, 18–35 (–50) µm broad, irregularly branched. Branches long, flexuous, generally of the same wide as the main filament; hormogonia occur at the ends of branches; sheath wide, yellow or yellow-brown in colour, slightly lamellated, up to 15 µm wide. Vegetative cells quadrate-globose or globose, 6–24 (–35) µm, blue-green to olive-green in colour, often with colourless to brownish coloured distinct individual envelopes; hormogonia cells short barrel-shaped, 8–15 µm long × 6–12 µm broad. Heterocytes intercalary, lateral, 10–24 µm in diameter.

Specimens examined:—Amity Swamp, North Stradbroke Is., Coomera R. at Lamington Natl Park, Burra Burra Section, Honey Eater L., Moreton Is. Natl Park, Moon Point Fens at Great Sandy Natl Park, Fraser Is. Section, Rainbow Beach Fens, Great Sandy Natl Park, Cooloola Section, Welsby Lagoon, North Stradbroke Is.

Other records:—Queensland: Canal Ck at Twin Falls, Cape York, A.B. Cribb, 1992 (BRI 0714696), Burster Ck, Cape York, A.B. Cribb, 1985 (BRI 0703551), Amiens, A.B. Cribb, 1972 (BRI 0703549), L. Broadwater, A.B. Cribb, 1985 (BRI 0703550), South Mimosa Ck, Blackdown Tablelands, A.B. Cribb, 1985 (BRI 0703554), Upper Kroombit Ck, Kroombit Tops, A.B. Cribb, 1986 (BRI 0703557), Sundown Natl Park, A.B. Cribb, 1985 (BRI 0703559), Missionary Bay, A.B. Cribb, 1979 (BRI 0703560), Refuge Bay, Scawfell Is., A.B. Cribb, 1994 (BRI 0715669); New South Wales: Swampy Plains R. above L. Cootapatamba, H. Steinmann, 1978 (CBG 7806032), Round Mountain Rd, near Barokee Rest Area, Cathedral Rocks Natl Park, Skinner, 2000 (NSW); Oakey R., Cathedral Rocks Natl Park, Cherry (Skinner 0174), 2000 (NSW), Quarantine Stn, North Head, Sydney Harbour Natl Park, Skinner, 2000 (NSW); Woronora R., Heathcote, Hamilton & Lucas, 1915 (NSW A2157–2160), Gadara Ck, Bilpin, Cherry, 1999 (NSW); Tomah Spur, Cherry, 2000 (NSW).

Observations:—Cosmopolitan species; recorded growing in the metaphyton of peaty wetlands, and from the littoral zone of wallum lakes and streams, amongst submerged vegetation (Komárek 2013). This is consistent with observations from similar temperate and tropical biotopes. Records from granitic substrates and the splash zone of cool, subtropical streams in New South Wales may refer to another species.

Other species known from Australia: Queensland: *Stigonema minutum*, Ling & Tyler (2000)

8. SYMPHONEMATACEAE

Symphyonemataceae Hoffmann, Komárek & Kaštovský (2005:109)
Type: *Symphyonema* Jao (1944: 75)

Thallose, irregular, flat to pulvinate; filamentous, with true branching; Sheath thin or thick, firm, or widened and mucilaginous, gelatinous, homogeneous or lamellated, colourless or yellow-brown in colour. Trichomes uniseriate, heteropolar or isopolar, not or distinctly constricted at the cross walls, with cylindrical or attenuated branches. Branching reverse Y-shaped, less commonly lateral T-like or V-like; branches usually of the same morphology as the main trichome or narrowed towards the apices. Vegetative cells barrel-shaped, irregularly barrel-shaped or cylindrical; apical cells usually rounded, rarely attenuated. Heterocytes usually solitary, intercalary, barrel-shaped to elongated-cylindrical. Reproduction by disintegration of thallus or in a few species, by production of hormogonia from the filament apices.

SYMPHYONEMA

Symphyonema Jao (1944: 75)
Type: *S. sinense* C.-C.Jao (1944: 81)

Thallose; thallus pulvinate or woolly, up to 1.5 cm thick, greyish blue with multiple densely coiled, or parallel arranged filaments, sometimes joined into erect fascicles. Filaments irregularly branched, not distinctly morphologically diversified in basal sections and branches. Trichomes uniseriate, isopolar, with vegetative cells usually longer than wide, cylindrical, not constricted or slightly constricted at cross walls, not attenuated towards the ends, with rounded terminal cells. Branching of two types, true or reverse Y-type, and false, scytonematoid; branching initiates remote from the heterocytes (reverse Y-branching originates always from special oblong cells, located between two shortened

cells, containing densely granular and deeply coloured contents; later the oblong cell lengthwise divides and new cells elongate). Sheaths firm, homogeneous or slightly lamellated, yellow-brown in colour in mature parts. Vegetative cells blue-green in colour with slightly granular content. Heterocytes intercalary, cylindrical, solitary. Akinetes not observed. Cell division crosswise to the trichome length. Reproduction by hormogonia, separating from trichome apices.

A small genus with two species currently taxonomically accepted; one epilithic species from limestone caves in Spain, and one aerophytic species known from French Guiana. Two strains of *Symphonema* were isolated from soil in Papua New Guinea and sequenced by Gugger & Hoffmann (2004), which supports the distinct phylogenetic position of this genus. This genus has not been previously described from Australian freshwaters. One new species is described here from north-eastern Australia. Bibliography: Gugger & Hoffmann (2004), Komárek (2013), Komárek *et al.* (2014).

Symphyonema kaboorum G. B. McGregor *sp. nov.* Figs. 86 A–F, 87 A–D, 88 A–D, 89 A–F.

Thallus pulvinate, formed by more or less parallel arranged filaments. Filaments 11–17 µm wide, erect, straight to irregularly flexuous, not tapered towards the ends, not constricted at the cross walls, surrounded by a firm, hyaline mucilage, up to 25 µm wide, lamellated closer to the trichome; with false-branching, and T- and Y-type true branching, lateral branches often slightly narrower than main filament. Vegetative cells isodiametric, or up to 4 × longer than broad, shorter than broad towards the apices, (8.5–) 12.5–18.5 (–26) µm long × 4.8–10.5 µm wide, with fine granular contents, often vacuolate; apical cells rounded. Heterocytes solitary, intercalary, rarely located at the point of branching, spherical to elongated cylindrical, up to 3.5 × longer than broad, 9.0–18.5 (–26) µm long × 5.5–13.8 µm wide.

Holotype:—Preserved specimen deposited in the Queensland Herbarium (BRI), accession number AQ826843. Type locality: Blue L., Naree Budjong Djara Natl Park, North Stradbroke Is. (27°32’01” S, 153°29’05” E). Etymology: the specific epithet refers to the indigenous Quandamooka word for Blue L. – Karboora.

Specimens examined:—Blue L., Naree Budjong Djara Natl Park, North Stradbroke Is.

Observations:—Aquatic; colonies forming expanded pulvinate growths on the upper surface of large, submerged logs and woody debris in the littoral zone of an acidic, coastal oligotrophic lake. There are no other aquatic species known from this genus; one epilithic species is known from limestone caves in Spain, and one aerophytic species known from French Guiana. The Y-type branching of this species is distinctive, often occurring in short succession, forming compound, M-type arrangements. Repeated efforts to isolate and sequence this species has not yet been successful. Here it is designated as a new species based on morphological and ecological criteria, which clearly separate it from existing *Symphyonema* species.

9. TOLYPOTHRICHACEAE

Tolypothrichaceae Hauer *et al.* (2014: 1093)
Type: *Tolypothrix* Kützing ex Bornet & Flahault (1886: 118)

Filaments polarized with mainly basal, uniporous heterocytes. Single false branching common, double branching occurring sporadically. Sheath thick or thin, but always present, sometimes yellow to yellow brown in colour. Vegetative cells isodiametric or shorter or longer than wide. Trichomes not or very slightly attenuated toward the ends. Reproduction by hormogonia with heteropolar germination, hormocytes, or trichome disintegration. Known from terrestrial, freshwater and marine habitats.

KEY TO GENERA

1. Trichomes with 2–16 parallely arranged filaments which often have their own, laterally coalescent sheaths, which divaricate in the terminal parts ..... 1. COLEODESMIUM
- Trichomes and branches uniseriate, commonly falsely branched, usually with solitary lateral branches ..... 2. TOLYPOTHRIX

COLEODESMIUM

Coleodesmium Borzì ex Geitler (1942: 154)
Type: *C. wrangelii* Borzì ex Geitler (1942: 356)

Filaments solitary or fasciculated, forming small irregular mats, shrub-like colonies or tufts on the substratum, heteropolar with obligatory false branching; branching typically initiated by trichome disintegration, lateral branches fan-like and remain parallel attached to the mother filament growing in a common sheath. Mucilaginous sheath colourless or yellow-brown in colour, often lamellated and containing 2–16 parallely arranged filaments which often have their own, laterally coalescent sheaths. Trichomes cylindrical, sometimes slightly narrowed at the base, constricted or unconstricted, constrictions usually more prevalent at the apical ends of the trichome. Vegetative cells cylindrical or barrel-shaped, terminal cells often hyaline and pseudo-vacuolated. Heterocytes basal, hemispherical, oval, ovoid or cylindrical with rounded ends, typically solitary, less frequently in series of 2–3. Akinetes not known. Reproduction by trichome disintegration through the formation of necridic cells, and horomocyte production from the apical regions.

Nine species described, most as epiphytes on aquatic plants or epilithic on boulders and stones in high altitude rivers and streams. Here one species is described from north-eastern Australia, one other species is known from elsewhere in Australia. Bibliography: Dutt *et al.* (1982), Komárek & Watanabe (1990), Elster *et al.* (1997), Skinner & Entwistle (2001), Flechtner *et al.* (2002).

Coleodesmium sp. A. Fig. 90 A–C.

Thallus heteropolar, attached at one end to the substratum, forming tufted, shrub-like colonies up to 8 cm in diameter; richly branched, mostly with lateral tangential false-branching, initiated by the lateral formation of a heterocytes; branches remain joined parallel to the mother filament and diverging on the upper parts, 21–45 μm wide; sheath hyaline or yellow-brown in colour, smooth, thin and occasionally crimped, extending just beyond the apex of the filaments. Trichomes cylindrical, constricted at the cross walls. Heterocytes generally solitary, ovoid, spherical or elliptical, basal and intercalary. Vegetative cells always distinctly broader than long, 16–19 (–20) μm broad, apical cells broadly rounded and often vacuolate. Akinetes not observed.

Specimens observed:—Mossman R. at Mossman Gorge, Daintree Natl Park.

Observations:—Epilithic on boulders and large granitic rocks, in rapidly flowing water in the upper coastal tropical rainforest reaches of the Mossman R. These populations most closely resemble *C. wrangelii* Borzì ex Geitler (1942: 356) however, the filaments are much broader. *C. wrangelii* has been reported by Entwisle (1994) and Skinner & Entwisle (2001) from similar montane habitats from the Lamington Natl Park in Queensland to the Marysville and Whitehouse Ck areas of the Victorian highlands and the upper reaches of the Yarra Valley.

Other species known from Australia: *C. wrangelii*, Canungra Ck, Picnic Rock, Lamington Natl Park, Queensland, Entwisle, 1993 (MEL), Polblue Ck near Polblue camping area, Barrington Tops, New South Wales, Entwisle, 1999 (NSW), Chichester S.F., near Barrington Tops, New South Wales, Entwisle, 1991 (MEL), Chaelundi Ck at Chaelundi Rest Area, Guy Fawkes Natl Park, New South Wales, Skinner & Cherry, 2000 (NSW), Deer Park R., Waterfall Way, New South Wales, Skinner, 2000 (NSW), Bullock Ck, 2 km in from Hwy on Point Lookout Rd, New South Wales, Skinner, 2000 (NSW), seepage 500 m from summit of Mt Kosciuszko, New South Wales, Entwisle, 2000 (NSW), Merrits Ck Mt Kosciuszko Walk, New South Wales, Entwisle, 2000 (NSW), tributary of Thredbo R., Crackenback Ridge, Thredbo, New South Wales, Entwisle, 2000 (NSW), Geroa R, Rockton, New South Wales, Entwisle, 1991 (MEL), Mongarlowe R., 17 km SE of Braidwood, New South Wales, Entwisle, 1991 (MEL), Yowrie R. at Yowrie R. Crossing, New South Wales, Skinner, 2000 (NSW), Steavenson R., Marysville, Victoria, Entwisle, 1993 (MEL).

TOLYPOTHRIX

Tolypothrix Kützing ex Bornet & Flahault (1886: 118)
Type: *T. distorta* Kützing ex Bornet & Flahault (1886: 119)

Filaments heteropolar, united into fasciculate, caespitose colonies, or dense woolly mats, basal parts with heterocytes and free apical ends, commonly falsely branched, usually with solitary lateral branches; branches initiate at intercalary, unipored heterocytes, divergent from the main filaments or for a short distance joined to the main filament and later

diverging. Sheaths thin or thick joined to the trichome, sometimes lamellated, colourless or yellow-brown in colour, open at the apex. Trichomes and branches uniseriate, with one or several basal heterocytes, cylindrical, not attenuated at the end, constricted or unconstricted at the cross walls. Vegetative cells cylindrical to barrel-shaped, isodiametric or slightly longer or shorter than wide, without aerotopes, blue-green, olive-green, greyish or reddish in colour, apical cells slightly narrowed or widened and rounded, sometimes spherical, without calyptra, sometimes vacuolated. Akinetes known from a few species. Cells divide crosswise to the trichome axis, with sub-terminal meristematic zones. Reproduction by hormogonia which separate at both ends.

A worldwide genus with species from aerophytic, marine and freshwater environments; 66 species are currently accepted taxonomically, six species are known from Australia, one species is described here from north-eastern Australia. Bibliography: Playfair (1971, 1918), Skinner & Entwisle (2001), Hauer *et al.* (2014).

Tolypothrix lanata Wartmann ex Bornet & Flahault (1886: 120) Fig. 91 A–E.

Colonies tufted, olive-green to blue-green in colour; thallus composed of interwoven, erect filaments of penicillate falsely branched trichomes; sheath uncoloured, thin and closely adpressed to the trichomes, (9–) 12–15 μm broad; trichomes heteropolar, cylindrical, apical cells domed, often protruding just beyond the sheath. Vegetative cells isodiametric to slightly shorter than broad, blue- or olive-green in colour, sometimes with granular contents, (L/D 0.5–1.2), 8.5–12 (–15) μm broad. Heterocytes at junctions or more rarely intercalary, in groups of two, three or four, 8–22 μm long × 11–16 μm broad. Hormogonia produced from terminal regions of trichomes.

Specimens observed:—Reedy Ck at Mount Byron Rd, Sandy Ck at Wivenhoe-Somerset Rd, Sheepstation Ck at Crossing no. 2, Wivenhoe Dam at Cormorant Bay, Walsh R. at Wrotham.

Other records:—Northern Territory: Playfair (1917, 1918).

Observations:—Forms macroscopic, tufted colonies, which are attached to woody debris and submerged aquatic vegetation in the littoral zone of streams and lakes in SE Queensland.

Other species known from Australia: *T. campylonemoides* S.L.Ghose (1924: 344), Northern Territory, Moewius (1953); *T. distorta* Kützing ex Bornet & Flahault (1886: 119), Watts (1865), Tasmania, New South Wales, Australian Capital Territory, Skinner & Entwisle (2001), Victoria, Ling & Tyler (2000); *T. flaccida* Kützing (1843: 228), Northern Territory, Sonder (1880); *T. tenuis* Kützing ex Bornet & Flahault (1886: 122), Queensland, New South Wales, Bailey (1895, 1913), McLeod (1975), Möbius (1895), Skinner & Entwisle (2001).

ACKNOWLEDGEMENTS

The author is grateful for financial support provided by the Australian Biological Resource Study, a division of the Australian Government's Department of Enviroment and Energy. I'm also grateful for the support and encouragement of the staff of the Water Planning Ecology group, Queensland Department of Environment and Science, and SunWater. Many of you have accompanied me in the field and provided me with specimens, and distributional information from across the vastness of north-eastern Australia. A special mention to Natasha Chan and Priya Muhid for their valuable assistance in the laboratory and Myriam Raymond for assistance in preparing figures. The following people have provided me with interesting specimens, advice, and inspiration along the way: Jiri Komárek, Hedy Kling, Gertrude Cronberg, Maree Smith, Karen Reardon, Peter Baker, Barbara Sendall, Lindsay Hunt, Dean Newman, Wendy Williams, Jon Holliday.

REFERENCES

Adame, M.F., Pettit, N.E., Valdez, D., Ward, D., Burford, M.A. & Bunn, S.E. (2017) The contribution of epiphyton to the primary production of tropical floodplain wetlands. *Biotropica*.

Aguilera, A., Komárek, J. & Echenique, R.O. (2016) *Anabaenopsis* morphospecies (Cyanobacteria, Nostocales) from Los Patos shallow lake (Province of Buenos Aires, Argentina). *Phytotaxa* 272 (3): 173–183. https://doi.org/10.11646/phytotaxa.272.3.1

Aguilera, A., Berrendero Gómex, Kaštovský, J., Echenique, R.O. & Salerno, G.L. (2018) The polyphasic analysis of two native *Raphidiopsis* isolates supports the unification of the genera *Raphidiopsis* and *Cylindrospermopsis* (Nostocales, Cyanobacteria). *Phycologia* 57 (2):

130–146.
https://doi.org/10.2216/17-2.1

Alster, A., Kaplan-Levy, R.N., Sukenik, A. & Zohary, T. (2010) Morphology and phylogeny of a non-toxic invasive *Cylindrospermopsis raciborskii* from a Mediterranean Lake. *Hydrobiologia* 639 (1): 115–128.
https://doi.org/10.1007/s10750-009-0044-y

Andreja, K.U.S.T., Kozlíková–Zapomělová, E., Mareš, J. & Řeháková, K. (2015) A detailed morphological, phylogenetic and ecophysiological analysis of four benthic *Anabaena* (Nostocales, Cyanobacteria) strains confirms deep heterogeneity within the genus. *Fottea* 15 (2): 191–202.

Antunes, J.T., Leão, P.N. & Vasconcelos, V.M. (2015) *Cylindrospermopsis raciborskii*: review of the distribution, phylogeography, and ecophysiology of a global invasive species. *Frontiers in Microbiology* 6: 473.
https://doi.org/10.3389/fmicb.2015.00473

Aptekar, E.M. (1926) De nova Cyanophycearum specie: *Anabaenopsis arnoldii* Apt. *Botanicheskie Materialy Instituta Sporovykh Rastenii Glavnogo Botanicheskogo Sada SSSR* 4: 41–55.

Bailey, F.M. (1893) Contributions to the Queensland Flora. Queensland Freshwater Algae. *Bot. Bull., Dept. Agric., Queensland,* No. 6.

Bailey, F.M. (1895) Contributions to the Queensland Flora. Queensland Freshwater Algae. *Bot. Bull., Dept. Agric., Queensland,* No. 11.

Bailey, F.M. (1913) Algae. *In:* Bailey, F.M. *Comprehensive Catalogue of Queensland Plants both Indigenous and Naturalised.* Queensland Department of Agriculture, Brisbane, pp. 678–682, 792–832, 832.

Baker, P.D. & Fabbro, L.D. (2002) *A guide to the identification of common blue-green algae (Cyanoprokaryotes) in Australian freshwaters.* Thrugoona, NSW: Cooperative Research Centre for Freshwater Ecology.

Baker, P.D. (1991) Identification of Common Noxious Cyanobacteria. Part I – Nostocales. *In: Urban Water Research Association of Australia, Report No. 29.* 205 pp.

Berrendero Gómez, E., Perona, E. & Mateo, P. (2008) Genetic and morphological characterization of *Rivularia* and *Calothrix* (Nostocales, Cyanobacteria) from running water. *International Journal of Systematic and Evolutionary Microbiology* 58 (2): 447–460.

Berrendero Gómez, E., Johansen, J.R., Kaštovský, J., Bohunická, M. & Čapková, K. (2016) *Macrochaete* gen. nov. (Nostocales, Cyanobacteria), a taxon morphologically and molecularly distinct from *Calothrix*. *Journal of Phycology* 52 (4): 638–655.

Bohunická, M., Pietrasiak, N., Johansen, J.R., Berrendero Gómez, E., Hauer, T., Gaysina, L.A. & Lukešová, A. (2015) *Roholtiella*, gen. nov. (Nostocales, Cyanobacteria)—a tapering and branching cyanobacteria of the family Nostocaceae. *Phytotaxa* 197 (2): 84–103.

Bolch, C.J., Orr, P.T., Jones, G.J. & Blackburn, S.I. (1999) Genetic, morphological, and toxicological variation among globally distributed strains of *Nodularia* (Cyanobacteria). *Journal of Phycology* 35 (2): 339–355.
https://doi.org/10.1046/j.1529-8817.1999.3520339.x

Bowling, L.C. & Baker, P.D. (1996) Major cyanobacterial bloom in the Barwon-Darling River, Australia, in 1991, and underlying limnological conditions. *Marine and Freshwater Research* 47 (4): 643–657.
https://doi.org/10.1071/MF9960643

Castenholz, R.W. (1996) Endemism and biodiversity of thermophilic cyanobacteria. *Nova Hedwigia Beiheft* 112: 33–48.

Cirés, S. & Ballot, A. (20160 A review of the phylogeny, ecology and toxin production of bloom-forming *Aphanizomenon* spp. and related species within the Nostocales (cyanobacteria). *Harmful Algae* 54: 21–43.

Cirés, S., Wörmer, L., Ballot, A., Agha, R., Wiedner, C., Velázquez, D., Casero, M.C. & Quesada, A. (2014) Phylogeography of cylindrospermopsin and paralytic shellfish toxin-producing Nostocales cyanobacteria from Mediterranean Europe (Spain). *Applied and Environmental Microbiology* 80 (4): 1359–1370.
https://doi.org/10.1128/AEM.03002-13

Cottingham, K.L., Ewing, H.A., Greer, M.L., Carey, C.C. & Weathers, K.C. (2015) Cyanobacteria as biological drivers of lake nitrogen and phosphorus cycling. *Ecosphere* 6 (1): 1–19.
https://doi.org/10.1890/ES14-00174.1

Cribb, A.B. (1974) Some freshwater algae from Fraser Island. *Queensland Naturalist* 21: 7–11.

Cribb, A.B. (1976) Some algae from Blackdown Tableland. *Queensland Naturalist* 21: 132–133.

Cribb, A.B. (1984) Some freshwater algae from the Burdekin River area, Queensland. *Queensland Naturalist* 24: 101–109.

Cribb, A.B. (1986) Some algae from Kroombit Tops, Queensland. *Queensland Naturalist* 27: 24–46.

Cribb, A.B. (1987) Further algae from Blackdown Tableland. *Queensland Naturalist* 27: 21.

Cribb, A.B. (1988) Some algae from the Mount Moffat area. *Queensland Naturalist* 28: 23–45.

Cronberg, G. (2003) New and interesting cyanoprokaryotes from temperate, brackish ponds and the Baltic Sea. *Algological Studies* 109 (1): 197–211.
https://doi.org/10.1127/1864-1318/2003/0109-0197

Darling, R.B. (1982) *A Floristic Survey of the Algae Inhabiting a Sphagnum Bog at Lake Mountain, Victoria.* BSc (Hons) Thesis, Botany Dept., University of Melbourne, Melbourne.

Day, S.A., Wickham, R.P., Entwisle, T.J. & Tyler, P.A. (1985) *Bibliographic Checklist of Non-Marine Algae in Australia. Flora of Australia Supplementary Series No. 4.* Australian Biological Resources Study, Canberra, 276 pp.

Desikachary, T.V. (1948) On *Camptylonema indicum* Schmidle and *Camptylonemopsis* gen. nov. Proceedings: *Plant Sciences* 28 (2): 35–50.

Desikachary, T.V. (1959) *Cyanophyta.* New Delhi: Indian Council of Agricultural Research.

Dutt, A.K., Datta, T.K. & Gupta, K.K. (1982) Studies on high altitude saxicolous Cyanophyta. X. On the morphology of *Coleodesmium wrangelii* (Ag.) Borzi and *Coleodesmiumopsis* gen. nov. *Cryptogamie Algologie* 3 (3): 177–186.

Dvořák, P., Poulíčková, A., Hašler, P., Belli, M., Casamatta, D.A. & Papini, A. (2015) Species concepts and speciation factors in cyanobacteria, with connection to the problems of diversity and classification. *Biodiversity and Conservation* 24 (4): 739–757. https://doi.org/10.1007/s10531-015-0888-6

Dwivedi, V.K., Tandon, R., Kant, R. & Tiwari, G.L. (2010) Critical evaluation of the genus *Macrospermum* Komárek 2008, Cyanoprocaryota. *Proceedings of the National Academy of Sciences India Section B-Biological Sciences* 80: 380–386.

Elster, J., Syobody, J., Komárek, J. & Marvan, P. (1997) Algal and cyanoprocaryote communities in a glacial stream, Sverdrup Pass, 79 N, Central Ellesmere Island, Canada. *Archiv fur Hydrobiologie-Supplement* 119: 57–93.

Entwisle, T.J. (1989) Macroalgae in the Yarra River basin: flora and distribution. *Proceedings of the Royal Society of Victoria* 101: 1–76.

Entwisle, T.J. (1990) Macroalgae in the upper Yarra and Watts River catchments: distribution and phenology. *Australian Journal of Marine and Freshwater Reserch* 41: 505–522. https://doi.org/10.1071/MF9900505

Entwisle, T.J. (1994) Macroalgae *in* T.J. Entwisle, Aquatic Cryptogams of Australia: A Guide to the Macroalgae, Larger Fungi, Lichens and Bryophytes of Australian Inland Waters, Australian Society for Limnology, Melourne.

Everson, S., Fabbro, L., Kinnear, S., Eaglesham, G. & Wright, P. (2009) Distribution of the cyanobacterial toxins cylindrospermopsin and deoxycylindrospermopsin in a stratified lake in north-eastern New South Wales, Australia. *Marine and Freshwater Research* 60 (1): 25–33. https://doi.org/10.1071/MF08115

Fabbro, L.D. & Duivenvoorden, L.J. (1996) Profile of a bloom of the cyanobacterium *Cylindrospermopsis raciborskii* (Wołoszyńska) Seenaya and Subba Raju in the Fitzroy River in tropical central Queensland. *Marine and Freshwater Research* 47 (5): 685–694. https://doi.org/10.1071/MF9960685

Fabbro, L.D. & Duivenvoorden, L.J. (1993) *A Photographic Guide to Common Cyanobacteria of Central Queensland.* River and Wetland Ecology Group, Faculty of Applied Science, Central Queensland University.

Fergusson, K.M. & Saint, C.P. (2000) Molecular phylogeny of *Anabaena circinalis* and its identification in environmental samples by PCR. *Applied and Environmental Microbiology* 66 (9): 4145–4148. https://doi.org/10.1128/AEM.66.9.4145-4148.2000

Fiore, M.F., Genuario, D.B., da Silva, C.S.P., Shishido, T.K., Moraes, L.A.B., Neto, R.C. & Silva-Stenico, M.E. (2009) Microcystin production by a freshwater spring cyanobacterium of the genus Fischerella. *Toxicon* 53 (7): 754–761. https://doi.org/10.1016/j.toxicon.2009.02.010

Flechtner, V.R., Boyer, S.L., Johansen, J.R. & DeNoble, M.L. (2002) *Spirirestis rafaelensis* gen. et sp. nov. (Cyanophyceae), a new cyanobacterial genus from arid soils. *Nova Hedwigia* 74 (1–2): 1–24.

Francis, G. (1878) Poisonous Australia lake. *Nature* 18: 11–12. https://doi.org/10.1038/018011d0

Gaget, V., Humpage, A.R., Huang, Q., Monis, P. & Brookes, J.D. (2017) Benthic cyanobacteria: A source of cylindrospermopsin and microcystin in Australian drinking water reservoirs. *Water Research* 124: 454–464. https://doi.org/10.1016/j.watres.2017.07.073

Geddes, M.C. (1984) Limnology of Lake Alexandrina, River Murray, South Australia, and its effects on nutrients and light on the phytoplankton. *Australian Journal of Marine and Freshwater Research* 35: 399–415. https://doi.org/10.1071/MF9840399

Genuário, D.B., Sant'Anna, C.L. & Melo, I.S. (2018) Elucidating the *Cronbergia* (Cyanobacteria) dilemma with the description of *Cronbergia amazonensis* sp. nov. isolated from Solimões river (Amazonia, Brazil). *Algal Research* 29: 233–241. https://doi.org/10.1016/j.algal.2017.11.034

Grimes, J.A. (1988) The algae. *In:* Scott, G.S. (Ed.) *Lake Broadwater, The Natural History of an Inland Lake and its Environs.* Darling Downs Institute Press [in association with Lake Broadwater Natural History Association], pp. 105–133.

Gugger, M.F. & Hoffmann, L. (2004) Polyphyly of true branching cyanobacteria (Stigonematales). *International Journal of Systematic and Evolutionary Microbiology* 54 (2): 349–357. https://doi.org/10.1099/ijs.0.02744-0

Gugger, M., Lyra, C., Henriksen, P., Coute, A., Humbert, J.F. & Sivonen, K. (2002a) Phylogenetic comparison of the cyanobacterial genera

Anabaena and *Aphanizomenon*. *International Journal of Systematic and Evolutionary Microbiology* 52 (5): 1867–1880.

Gugger, M., Lyra, C., Suominen, I., Tsitko, I., Humbert, J.F., Salkinoja-Salonen, M.S. & Sivonen, K. (2002b) Cellular fatty acids as chemotaxonomic markers of the genera *Anabaena, Aphanizomenon, Microcystis, Nostoc* and *Planktothrix* (cyanobacteria). *International Journal of Systematic and Evolutionary Microbiology* 52 (3): 1007–1015.

Hardy, A.D. (1906) The freshwater algae of Victoria, Part III. *Victorian Naturalist* 22 (18–22): 33–42.

Hardy, A.D. (1907) Notes on a peculiar habitat of a Chlorophyte, *Myxonema tenue*. *Journal of the Royal Microscopical Society of London* 1907: 279–281.
https://doi.org/10.1111/j.1365-2818.1907.tb01656.x

Hašler, P., Dvořák, P., Ondrej, V., Kitner, M., Hlousková, P. & Poulíčková, A. (2011) The importance of the polyphasic approach in a comparative study of *Nodularia* (Nostocales, Cyanobacteria). *Preslia* 83 (1): 167–182.

Hauer, T., Bohunická, M. & Muehlsteinová, R. (2013) *Calochaete* gen. nov. (Cyanobacteria, Nostocales), a new cyanobacterial type from the "páramo" zone in Costa Rica. *Phytotaxa* 109 (1): 36–44.

Hauer, T., Bohunická, M., Johansen, J.R., Mareš, J. & Berrendero Gómez, E. (2014) Reassessment of the cyanobacterial family Microchaetaceae and establishment of new families Tolypothrichaceae and Godleyaceae. *Journal of Phycology* 50 (6): 1089–1100.
https://doi.org/10.1111/jpy.12241

Hawkins, P.R., Runnegar, M.T., Jackson, A.R. & Falconer, I.R. (1985) Severe hepatotoxicity caused by the tropical cyanobacterium (blue-green alga) *Cylindrospermopsis raciborskii* (Wołoszyńska) Seenaya and Subba Raju isolated from a domestic water supply reservoir. *Applied and Environmental Microbiology* 50 (5): 1292–1295.

Hayes, K.P. & Burch, M.D. (1989) Odorous compounds associated with algal blooms in South Australian waters. *Water Research* 23 (1): 115–121.
https://doi.org/10.1016/0043-1354(89)90069-9

Heresztyn, T. & Nicholson, B.C. (1997) Nodularin concentrations in Lakes Alexandrina and Albert, South Australia, during a bloom of the cyanobacterium (blue-green alga) *Nodularia spumigena* and degradation of the toxin. *Environmental Toxicology* 12 (4): 273–282.
https://doi.org/10.1002/(SICI)1098-2256(1997)12:4%3C273::AID-TOX1%3E3.0.CO;2-5

Hindák, F. (1988) Planktic species of two related genera *Cylindrospermopsis* and *Anabaenopsis* from Western Slovakia. *Algological Studies/Archiv für Hydrobiologie*, *Supplement* 1988: 283–302.

Hindák, F. (2000) Morphological variation of four planktic nostocalean cyanophytes–members of the genus *Aphanizomenon* or *Anabaena*? *Hydrobiologia* 438 (1–3): 107–116.

Hindák, F. (2001) Thermal microorganisms from a hot spring on the coast of Lake Bogoria, Kenya. *Nova Hedwigia Beiheft* 123: 77–94.

Hindák, F. (2012) Hormogonia in two nostocalean cyanophytes (cyanobacteria) from the genera *Hapalosiphon* and *Fischerella*. *Biologia* 67 (6): 1075–1079.
https://doi.org/10.2478/s11756-012-0100-3

Hindák, F. & Hindáková, A. (2003) Diversity of cyanobacteria and algae of urban gravel pit lakes in Bratislava, Slovakia: a survey. *Hydrobiologia* 506 (1–3): 155–162.
https://doi.org/10.1023/B:HYDR.0000008631.82041.c7

Hindáková, A. & Hindák, F. (2017) Life cycle of *Aulosira epiphytica* comb. nova (Cyanobacteria) just completed. *Biologia* 72 (5): 494–499.

Hoffmann, L., Komárek, J. & Kaštovský, J. (2005) System of cyanoprokaryotes (cyanobacteria)–state in 2004. *Algological Studies* 117 (1): 95–115.
https://doi.org/10.1127/1864-1318/2005/0117-0095

Hötzel, G. & Croome, R. (1999) *A phytoplankton methods manual for Australian freshwaters.* Occasional Paper 22/99, Land and Water Resources Research and Development Corporation, Canberra, 66 pp.

Hrouzek, P., Lukešová, A., Mareš, J. & Ventura, S. (2013) Description of the cyanobacterial genus *Desmonostoc* gen. nov. including *D. muscorum* comb. nov. as a distinct, phylogenetically coherent taxon related to the genus *Nostoc*. *Fottea* 13 (2): 201–213.

Huber, A.L. (1984) *Nodularia* (Cyanobacteriaceae) akinetes in the sediments of the Peel-Harvey Estuary, Western Australia: potential inoculum source for *Nodularia* blooms. *Applied and Environmental Microbiology* 47 (2): 234–238.

Huber, A.L. (1986) Nitrogen fixation by *Nodularia spumigena* Mertens (Cyanobacteriaceae). 1: Field studies and the contribution of blooms to the nitrogen budget of the Peel-Harvey Estuary, Western Australia. *Hydrobiologia* 131 (3): 193–203.

Humpage, A., Gaget, V., Lau, M., Froscio, S. & Laingam, S. (2013) *CyanoSurvey: a national update on toxic cyanobacteria and their distribution.* Final Report Project 1022, Water Research Australia Limited, Adelaide.

Iteman, I., Rippka, R., de Marsac, N.T. & Herdman, M. (2002) rDNA analyses of planktonic heterocystous cyanobacteria, including members of the genera *Anabaenopsis* and *Cyanospira*. *Microbiology* 148 (2): 481–496.
https://doi.org/10.1099/00221287-148-2-481

Jeeji-Bai, N., Hegewald, E. & Soeder, C.J. (1977) Revision and taxonomic analysis of the genus *Anabaenopsis*. *Algological Studies/Archiv*

für Hydrobiologie, Supplement 1977: 3–24.

Johansen, J.R., Bohunická, M., Lukešová, A., Hrčková, K., Vaccarino, M.A. & Chesarino, N.M. (2014) Morphological and molecular characterization within 26 strains of the genus *Cylindrospermum* (Nostocaceae, Cyanobacteria), with descriptions of three new species. *Journal of Phycology* 50 (1): 187–202.
https://doi.org/10.1111/jpy.12150

Joneson, S. & O'Brien, H. (2017) A molecular investigation of free-living and lichenized *Nostoc* sp. and symbiotic lifestyle determination. *The Bryologist* 120 (4): 371–381.

Kaštovský, J. & Johansen, J.R. (2008) *Mastigocladus laminosus* (Stigonematales, Cyanobacteria): phylogenetic relationship of strains from thermal springs to soil-inhabiting genera of the order and taxonomic implications for the genus. *Phycologia* 47 (3): 307–320.
https://doi.org/10.2216/PH07-69.1

Kemp, A.S. (2009) *Freshwater cyanoprokaryota blooms in the Swan Coastal Plain wetlands: ecology, taxonomy and toxicology.* Doctoral dissertation, Curtin University, Perth.

Kling, H.J. (2009) *Cylindrospermopsis raciborskii* (Nostocales, Cyanobacteria): a brief historic overview and recent discovery in the Assiniboine River (Canada). *Fottea* 9 (1): 45–47.
https://doi.org/10.5507/fot.2009.002

Komárek, J. (1989) Studies on the Cyanophytes of Cuba 4–6. *Folia Geobotanica* 24 (1): 57–97.
https://doi.org/10.1007/BF02854793

Komárek, J. (1989) Studies on the Cyanophytes of Cuba 7–9. *Folia Geobotanica* 24 (2): 171–206.
https://doi.org/10.1007/BF02853041

Komárek, J. (2003) Two *Camptylonemopsis* species (cyanoprokaryotes) from" Mata Atlântica" in coastal Brazil. *Preslia* 75 (3): 223–232.

Komárek, J. (2005) Phenotype diversity of the heterocytous cyanoprokaryotic genus *Anabaenopsis*. *Fottea* 5 (1): 1–35.

Komárek, J. (2013) *Süsswasserflora von Mitteleuropa: Bd. 19/3. Cyanoprokaryota 3. Teil. Heterocytous Genera.* Springer Spektrum, Berlin.

Komárek, J. (2016) Review of the cyanobacterial genera implying planktic species after recent taxonomic revisions according to polyphasic methods: state as of 2014. *Hydrobiologia* 764 (1): 259–270.
https://doi.org/10.1007/s10750-015-2242-0

Komárek, J. & Kling, H. (1991) Variation in six planktonic cyanophyte genera in Lake Victoria (East Africa). *Algological Studies/Archiv für Hydrobiologie, Supplement* 1991: 21–45.

Komárek, J. & Komárková, J. (2003) Phenotype diversity of the cyanoprokaryotic genus *Cylindrospermopsis* (Nostocales); review 2002. *Czech Phycology* 3 (1): 1–30.

Komárek, J. & Komárková, J. (2006) Diversity of *Aphanizomenon*-like cyanobacteria. *Czech Phycology* 6: 1–32.

Komárek, J. (2016) A polyphasic approach for the taxonomy of cyanobacteria: principles and applications. *European Journal of Phycology*, 51 (3): 346–353.
https://doi.org/10.1080/09670262.2016.1163738

Komárek, J. & Mareš, J. (2012) An update to modern taxonomy (2011) of freshwater planktic heterocytous cyanobacteria. *Hydrobiologia* 698 (1): 327–351.

Komárek, J. & Watanabe, M. (1990) Morphology and taxonomy of the genus *Coleodesmium* (Cyanophyceae/Cyanobacteria). *Cryptogams of the Himalayas* 2: 1–22.

Komárek, J. & Watanabe, M. (1998) Contribution to the attached cyanoprokaryotes from submersed biotopes in Sagarmatha National Park (Eastern Nepal). *Bulletin of the National Science Museum, Tokyo, Ser. B*. 24 (4): 117–135.

Komárek, J. & Zapomělová, E. (2007) Planktic morphospecies of the cyanobacterial genus *Anabaena*= subg. *Dolichospermum*–1. part: coiled types. *Fottea* 7 (1): 1–31.

Komárek, J. & Zapomělová, E. (2008) Planktic morphospecies of the cyanobacterial genus *Anabaena*= subg. *Dolichospermum*–2. part: straight types. *Fottea* 8 (1): 1–14.

Komárek, J., Sant'Anna, C.L., Bohunická, M., Mareš, J., Hentschke, G.S., Rigonato, J. & Fiore, M.F. (2013b) Phenotype diversity and phylogeny of selected *Scytonema*-species (Cyanoprokaryota) from SE Brazil. *Fottea* 13 (2): 173–200.

Komárek, J., Hübel, M., Hübel, H. & Šmarda, J. (1993) The *Nodularia* studies. 2. Taxonomy. *Algological Studies/Archiv für Hydrobiologie, Supplement* 1993: 1–25.

Komárek, J. (2010) Recent changes (2008) in cyanobacteria taxonomy based on a combination of molecular background with phenotype and ecological consequences (genus and species concept). *Hydrobiologia* 639 (1): 245–259.

Komárek, J., Kaštovský, J., Mareš, J. & Johansen, J.R. (2014) Taxonomic classification of cyanoprokaryotes (cyanobacterial genera) 2014, using a polyphasic approach. *Preslia* 86 (4): 295–335.

Kozlíková-Zapomělová, E., Ferrari, G. & del Pérez, M.C. (2016) *Dolichospermum uruguayense* sp. nov., a planktic nostocacean

cyanobacterium from the Lower Uruguay River, South America. *Fottea* 16 (2): 189–200.

Krüger, T., Oelmüller, R. & Luckas, B. (2009) Comparative PCR analysis of toxic *Nodularia spumigena* and non-toxic *Nodularia harveyana* (Nostocales, Cyanobacteria) with respect to the nodularin synthetase gene cluster. *European Journal of Phycology* 44 (3): 291–295.
https://doi.org/10.1080/09670260802588434

Kust, A., Kozlíková–Zapomělová, E., Mareš, J. & Řeháková, K. (2015) A detailed morphological, phylogenetic and ecophysiological analysis of four benthic *Anabaena* (Nostocales, Cyanobacteria) strains confirms deep heterogeneity within the genus. *Fottea* 15 (2): 191–202.
https://doi.org/10.5507/fot.2015.019

Lee, E., Ryan, U.M., Monis, P., McGregor, G.B., Bath, A., Gordon, C. & Paparini, A. (2014) Polyphasic identification of cyanobacterial isolates from Australia. *Water Research* 59: 248–261.
https://doi.org/10.1016/j.watres.2014.04.023

León-Tejera, H.P., Gonzalez-Resendiz, L., Johansen, J.R., Segal-Kischinevsky, C., Escobar, V. & Lois, L.A. (2016) Phylogenetic position reevaluation of *Kyrtuthrix* and description of a new species *K. huatulcensis* from Mexico´s Pacific coast. *Phytotaxa* 278 (1): 1–18.

Li, R., Watanabe, M. & Watanabe, M.M. (2000) Taxonomic studies of planktic species of *Anabaena* based on morphological characteristics in cultured strains. *Hydrobiologia* 438 (1): 117–138.
https://doi.org/10.1023/A:1004170230774

Li, R. & Watanabe, M.M. (2001) Fatty acid profiles and their chemotaxonomy in planktonic species of *Anabaena* (Cyanobacteria) with straight trichomes. *Phytochemistry* 57 (5): 727–731.
https://doi.org/10.1016/S0031-9422(01)00082-6

Li, R., Carmichael, W.W., Liu, Y. & Watanabe, M.M. (2000) Taxonomic re-evaluation of *Aphanizomenon flos-aquae* NH-5 based on morphology and 16S rRNA gene sequences. *Hydrobiologia* 438 (1): 99–105.
https://doi.org/10.1023/A:1004166029866

Li, R., Carmichael, W.W. & Pereira, P. (2003) Morphological and 16S rRNA gene evidence for reclassification of the paralytic shellfish toxin producing *Aphanizomenon flos*-aquae LMECYA 31 as *Aphanizomenon issatschenkoi* (Cyanophyceae). *Journal of Phycology* 39 (4): 814–818.
https://doi.org/10.1046/j.1529-8817.2003.02199.x

Li, R., Wilhelm, S.W., Carmichael, W.W. & Watanabe, M.M. (2008) Polyphasic characterization of water bloom forming *Raphidiopsis* species (cyanobacteria) from central China. *Harmful Algae* 7 (2): 146–153.
https://doi.org/10.1016/j.hal.2007.06.003

Li, X., Yang, Y. & Li, R. (2015) Phenotypic and genotypic validation of the rare species *Sphaerospermopsis eucompacta* comb. nov. (Nostocales, Cyanobacteria) isolated from China. *Phycologia* 54 (3): 299–306.

Li, X., Yang, Y., Cai, F., Yang, P., Song, L. & Li, R. (2016a) New insights into the taxonomy of the genus *Sphaerospermopsis* (Nostocales, Cyanobacteria) with the description *of Sphaerospermopsis crassa* sp. nov. *Phycologia* 56 (2): 147–158.

Li, X., Dreher, T.W. & Li, R. (2016b) An overview of diversity, occurrence, genetics and toxin production of bloom-forming *Dolichospermum* (*Anabaena*) species. *Harmful Algae* 54: 54–68.

Ling, H.U. & Tyler, P.A. (2000) Australian freshwater algae. *Bibliotheca Phycologica*. Band 105. XII, 643 pp, 159 pls, 1 fig.

Lukešová, A., Johansen, J.R., Martin, M.P. & Casamatta, D.A. (2009) *Aulosira bohemensis* sp. nov.: further phylogenetic uncertainty at the base of the Nostocales (Cyanobacteria). *Phycologia* 48 (2): 118–129.

Lyra, C., Suomalainen, S., Gugger, M., Vezie, C., Sundman, P., Paulin, L. & Sivonen, K. (2001) Molecular characterization of planktic cyanobacteria of *Anabaena*, *Aphanizomenon*, *Microcystis* and *Planktothrix* genera. *International Journal of Systematic and Evolutionary Microbiology* 51 (2): 513–526.
https://doi.org/10.1099/00207713-51-2-513

Lyra, C., Laamanen, M., Lehtimäki, J.M., Surakka, A. & Sivonen, K. (2005) Benthic cyanobacteria of the genus *Nodularia* are non-toxic, without gas vacuoles, able to glide and genetically more diverse than planktonic *Nodularia*. *International Journal of Systematic and Evolutionary Microbiology* 55 (2): 555–568.
https://doi.org/10.1099/ijs.0.63288-0

Mareš, J., Lara, Y., Dadáková, I., Hauer, T., Uher, B., Wilmotte, A. & Kaštovský, J. (2015) Phylogenetic analysis of cultivation-resistant terrestrial cyanobacteria with massive sheaths (*Stigonema* spp. and *Petalonema alatum*, Nostocales, Cyanobacteria) using single-cell and filament sequencing of environmental samples. *Journal of Phycology* 51 (2): 288–297.

May, V. (1970) New or interesting algal records from Australia. *Contributions of the New South Wales National Herbarium* 4: 79–83.

May, V. (1972) Blue-green algal booms of Braidwood, New South Wales (Australia). *Science Bulletin of the Department of Agriculture, New South Wales* 82: 1–45.

May, V. (1978) Areas of recurrence of toxic algae within Burrinjuck Dam, New South Wales, Australia. *Telopea* 1: 295–313.

https://doi.org/10.7751/telopea19783501

May, V. (1981) Freshwater algae. *In:* Sainty, G.R. & Jacobs, S.W.L. (Eds.) *Waterplants of New South Wales*. Water Resources Commission, New South Wales, pp. 446–460.

May, V. & McBarron, E.J. (1973) Occurrence of the blue-green alga, *Anabaena circinalis* Rabenh., in new South Wales and toxicity to mice and honey bees. *Journal of the Australian Institute of Agricultural Science* 39: 164–266.

McGregor, G.B. (2007) *Freshwater Cyanoprokaryota of North-eastern Australia: 1: Oscillatoriales.* Flora of Australia Supplementary Series No. 24, Australian Biological Resources Study, Canberra, 123 pp.

McGregor, G.B. (2013) Freshwater Cyanobacteria of North-eastern Australia: 2: Chroococcales. *Phytotaxa* 133 (1): 1–130. https://doi.org/10.11646/phytotaxa.133.1.1

McGregor, G.B. & Everding, K.L. (1998) Blue-green Algae Monitoring Program: Monitoring Program Report October 1997–June 1998. *In: Freshwater Biological Monitoring Report No. 6.* Queensland Department of Natural Resources, Brisbane.

McGregor, G.B. & Fabbro, L.D. (2000) Dominance of *Cylindrospermopsis raciborskii* (Nostocales, Cyanoprokaryota) in Queensland tropical and subtropical reservoirs: implications for monitoring and management. *Lakes & Reservoirs: Research & Management* 5 (3): 195–205. https://doi.org/10.1046/j.1440-1770.2000.00115.x

McGregor, G.B. & Rasmussen, J.P. (2007) Cyanobacterial composition of microbial mats from an Australian thermal spring: a polyphasic evaluation. *FEMS Microbiology Ecology* 63 (1): 23–35.

McGregor, G.B., Sendall, B.C., Hunt, L.T. & Eaglesham, G.K. (2011) Report of the cyanotoxins cylindrospermopsin and deoxy-cylindrospermopsin from *Raphidiopsis mediterranea* Skuja (Cyanobacteria/Nostocales). *Harmful Algae* 10 (4): 402–410. https://doi.org/10.1016/j.hal.2011.02.002

McGregor, G.B., Stewart, I., Sendall, B.C., Sadler, R., Reardon, K., Carter, S., Wruck, D. & Wickramasinghe, W. (2012) First report of a toxic *Nodularia spumigena* (Nostocales/Cyanobacteria) bloom in subtropical Australia. I. Phycological and public health investigations. *International Journal of Environmental Research and Public Health* 9 (7): 2396–2411.

McGregor, G.B. & Sendall, B.C. (2017a) *Iningainema pulvinus* gen nov., sp nov. (Cyanobacteria, Scytonemataceae) a new nodularin producer from Edgbaston Reserve, north-eastern Australia. *Harmful Algae* 62: 10–19.

McGregor, G.B. & Sendall, B.C. (2017b) *Ewamiania thermalis* gen. et sp. nov. (Cyanobacteria, Scytonemataceae), a new cyanobacterium from Talaroo thermal springs, north-eastern Australia. *Australian Systematic Botany* 30 (1): 38–47.

McLeod, J.A. (1975) *The freshwater algae of south-eastern Queensland.* PhD Thesis, University of Queensland, Brisbane.

Miller, S.R., Purugganan, M.D. & Curtis, S.E. (2006) Molecular population genetics and phenotypic diversification of two populations of the thermophilic cyanobacterium *Mastigocladus laminosus*. *Applied and Environmental Microbiology* 72 (4): 2793–2800. https://doi.org/10.1128/AEM.72.4.2793-2800.2006

Miller, S.R., Castenholz, R.W. & Pedersen, D. (2007) Phylogeography of the thermophilic cyanobacterium *Mastigocladus laminosus*. *Applied and Environmental Microbiology* 73 (15): 4751–4759. https://doi.org/10.1128/AEM.02945-06

Möbius, M. (1895) Australische Süsswasseralgen. II. *Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft* 18: 310–350.

Mohamed, Z.A. (2006) First report of toxic *Cylindrospermopsis raciborskii* and *Raphidiopsis mediterranea* (Cyanoprokaryota) in Egyptian fresh waters. *FEMS Microbiology Ecology* 59 (3): 749–761.

Moreira, C., Fathalli, A., Vasconcelos, V. & Antunes, A. (2015) Phylogeny and biogeography of the invasive cyanobacterium *Cylindrospermopsis raciborskii*. *Archives of Microbiology* 197 (1): 47–52. https://doi.org/10.1007/s00203-014-1052-5

Moustaka-Gouni, M., Kormas, K.A., Vardaka, E., Katsiapi, M. & Gkelis, S. (2009) *Raphidiopsis mediterranea* Skuja represents non-heterocytous life-cycle stages of *Cylindrospermopsis raciborskii* (Wołoszyńska) Seenayya et Subba Raju in Lake Kastoria (Greece), its type locality: evidence by morphological and phylogenetic analysis. *Harmful Algae* 8 (6): 864–872. https://doi.org/10.1016/j.hal.2009.04.003

Noble, J.C. & Happey-Wood, C.M. (1987) Some aspects of the ecology of algal communities in ricefields and rice irrigation systems of southern New South Wales. *Journal of the Institute of Agricultural Science* 53: 170–284.

Nordstedt, C.F.O. (1888) Einige Characeenbestimmungen. *Hedwigia* 27: 181–196.

Oren, A. & Ventura, S. (2017) The current status of cyanobacterial nomenclature under the "prokaryotic" and the "botanical" code. *Antonie van Leeuwenhoek* 110 (10): 1257–1269. https://doi.org/10.1007/s10482-017-0848-0

Padisák, J. (1997) *Cylindrospermopsis raciborskii* (Wołoszyńska) Seenayya et Subba Raju, an expanding, highly adaptive cyanobacterium: worldwide distribution and review of its ecology. *Archiv für Hydrobiologie Supplement Band* 107 (4): 563–593.

Piccini, C., Aubriot, L., Fabre, A., Amaral, V., González-Piana, M., Giani, A., Figueredo, C.C., Vidal, L., Kruk, C. & Bonilla, S. (2011)

Genetic and eco-physiological differences of South American *Cylindrospermopsis raciborskii* isolates support the hypothesis of multiple ecotypes. *Harmful Algae* 10 (6): 644–653.
https://doi.org/10.1016/j.hal.2011.04.016

Playfair, G.I. (1915) Freshwater algae of the Lismore District: with an appendix of the algal funci and schizomycetes. *Proceedings of the Linnean Socity of New South Wales* 40: 310–362.
https://doi.org/10.5962/bhl.part.18876

Playfair, G.I. (1917) Census of New South Wales freshwater algae. *In:* Maiden, J.H. & Betche, E. (Eds.) *A Census of New South Wales Plants, Suppl.* 1: 219–262.

Playfair, G.I. (1918) New and rare freshwater algae. *Proceedings of the Linnean Socity of New South Wales* 43: 497–543.

Rajaniemi, P., Komárek, J., Willame, R., Hrouzek, P., Kaštovská, K., Hoffmann, L. & Sivonen, K. (2005a) Taxonomic consequences from the combined molecular and phenotype evaluation of selected *Anabaena* and *Aphanizomenon* strains. *Algological Studies* 117 (1): 371–391.

Rajaniemi, P., Hrouzek, P., Kaštovska, K., Willame, R., Rantala, A., Hoffmann, L., Komárek, J. & Sivonen, K. (2005b) Phylogenetic and morphological evaluation of the genera *Anabaena*, *Aphanizomenon*, *Trichormus* and *Nostoc* (Nostocales, Cyanobacteria). *International Journal of Systematic and Evolutionary Microbiology* 55 (1): 11–26.

Řeháková, K., Mareš, J., Lukešová, A., Zapomělová, E., Bernardová, K. and Hrouzek, P. (2014) *Nodularia* (Cyanobacteria, Nostocaceae): a phylogenetically uniform genus with variable phenotypes. *Phytotaxa* 172 (3): 235–246.
https://doi.org/10.11646/phytotaxa.172.3.4

Saker, M.L. & Eaglesham, G.K. (1999) The accumulation of cylindrospermopsin from the cyanobacterium *Cylindrospermopsis raciborskii* in tissues of the Redclaw crayfish *Cherax quadricarinatus*. *Toxicon* 37 (7): 1065–1077.
https://doi.org/10.1016/S0041-0101(98)00240-2

Sant'Anna, C.L., Kaštovský, J., Hentschke, G.S. & Komárek, J. (2013) Phenotypic studies on terrestrial stigonematacean cyanobacteria from the Atlantic Rainforest, Sao Paulo State, Brazil. *Phytotaxa* 89 (1): 1–23.
https://doi.org/10.11646/phytotaxa.89.1.1

de Souza Santos, K.R., Jacinavicius, F.R. & Leite, C. (2011) Effects of the pH on growth and morphology of *Anabaenopsis elenkinii* Miller (Cyanobacteria) isolated from the alkaline shallow lake of the Brazilian Pantanal. *Fottea* 11 (1): 119–126.
https://doi.org/10.5507/fot.2011.012

Schmidle, W. (1896) Süsswasseralgen aus Australien. *Flora Jena* 82: 297–313.

Scott, A.M. & Prescott, G.W. (1958) Some freshwater algae from Arnhem Land in the Northern Territory of Australia. *Records of the American-Australian Science Expedition to Arnhem Land* 3: 9–136.

Sendall, B.C. & McGregor, G.B. (2018) *Heteroscytonema* gen nov. (Cyanobacteria/Heteroscytonemataceae), toxicity and cryptic diversity within the *Scytonema* complex. *Harmful Algae.* [in review]

Shaw, G.R., Sukenik, A., Livne, A., Chiswell, R.K., Smith, M.J., Seawright, A.A., Norris, R.L., Eaglesham, G.K. & Moore, M.R. (1999) Blooms of the cylindrospermopsin containing cyanobacterium, *Aphanizomenon ovalisporum* (Forti), in newly constructed lakes, Queensland, Australia. *Environmental Toxicology* 14 (1): 167–177.
https://doi.org/10.1002/(SICI)1522-7278(199902)14:1%3C167::AID-TOX22%3E3.0.CO;2-O

Shalygin, S., Shalygina, R., Johansen, J.R., Pietrasiak, N., Berrendero Gómez, E., Bohunická, M., Mareš, J. & Sheil, C.A. (2016) *Cyanomargarita* gen. nov. (Nostocales, Cyanobacteria): convergent evolution resulting in a cryptic genus. *Journal of Phycology* 53: 762–777.
https://doi.org/10.1111/jpy.12542

Silva, S.M.F. & Sant'Anna, C.L. (1990) Stigonemataceae (Cyanophyceae) do estado de São Paulo, Brazil, 1: O genero *Hapalosiphon* Naegli ex Bornet, & Flahault. *Hoehnea* 17 (2): 63–91.

Singh, R.N. (1942) *Wollea bharadwajae* sp. nov. and its autecology. *Annals of Botany* 6 (24): 593–606.

Skinner, S. & Entwisle, T.J. (2001) Non-marine algae of Australia: 1. Survey of colonial gelatinous blue-green macroalgae (Cyanobacteria). *Telopea* 9 (3): 573–599.

Šmarda, J., Komárek, J. & Hübel, M. (1988) The *Nodularia* studies. 1. Introduction, fine structure. *Algological Studies/Archiv für Hydrobiologie, Supplement* 50–53: 109–129.

Smith, F.M., Wood, S.A., van Ginkel, R., Broady, P.A. & Gaw, S. (2011) First report of saxitoxin production by a species of the freshwater benthic cyanobacterium, Scytonema Agardh. *Toxicon* 57 (4): 566–573.
https://doi.org/10.1016/j.toxicon.2010.12.020

Sonder, O. (1880) Algae Australienae hactenus cognitae. *In:* Mueller, F. (Ed.) *Fragmenta Phytographie Australiae* 11: 1–42.

Sonder, O. (1881) Algae. *In:* Mueller, F. (Ed.) *Fragmenta Phytographie Australiae* 11: 105–107.

Stewart, I., Eaglesham, G.K., McGregor, G.B., Chong, R., Seawright, A.A., Wickramasinghe, W.A., Sadler, R., Hunt, L. and Graham, G. (2012) First report of a toxic *Nodularia spumigena* (Nostocales/Cyanobacteria) bloom in sub-tropical Australia. II. Bioaccumulation

of nodularin in isolated populations of mullet (Mugilidae). *International Journal of Environmental Research and Public Health* 9 (7): 2412–2443.

Stüken, A., Rücker, J., Endrulat, T., Preussel, K., Hemm, M., Nixdorf, B., Karsten, U. & Wiedner, C. (2006) Distribution of three alien cyanobacterial species (Nostocales) in northeast Germany: *Cylindrospermopsis raciborskii*, *Anabaena bergii* and *Aphanizomenon aphanizomenoides*. *Phycologia* 45 (6): 696–703.
https://doi.org/10.2216/05-58.1

Stüken, A., Campbell, R.J., Quesada, A., Sukenik, A., Dadheech, P.K. & Wiedner, C. (2009) Genetic and morphologic characterization of four putative cylindrospermopsin producing species of the cyanobacterial genera *Anabaena* and *Aphanizomenon*. *Journal of Plankton Research* 31 (5): 465–480.
https://doi.org/10.1093/plankt/fbp011

Sukenik, A., Hadas, O., Kaplan, A. & Quesada, A. (2012) Invasion of Nostocales (cyanobacteria) to subtropical and temperate freshwater lakes–physiological, regional, and global driving forces. *Frontiers in Microbiology* 3: 1–9.
https://doi.org/10.3389/fmicb.2012.00086

Sullivan, C.M., Saunders, J. & Welsh, D. (1988) *Phytoplankton of the River Murray. Review of Monitoring 1980–1985. Water Quality Report No. 2.* Murray-Darling Basin Commission, Canberra.

Thomasson, K. (1986) Algal vegetation in North Australian billabongs. *Nova Hedwigia* 42: 301–378.

Townsend, S.A. & Douglas, M.M. (2017) Discharge-driven flood and seasonal patterns of phytoplankton biomass and composition of an Australian tropical savannah river. *Hydrobiologia* 794 (1): 203–221.
https://doi.org/10.1007/s10750-017-3094-6

Vaccarino, M.A. & Johansen, J.R. (2011) *Scytonematopsis contorta* sp. nov. (Nostocales), a new species from the Hawaiian Islands. *Fottea* 11 (1): 149–161.

Vigna, M.S., Alberghina, J. & Belmonte, C.F. (2001) Remarks about the taxonomical position of *Nodularia harveyana* Thuret ex Bornet et Flahault (Cyanophyta, Nostocales) growing on soil. *Nova Hedwigia* Band 72, Heft 1–2: 241–250.

Wacklin, P., Hoffmann, L. & Komárek, J. (2009) Nomenclatural validation of the genetically revised cyanobacterial genus *Dolichospermum* (Ralfs ex Bornet et Flahault) comb. nova. *Fottea* 9 (1): 59–64.
https://doi.org/10.5507/fot.2009.005

Walker, K.F. & Hillman, T.J. (1977) *Limnological survey of the River Murray in relation to Albury-Wodonga, 1973–1976.* Albury-Wodonga Development Corporation and Gutteridge Haskins & Davey.

Walker, K.F. & Hillman, T.J. (1982) Phosphorus and nitrogen loads in waters associated with the River Murray near Albury-Wodonga, and their effects on phytoplankton populations. *Marine and Freshwater Research* 33 (2): 223–243.
https://doi.org/10.1071/MF9820223

Werner, V.R., Laughinghouse IV, H.D., Fiore, M.F., Sant'Anna, C.L., Hoff, C., de Souza Santos, K.R., Neuhaus, E.B., Molica, R.J.R., Honda, R.Y. & Echenique, R.O., 2012. Morphological and molecular studies of *Sphaerospermopsis torques-reginae* (Cyanobacteria, Nostocales) from South American water blooms. *Phycologia* 51 (2): 228–238.

Whitton, B.A. & Mateo, P. (2012) Rivulariaceae. *In:* Whitton, B.A. (Ed.) *Ecology of Cyanobacteria II.* Springer Netherlands, pp. 561–591.
https://doi.org/10.1007/978-94-007-3855-3_22

Willame, R., Boutte, C., Grubisic, S., Wilmotte, A., Komárek, J. & Hoffmann, L. (2006) Morphological and molecular characterization of planktonic cyanobacteria from Belgium and Luxembourg. *Journal of Phycology* 42 (6): 1312–1332.
https://doi.org/10.1111/j.1529-8817.2006.00284.x

Willis, A. (2016) *Algal bloom turns 400 km of the Murray River green.* Catchment to Coast, Australian Rivers Institute, Brisbane.

Zapomělová, E., Řeháková, K., Znachor, P. & Komárková, J. (2007) Morphological diversity of coiled planktonic types of the genus *Anabaena* (cyanobacteria) in natural populations: Taxonomic consequences. *Cryptogamie Algologie* 28 (4): 353–371.

Zapomělová, E., Jezberová, J., Hrouzek, P., Hisem, D., Řeháková, K., & Komárková, J. (2010) Polyphasic characterisation of three strains of *Anabaena reniformis* and *Aphanizomenon aphanizomenoides* (cyanobacteria) and their reclassification to *Sphaerospermum* gen. nov. (incl. *Anabaena kisseleviana*). *Journal of Phycology* 45 (6): 1363–1373.

Zapomělová, E., Skácelová, O., Pumann, P., Kopp, R. & Janeček, E. (2012) Biogeographically interesting planktonic Nostocales (Cyanobacteria) in the Czech Republic and their polyphasic evaluation resulting in taxonomic revisions of *Anabaena bergii* Ostenfeld 1908 (*Chrysosporum* gen. nov.) and *A. tenericaulis* Nygaard 1949 (*Dolichospermum tenericaule* comb. nova). *Hydrobiologia* 698 (1): 353–365.

ABBREVIATIONS AND CONTRACTIONS

Literature

Author abbreviations follow R.K.Brummitt & C.E.Powell, *Authors of Plant Names* (Royal Botanic Gardens, Kew, 1992).

Journal titles are abbreviated in accordance with G.H.M.Lawrence *et al.*, *Botanico-Periodicum-Huntianum* (Hunt Botanical Library, Pittsburgh, 1968) and G.D.R.Bridson & E.R.Smith, *Botanico-Periodicum-Huntianum/Supplementum* (Hunt Institute for Botanical Documentation, Pittsburgh, 1991).

Other literature is abbreviated in accordance with F.A.Stafleu & R.S.Cowan, *Taxonomic Literature*, 2nd edn (Bohn, Scheltema & Holkema, Utrecht, 1976–1987), except that upper case initial letters are used for proper names and significant words.

Herbaria

Abbreviations of herbaria are in accordance with P.K.Holmgren, N.H.Holmgren & L.C.Barnett, *Index Herbariorum* Part I, 8th edn (New York Botanical Garden, 1990). Those most commonly cited are:

AD State Herbarium of South Australia, Adelaide
BM The Natural History Museum, London
BRI Queensland Herbarium, Brisbane
CANB Australian National Herbarium, Canberra
DNA Northern Territory Herbarium, Darwin
HO Tasmanian Herbarium, Hobart
MEL National Herbarium of Victoria, Melbourne
NSW National Herbarium of New South Wales, Sydney
PERTH Western Australian Herbarium, Perth

States, Territories

Abbreviations of Australian States and Territories as used in statements of distribution and citation of collections are:

A.C.T. Australian Capital Territory
N.S.W. New South Wales
N.T. Northern Territory
Qld Queensland
S.A. South Australia
Tas. Tasmania
Vic. Victoria
W.A. Western Australia

General abbreviations

add. addendum
alt. altitude
app. appendix
auct. auctoris/auctorum (of an author or authors)
auct. mult. auctorum multorum (of many authors)
auct. non auctorum non (of authors [but] not....), used for misapplied names
c. *circa* (about)
cf. *confer* (compare)
Ck Creek
cm centimetre
coll. collector
colln collection
comb. combinatio/combination
cons. conservandus
descr. descriptio
diam. diameter

E east
ed./eds editor/editors
edn edition
e.g. *exempli gratia* (for example)
et al. et alii/*et aliorum*; and others/and of others
f. *forma/*form
fam. *familia/*family
fig./figs figure/figures (in other works)
gen. *genus/*genus
gen. nov. genus novus (new genus)
holo holotype
HS Homestead
Hwy Highway
i.e. *id est* (that is)
ined. ineditus (unpublished)
in litt. in litteris (in correspondence)
I./Is. Island/Islands
iso isotype
isolecto isolectotype
km kilometre
L. Lake
lat. latitude
lecto lectotype
loc. cit. loco citato (in bibliographic citations: in the same work and page as just cited)
loc. id. loco idem (in specimen citations: in the same place as just cited)
long. longitude
m metre
mm millimetre
Mt/Mts Mount/Mounts
Mtn/Mtns Mountain/Mountains
N north
Natl National
NE north-east
neo neotype
nom. cons. nomen conservandum (conserved name)
prop. nomen conservandum propositus (proposed conserved name)
nom. illeg. nomen illegitimum (illegitimate name)
nom. inval. nomen invalidum (name not validly published)
nom. nov. nomina nova (new name)
nom. nud. nomen nudum (name published without a description or reference to a published description)
nom. rej. nomen rejiciendum (rejected name)
nom. superfl. nomen superfluum (superfluous name)
*nov. novus/*new
n. ser. new series
n.v. non vidi (not seen)
NW north-west
op. cit. opere citato (in the work cited above)
opp. opposite
orth. orthography, orthographic
p./pp. page/pages
Penin. Peninsula
pers. comm. by personal communication
pl./pls plate/plates
p.p. pro parte (in part)

p.p. max pro parte maxima, the larger part
p.p. min pro parte minore, the smaller part
q.v. quod vide (which see)
R. River
Ra. Range
Rd Road
Res. Reservoir
Rly Railway
S south
SE south-east
sect. *sectio*/section
SEM Scanning Electron Micrograph
ser./sér. series/série
S.F. State Forest
s. lat. sensu lato (in a wide sense)
s. loc. sine loco (without locality)
s.n. sine numero (without number)
sp./spp. species (singular/plural)
sp. aff. species affinis (species related to)
sp. nov. species nova (new species)
s. str. sensu stricto (in a narrow sense)
St Saint/Street
stat. status/status
Stn (pastoral) Station
subg. subgenus
subsp./ subspp. subspecies (singular/plural)
subsp. nov. subspecies nova (new subspecies)
suppl. supplement
SW south-west
syn syntype
synon. synonym
T Type (collection)
t./tt. *tabula/tabulae* (plate/plates)
topo topotype
trib. *tribus*/tribe
trig. trigonometric station
T.S. transverse section
typ. cons. typus conservandus (conserved type)
var. *varietas*/variety
viz. videlicet (namely)
W west

Symbols
± *in species descriptions*, more or less
< less than
> more than
µm micrometre

Appendix 1. Sample sites; P, plankton; B, benthos; M, macrophytes.

Site	Latitude	Longitude	Biotope	Habitats
Albert R. at Stanmore Rd Crossing	27° 47’ 11”	153° 11’ 22”	riverine	B
Alice R. at Charles Lloyd Jones Weir	23° 39’ 28”	145° 12’ 21”	riverine	P
Amity Swamp at North Stradbroke Is.	27° 26’ 11”	153° 26’ 27”	palustrine wetland	B, M
Archer R. at Penninsula Development Rd	13° 26’ 10”	142° 56’ 41”	riverine	B
Archer R. wetland #1	13° 36’ 12”	141° 40’ 52”	palustrine wetland	B
Atkinson Dam	27° 24’ 43”	152° 26’ 31”	reservoir	P, B
Awoonga Dam	24° 04’ 27”	151° 18’ 04”	reservoir	P, B
Babinda Ck at the Boulders	23° 00’ 00”	144° 50’ 38”	riverine	B
Balonne Minor R. at Cubbie Intake	28° 38’ 44”	148° 05’ 09”	riverine	P, B
Balonne Minor R. near Miegunyah	28° 27’ 58”	148° 18’ 41”	riverine	P, B
Balonne R. at Kurray	28° 11’ 35”	148° 31’ 47”	riverine	P, B
Balonne R. at St George	28° 03’ 40”	148° 33’ 40”	riverine	P, B
Balonne R. at Weribone	27° 19’ 07”	148° 49’ 34”	riverine	P, B
Balonne R. at Whenbah bridge	28° 23’ 23”	148° 19’ 00”	riverine	P, B
Balonne R. nr Brookdale	28° 17’ 20”	148° 25’ 06”	riverine	P, B
Barron R. at L. Placid	16° 52’ 13”	145° 40’ 21”	riverine	B
Barwon R. Devils Waterhole at Bellevue	29° 29’ 56”	148° 41’ 08”	riverine	P, B
Baroon Pocket Dam	26° 42’ 11”	152° 52’ 04”	reservoir	P
Barwon R. floodplain Willabilla Lagoon at Willabilla	29° 29’ 10”	148° 39’ 54”	riverine	P, B
Barwon R. Rocky Waterhole at Purtles	29° 11’ 06”	148° 46’ 56”	riverine	P, B
Barwon R. Saltbush Waterhole at Saltbush	29° 12’ 21”	148° 45’ 42”	riverine	P, B
Basin L. at Great Sandy Natl Park, Fraser Is. Sect.	25° 28’ 02”	153° 02’ 35”	lacustrine wetland	P, B
Benargie Ck at Thinoomba Rd	25° 38’ 59”	152° 33’ 25”	riverine	P, B, M
Bertie Ck	11° 45’ 25”	142° 35’ 26”	riverine	B
Bill Gunn Dam	27° 37’ 45”	152° 22’ 40”	reservoir	P
Bjelke-Petersen Dam	26° 18’ 16”	151° 58’ 39”	reservoir	P
Blackhole Lagoon, Bribie Is.	27° 03’ 50”	153° 11’ 35”	lacustrine wetland	B
Blue Eye spring	22° 42’ 60”	145° 25’ 40”	palustrine wetland	B
Blue Lagoon at Moreton Is. Natl Park, Moreton Is.	27° 05’ 34”	153° 26’ 26”	lacustrine wetland	P, B
Blue L. at Budjong Djara Natl Park North Stradbroke Is.	27° 32’ 01”	153° 29’ 05”	lacustrine wetland	P, B, M
Blue L. at the outflow	27° 32’ 06”	153° 28’ 07”	riverine	B, M
Boggomoss Springs	25° 25’ 00”	150° 10’ 00”	palustrine wetland	B
Bokhara R. at Woolerbilla-Hebel Rd	28° 57’ 11”	147° 46’ 17”	riverine	P, B
Bokhara R. near Kirrima	28° 43’ 34”	148° 03’ 06”	riverine	P, B
Booloumba Ck at Camping Area #1	26° 38’ 26”	152° 38’ 41”	riverine	B, M
Booloumba Ck at the Falls	26° 40’ 36”	152° 37’ 14”	riverine	B
Boomerang L.s at Great Sandy Natl Park, Fraser Is. Sect.	25° 13’ 34”	153° 08’ 04”	lacustrine wetland	B, M
Boondooma Dam	26° 05’ 38”	151° 25’ 59”	reservoir	P
Borumba Dam	26° 30’ 14”	152° 34’ 59”	reservoir	P
Bowie’s Flat Wetlands	27° 29’ 37”	153° 03’ 52”	palustrine wetland	B
Braire Ck at Brairy lagoon	28° 48’ 24”	147° 48’ 05”	riverine	P, B
Brisbane R.	26° 34’ 19”	152° 14’ 56”	riverine	B
Brisbane R.	26° 53’ 42”	152° 18’ 34”	riverine	B
Brisbane R.	27° 29’ 59”	152° 41’ 23”	riverine	B
Brisbane R. at Savages Crossing	27° 26’ 12”	152° 38’ 01”	riverine	B, M

.....continued on the next page

Appendix 1. (Conintued)

Site	Latitude	Longitude	Biotope	Habitats
Brisbane R. at Colleges Crossing	27° 33’ 36”	152° 48’ 00”	riverine	B, M
Broken R. at Turkey’s Nest	20° 39’ 46”	147° 53’ 27”	reservoir	P
Bromelton offstream storage	27° 56’ 44”	152° 57’ 14”	reservoir	P
Brown L. at North Stradbroke Is.	27° 29’ 32”	153° 26’ 33”	lacustrine wetland	P, B, M
Buaraba Ck	27° 21’ 33”	152° 19’ 19”	riverine	B
Buckley Ck at Litchfield Natl Park	13° 06’ 12”	130° 47’ 32”	riverine	B
Bulimba Ck	27° 33’ 11”	153° 06’ 44”	riverine	B
Bulimba Ck at Mansfield	27° 31’ 54”	153° 06’ 14”	riverine	B
Bulldogs Lagoon, Bribie Is.	27° 04’ 54”	153° 10’ 43”	lacustrine wetland	B
Burdekin R. at Bowen R. Weir	20° 44’ 45”	147° 56’ 19”	reservoir	P
Burdekin R. at Burdekin Falls Dam	20° 39’ 11”	147° 08’ 49”	reservoir	P
Burdekin R. at Clare Weir	19° 51’ 45”	147° 14’ 13”	reservoir	P
Burnett R. at Ben Anderson Barrage	24° 53’ 35”	152° 17’ 17”	reservoir	P
Burnett R. at Claude Wharton Weir	25° 37’ 08”	151° 35’ 28”	reservoir	P
Burnett R. at Jones Weir	25° 35’ 42”	151° 17’ 42”	reservoir	P
Burnett R. at Kirar Weir	25° 20’ 42”	151° 04’ 40”	reservoir	P
Burnett R. at New Churchward Weir	25° 25’ 50”	152° 04’ 60”	reservoir	P
California Ck at Gavin Way	27° 39’ 48”	153° 12’ 27”	riverine	B
Callide Dam	24° 22’ 26”	150° 36’ 47”	reservoir	P
Canal Ck at Eliot Falls	11° 23’ 01”	142° 24’ 45”	riverine	B
Cania Dam	24° 38’ 60”	150° 59’ 06”	reservoir	B
Capalaba Wetlands	27° 31’ 09”	153° 11’ 18”	palustrine wetland	P
Captain Billy Spring at Source	11° 39’ 40”	142° 43’ 25”	riverine	B, M
Carbrook L.s	27° 41’ 24”	153° 15’ 44”	lacustrine wetland	P
Cattle Ck at Gargett	21° 09’ 15”	148° 43’ 60”	riverine	B
Cedar Grove Weir	27° 50’ 47”	152° 58’ 30”	reservoir	P
Chillagoe Ck at Balancing Rock	17° 10’ 01”	144° 30’ 37”	riverine	B
Cholmondoley Ck at Telegraph Rd	11° 48’ 45”	142° 29’ 46”	riverine	B
Christmas Ck at Stinson Memorial Park	28° 17’ 13”	153° 02’ 13”	riverine	B
Cockatoo Ck at Heathlands	11° 43’ 44”	142° 33’ 22”	riverine	B
Coen R. at Penninsula Development Rd	13° 55’ 22”	143° 11’ 37”	riverine	B
Condamine R. at Cecil Weir	27° 31’ 58”	151° 12’ 10”	reservoir	P, B
Condamine R. at Chinchilla Weir Pondage	26° 47’ 47”	150° 40’ 39”	riverine	P, B
Condamine R. at Connell’s Bridge	28° 09’ 34”	151° 50’ 50”	riverine	P, B
Condamine R. at Cotswold	27° 05’ 08”	149° 47’ 14”	riverine	P, B
Condamine R. at Elbow Valley	28° 22’ 12”	152° 08’ 37”	riverine	P, B
Condamine R. at Leslie Reserve	28° 10’ 10”	151° 55’ 15”	riverine	P, B
Condamine R. at McLean’s	27° 43’ 38”	151° 16’ 39”	riverine	P, B
Condamine R. at Rangers Bridge	27° 07’ 21”	151° 05’ 24”	riverine	P, B
Condamine R. at Sunnyside	27° 02’ 59”	149° 55’ 23”	riverine	P, B
Condamine R. at Talgai Tailwater	28° 00’ 08”	151° 45’ 52”	riverine	P, B
Condamine R. at Warwick	28° 12’ 52”	152° 02’ 54”	riverine	P, B
Condamine R. at Yarramalong	27° 50’ 05”	151° 26’ 57”	riverine	P, B
Coolmunda Dam	28° 26’ 10”	151° 12’ 40”	reservoir	P
Coomera R at Lamington Natl Park, Binna Burra Sect.	28° 10’ 03”	153° 10’ 07”	riverine	B

.....continued on the next page

Appendix 1. (Conintued)

Site	Latitude	Longitude	Biotope	Habitats
Coomera R d/s Yarrabilgong Falls, Lamington Natl Park	28° 13’ 08”	153° 10’ 59”	riverine	B
Coondoo Ck at Tin Can Bay Rd	25° 59’ 42”	152° 50’ 23”	riverine	B
Coonoongibber Ck at Kenilworth-Brooloo Rd	26° 30’ 46”	152° 41’ 57”	riverine	B
Cooperfield R. at Blackbrae	19° 27’ 59”	144° 09’ 32”	riverine	B
Coopers Ck Glenmurken Waterhole at Windorah	25° 26’ 52”	142° 40’ 43”	riverine	P, B
Coopers Ck Homestead Waterhole at Springfield	25° 49’ 28”	143° 02’ 36”	riverine	P, B
Coopers Ck Mayfield Waterhole at Windorah	25° 26’ 11”	142° 43’ 37”	riverine	P, B
Coopers Ck Murken Waterhole at Windorah	25° 25’ 47”	142° 43’ 58”	riverine	P, B
Coopers Ck One Mile Waterhole at Springfield	25° 50’ 42”	143° 03’ 07”	riverine	P, B
Coopers Ck Shed Waterhole at Hammond Downs	25° 23’ 42”	142° 49’ 39”	riverine	P, B
Coopers Ck Tanbar Waterhole at Tanbar	25° 50’ 13”	141° 55’ 00”	riverine	P, B
Coopers Ck Warrannee Waterhole at Springfield	25° 54’ 31”	143° 05’ 24”	riverine	P, B
Coopers Ck Yalungah Waterhole at Tanbar	25° 51’ 14”	141° 58’ 25”	riverine	P, B
Coopers Ck Yappi Waterhole at Tanbar	25° 48’ 58”	142° 01’ 42”	riverine	P, B
Coopers Ck Yorakah Waterhole at Tanbar	25° 57’ 31”	141° 52’ 42”	riverine	P, B
Coorparoo Ponds	27° 29’ 32”	153° 02’ 55”	palustrine wetland	B
Copperfield Dam	19° 02’ 20”	144° 07’ 34”	reservoir	P
Corella Dam	20° 18’ 05”	140° 08’ 35”	reservoir	P
Creek at Old Gympie Rd Landsborough	26° 48’ 03”	152° 58’ 24”	riverine	B
Crows Nest Ck at Crows Nest Natl Park	27° 15’ 32”	152° 06’ 47”	riverine	B
Culgoa R. at Cubbie	28° 36’ 41”	147° 58’ 50”	riverine	P, B
Culgoa R. at Ingie Bridge Rd	28° 40’ 11”	147° 48’ 18”	riverine	P, B
Culgoa R. at Whyenbah	28° 25’ 53”	148° 16’ 10”	riverine	P, B
Culgoa R. at Woolerbilla	28° 47’ 12”	147° 37’ 44”	riverine	P, B
Cunnamulla Bore #9 Turkey’s Nest	28° 07’ 04”	145° 11’ 41”	reservoir	B
Curbine Ck Mirage Waterhole at Mirage Plains	28° 40’ 25”	145° 36’ 16”	riverine	B
Curra Ck at Bruce Highway	26° 02’ 37”	152° 34’ 13”	riverine	B
Cuttaburra Ck Binya Waterhole at Binya	28° 52’ 25”	145° 32’ 41”	riverine	P, B
Cuttaburra Ck Rocky Waterhole at Glencoe	28° 19’ 25”	145° 38’ 44”	riverine	P, B
Cuttaburra Ck Tinnenburra Waterhole at Tinnenburra	28° 45’ 25”	145° 33’ 01”	riverine	P, B
Cylinder Beach wetland, North Stradbroke Is.	27° 25’ 32”	153° 32’ 04”	palustrine wetland	B
Doramera Ck at Tiaro Rd	25° 44’ 16”	152° 26’ 09”	riverine	B
Douglas Hot Springs at Tjuwaliyn Hot Springs Park	14° 16’ 25”	131° 09’ 21”	thermal	B
Dowse Lagoon	27° 08’ 15”	153° 03’ 50”	lacustrine wetland	P, B
East Leichhardt Dam	20° 16’ 31”	139° 16’ 32”	reservoir	P
Ed Camp16 spring	22° 43’ 54”	145° 25’ 51”	palustrine wetland	B
Edgbaston spring	25° 37’ 12”	152° 33’ 10”	palustrine wetland	B
Eighteen Mile Ck at Yerra Rd	18° 06’ 01”	143° 57’ 01”	riverine	B
Eighteen Mile Swamp at Budjong Djara Natl Park North Stradbroke Is.	25° 31’ 36”	153° 29’ 39”	lacustrine wetland	B, M
Einasleigh R. at The Beach	25° 17’ 41”	153° 13’ 21”	riverine	B
Eli Ck at Great Sandy Natl Park, Fraser Is. Sect.	11° 23’ 02”	142° 24’ 52”	riverine	B
Eliot Ck at Eliot Falls, Jardine R. Natl Park	11° 26’ 22”	142° 26’ 05”	riverine	B
Eliot Ck at Fruit Bat Falls, Jardine R. Natl Park	11° 21’ 48”	142° 24’ 06”	riverine	B
Eliot Ck at Telegraph Rd	18° 02’ 44”	144° 03’ 37”	riverine	B

.....continued on the next page

Appendix 1. (Conintued)

Site	Latitude	Longitude	Biotope	Habitats
Elizabeth Ck at The Oasis	16° 02’ 28”	145° 27’ 28”	riverine	B
Emmagen Ck at Cape Tribulation, Daintree Natl Park	26° 57’ 47”	152° 17’ 34”	riverine	B
Emu Ck	15° 25’ 55”	145° 06’ 58”	riverine	B
Endeavour R. at Jensen’s Crossing	27° 26’ 27”	152° 53’ 26”	riverine	B
Enogerra Ck	18° 52’ 54”	142° 33’ 44”	riverine	B
Esmerakda Ck at Esmeralda	27° 57’ 04”	144° 46’ 19”	riverine	B
Eulo GAB Spring Yowah3 at Bundoona	27° 57’ 08”	144° 46’ 11”	palustrine wetland	B
Eulo GAB Spring Yowah4 at Bundoona	27° 56’ 31”	144° 46’ 37”	palustrine wetland	B
Eulo GAB Spring Yowah5 at Bundoona	21° 08’ 13”	148° 23’ 10”	palustrine wetland	B
Eungella Dam	25° 30’ 48”	153° 07’ 34”	reservoir	P
Eurong Beach stream 1 at Great Sandy Natl Park, Fraser Is. Sect.	11° 45’ 14”	142° 35’ 16”	riverine	B
Everlasting Spring	26° 47’ 43”	152° 59’ 42”	riverine	B
Ewen Maddock Wetlands	23° 39’ 25”	148° 03’ 54”	palustrine wetland	B
Fairbairn Dam	26° 07’ 03”	152° 17’ 20”	reservoir	P
Fat Hen Ck at Kilkivan	26° 06’ 59”	152° 17’ 24”	riverine	B
Fitzroy R. at Alligator Ck Junction	23° 20’ 31”	148° 52’ 12”	riverine	B
Fitzroy R. at Bedford Weir	23° 05’ 06”	149° 01’ 48”	reservoir	P
Fitzroy R. at Bingegang Weir	23° 05’ 25”	150° 07’ 05”	reservoir	P
Fitzroy R. at Eden Bann Weir	25° 27’ 43”	150° 01’ 34”	reservoir	P
Fitzroy R. at Glebe Weir	24° 35’ 12”	149° 54’ 20”	reservoir	P
Fitzroy R. at Moura Weir	24° 09’ 57”	149° 49’ 43”	reservoir	P
Fitzroy R. at Neville Hewitt Weir	22° 56’ 53”	149° 25’ 05”	reservoir	P
Fitzroy R. at Tartrus Weir	24° 56’ 39”	150° 04’ 06”	reservoir	P
Fitzroy R. at Theodore Weir	27° 25’ 21”	153° 29’ 58”	reservoir	P
Flinders Swamp, North Stradbroke Is.	24° 52’ 15”	151° 51’ 08”	palustrine wetland	B
Fred Haigh Dam	12° 39’ 27”	142° 51’ 01”	reservoir	P, B, M
Frenchmans Spring #1	12° 39’ 45”	142° 55’ 25”	riverine	B
Frenchmans Spring #2	25° 59’ 48”	153° 08’ 26”	riverine	B
Freshwater L. at Great Sandy Natl Park, Cooloola Sect.	12° 45’ 18”	143° 06’ 20”	lacustrine wetland	P, B
Garraway Ck at Portland’s Rd	20° 45’ 18”	147° 56’ 24”	riverine	B
Gattonvale offstream storage	25° 33’ 03”	153° 06’ 40”	reservoir	P
Geronwweea Ck at the mouth, Great Sandy Natl Park, Fraser Is. Sect.	26° 13’ 04”	152° 31’ 16”	riverine	B
Gladstonbury Ck at Gladstonbury	28° 15’ 17”	151° 21’ 09”	riverine	B
Glen Niven Dam	28° 58’ 05”	151° 27’ 36”	reservoir	P
Glenlyon Dam	29° 27’ 32”	148° 42’ 42”	reservoir	P
Gnungarah Ck at Bellevue	19° 30’ 34”	147° 06’ 41”	riverine	B
Haughton R. at Giru Weir	12° 38’ 28”	142° 48’ 07”	reservoir	P
Heineman Lagoon	12° 38’ 31”	142° 48’ 06”	lacustrine wetland	P, B
Heineman Spring	25° 14’ 07”	153° 10’ 14”	riverine	B
Hidden L. at Great Sandy Natl Park, Fraser Is. Sect.	28° 03’ 01”	153° 17’ 02”	lacustrine wetland	P
Hinze Dam	27° 25’ 36”	153° 31’ 59”	reservoir	P
Home Beach Swamp at North Stradbroke Is.	27° 05’ 48”	153° 26’ 01”	palustrine wetland	B
Honey Eater L., Moreton Is. Natl Park, Moreton Is.	10° 37’ 39”	142° 18’ 39”	lacustrine wetland	P, B, M
Horn Is. Dam	25° 35’ 34”	152° 22’ 33”	reservoir	P

.....continued on the next page

Appendix 1. (Conintued)

Site	Latitude	Longitude	Biotope	Habitats
Hunters Hut Ck at Hunters Hut Ck Rd Xing #1	17° 09’ 13”	145° 04’ 29”	riverine	B
Ibis Dam	11° 06’ 12”	142° 17’ 02”	reservoir	P
Jardine R. at Penninsula Development Rd, Jardine R. Natl Park	20° 11’ 14”	139° 43’ 47”	riverine	B
Julius Dam	17° 08’ 39”	145° 04’ 50”	reservoir	P
Jumna Dam	26° 23’ 33”	152° 38’ 35”	reservoir	P
Kandanga Ck at Hygait	21° 12’ 33”	148° 53’ 56”	riverine	B
Kinchant Dam	24° 51’ 29”	152° 04’ 23”	reservoir	P
Kolan R. at Bucca Weir	25° 12’ 23”	153° 12’ 33”	reservoir	P
Lake Allom at Great Sandy Natl Park, Fraser Is. Sect.	12° 38’ 24”	132° 41’ 47”	lacustrine wetland	P
Lake Bennett	27° 21’ 09”	151° 05’ 34”	lacustrine wetland	P, B
Lake Broadwater via Dalby	31° 32’ 50”	152° 51’ 14”	lacustrine wetland	P, B
Lake Cathie	27° 31’ 00”	152° 20’ 60”	lacustrine wetland	B
Lake Clarendon	25° 13’ 25”	153° 10’ 06”	reservoir	P
Lake Coomboo at Great Sandy Natl Park, Fraser Is. Sect.	17° 17’ 09”	145° 37’ 29”	lacustrine wetland	P
Lake Eacham at Crater Lakes Natl Park	21° 32’ 24”	148° 14’ 12”	lacustrine wetland	P
Lake Elphinstone	25° 19’ 38”	153° 09’ 23”	lacustrine wetland	P, B
Lake Garawongera at Great Sandy Natl Park, Fraser Is. Sect.	25° 29’ 40”	153° 03’ 19”	riverine	P
Lake Jennings at Great Sandy Natl Park, Fraser Is. Sect.	26° 25’ 00”	152° 55’ 00”	lacustrine wetland	P, B
Lake MacDonald	23° 53’ 53”	151° 15’ 23”	reservoir	P, B, M
Lake Toondoon at Gladstone Toondoon Botanic Gardens	25° 27’ 54”	153° 07’ 51”	palustrine wetland	B
Lake Wabby at Great Sandy Natl Park, Fraser Is. Sect.	18° 41’ 45”	138° 29’ 13”	lacustrine wetland	P, B
Lawn Hill Ck at Lawn Hill Natl Park	20° 34’ 54”	139° 34’ 13”	riverine	B
Leichardt R. at L. Moondarra	28° 08’ 37”	153° 17’ 06”	reservoir	P
Little Nerang Dam	18° 16’ 24”	142° 41’ 08”	reservoir	P
Little R. at Gulf Development Rd	26° 37’ 25”	152° 41’ 23”	riverine	B
Little Yabba Ck at Maleny Kenilworth Rd Crossing	27° 26’ 43”	152° 34’ 17”	riverine	B
Lockyer Ck	25° 40’ 37”	152° 41’ 03”	riverine	B
Logging Ck upstream Tinana Ck	17° 25’ 44”	145° 11’ 60”	riverine	B
Loudon Dam	28° 39’ 53”	150° 20’ 11”	reservoir	P
Macintyre R. floodplain Maynes Lagoon at Parkdale	28° 40’ 33”	150° 29’ 21”	riverine	B
Macintyre R. Ironbark Waterhole at u/s Toomelah	28° 41’ 18”	149° 23’ 33”	riverine	B
Macintyre R. Kanowna Waterhole at Jericho	12° 27’ 23”	142° 55’ 44”	riverine	B
Maloney Springs	27° 43’ 38”	148° 28’ 20”	riverine	B
Maranoa R. at Cashmere	27° 32’ 53”	148° 22’ 27”	riverine	P, B
Maranoa R. at Jillambie Rd	27° 15’ 44”	148° 4’ 19”	riverine	P, B
Maranoa R. at Woodlands	26° 58’ 43”	152° 20’ 01”	riverine	P, B
Maronghi Ck	28° 11’ 02”	152° 39’ 50”	riverine	B
Maroon Dam	26° 22’ 06”	152° 44’ 29”	reservoir	P
Mary R. at Carlson Rd Pump Station	26° 10’ 25”	152° 35’ 56”	riverine	P, B
Mary R. at Fishermans Pocket	26° 38’ 35”	152° 41’ 06”	riverine	P, B
Mary R. at Gregor Bridge	26° 11’ 60”	152° 39’ 36”	riverine	P, B
Mary R. at Gympie	25° 45’ 58”	152° 31’ 41”	riverine	P, B
Mary R. at Home Park	25° 57’ 19”	152° 29’ 45”	riverine	P, B
Mary R. at Miva	26° 30’ 54”	152° 44’ 38”	riverine	P, B
Mary R. at Moy Pocket	25° 38’ 54”	152° 37’ 17”	riverine	P, B

.....continued on the next page

Appendix 1. (Conintued)

Site	Latitude	Longitude	Biotope	Habitats
Mary R. at Owanyilla Pump Station	25° 43’ 26”	152° 34’ 31”	riverine	P, B
Mary R. at Tairo Water Intake	26° 02’ 13”	152° 30’ 36”	riverine	P, B
Mary R. at Yarrum Loop	14° 55’ 33”	133° 08’ 51”	riverine	P, B
Mataranka Springs	27° 28’ 58”	153° 06’ 55”	thermal	B
Minnippi Lagoon at Minnippi Parklands	16° 33’ 45”	144° 53’ 25”	palustrine wetland	P, B
Mitchell R. at Cooktown Crossing	28° 01’ 16”	152° 32’ 42”	riverine	B
Monterey Keys at Helensvale	27° 53’ 14”	153° 20’ 32”	lacustrine wetland	P
Moogerah Dam	25° 12’ 59”	153° 03’ 45”	reservoir	B
Moon Point Fens at Great Sandy Natl Park, Fraser Is. Sect.	29° 09’ 07”	148° 37’ 41”	palustrine wetland	B
Mooni R. Goondoobluie Waterhole at Goondoobluie	29° 12’ 35”	148° 38’ 34”	riverine	P, B
Mooni R. Tchuringa Waterhole at Tchuringa	28° 39’ 33”	150° 16’ 14”	riverine	P, B
Morella Watercourse Punbougal Lagoon at Korolea	16° 28’ 23”	145° 19’ 42”	riverine	P, B
Mossman R. at Mossman Gorge, Daintree Natl Park	28° 14’ 19”	152° 43’ 46”	riverine	B
Mt Barney Ck at Lower Portoles, Mt Barney Natl Park	25° 37’ 12”	152° 13’ 49”	riverine	B
Munna Ck at Haynesmere Bridge	25° 43’ 60”	152° 17’ 42”	riverine	B
Munna Ck at Kolbor Rd Xing	25° 55’ 33”	152° 25’ 51”	riverine	B
Munna Ck at Munna Ck 3rd Xing (West)	23° 08’ 33”	150° 10’ 21”	riverine	B
Murray Lagoon	25° 37’ 46”	152° 30’ 40”	lacustrine wetland	P
Myrtle Ck at Jacobsens Rd	12° 57’ 36”	131° 09’ 57”	riverine	B
Nanambu Ck at Kakadu Natl Park	28° 50’ 45”	148° 03’ 10”	riverine	B
Narran R. at Dirrandandi-Hebel Rd	22° 43’ 12”	145° 26’ 21”	riverine	P, B
Nerang R. at Numingbah State Forest Park	28° 09’ 07”	152° 59’ 40”	riverine	B
Nettle Ck at Innot Hot Springs	17° 39’ 56”	145° 14’ 21”	thermal	B
Noorama Ck Noorama Waterhole at Noorama	28° 44’ 26”	146° 14’ 05”	riverine	P, B
North Johnstone R. at Malanda Falls	17° 21’ 22”	145° 35’ 07”	riverine	B
Northbrook Ck	27° 18’ 21”	152° 40’ 56”	riverine	B
Obi Obi Ck at Aplin Rd	26° 46’ 19”	152° 48’ 37”	riverine	B
Obi Obi Ck at Obi Obi Ck Crossing #4	26° 39’ 04”	152° 48’ 47”	riverine	B
Ocean L. at Great Sandy Natl Park, Fraser Is. Sect.	24° 55’ 32”	153° 16’ 35”	riverine	P
Palmer R. at Gum Ck	16° 06’ 05”	144° 30’ 24”	riverine	B
Palmer R. at NESP Purple	16° 03’ 13”	144° 17’ 06”	riverine	B
Palmer R. at NESP Red	15° 56’ 17”	143° 59’ 04”	riverine	B
Paradise Dam	25° 21’ 00”	151° 55’ 07”	reservoir	P
Pascoe R. at Fall Ck	12° 52’ 49”	142° 58’ 60”	riverine	B
Pascoe R. at Spring #1	12° 44’ 04”	143° 03’ 37”	riverine	B
Peter Faust Dam	20° 21’ 54”	148° 22’ 41”	reservoir	P
Pie Ck at Lorensen Bridge	26° 13’ 04”	152° 37’ 36”	riverine	B
Pinnacle Ck at Torwood	17° 26’ 06”	143° 53’ 08”	riverine	B
Pioneer R. at Dumbleton Weir	21° 08’ 46”	149° 04’ 34”	reservoir	P
Pioneer R. at Marian Weir	21° 08’ 35”	148° 55’ 59”	reservoir	P
Pioneer R. at Mirani Weir	21° 10’ 48”	148° 49’ 37”	reservoir	P
Pool Ck at Talaroo	18° 07’ 09”	142° 57’ 43”	riverine	B
Poona L. at Great Sandy Natl Park, Cooloola Sect.	25° 57’ 51”	154° 04’ 13”	lacustrine wetland	P, B
Porcupine Ck at Porcupine Gorge Natl Park	20° 21’ 14”	144° 27’ 56”	riverine	B
Purling Brook at Warringa Pool	28° 10’ 49”	153° 16’ 06”	riverine	B

.....continued on the next page

Appendix 1. (Conintued)

Site	Latitude	Longitude	Biotope	Habitats
Rainbow Beach Fen, Great Sandy Natl Park, Cooloola Sect.	25° 55’ 08”	153° 04’ 43”	palustrine wetland	B
Red Mud Pond at Boyne Is.	27° 49’ 17”	151° 25’ 60”	lacustrine wetland	B
Reedy Ck	27° 07’ 48”	152° 38’ 24”	riverine	B
Rocky Waterholes Ck	27° 32’ 44”	153° 01’ 00”	riverine	B
Running Ck at Biggenden Rd Crossing	25° 56’ 10”	152° 19’ 48”	riverine	B
Saltwater Ck at Bruce Highway	25° 28’ 11”	152° 39’ 24”	riverine	B
Sandy Ck	27° 13’ 29”	152° 33’ 19”	riverine	B
Sandy Ck at Bauple-Woolooga Rd	25° 53’ 14”	152° 18’ 14”	riverine	B
Sandy Ck at Inndooroolabah Rd Xing	25° 41’ 48”	152° 07’ 26”	riverine	B
Saucepan Spring at Eliot Ck	11° 23’ 11”	142° 24’ 57”	riverine	B
Scrub Turkey Ck at Missings Rd Xing	25° 48’ 38”	152° 39’ 22”	riverine	B
Searys Ck at Bracken Log, Great Sandy Natl Park, Cooloola Sect.	25° 58’ 29”	153° 04’ 19”	riverine	B
Serpentine Ck at Wide Bay Highway	26° 5’ 35”	152° 21’ 29”	riverine	B
Sheep Station Ck	26° 52’ 01”	152° 31’ 29”	riverine	B, M
Six Mile Ck at Bajool Weir	23° 38’ 23”	150° 40’ 40”	reservoir	P
Six Mile Ck at Bruce Highway	26° 14’ 20”	152° 41’ 37”	riverine	B
Six Mile Ck at Old Noosa Rd	26° 19’ 54”	152° 48’ 29”	riverine	B
Six Mile Ck at Ooralat	17° 58’ 24”	143° 58’ 49”	riverine	B
Soda Springs	14° 25’ 41”	142° 50’ 59”	riverine	B
South Amamoor Ck at Amamoor Range West	26° 22’ 29”	152° 30’ 12”	riverine	B
South Maclean Weir	27° 28’ 54”	153° 00’ 44”	reservoir	P
South Pine R. at Carter Court	27° 21’ 03”	152° 56’ 03”	riverine	B, M
South Pine R.	27° 21’ 03”	152° 56’ 03”	riverine	B
South Pine R. at Bunya Crossing Reserve	27° 21’ 12”	152° 57’ 03”	riverine	B
Spring Ck at Bauple-Woolooga Rd	25° 44’ 36”	152° 14’ 22”	riverine	B
Spring Ck at Gulf Development Rd	18° 14’ 26”	142° 44’ 02”	riverine	B
Spring L. at Springfield	27° 40’ 03”	152° 55’ 05”	lacustrine wetland	P, B
Stag Ck Weir	24° 18’ 24”	150° 48’ 35”	reservoir	P
Swallow Lagoon, North Stradbroke Is.	27° 29’ 55”	153° 27’ 17”	lacustrine wetland	P, B
Tallaroo Hot Springs	18° 07’ 09”	143° 57’ 40”	thermal	B
Tallaroo Hot Springs at Baby Vent	18° 07’ 08”	143° 57’ 41”	thermal	B
Tallaroo Hot Springs at Hot Stuff Vent	18° 07’ 08”	143° 57’ 41”	thermal	B
Tallaroo Hot Springs at Junior Vent	18° 07’ 08”	143° 57’ 41”	thermal	B
Tallaroo Hot Springs at Low Vent	18° 07’ 09”	143° 57’ 41”	thermal	B
Tallaroo Hot Springs at Top Vent	18° 07’ 09”	143° 57’ 41”	thermal	B
Tallaroo Hot Springs at Wallaby Vent	18° 07’ 09”	143° 57’ 40”	thermal	B
Tate R. at Torwood	17° 21’ 37”	143° 44’ 21”	riverine	B
Teebar Ck at Bauple-Woolooga Rd	25° 42’ 18”	152° 12’ 01”	riverine	B
Teemburra Dam	21° 13’ 02”	148° 39’ 53”	reservoir	P
Thomson R. at Longreach	23° 24’ 18”	144° 14’ 39”	riverine	P, B
Thomson R. Bottom Waterhole at Noonbah	24° 11’ 03”	143° 21’ 06”	riverine	P, B
Thomson R. Pelican Waterhole at Noonbah	24° 13’ 35”	143° 20’ 06”	riverine	P, B
Thomson R. Top Waterhole at Noonbah	24° 16’ 31”	143° 18’ 08”	riverine	P, B
Thomson R. Waterloo Waterhole at Noonbah	24° 13’ 38”	143° 17’ 23”	riverine	P, B
Thurrulgoonia Ck Disco Waterhole at Thurrulgoonia	28° 48’ 25”	145° 58’ 36”	riverine	P, B

.....continued on the next page

Appendix 1. (Conintued)

Site	Latitude	Longitude	Biotope	Habitats
Thurrulgoonia Ck Thurrulgoonia Homestead Waterhole at Thurrulgoonia	28° 45’ 25”	145° 56’ 09”	riverine	P, B
Tinana Ck at Barrage Highway	25° 34’ 25”	152° 42’ 58”	riverine	B
Tinana Ck at Bauple East	25° 49’ 19”	152° 43’ 16”	riverine	B
Tinana Ck at Tagigan Rd	26° 04’ 45”	152° 46’ 57”	riverine	B
Tinana Ck at Teddington Weir	25° 40’ 48”	152° 39’ 47”	reservoir	B
Tinana Ck at Tuan State Forest	25° 53’ 32”	152° 45’ 15”	riverine	B
Tinaroo Falls Dam	17° 09’ 55”	145° 32’ 50”	reservoir	B
Tingalpa Ck at Venmans Bushland Natl Park	27° 37’ 56”	153° 12’ 17”	riverine	B
Toogoom Lagoon at Northshore	25° 16’ 37”	152° 46’ 02”	lacustrine wetland	B
Tortoise Lagoon at Budjong Djara Natl Park North Stradbroke Is.	27° 31’ 32”	153° 28’ 39”	lacustrine wetland	B
Unnamed palustrine wetland	12° 01’ 51”	142° 41’ 22”	lacustrine wetland	B
Wallaby Ck at Talaroo	18° 07’ 07”	143° 57’ 42”	riverine	B
Wallaby Ck	26° 53’ 50”	152° 16’ 39”	riverine	B
Walsh R. at Wrotham	16° 49’ 53”	143° 57’ 55”	riverine	B
Wanggoolba Ck at Great Sandy Natl Park, Fraser Is. Sect.	25° 28’ 24”	153° 03’ 14”	riverine	B
Warrego R. at Allan Tannock Weir	28° 07’ 01”	145° 41’ 08”	reservoir	P, B
Warrego R. Clear Waterhole at Quilberry	27° 06’ 25”	145° 57’ 27”	riverine	P, B
Warrego R. Glencoe Waterhole at Glencoe	28° 14’ 25”	145° 42’ 52”	riverine	P, B
Warrego R. Key Waterhole at Glencoe	28° 21’ 25”	145° 43’ 39”	riverine	P, B
Warrego R. Quilberry Waterhole at Quilberry	27° 06’ 25”	145° 55’ 23”	riverine	P, B
Warrego R. Red Waterhole at Binya	28° 49’ 25”	145° 37’ 49”	riverine	P, B
Warrego R. Sandford Park Lagoon at Sandford Park	26° 57’ 26”	146° 02’ 14”	riverine	P, B
Warrego R. Sandford Park Waterhole at Sandford Park	26° 56’ 26”	146° 01’ 60”	riverine	P, B
Weir R. floodplain Wolonga Lagoon at Wolonga	28° 36’ 25”	149° 24’ 28”	riverine	P, B
Weir R. Mill Waterhole at Jericho	28° 38’ 51”	149° 21’ 57”	riverine	P, B
Weir R. Newinga Waterhole at Newinga	28° 35’ 04”	149° 26’ 25”	riverine	P, B
Welsby Lagoon, North Stradbroke Is.	27° 26’ 12”	153° 27’ 18”	palustrine wetland	P, B, M
Wenlock R. at Heineman Spring	12° 38’ 28”	142° 47’ 59”	riverine	B
Wenlock R. at Moreton	12° 27’ 20”	142° 38’ 26”	riverine	B
West Barron Main Channel at Mareeba	17° 01’ 09”	145° 20’ 60”	riverine	B
Whalan Ck at Merawah	28° 40’ 39”	150° 25’ 11”	riverine	B
Wide Bay Ck at Bauple-Woolooga Rd	26° 00’ 41”	152° 22’ 46”	riverine	B
Wide Bay Ck at Kilkivan	26° 04’ 52”	152° 13’ 05”	riverine	B
Widgee Ck at Gympie/Kilkevan Rd	26° 05’ 41”	152° 30’ 31”	riverine	B
Wivenhoe Dam	27° 23’ 47”	152° 36’ 08”	reservoir	P, B, M
Woggonorra Ck Woggonorra Waterhole at Glencoe	28° 21’ 25”	145° 41’ 42”	riverine	B
Wolvi Ck at Pomona/KinKin Rd	26° 10’ 60”	152° 53’ 51”	riverine	B
Wuruma Dam	25° 11’ 56”	150° 59’ 28”	reservoir	P
Wyndham Dam	17° 35’ 15”	145° 08’ 23”	reservoir	P
Yabba Ck at Bella Ck Rd	26° 29’ 30”	152° 35’ 16”	riverine	B
Yabba Ck at Biddle Rd	26° 27’ 07”	152° 41’ 36”	riverine	B
Yabba Ck at Grazing Lease N/W Jimna	26° 36’ 50”	152° 25’ 55”	riverine	B
Yabba Ck at Stirling’s Crossing	26° 29’ 45”	152° 37’ 58”	riverine	B
Yellow Patch Lagoon at Moreton Is. Natl Park, Moreton Is.	27° 01’ 37”	153° 26’ 51”	palustrine wetland	B
Yeppen Yeppen Lagoon	23° 8’ 39”	150° 10’ 21”	lacustrine wetland	P, B

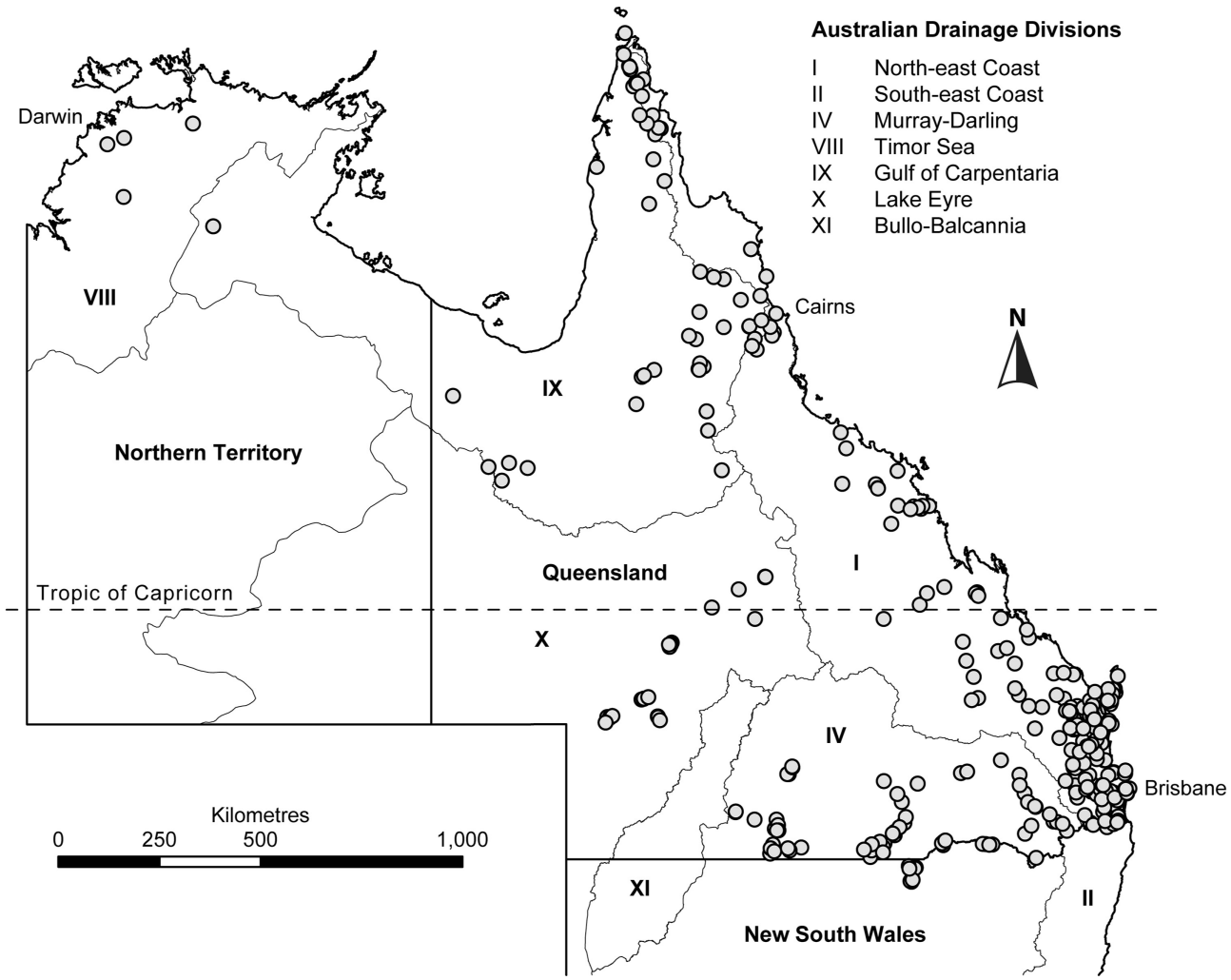

FIGURE 1. North-eastern Australia, showing the major drainage divisions, and the location of sampling sites.

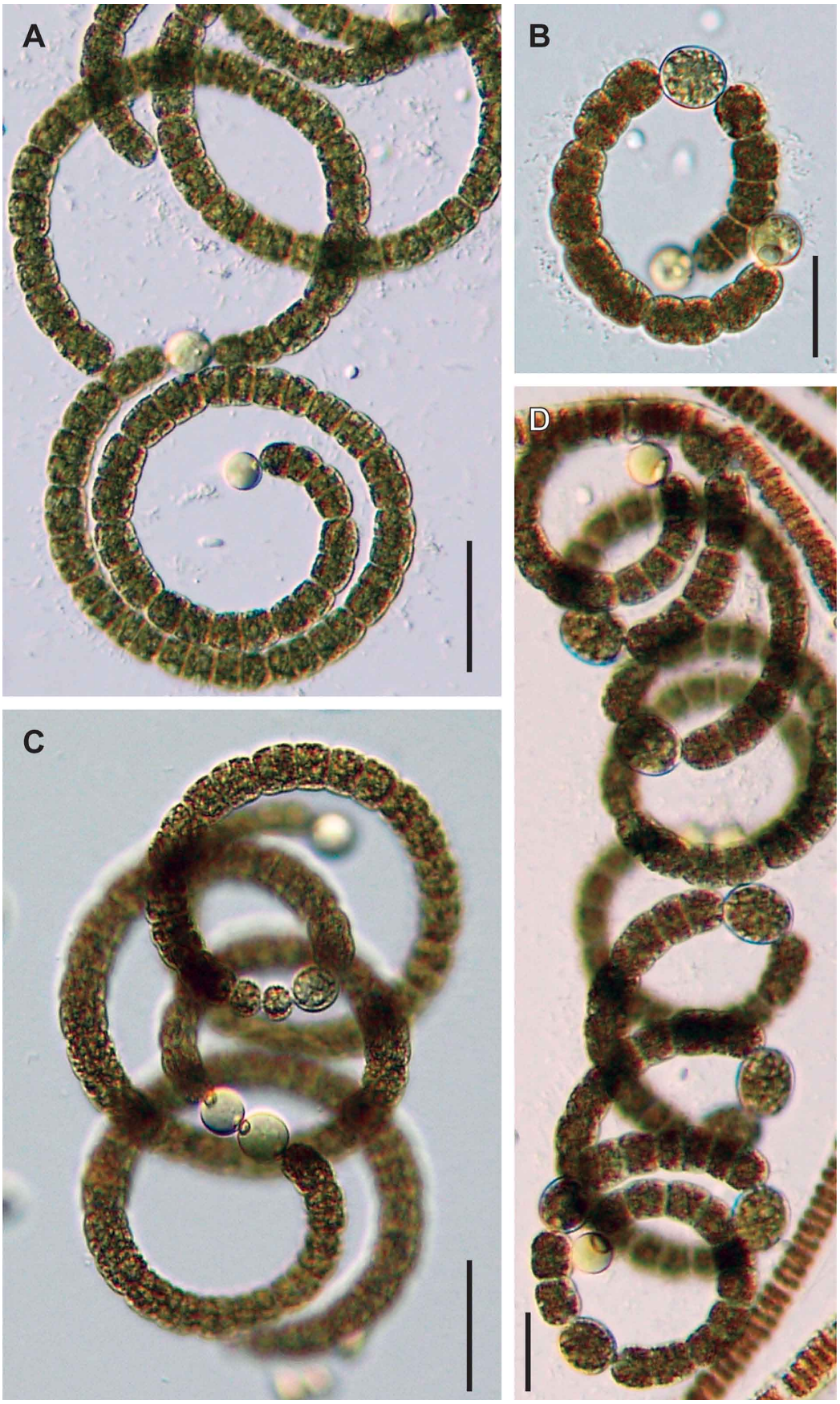

FIGURE 2. A–D *Anabaenopsis arnoldii*. Scale bars = 20 µm

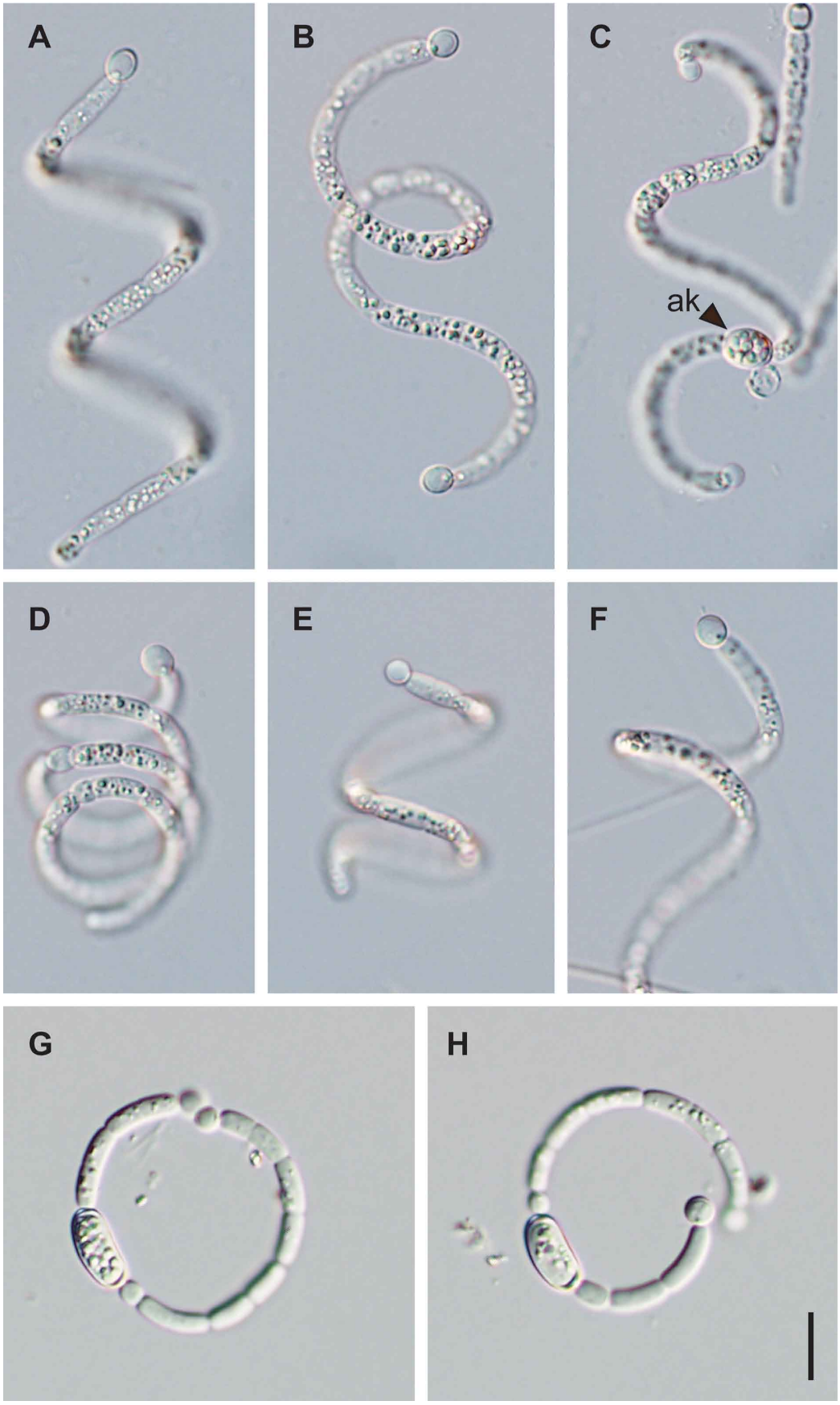

FIGURE 3. A–F *Anabaenopsis tanganyikae* (ak = akinete); G–H *Anabaenopsis circularis*. Scale bars = 20 µm

FIGURE 4. A–D *Anabaenopsis elenkinii*. Scale bars = 20 µm

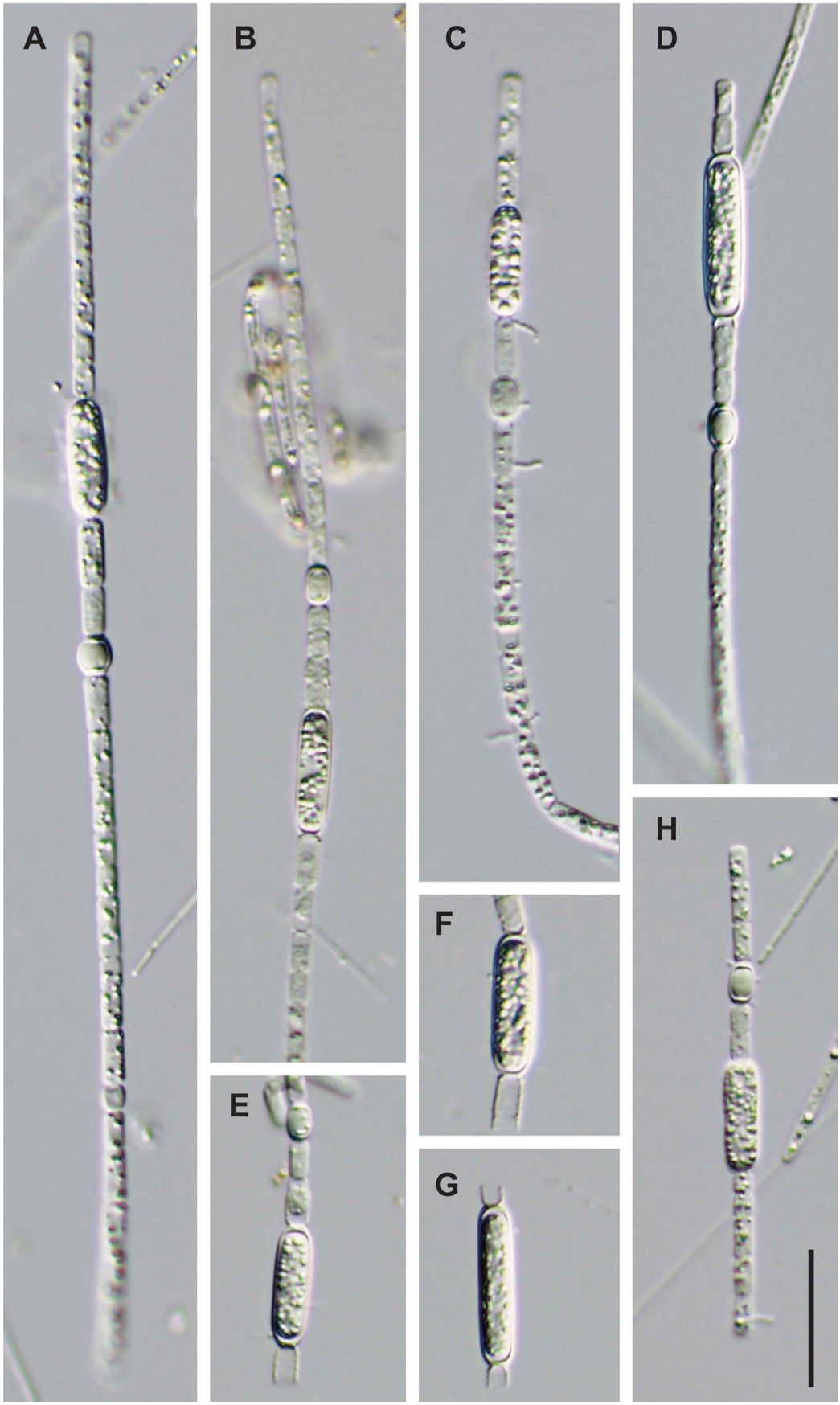

FIGURE 5. A–H *Aphanizomenon gracile*. Scale bars = 20 µm

FIGURE 6. A–E *Chrysosporum bergii*. Scale bars = 20 µm

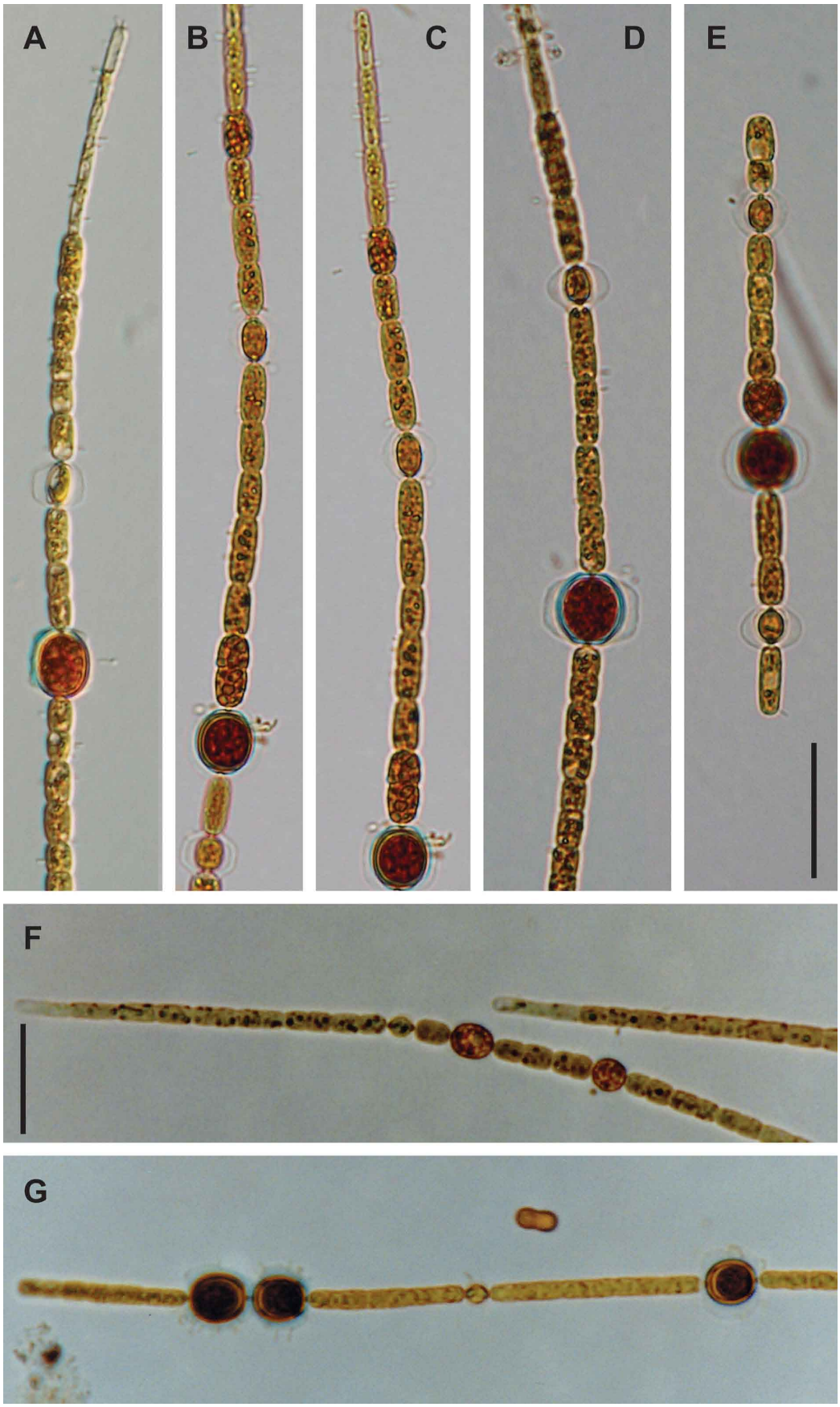

FIGURE 7. A–G *Chrysosporum ovalisporum*. Scale bars = 20 µm

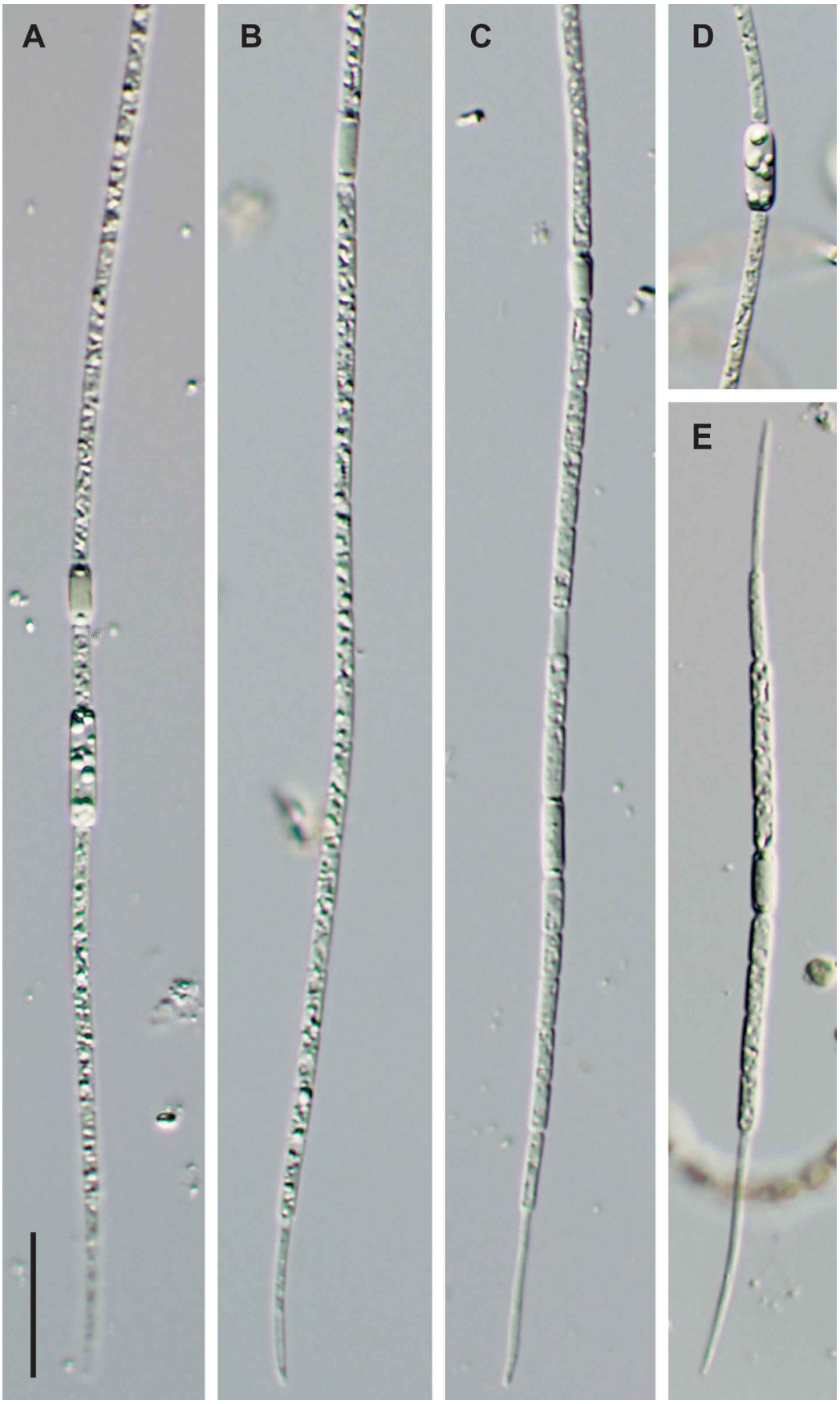

FIGURE 8. A–E *Cuspidothrix issatschenkoi*. Scale bars = 20 µm

FIGURE 9. A–D *Dolichospermum affine*. Scale bars = 20 µm

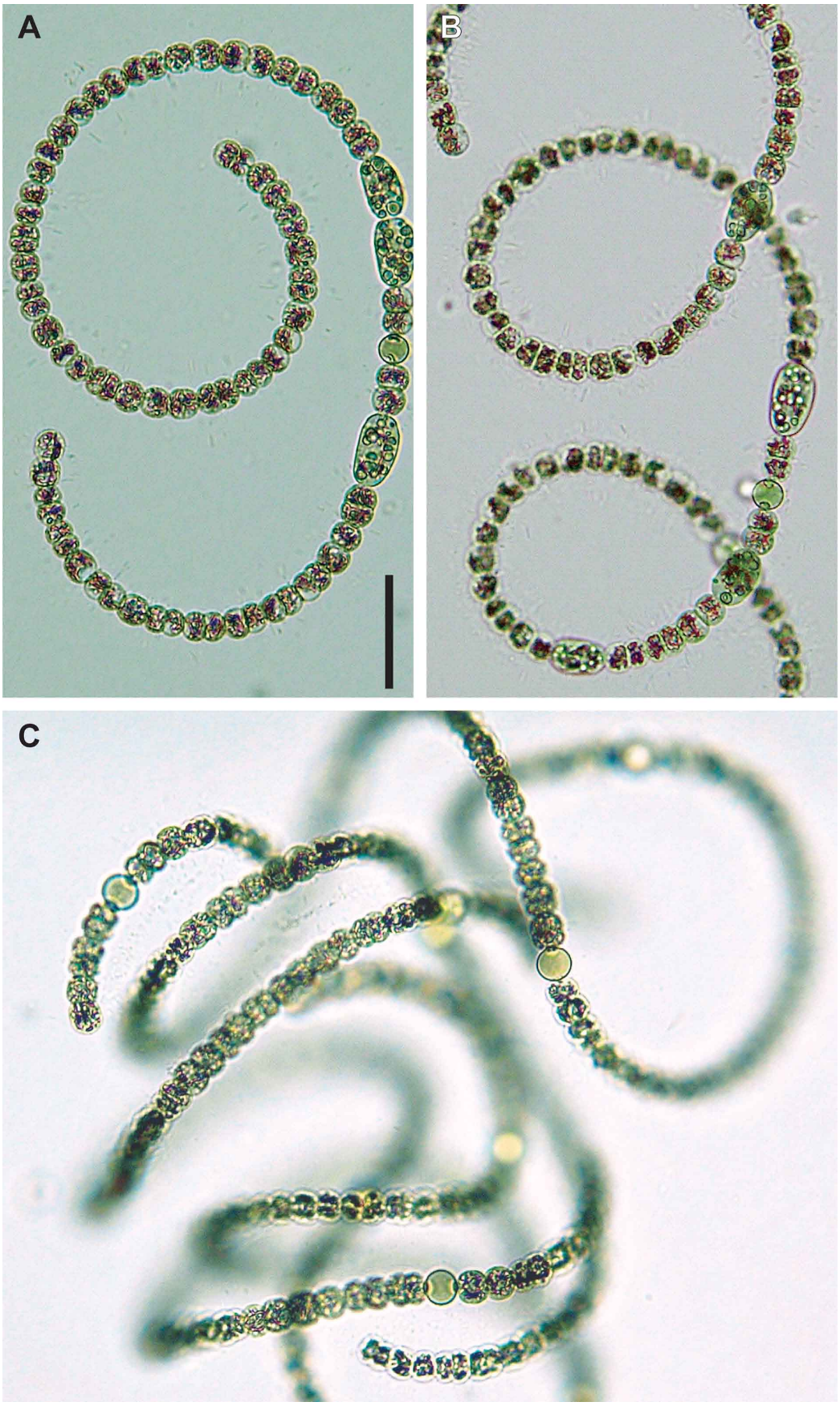

FIGURE 10. A–C *Dolichospermum circinale*. Scale bars = 20 µm

FIGURE 11. A–E *Dolichospermum crassum*. Scale bars = 20 µm

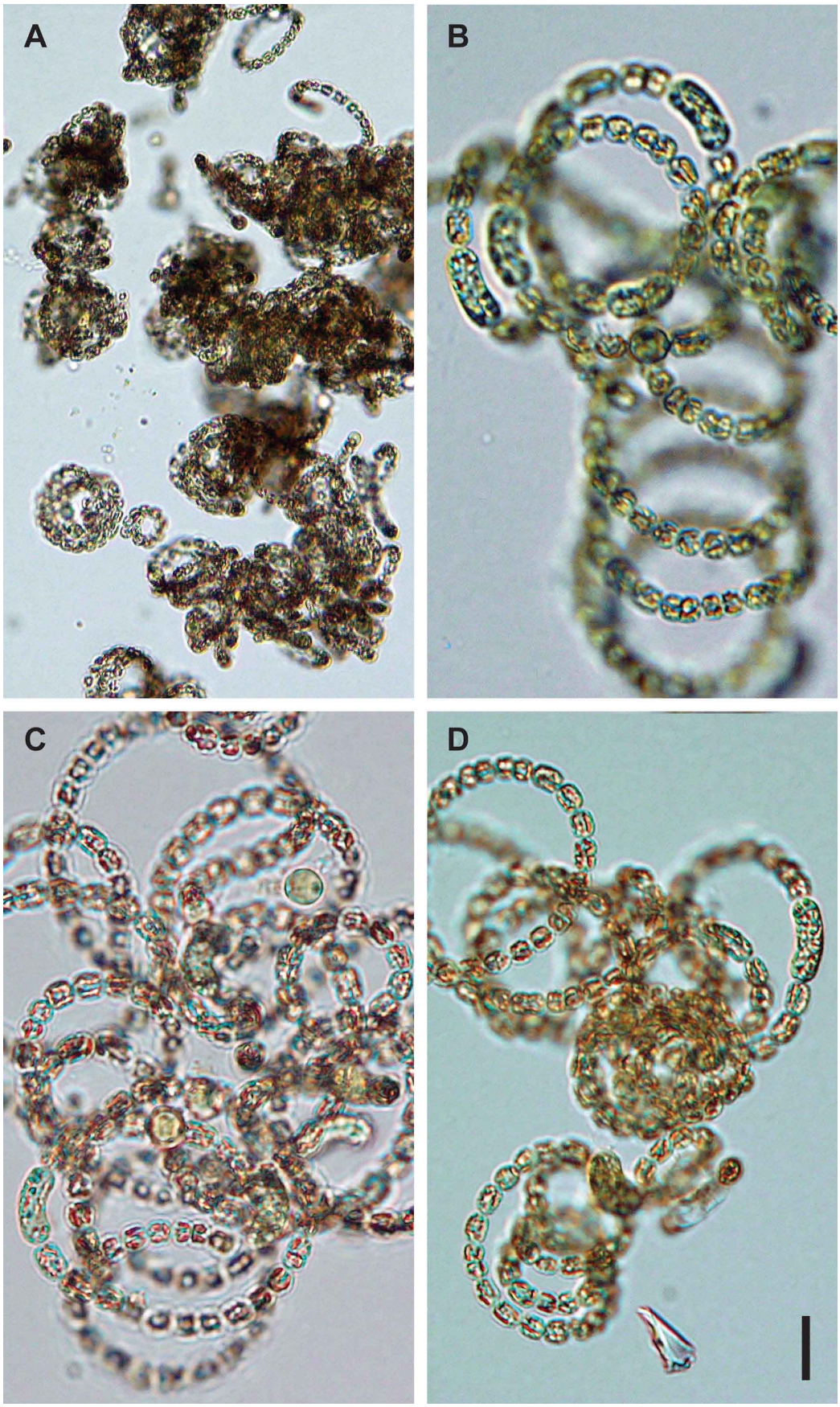

FIGURE 12. A–D *Dolichospermum flosaquae*. Scale bars = 20 µm

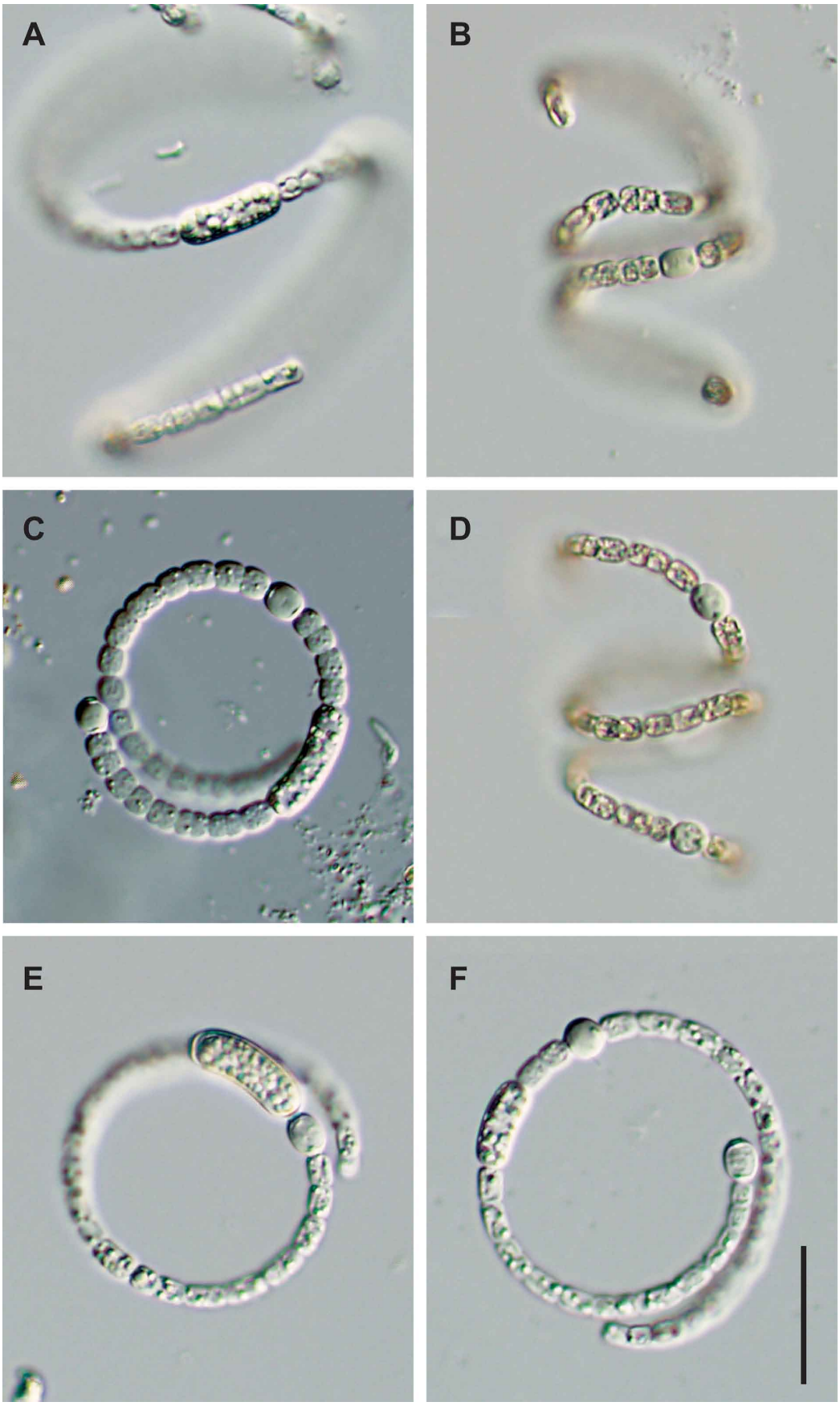

FIGURE 13. A–F *Dolichospermum helicoideum*. Scale bars = 20 µm

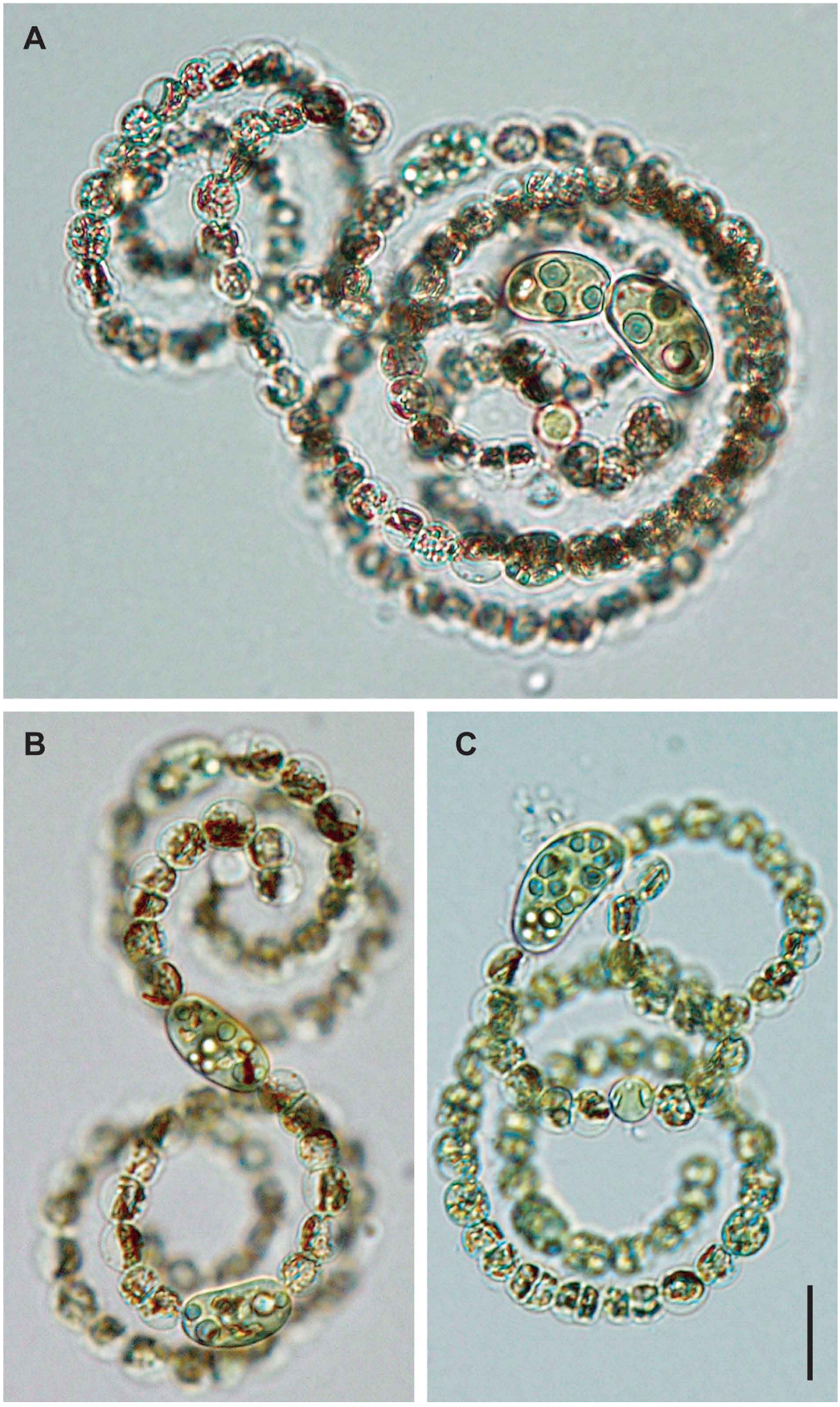

FIGURE 14. A–C *Dolichospermum perturbatum*. Scale bars = 20 µm

FIGURE 15. A–C *Dolichospermum planctonicum*. Scale bars = 20 µm

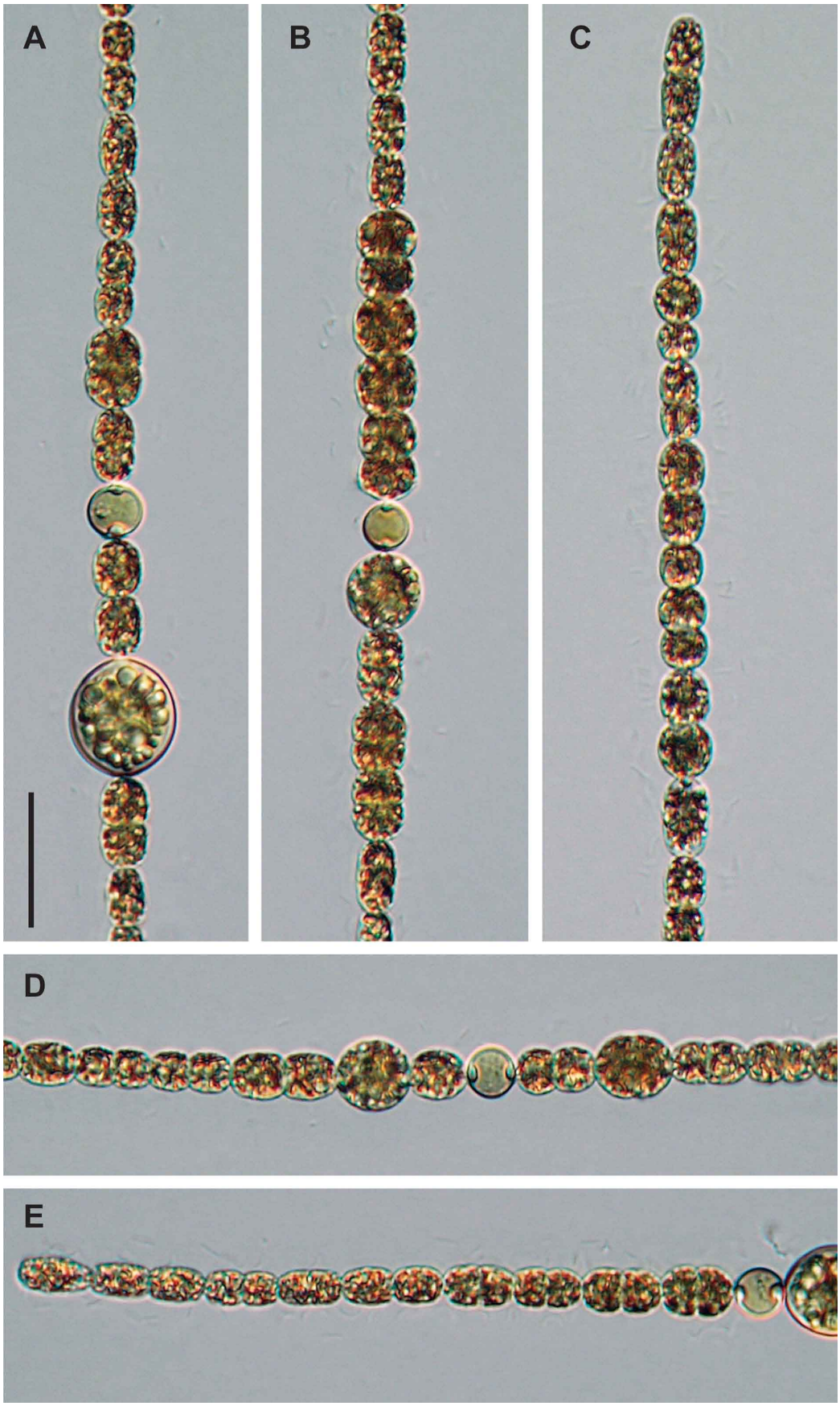

FIGURE 16. A–E *Dolichospermum smithii*. Scale bars = 20 µm

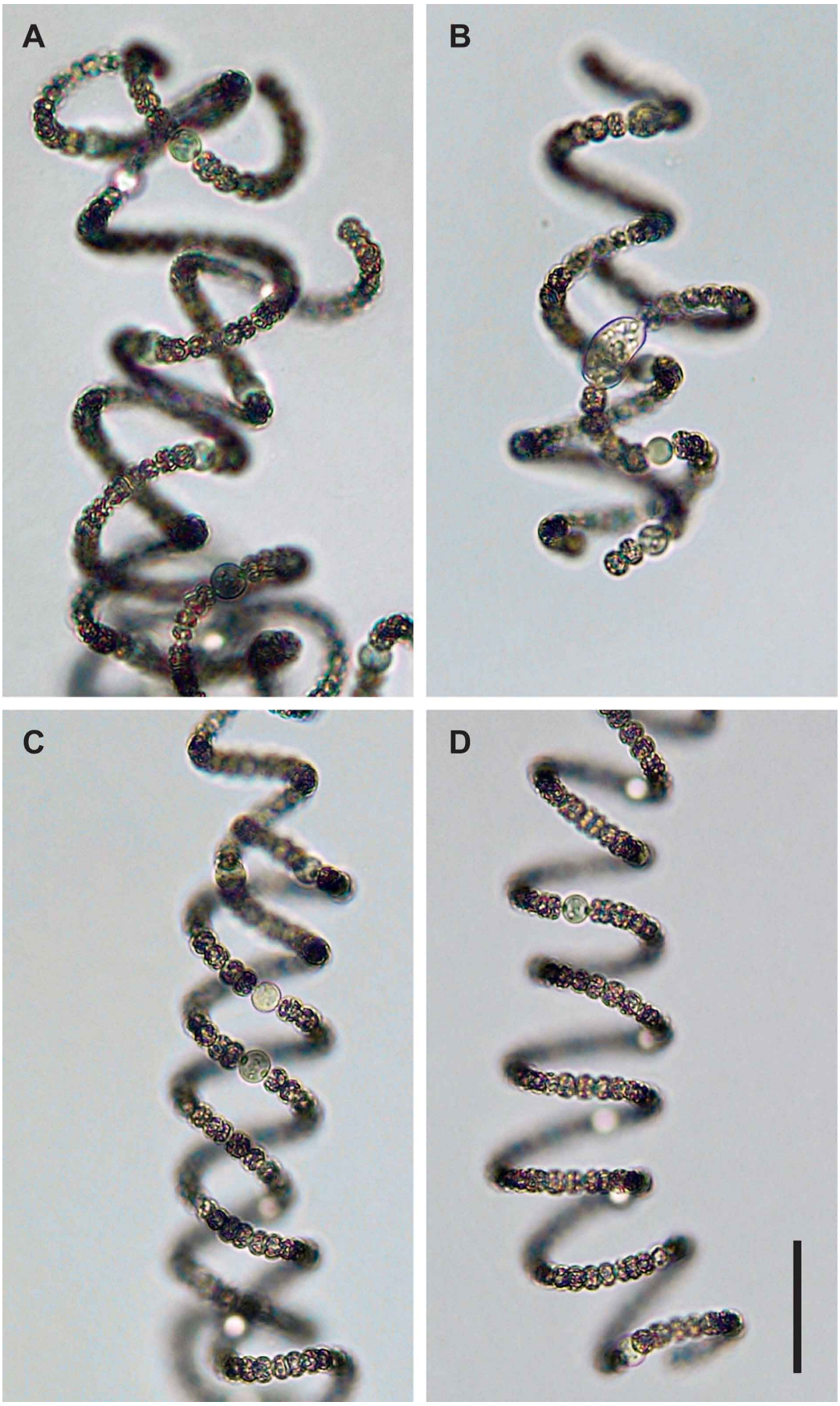

FIGURE 17. A–D *Dolichospermum spiroides*. Scale bars = 20 µm

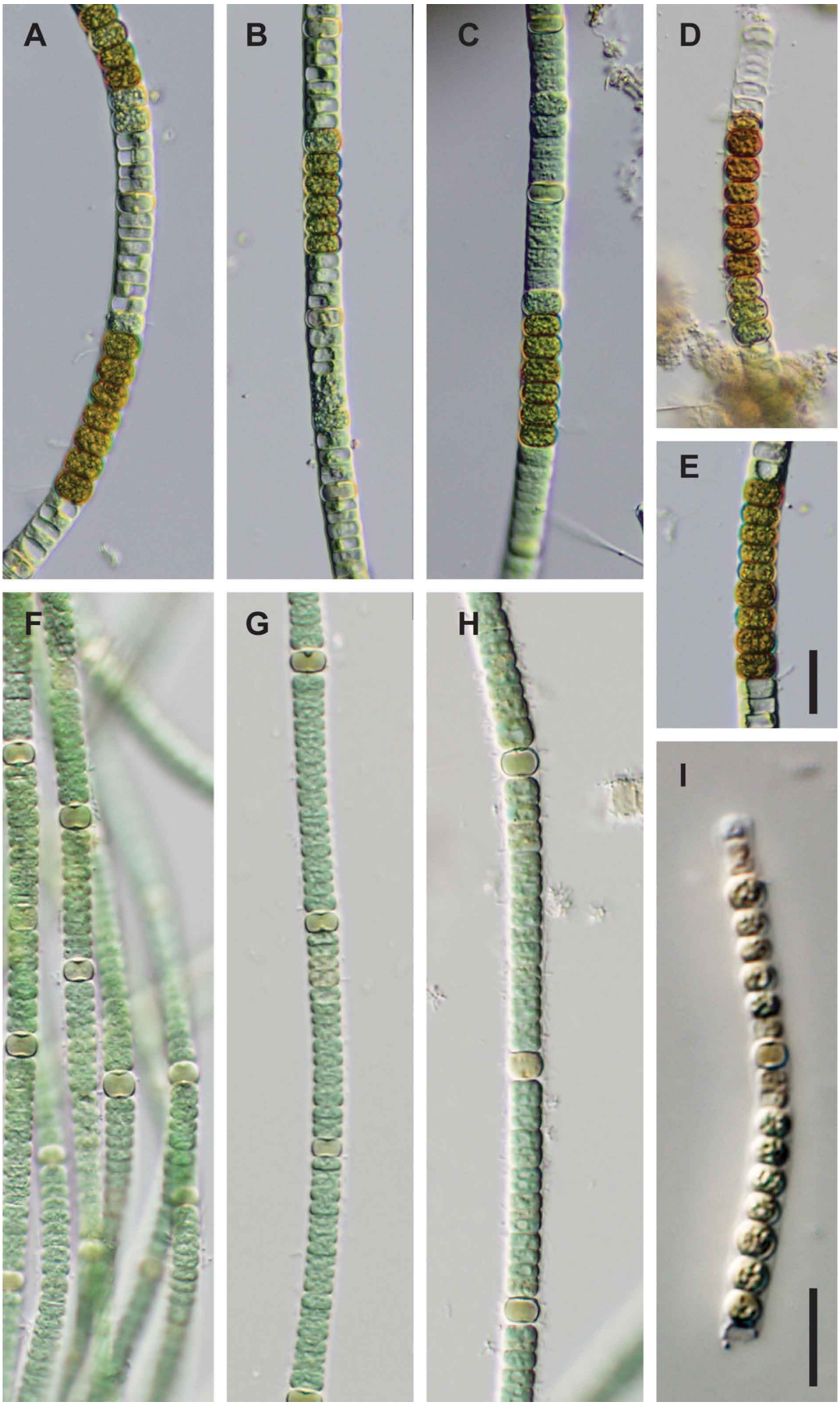

FIGURE 18. A–E *Nodularia willei*; F–I *Nodularia harveyana.* Scale bars = 20 µm

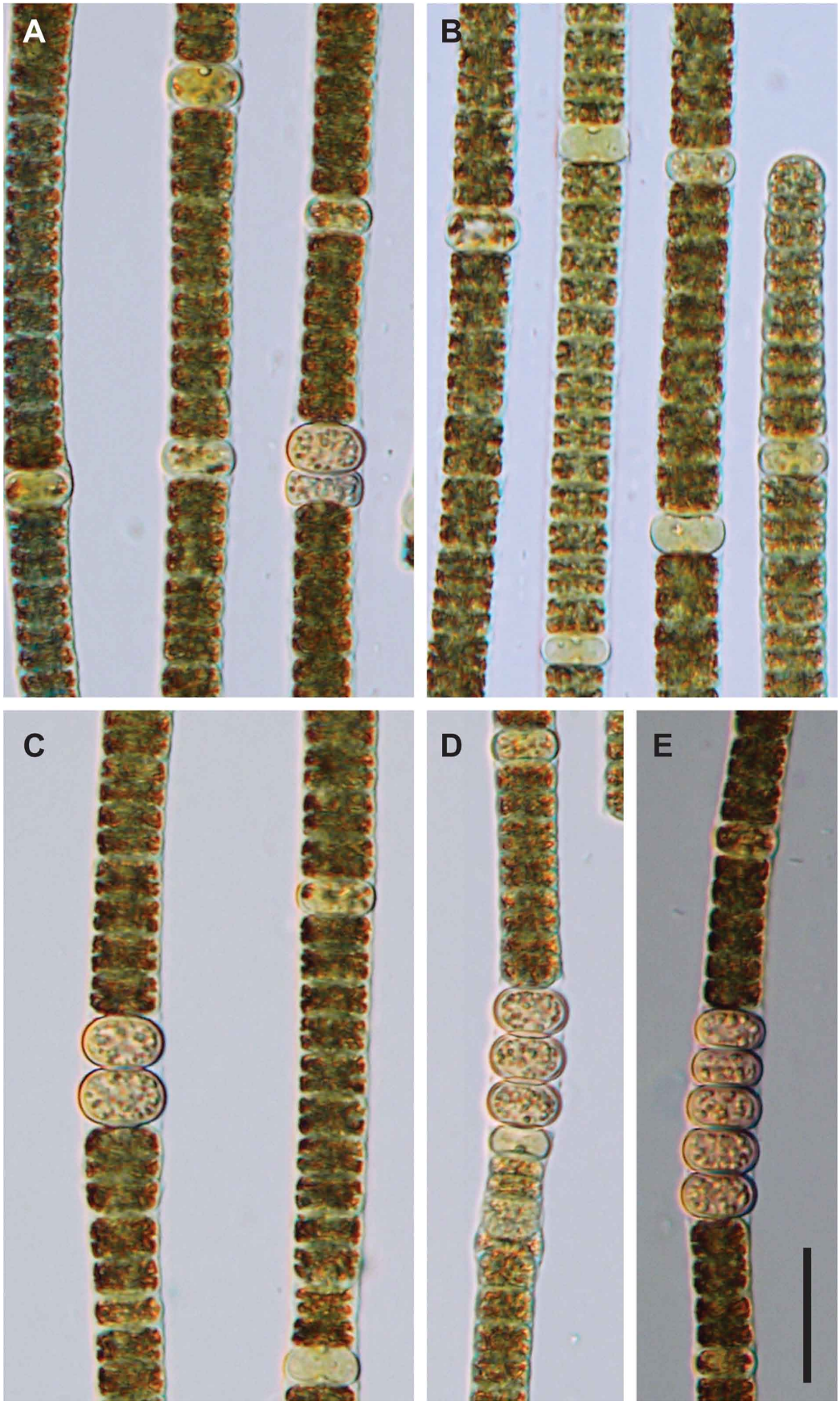

FIGURE 19. A–E *Nodularia spumigena*. Scale bars = 20 µm

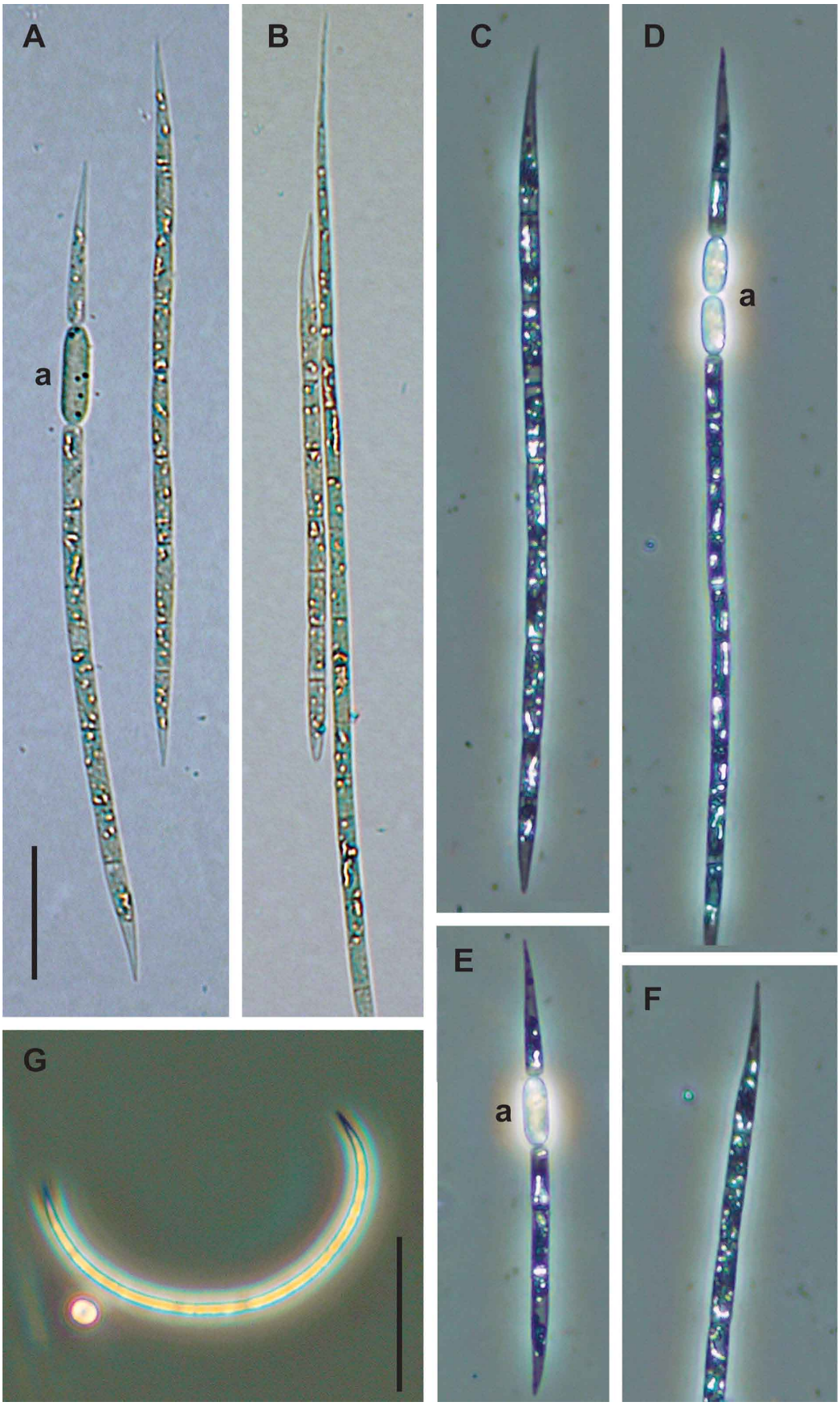

FIGURE 20. A–F *Raphidiopsis mediterranea*; G *Raphidiopsis curvata*. Scale bars = 20 µm

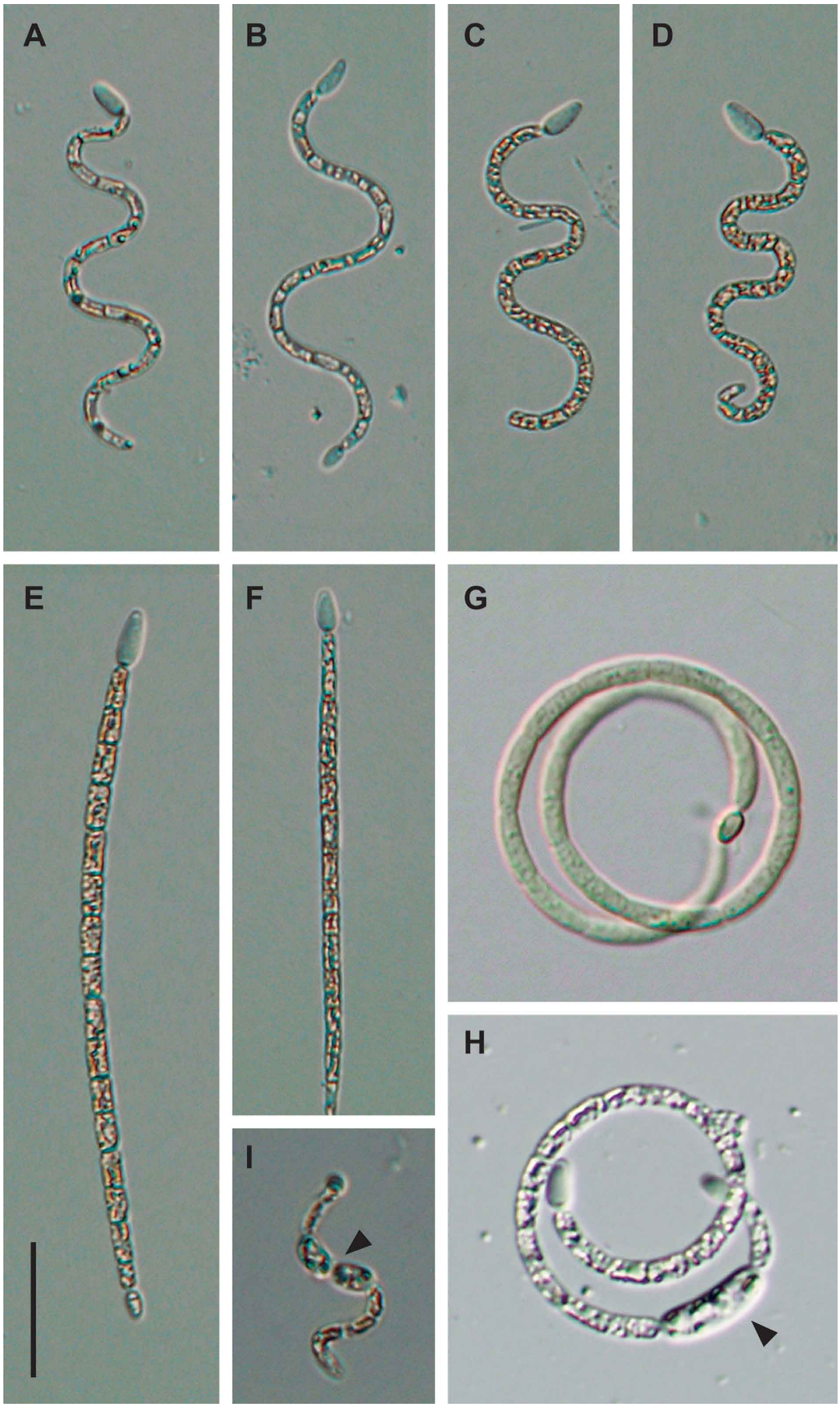

FIGURE 21. A–H *Raphidiopsis raciborskii* (arrows indicate position of akinetes). Scale bars = 20 µm

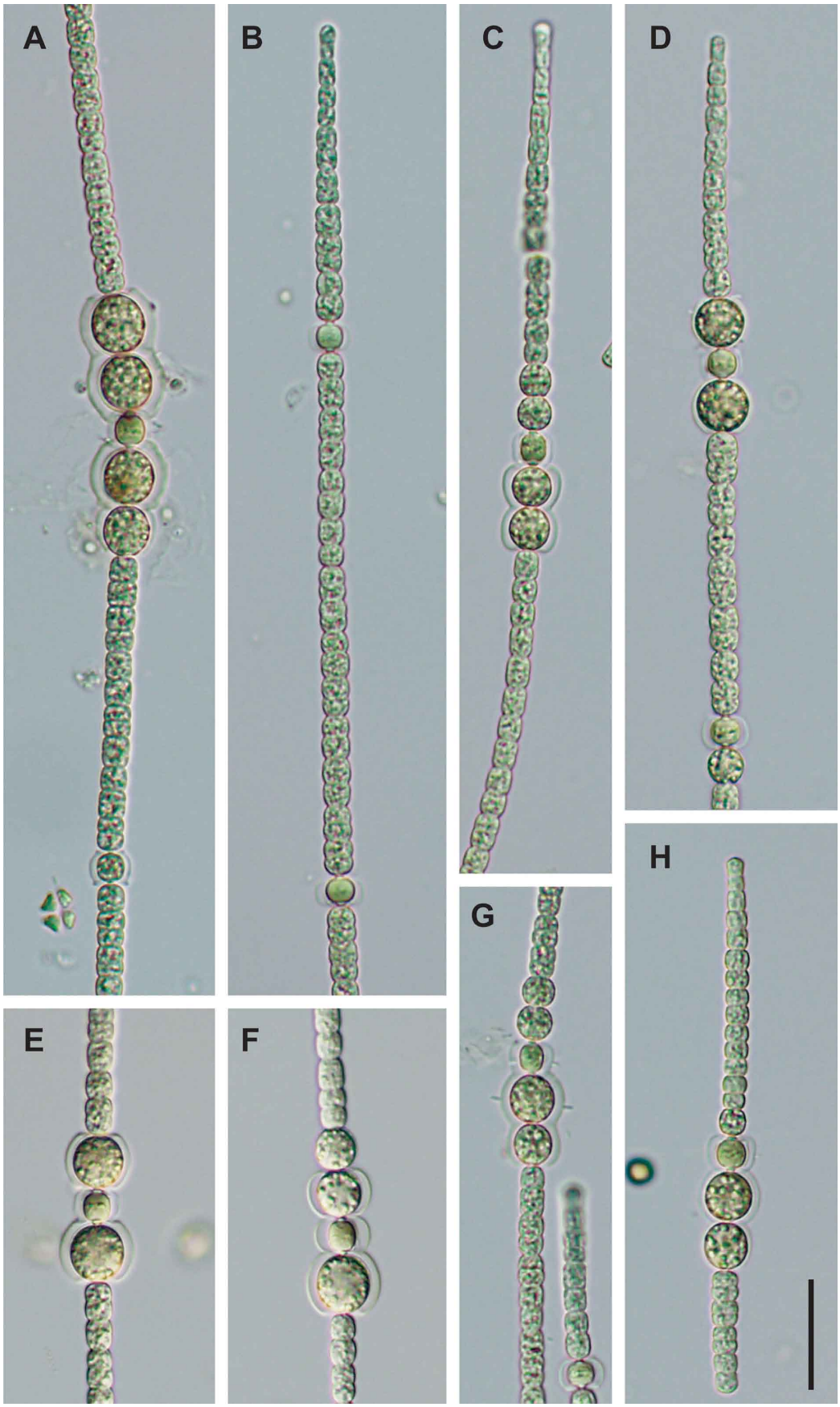

FIGURE 22. A–H *Sphaerospermopsis aphanizomenoides*. Scale bars = 20 µm

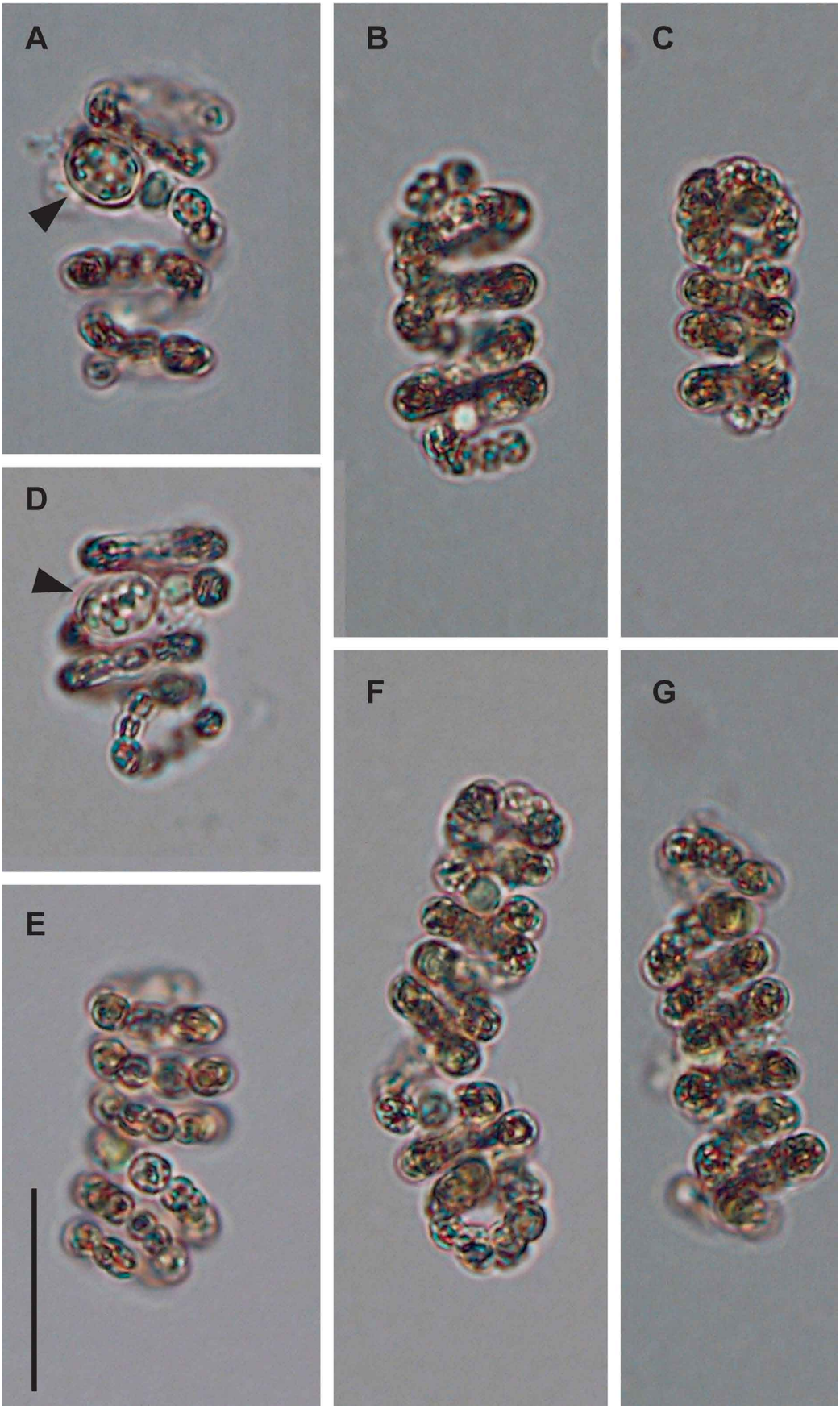

FIGURE 23. A–G *Sphaerospermopsis eucompacta* (arrows indicate position of akinetes). Scale bars = 20 µm

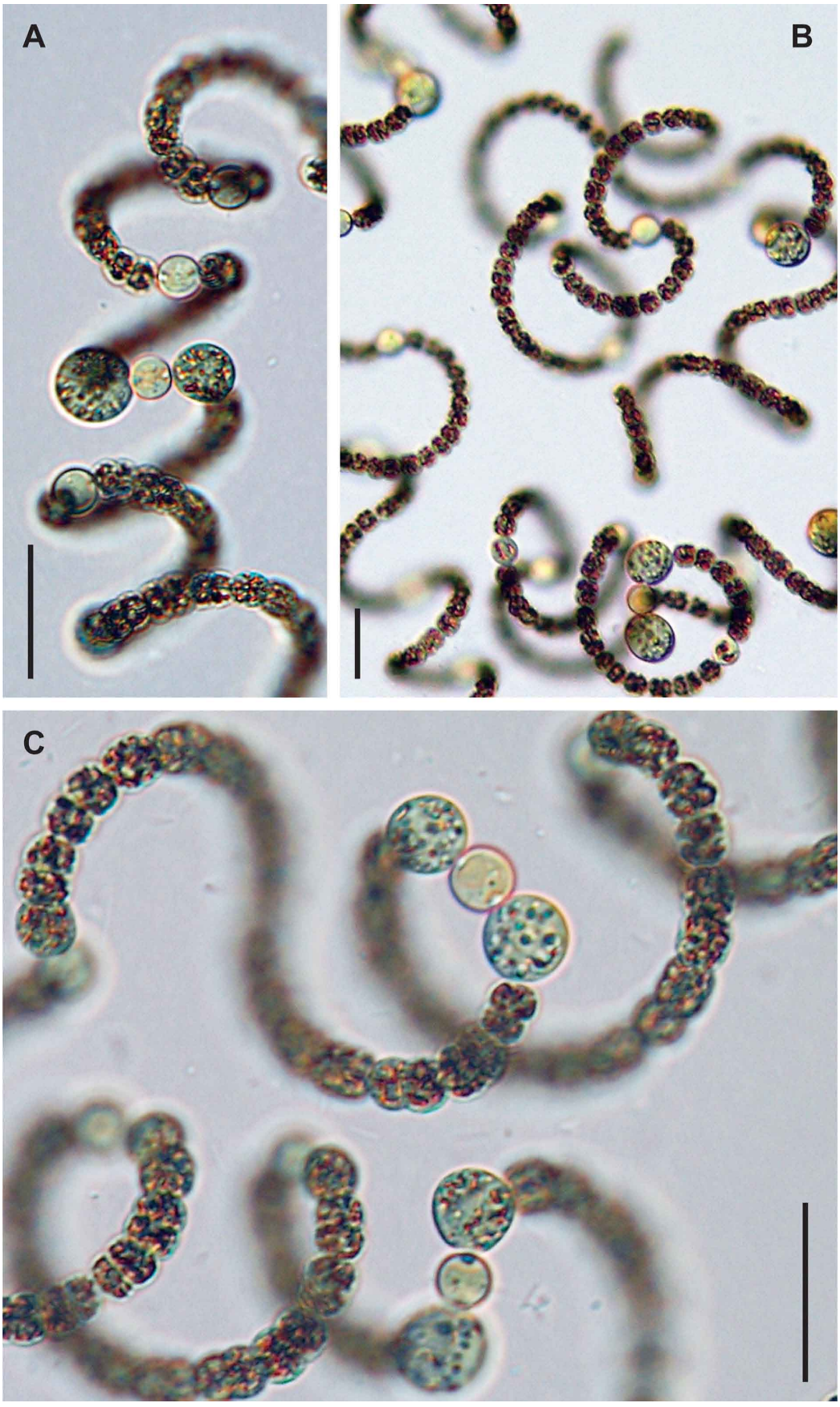

FIGURE 24. A–C *Sphaerospermopsis reniformis*. Scale bars = 20 µm

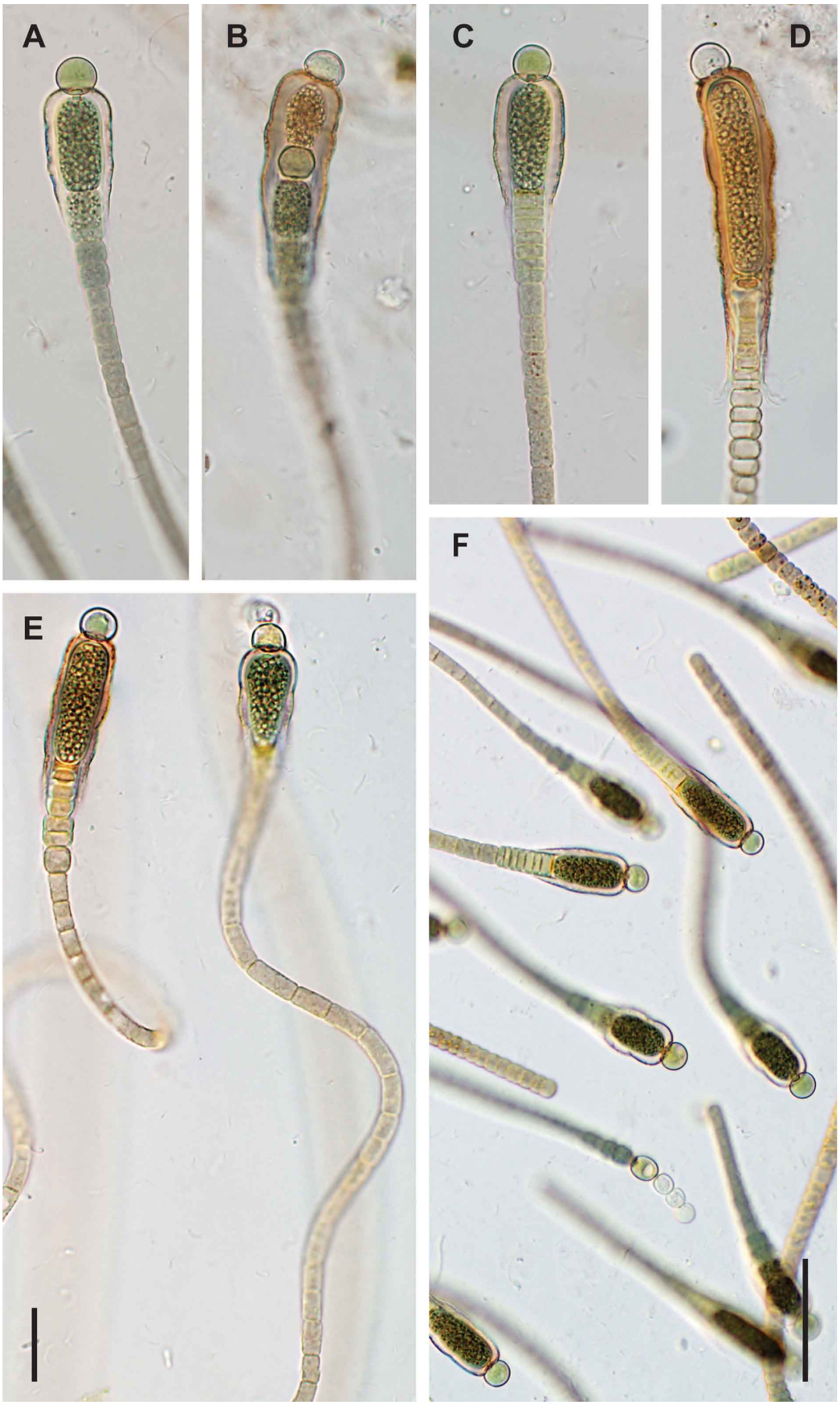

FIGURE 25. A–F *Gloeotrichia natans*. Scale bars = 20 µm

FIGURE 26. A–D *Gloeotrichia raciborskii*; E Spherical colonies sitting loosely on the sediment in the littoral zone of a tropical river. Scale bars A = 50 µm, B–D = 20 µm

FIGURE 27. A–F *Fischerella* sp. A. Scale bars = 20 µm

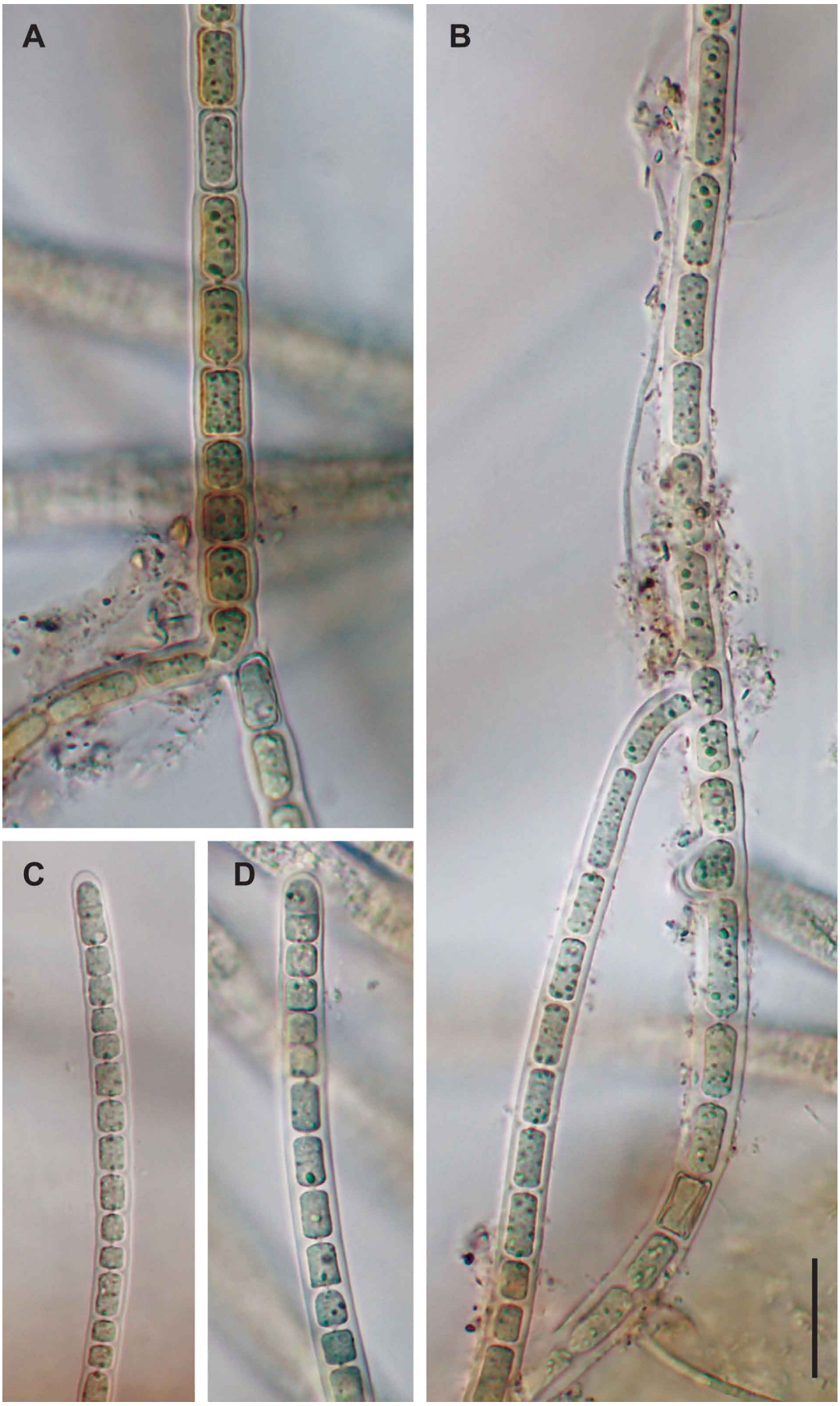

FIGURE 28. A–D *Hapalosiphon hibernicus*. Scale bars = 20 µm

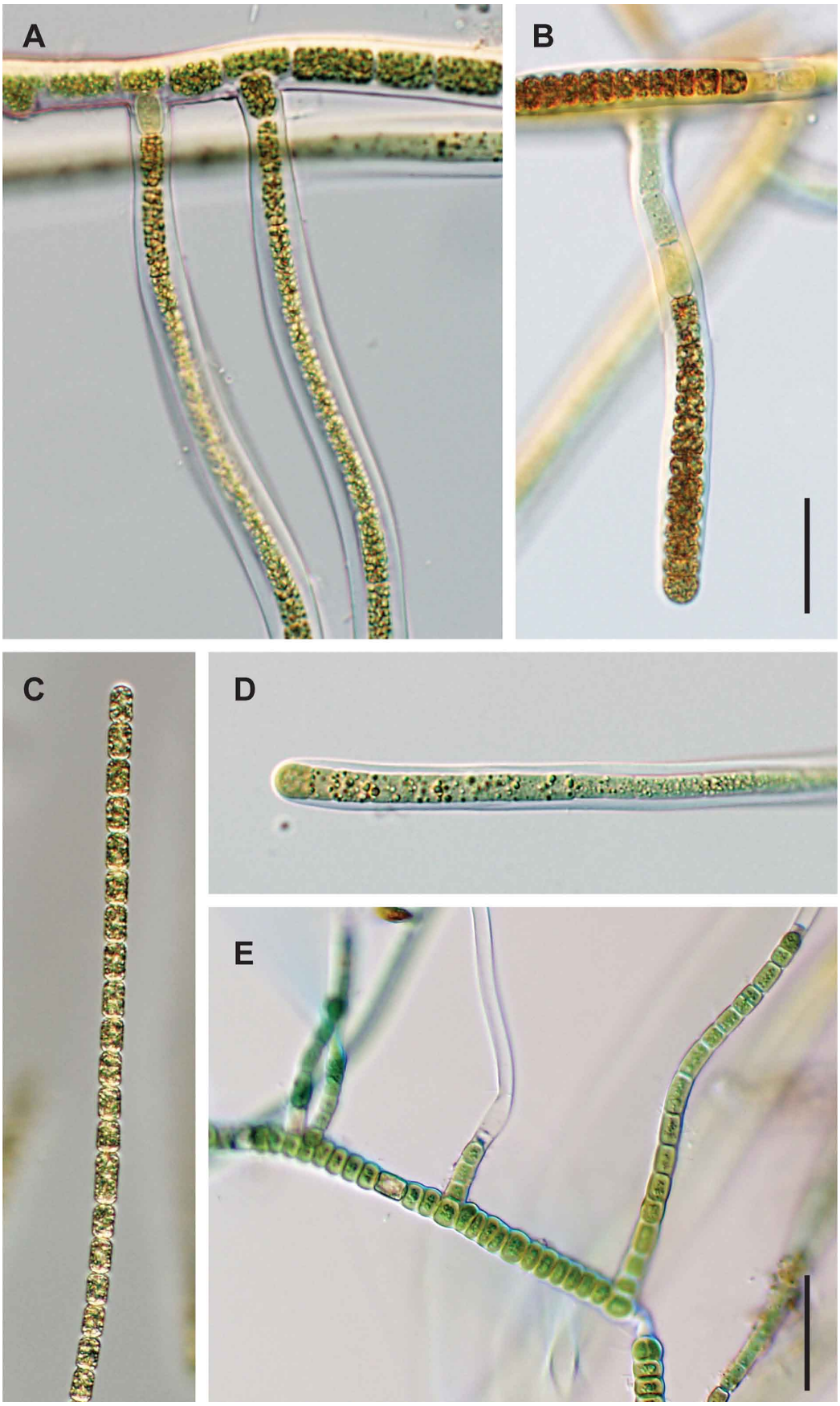

FIGURE 29. A–E *Hapalosiphon pumilus*; B–C Hormogonia with aerotopes. Scale bars = 20 µm

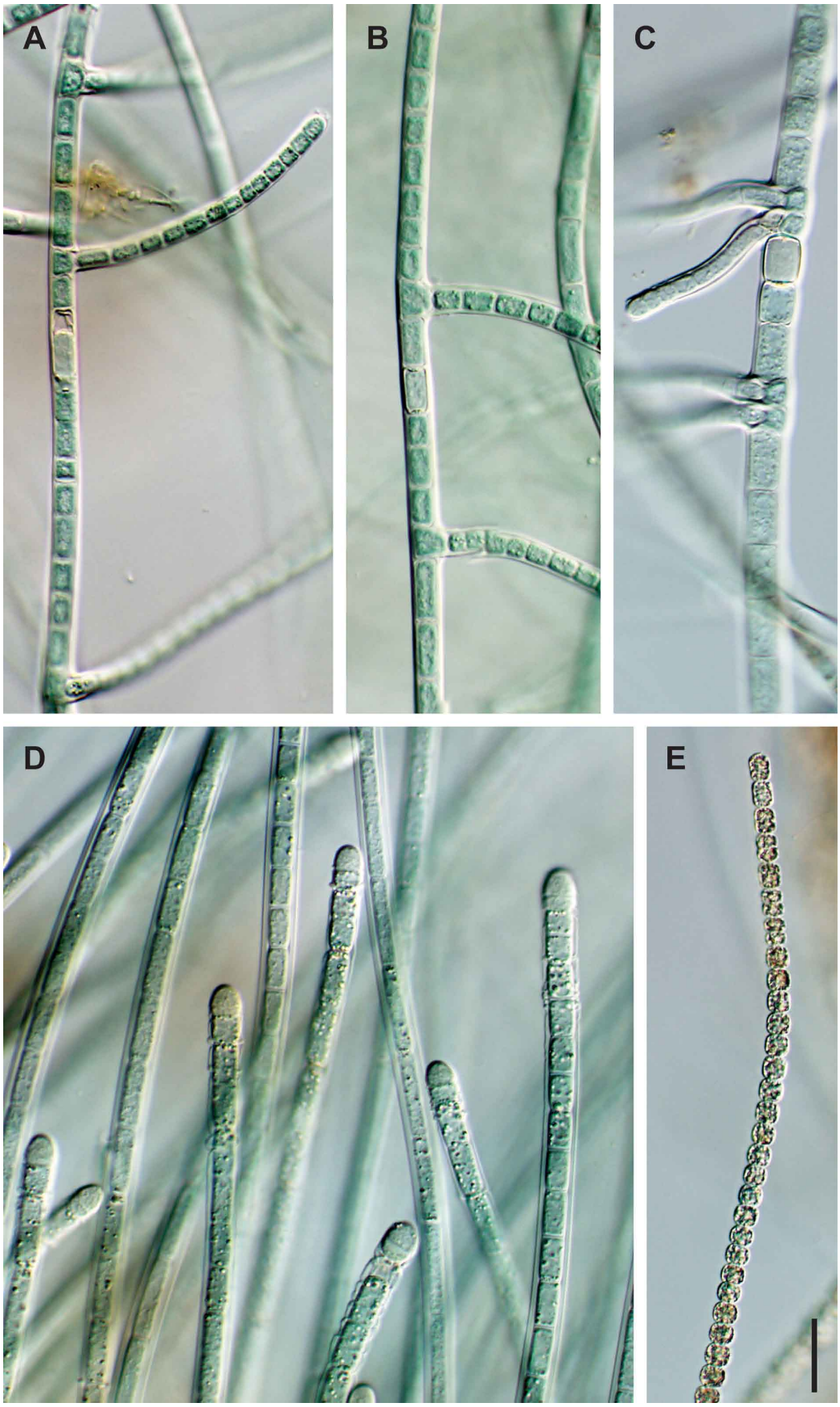

FIGURE 30. A–E *Hapalosiphon pumilus*; E Hormogonia with aerotopes. Scale bars = 20 µm

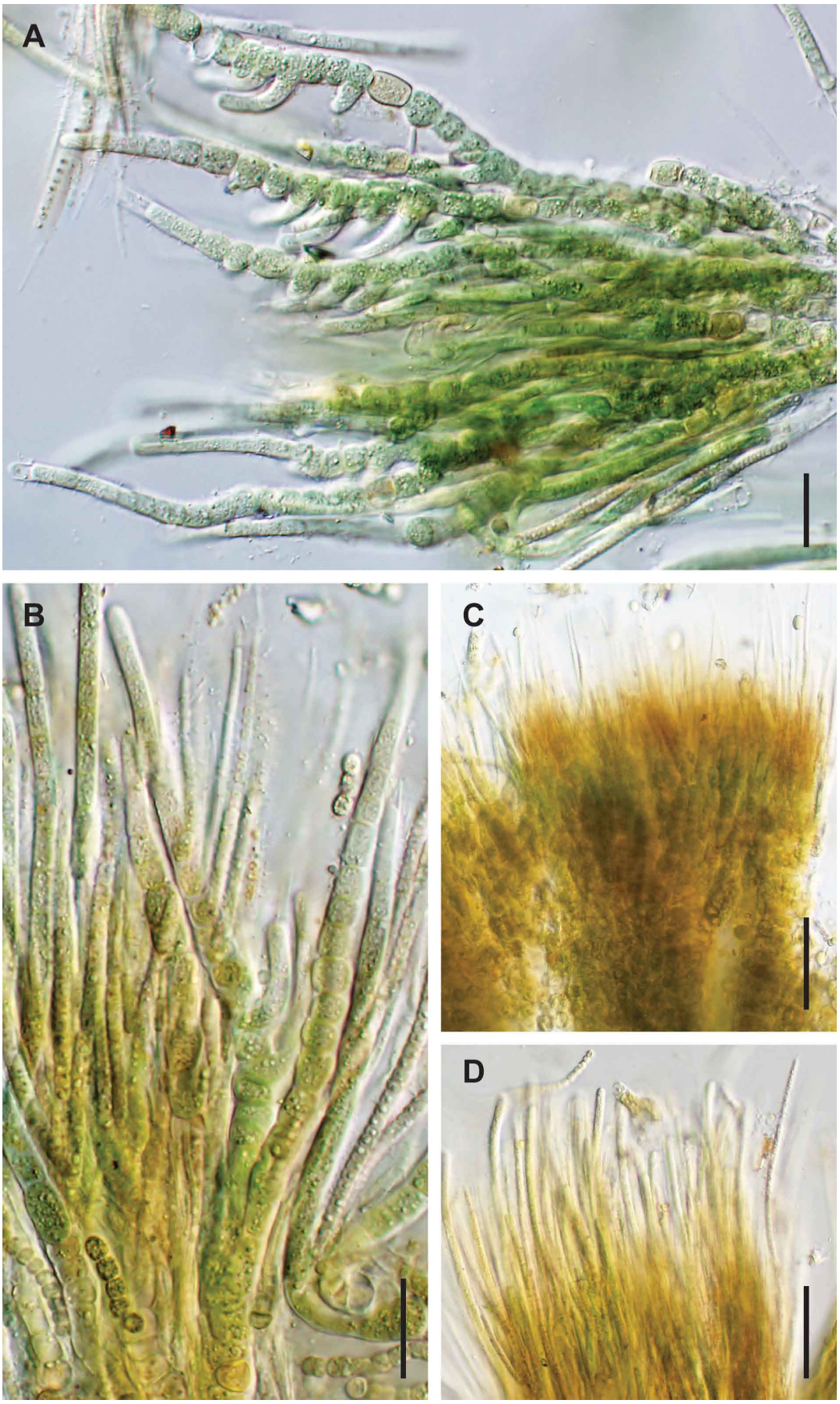

FIGURE 31. A–D *Hapalosiphon welwitschia*. Scale bars A–B =20 µm, C–D = 50 µm

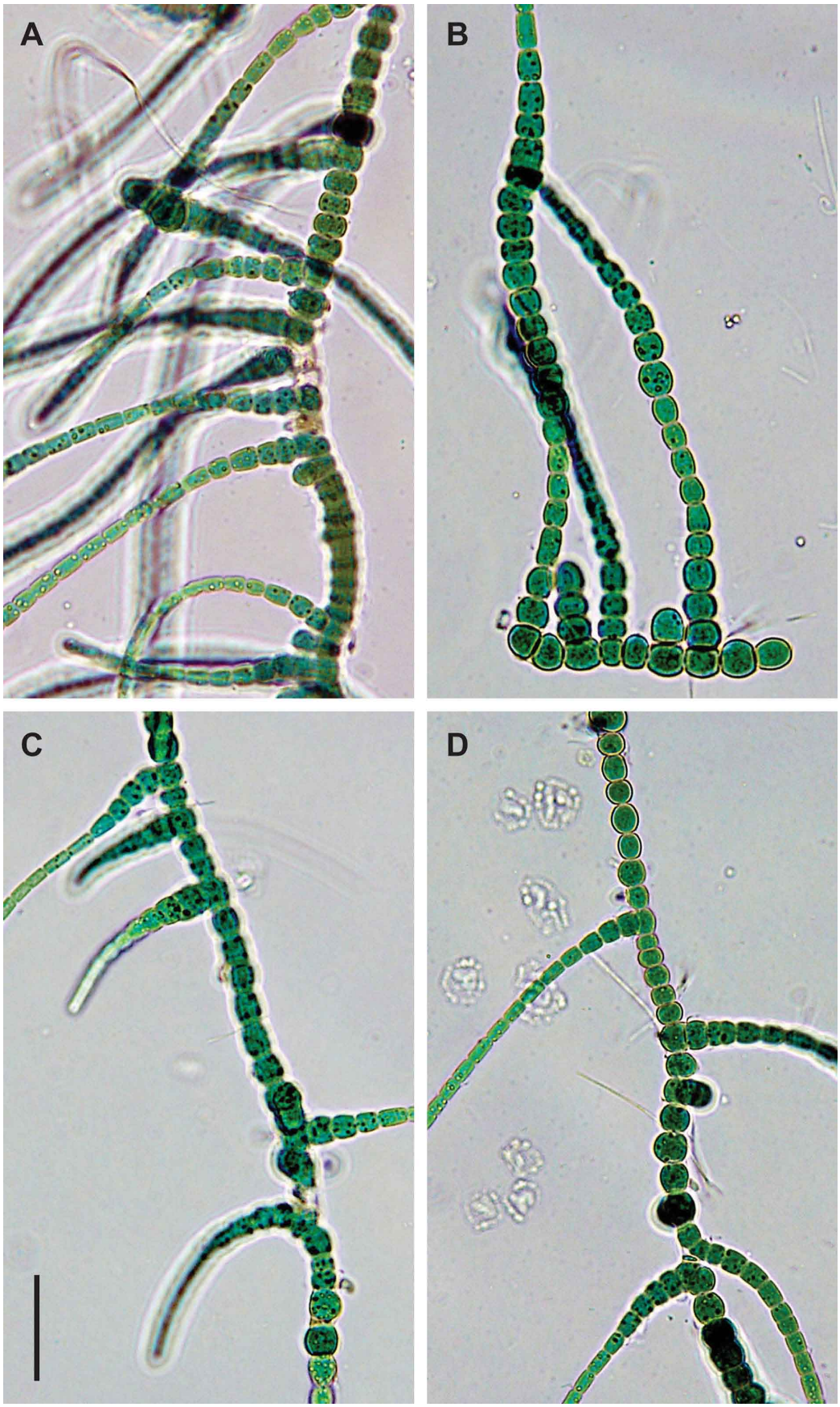

FIGURE 32. A–D *Mastigocladus laminosus*. Scale bars = 20 µm

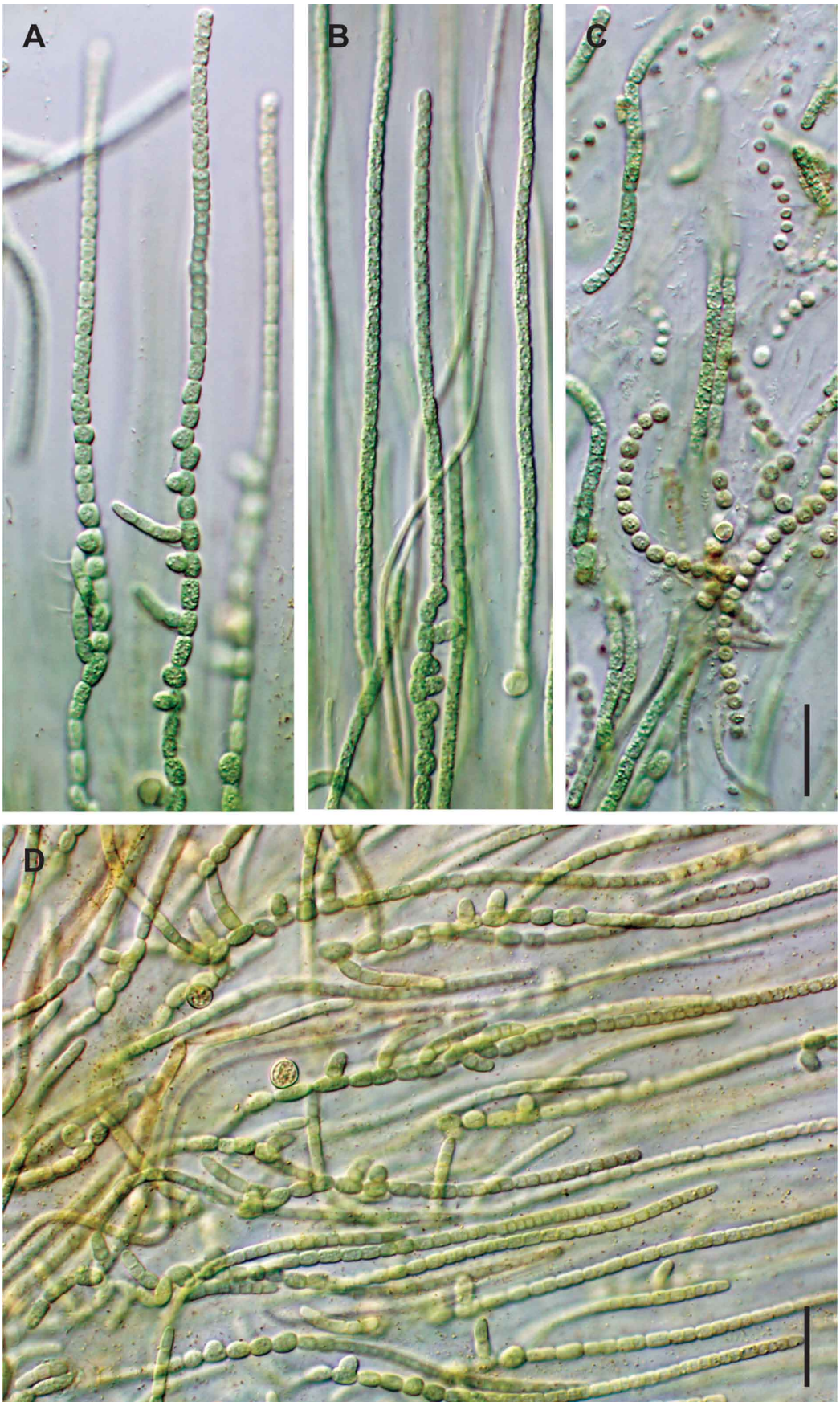

FIGURE 33. A–D *Nostochopsis lobatus.* Scale bars = 20 µm

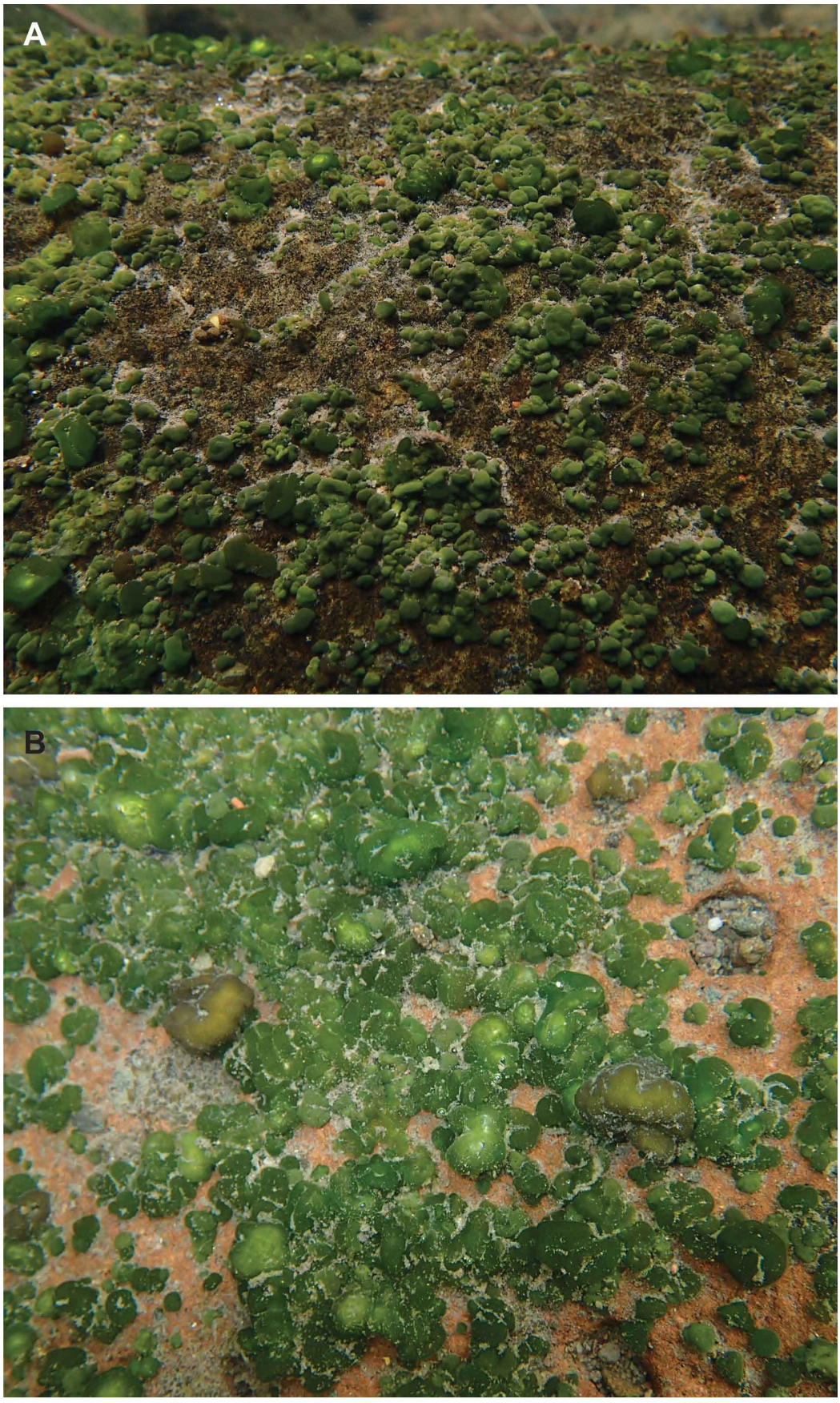

FIGURE 34. A–B Colonies of *Nostochopsis lobatus* growing on granitic rocks.

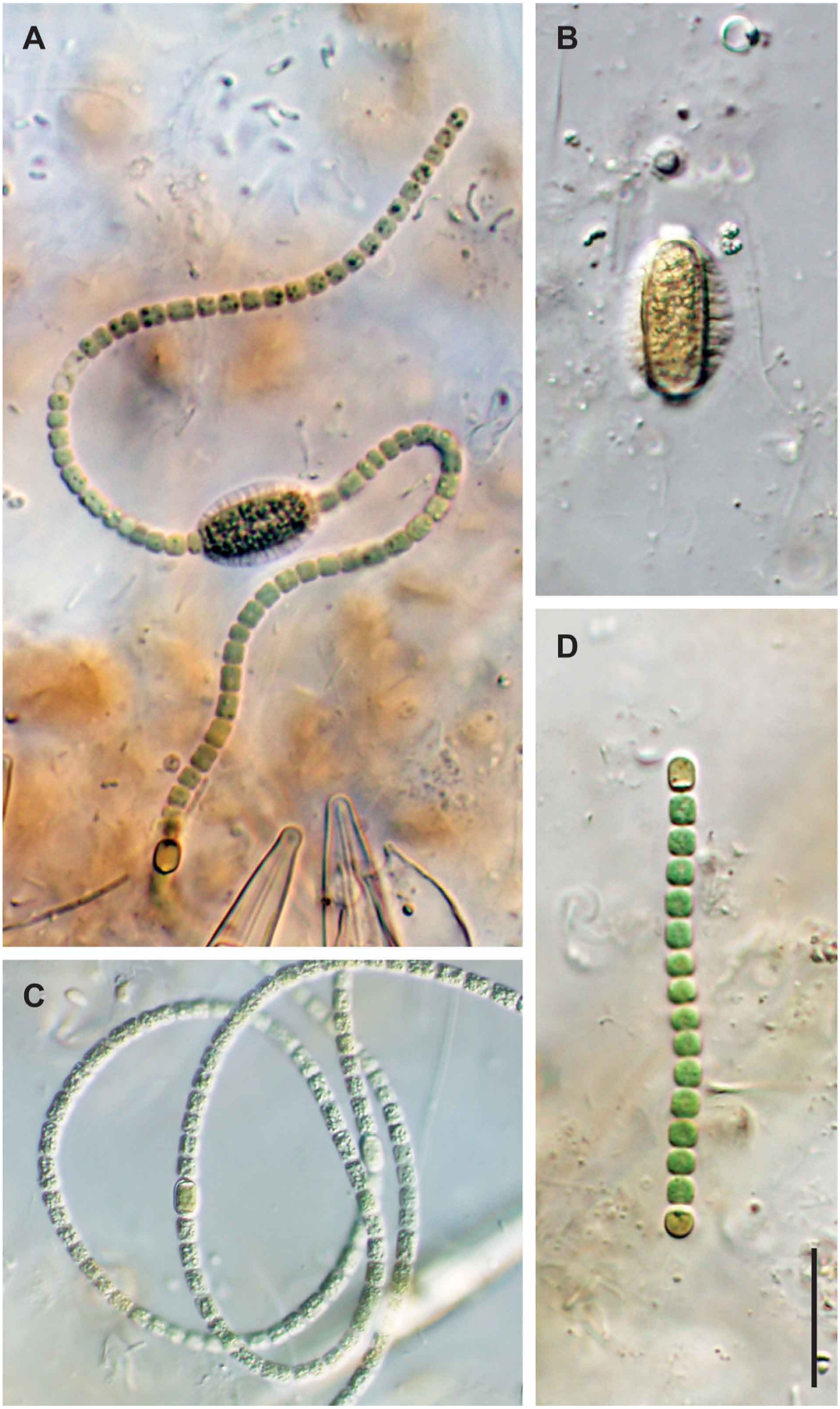

FIGURE 35. A–C *Anabaena* cf. *alatospora*; D *Cronbergia siamensis*. Scale bars = 20 µm

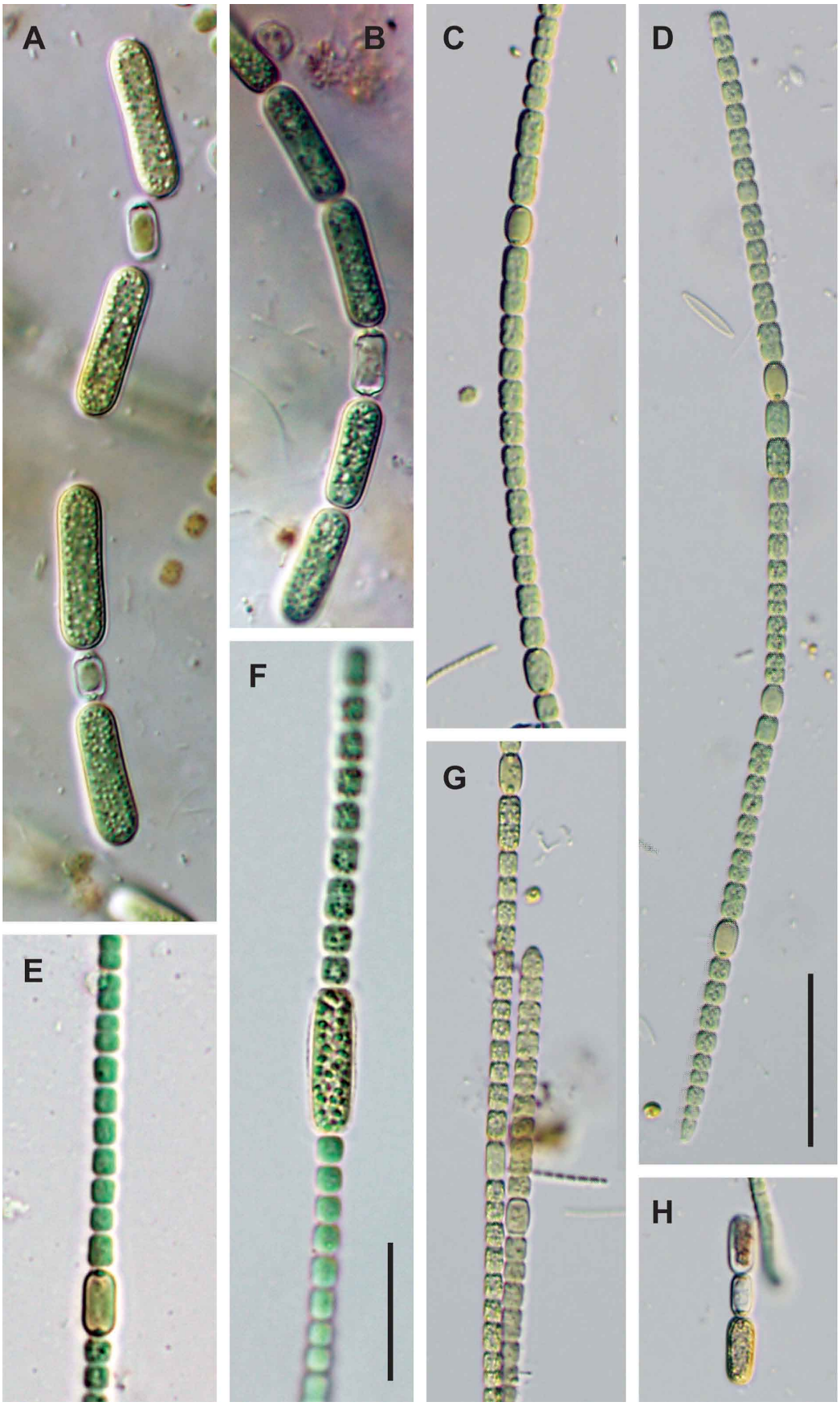

FIGURE 36. A–B *Anabaena cylindrica*; C–D, G–H *Anabaena oscillarioides*; E–F *Anabaena* cf. *augstumalis*. Scale bars = 20 µm

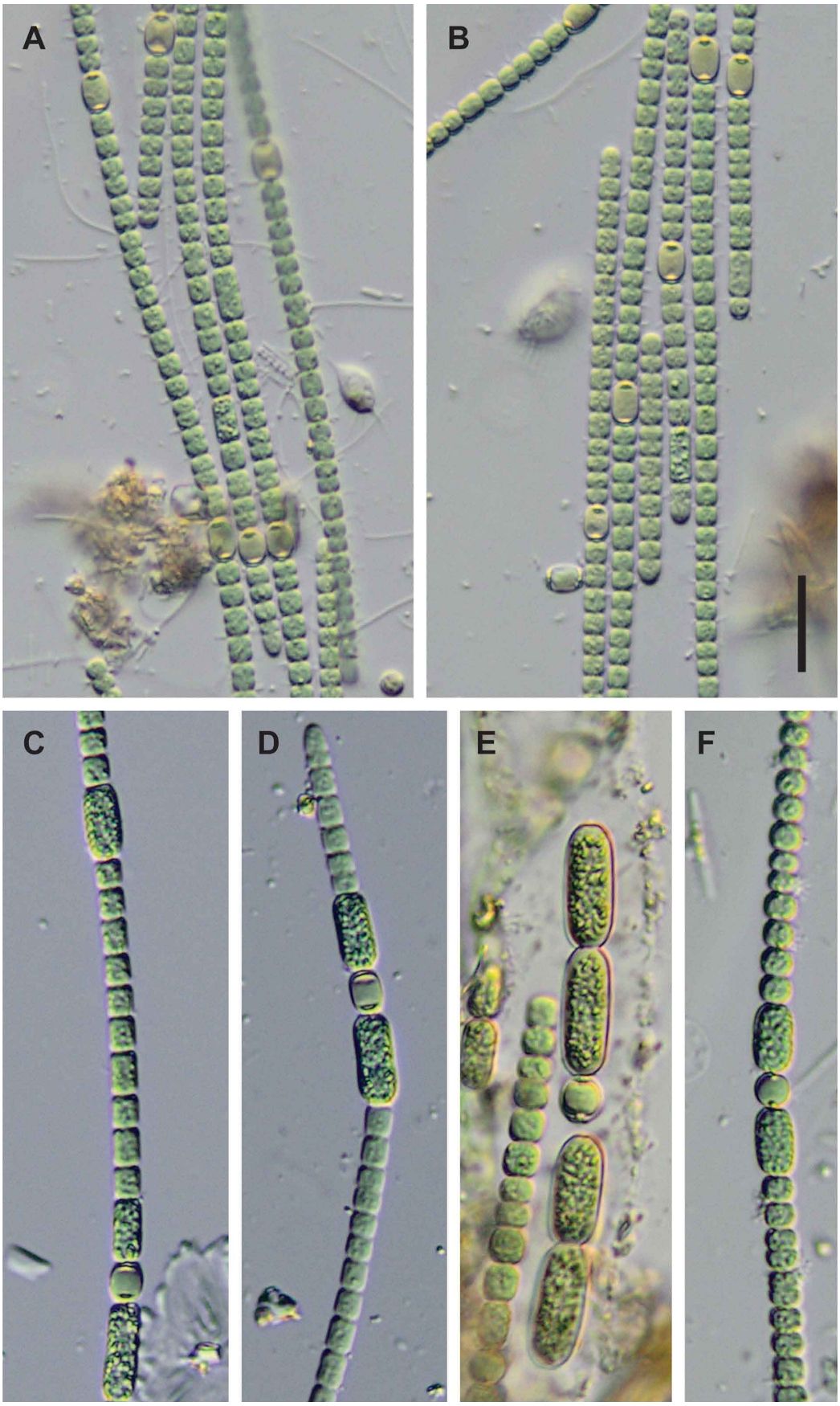

FIGURE 37. A–B *Anabaena inaequalis*; C–F *Anabaena torulosa*. Scale bars = 20 µm

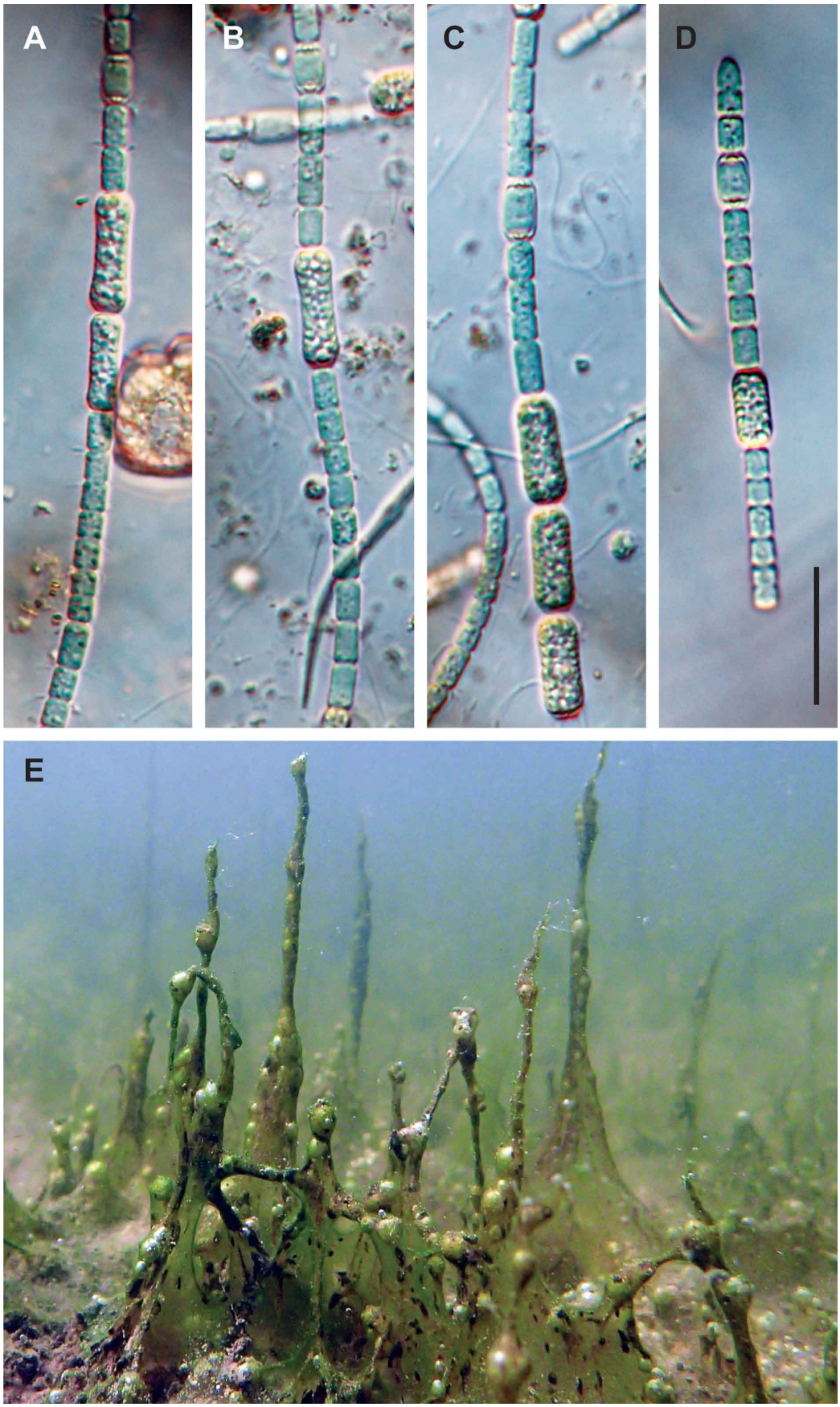

FIGURE 38. A–D *Anabaena* cf. *oblonga*; E Columnar structures of mature benthic mats. Scale bars = 20 µm

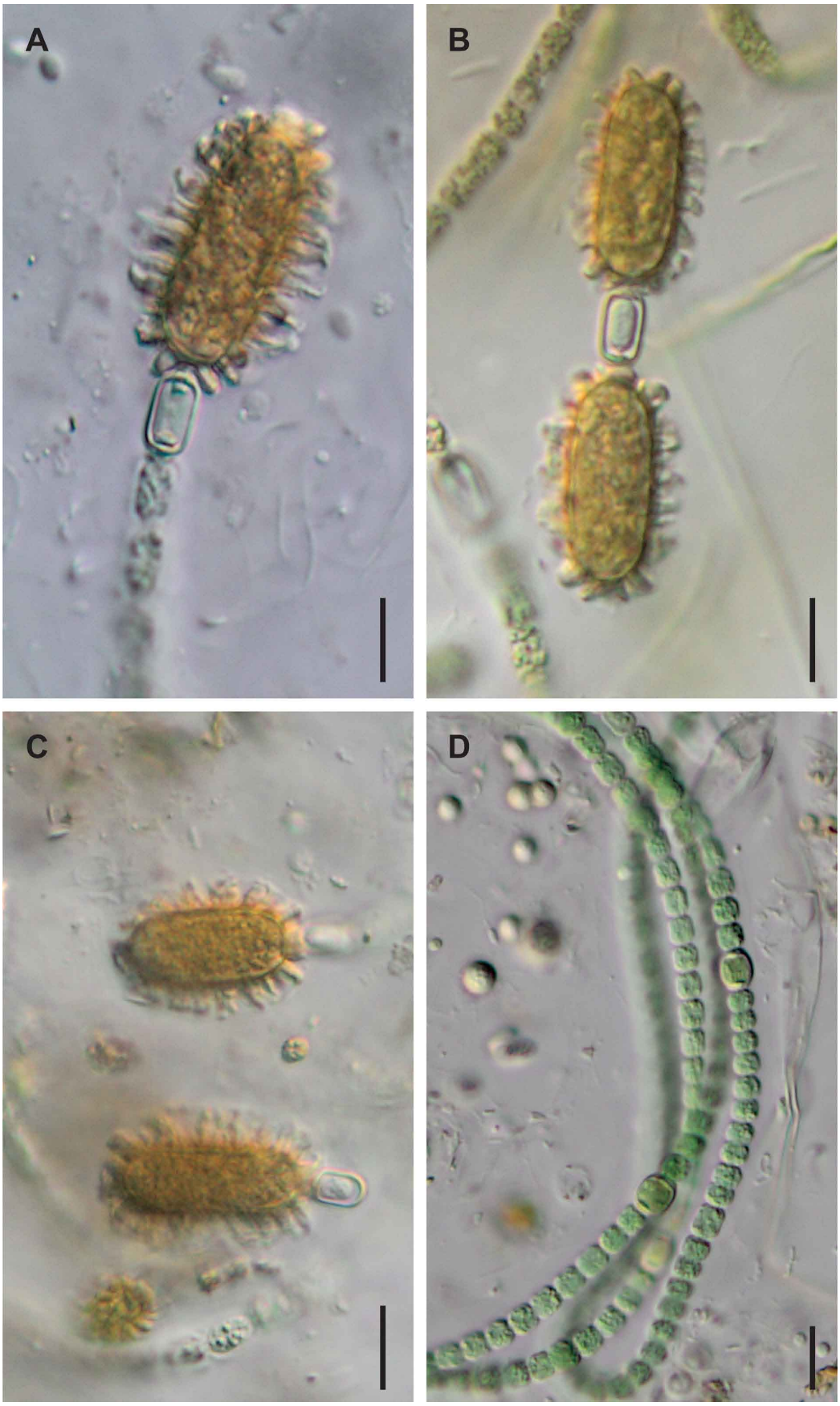

FIGURE 39. A–D *Anabaena wallumensis*. Scale bars = 20 µm

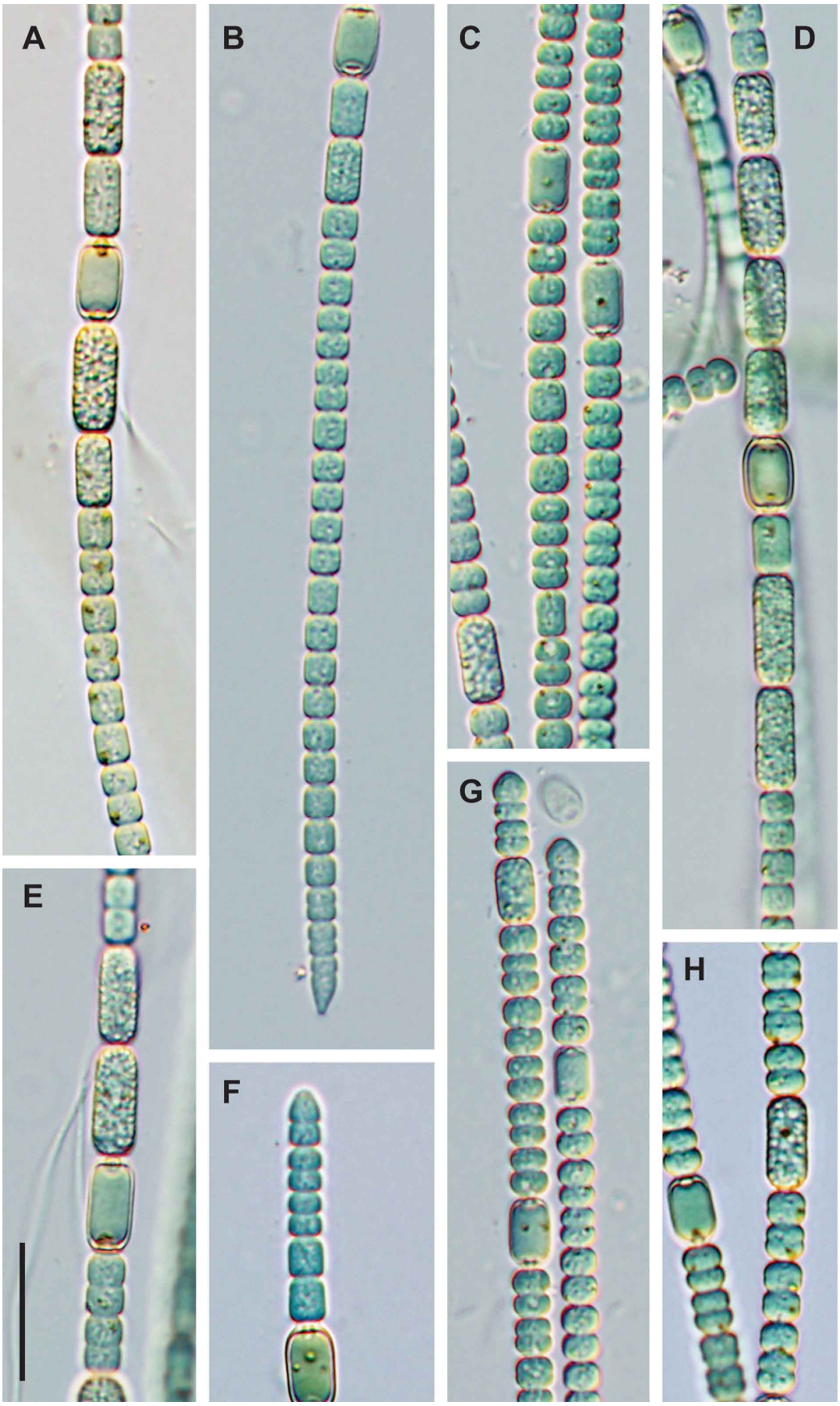

FIGURE 40. A–H *Anabaena* cf. *willei*. Scale bars = 20 µm

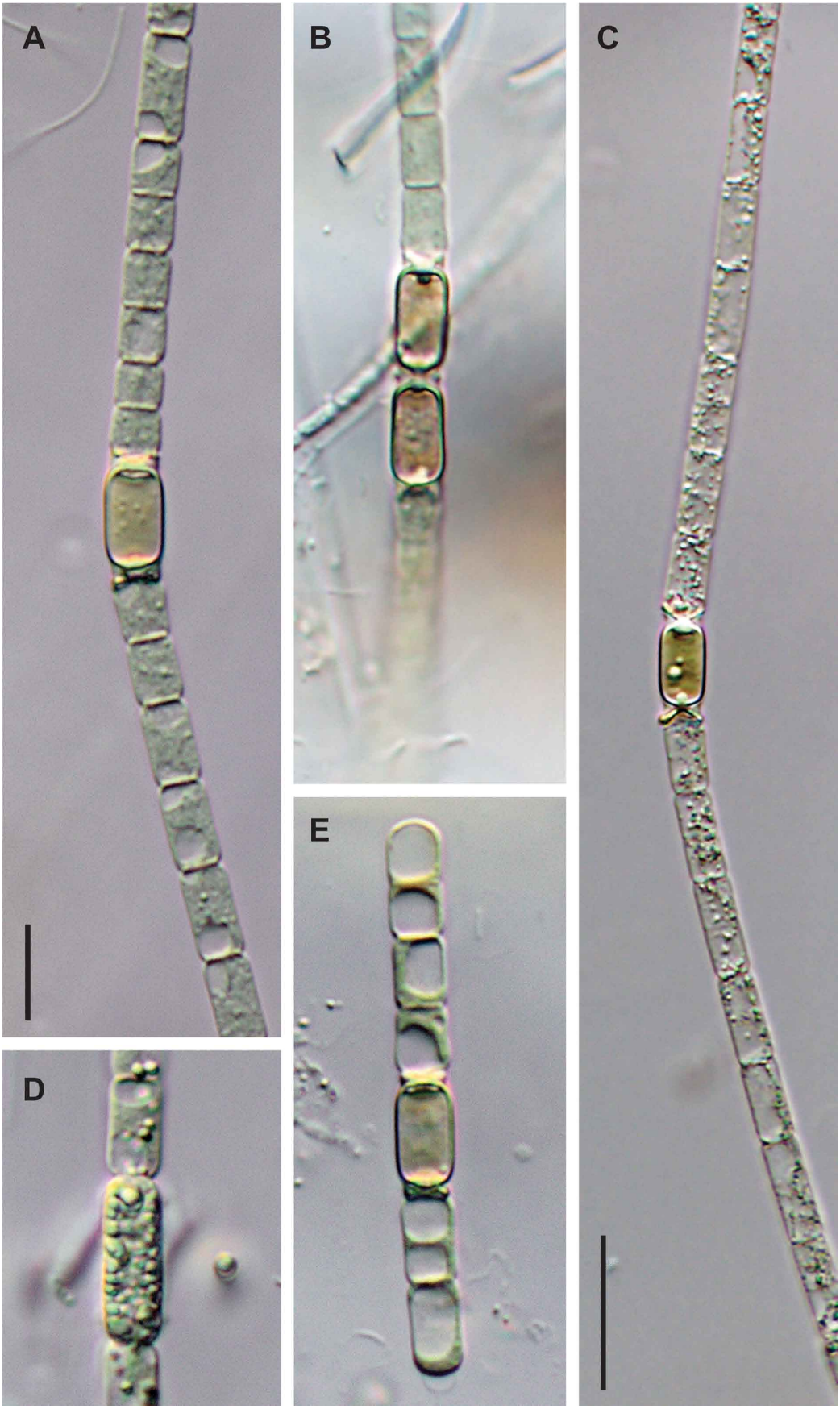

FIGURE 41. A–E *Anabaena* sp. A. Scale bars = 20 µm

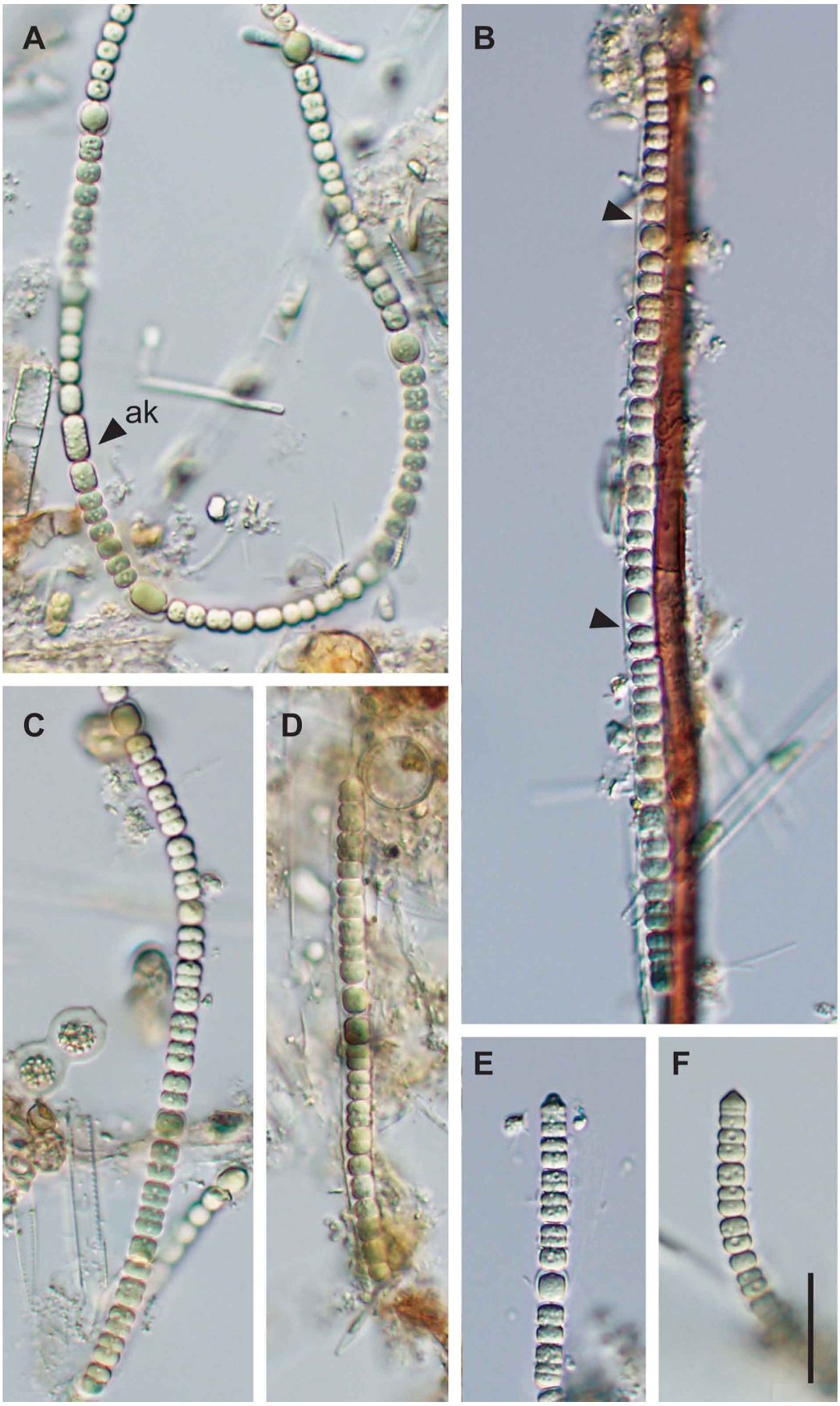

FIGURE 42. A–F *Aulosira* cf. *epiphytica* (ak = akinetes, arrows indicate position of sheath). Scale bars = 20 µm

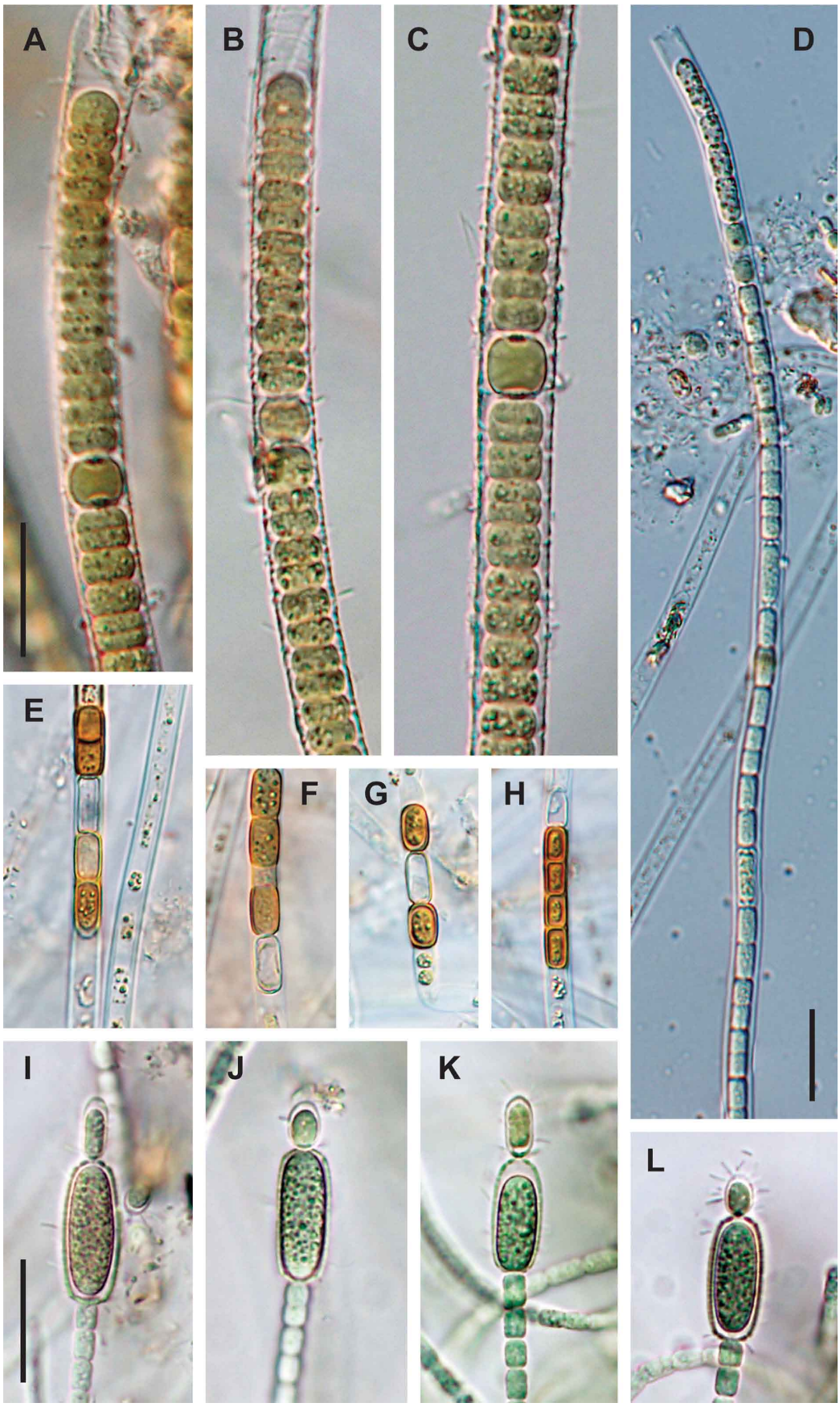

FIGURE 43. A–C *Aulosira laxa*; D–H *Aulosira* sp. A; I–L *Cylindrospermum stagnale*. Scale bars = 20 µm

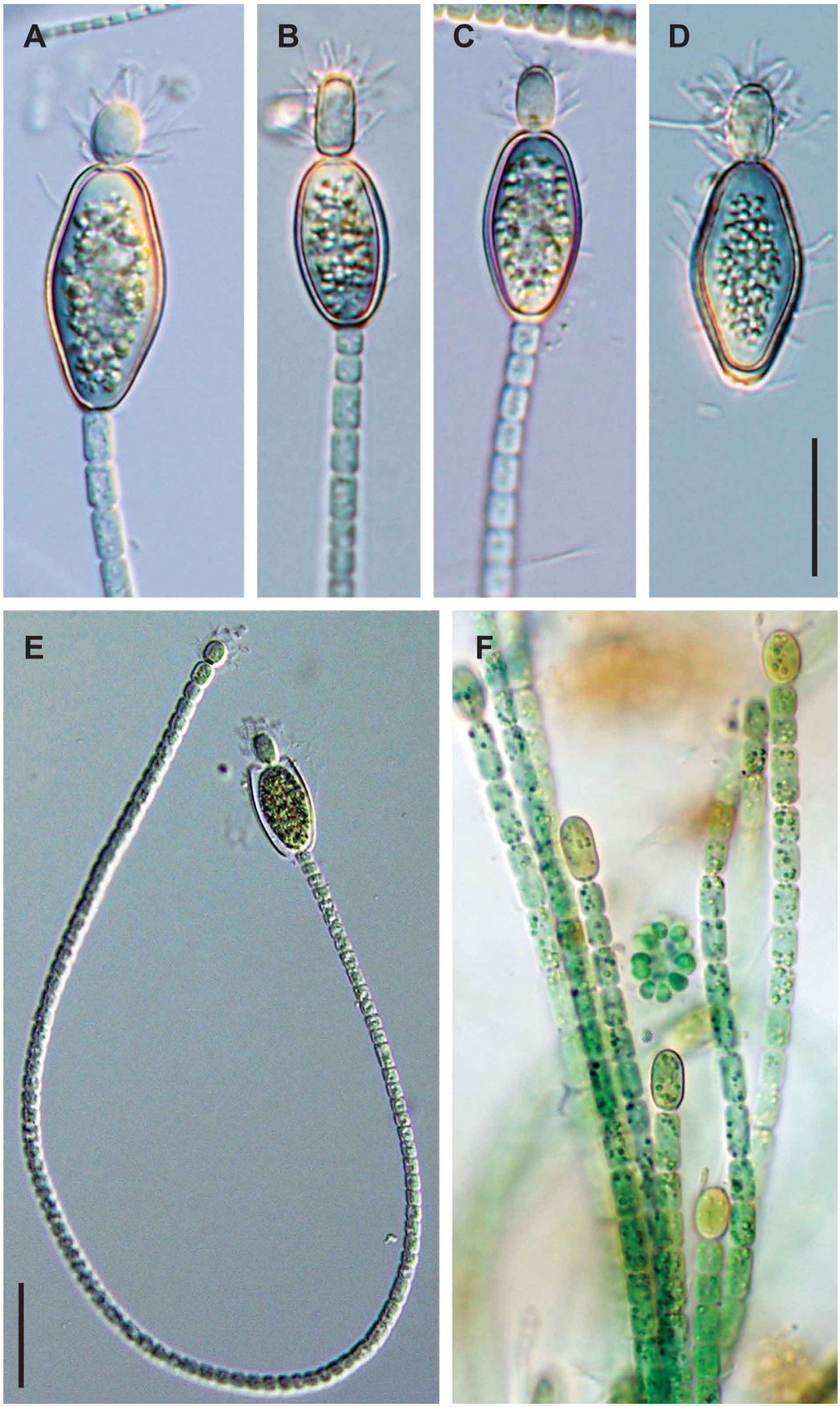

FIGURE 44. A–F *Cylindrospermum licheniforme*. Scale bars = 20 µm

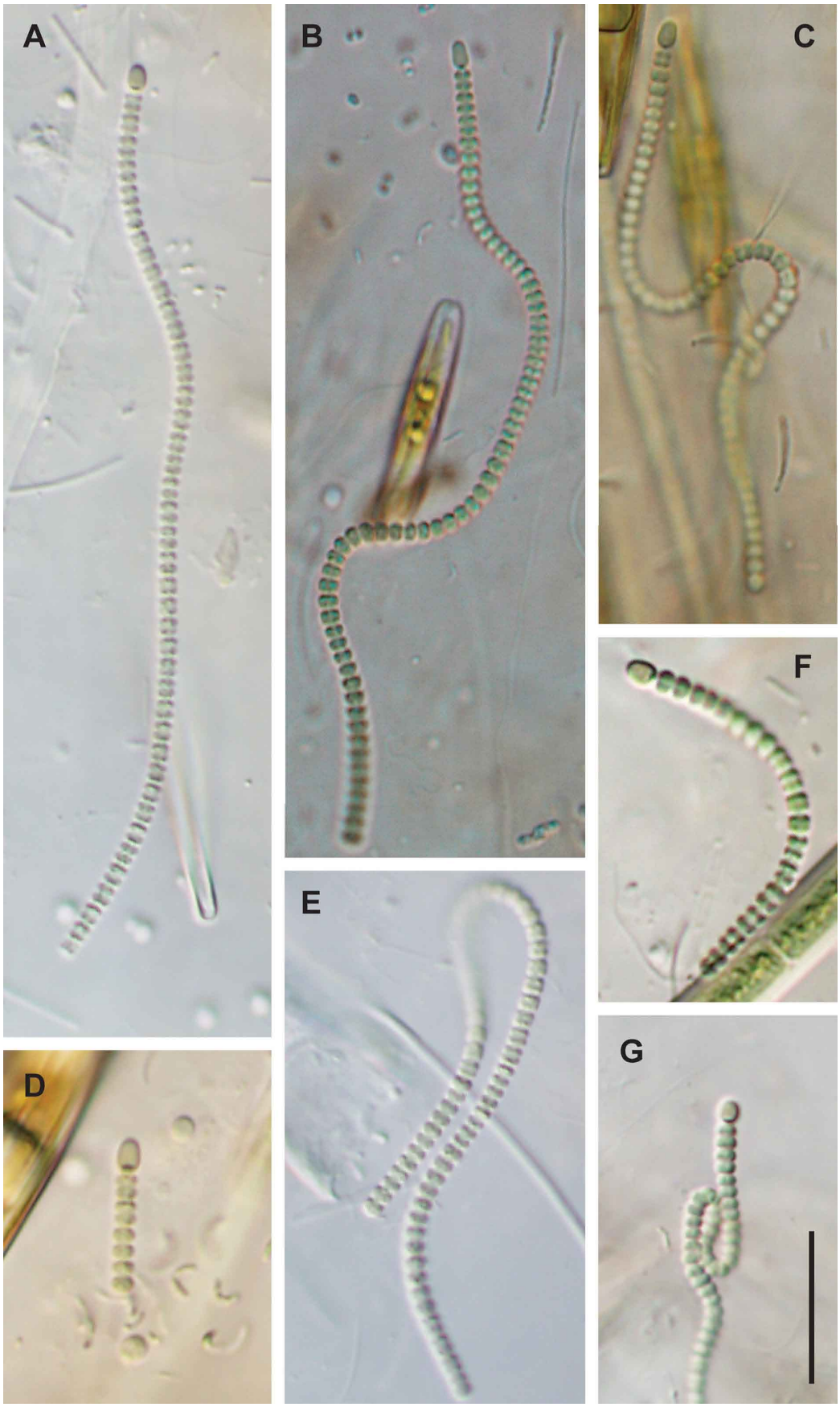

FIGURE 45. A–G *Cylindrospermum* sp. A. Scale bars = 20 µm

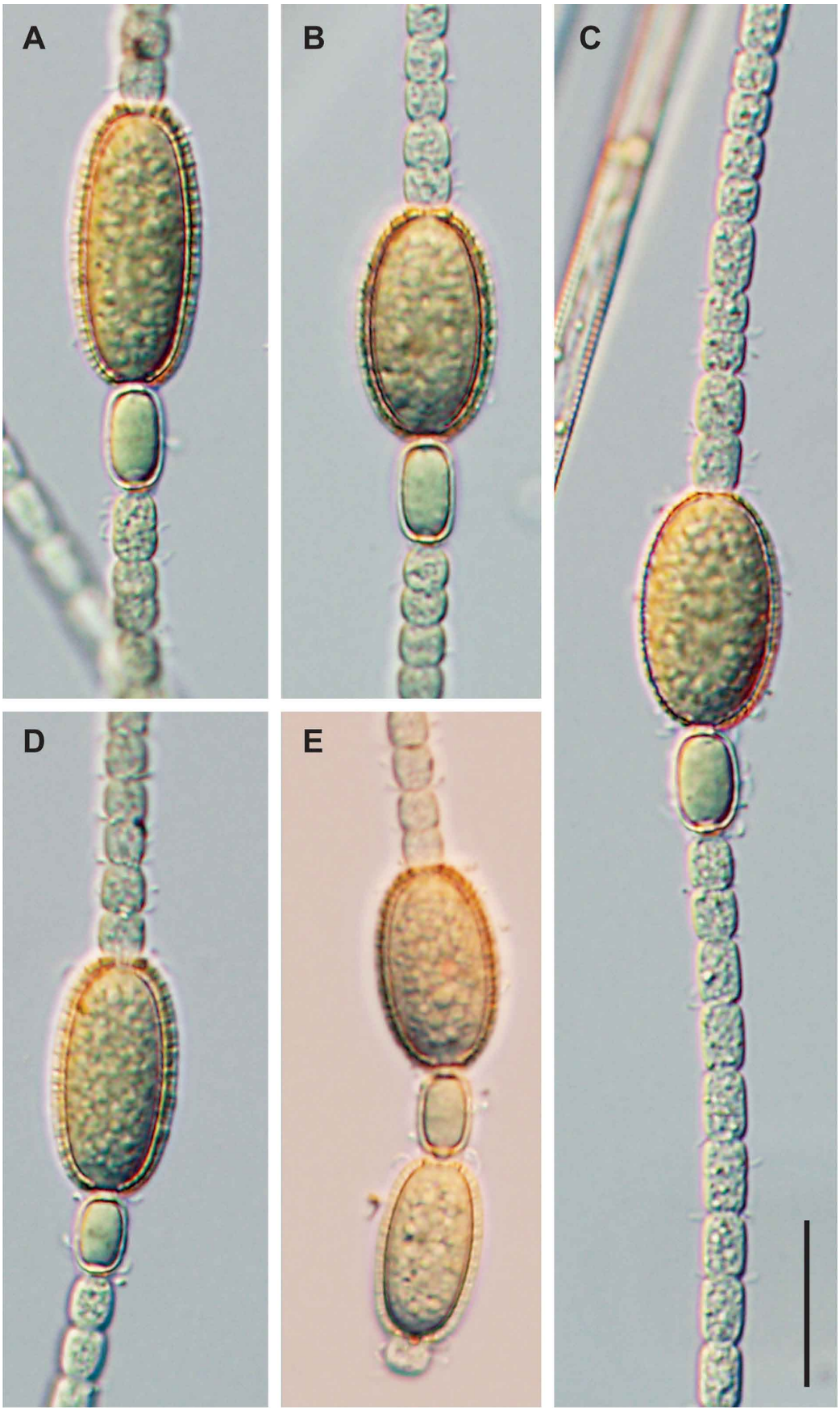

FIGURE 46. A–E *Macrospermum volzii*. Scale bars = 20 µm

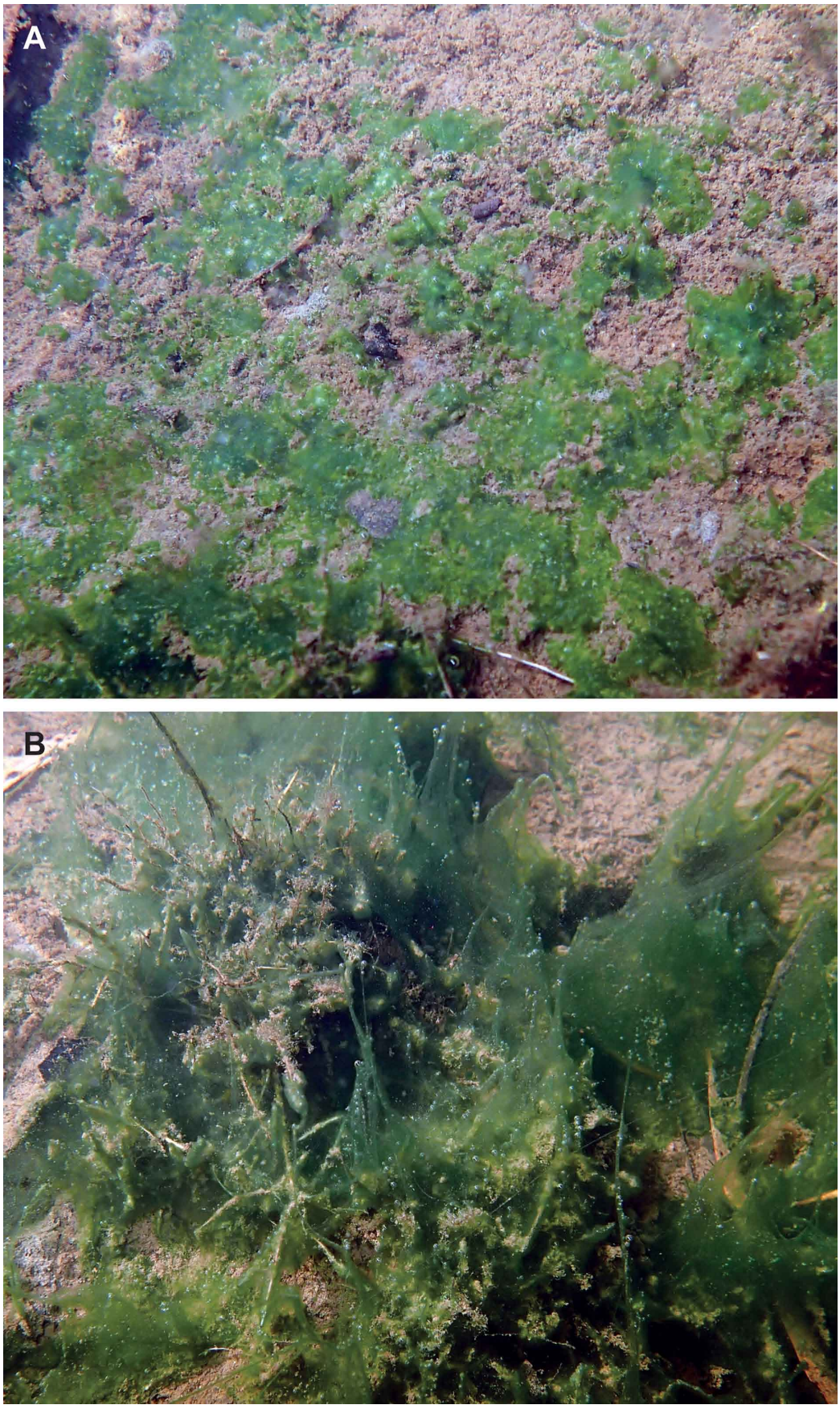

FIGURE 47. A–B Mats of *Macrospermum volzii* growing on soft sandy sediments.

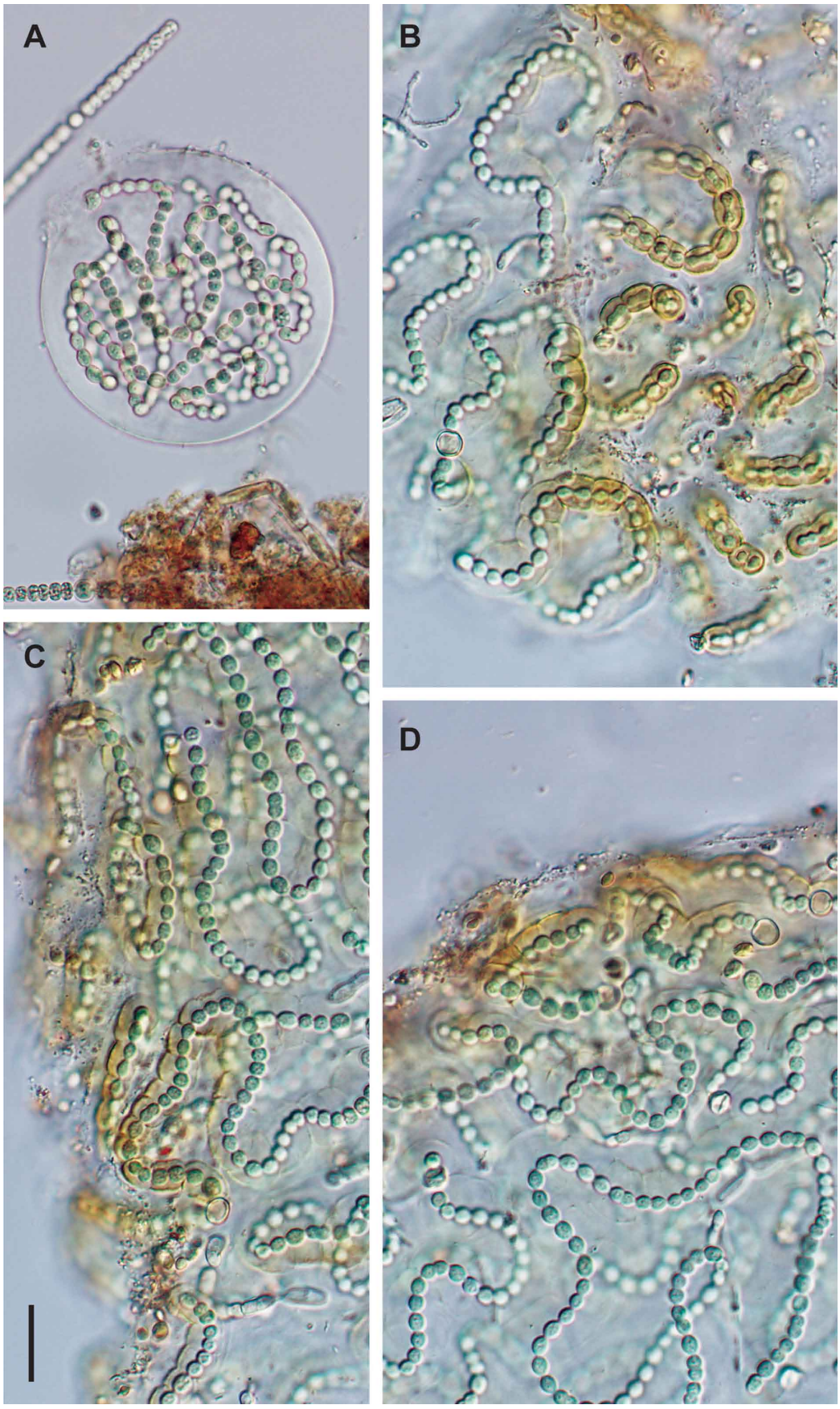

FIGURE 48. A–D *Nostoc commune*. Scale bars = 20 µm

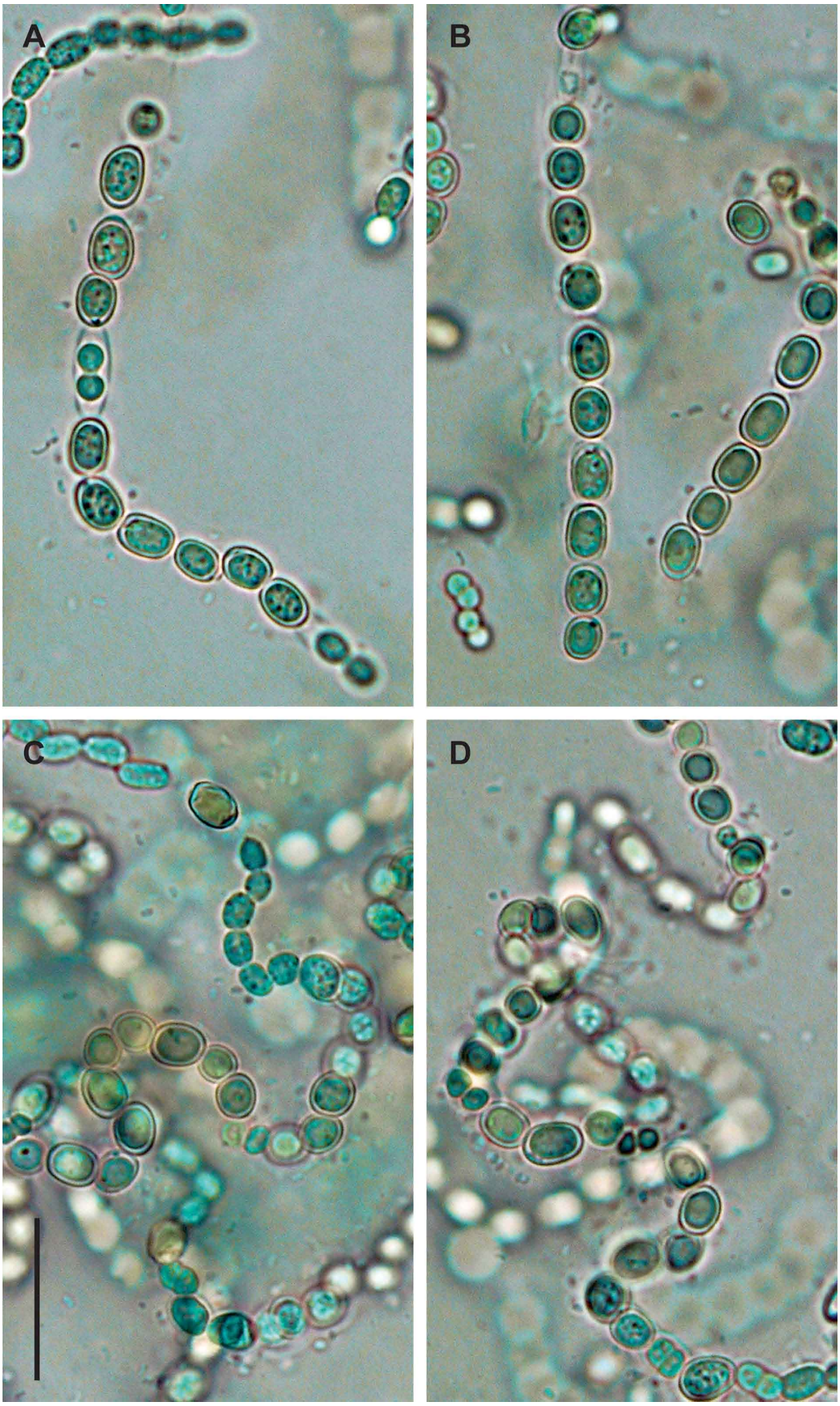

FIGURE 49. A–D *Nostoc linckia*. Scale bars = 20 µm

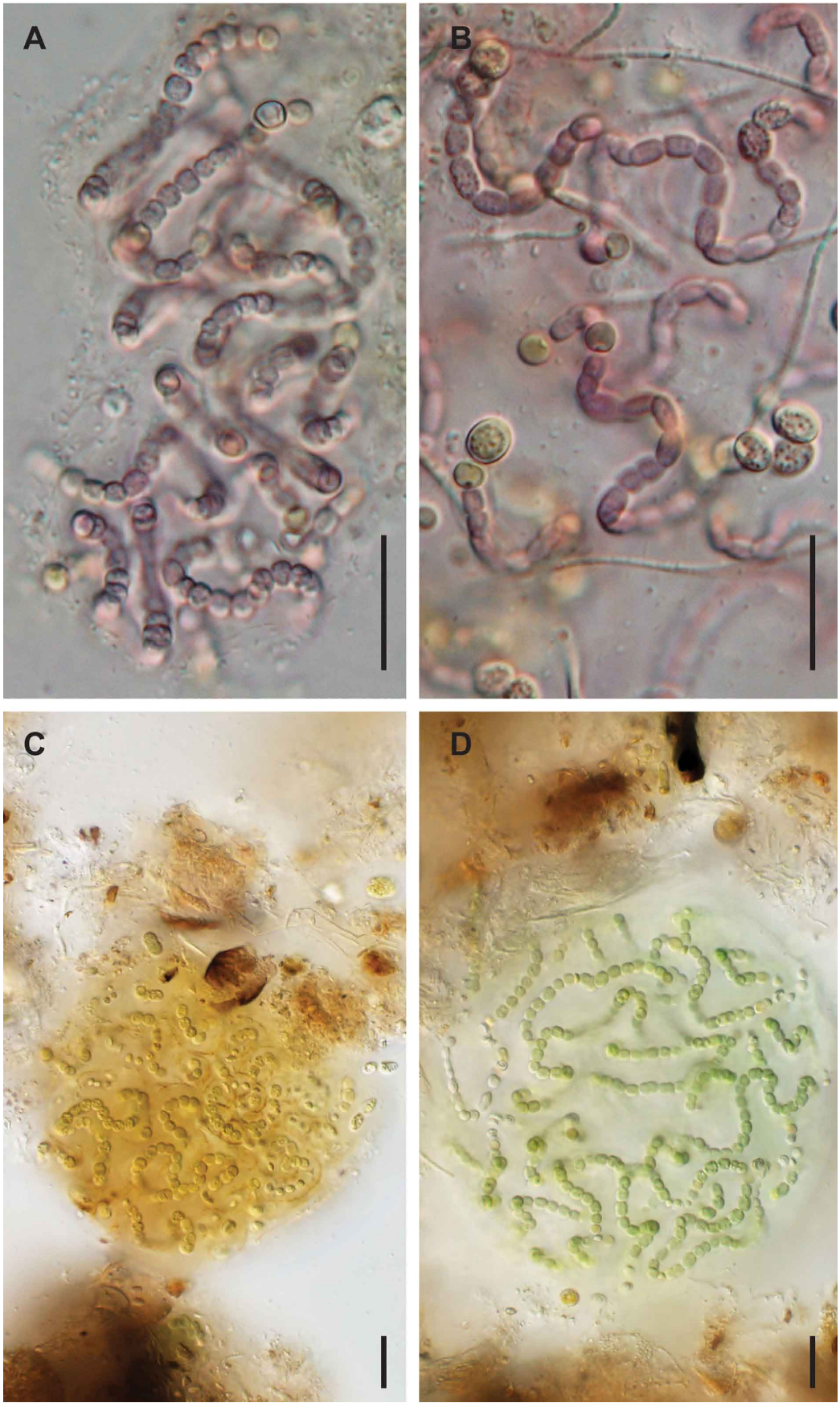

FIGURE 50. A–B *Nostoc* sp. B; C–D *Nostoc sphaericum*. Scale bars = 20 µm

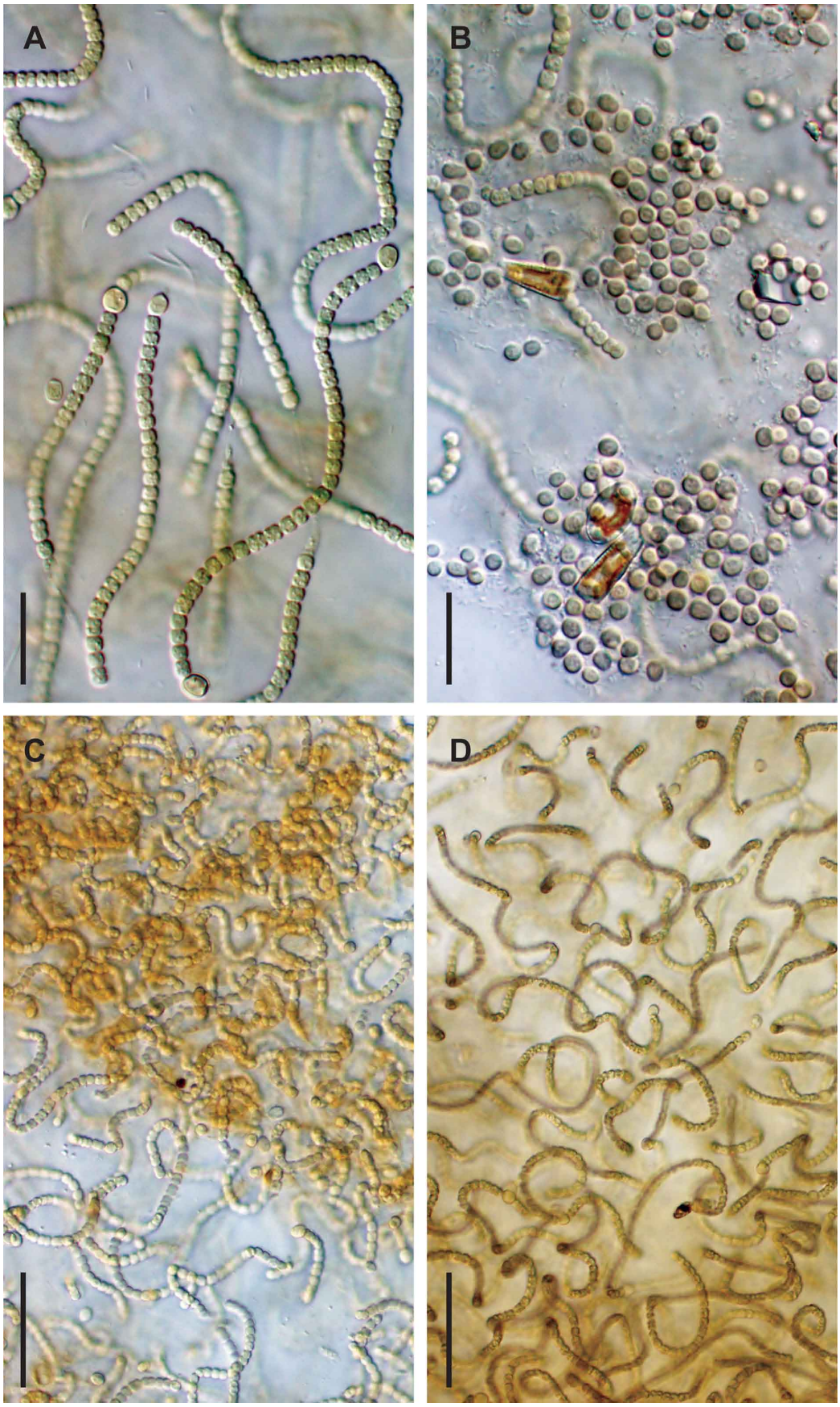

FIGURE 51. A–D *Nostoc verrucosum*. Scale bars A–B = 20 µm, C–D = 50 µm

FIGURE 52. A–B Colonies of *Nostoc verrucosum* growing on granitic rocks.

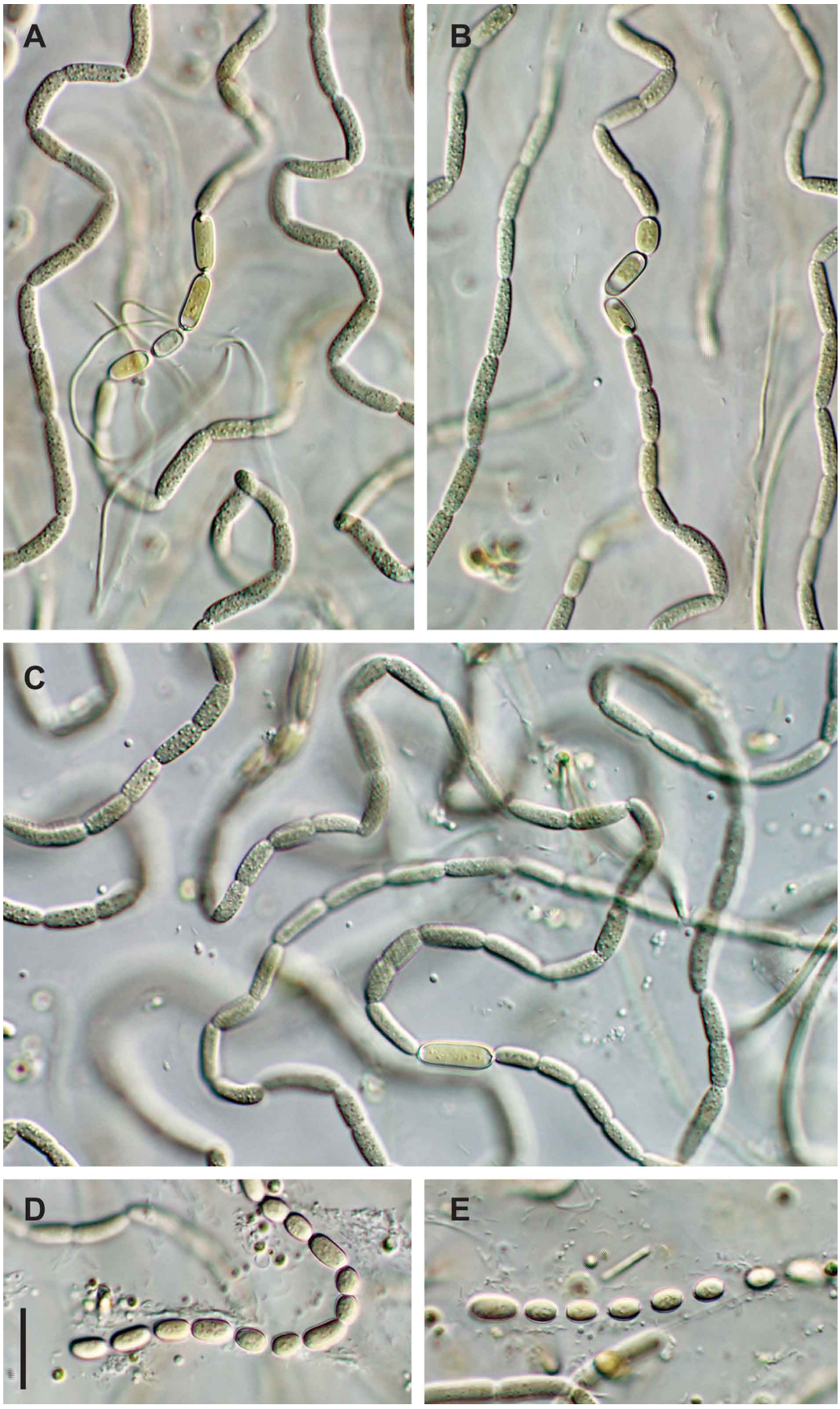

FIGURE 53. A–E *Nostoc* sp. A. Scale bars = 20 μm

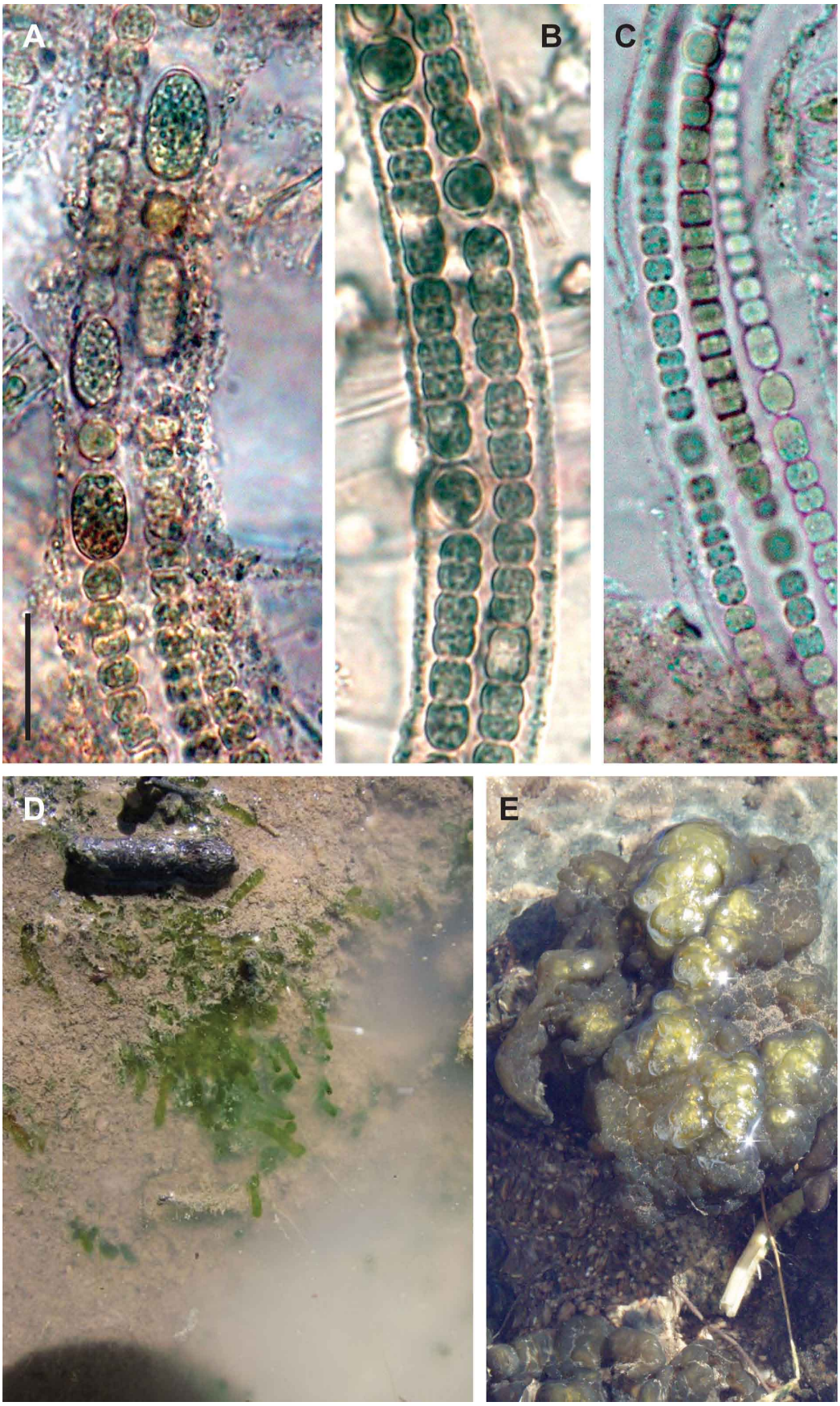

FIGURE 54. A–C *Wollea ambigua*; D Colonies of *Wollea saccata*; Colonies of *Nostoc verrucosum.* Scale bars = 20 µm

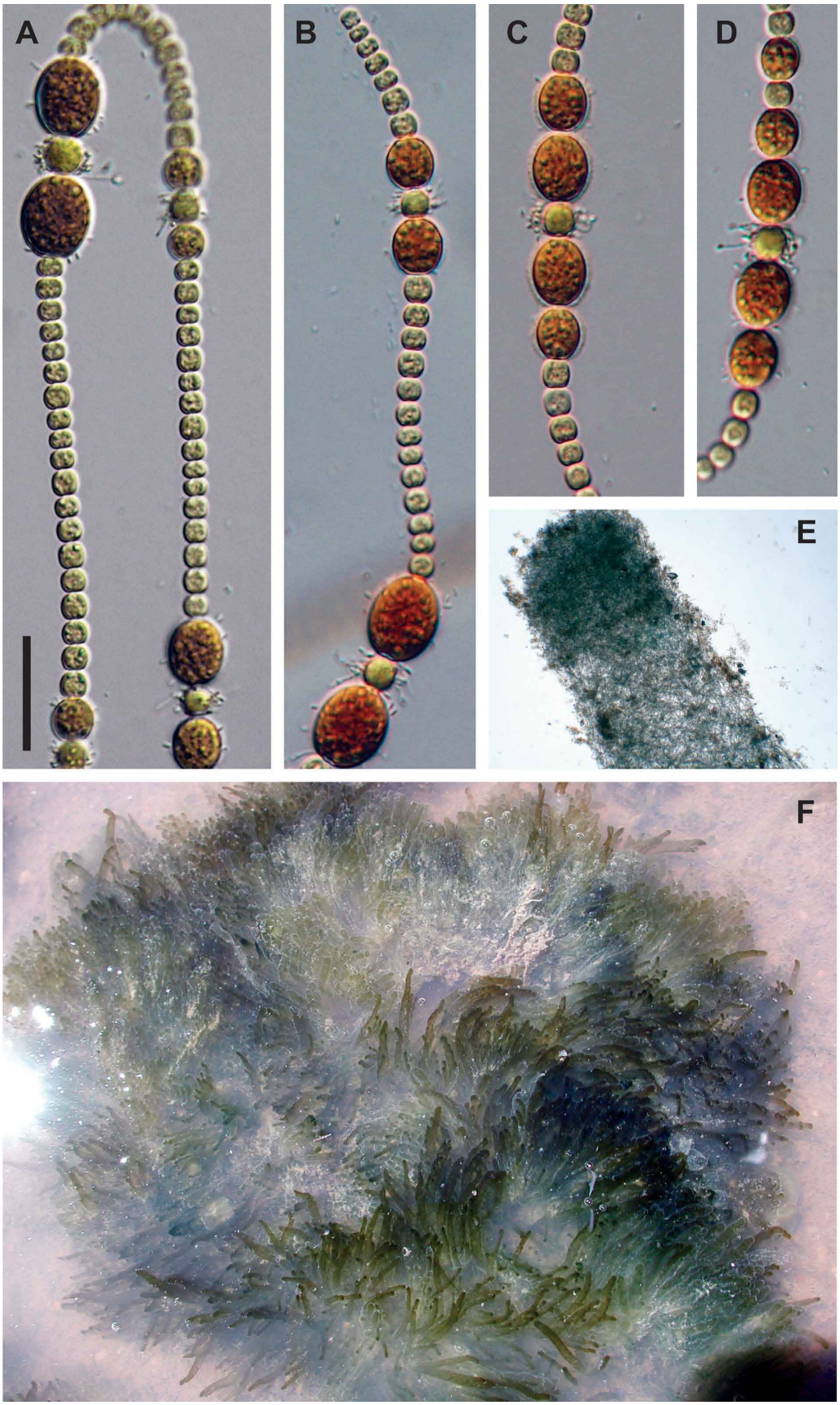

FIGURE 55. A–F *Wollea bharadwajae*; F Gelatinous colony growing on sandy sediments. Scale bars = 20 µm

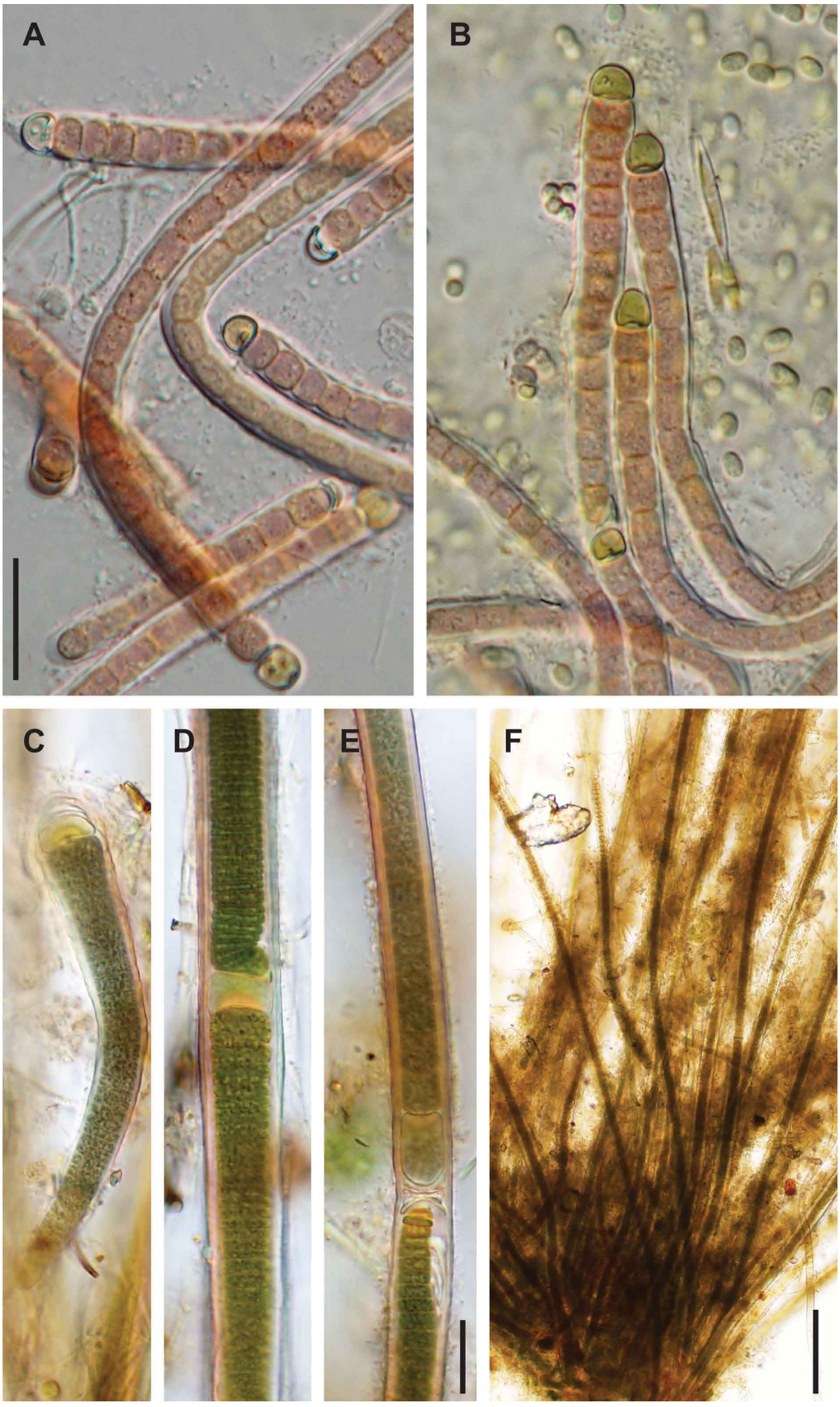

FIGURE 56. A–B *Calothrix atricha*; C–F *Calothrix* sp. D. Scale bars A–E = 20 µm, F = 50 µm

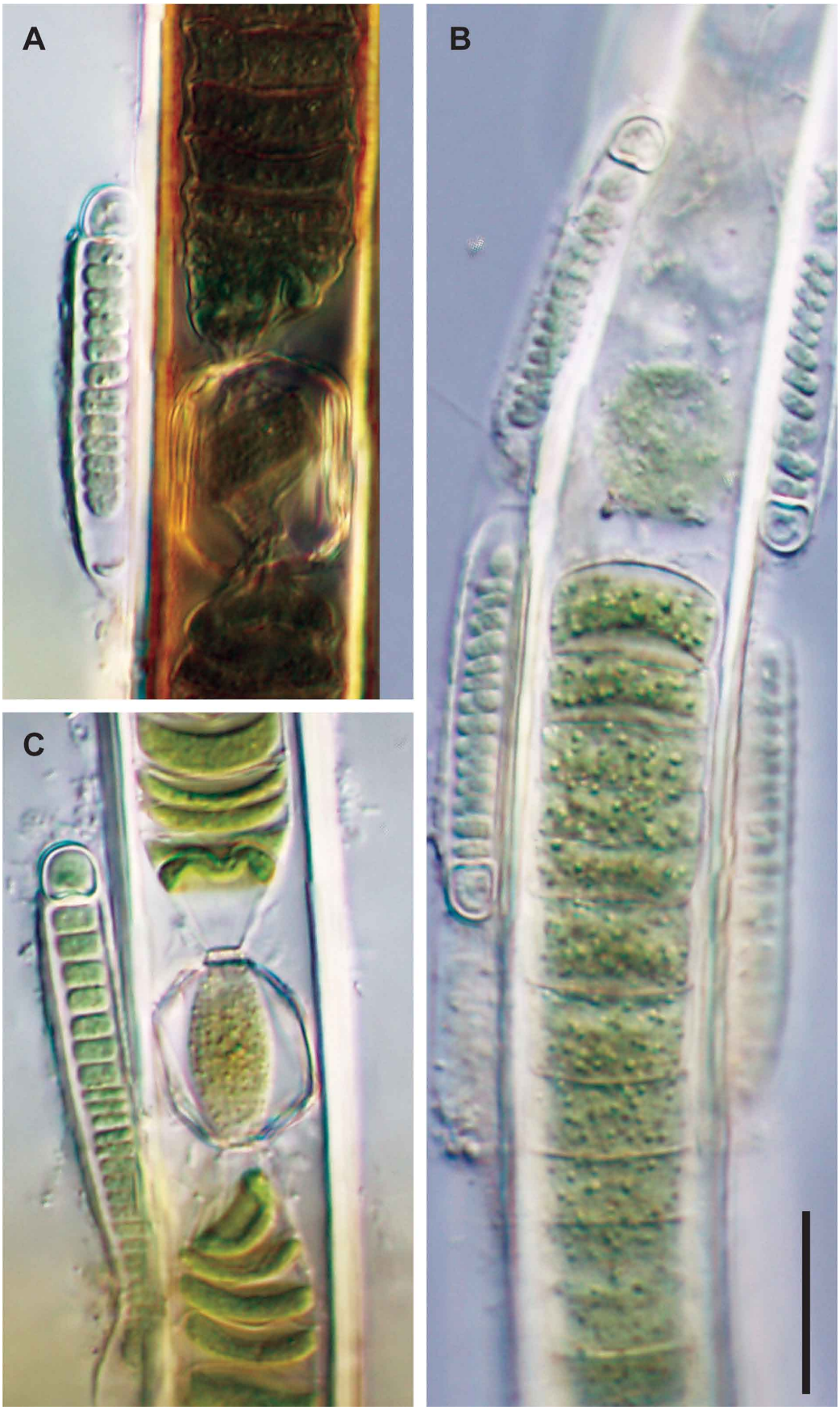

FIGURE 57. A–C *Calothrix brevissima*. Scale bars = 20 µm

FIGURE 58. A–D *Calothrix* cf. *fusca*. Scale bars = 20 µm

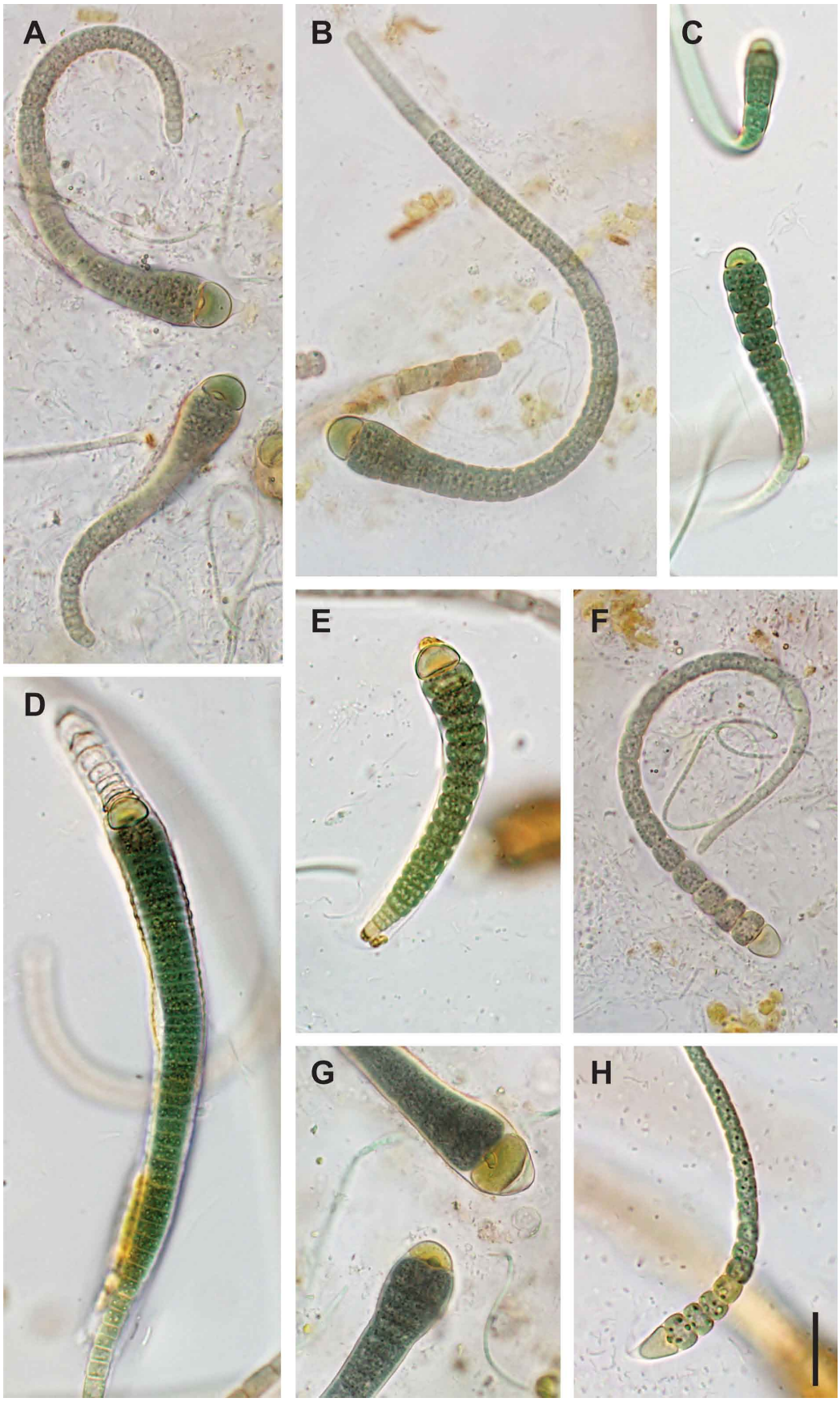

FIGURE 59. A, B, D, E, G *Calothrix* sp. A; C, F, H *Calothrix* sp. B. Scale bars = 20 µm

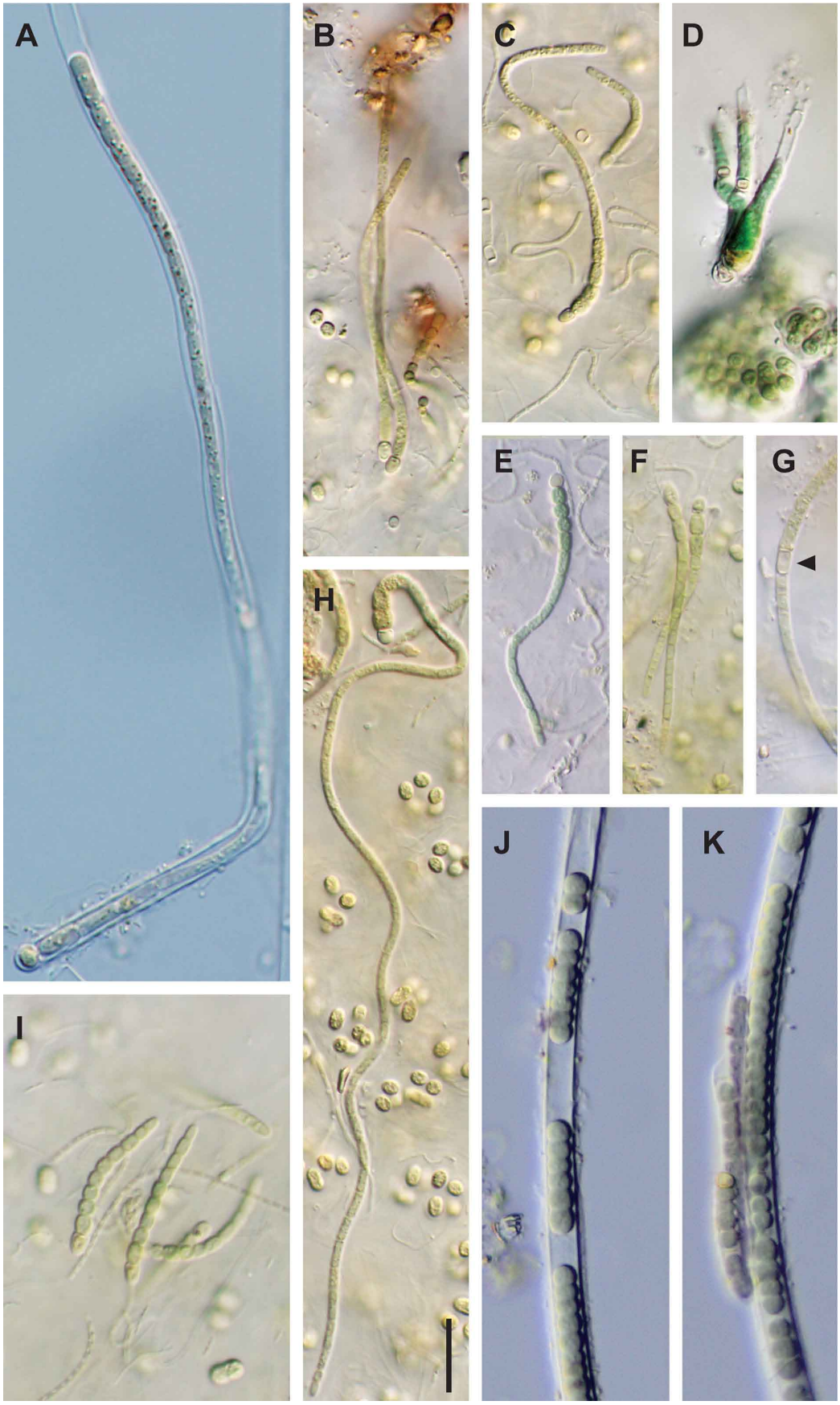

FIGURE 60. A *Fortiea* sp. A; B–I *Calothrix* sp. C; J–K *Microchaete* sp. A. Scale bars = 20 µm

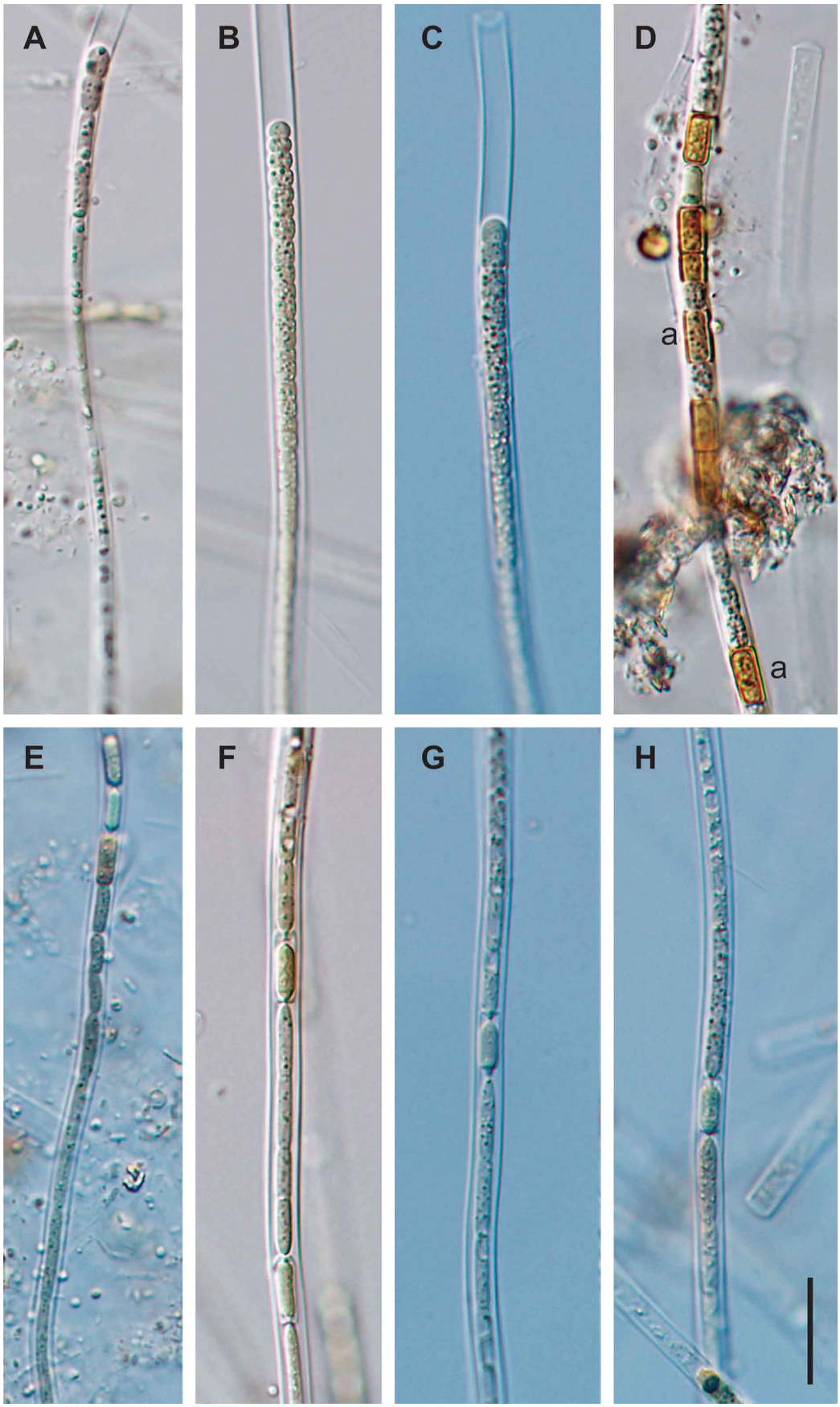

FIGURE 61. A–H *Camptylonemopsis* cf. *pulneyensis*. Scale bars = 20 µm

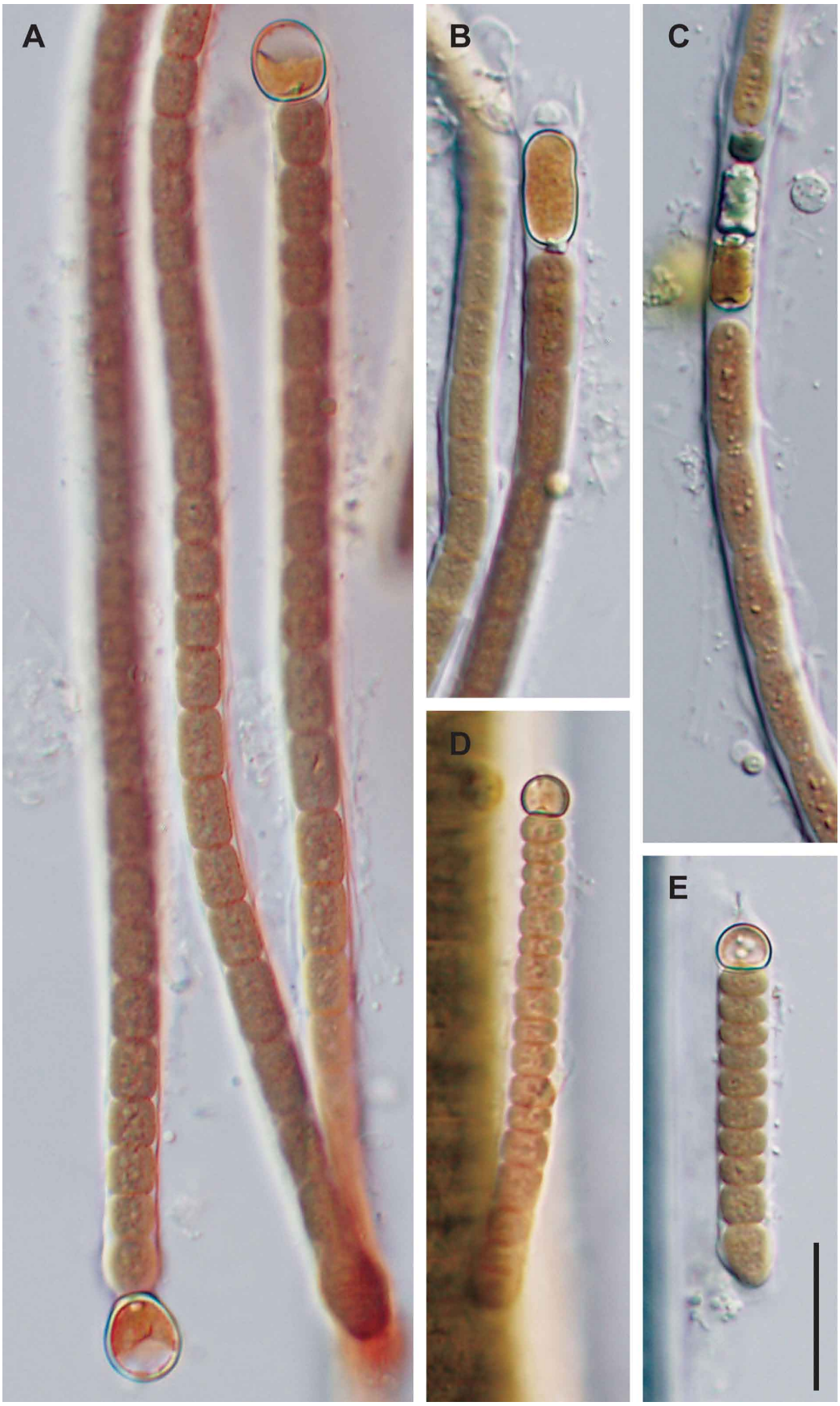

FIGURE 62. A–E *Microchaete* cf. *investiens*. Scale bars = 20 µm

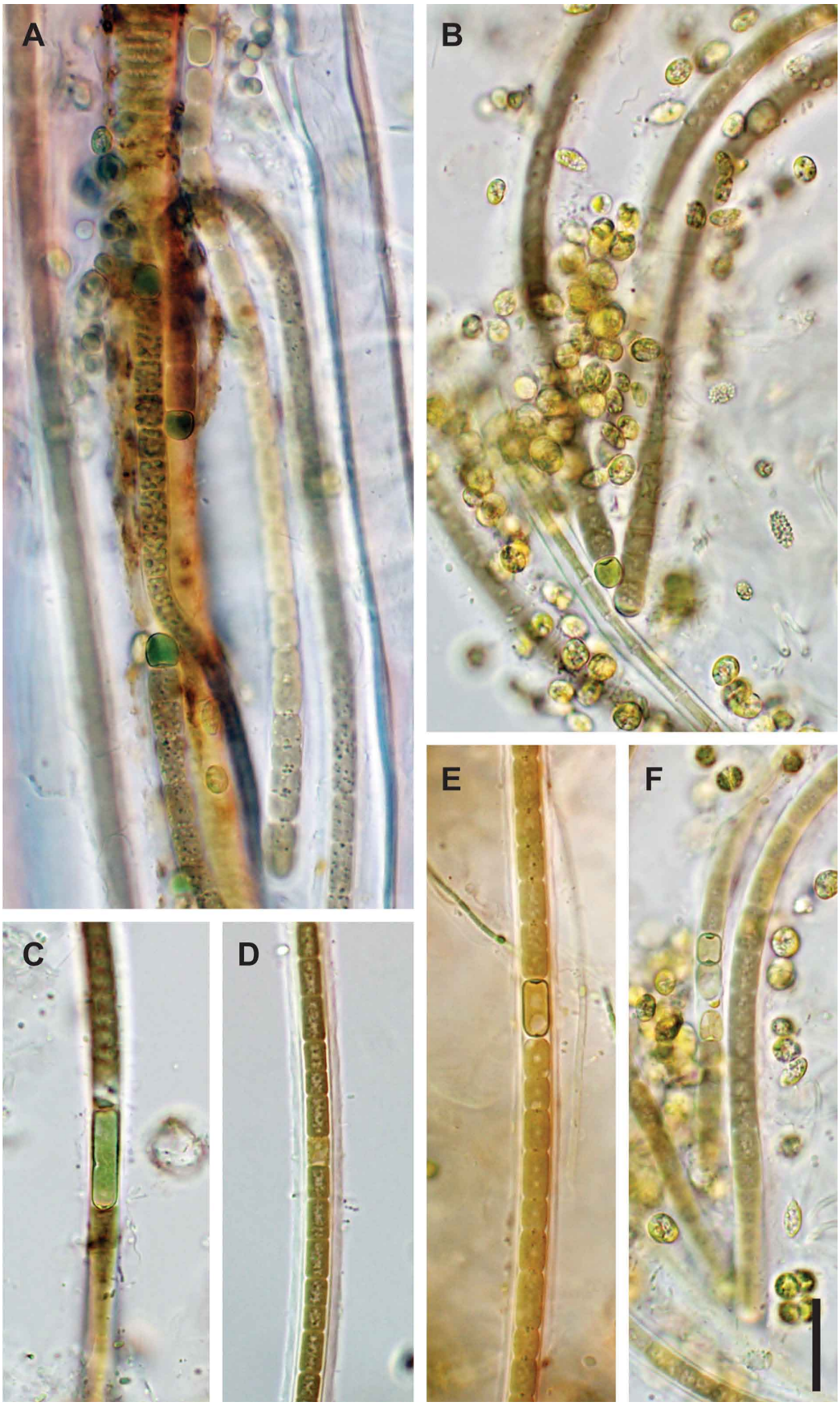

FIGURE 63. A–F *Microchaete tenera*. Scale bars = 20 µm

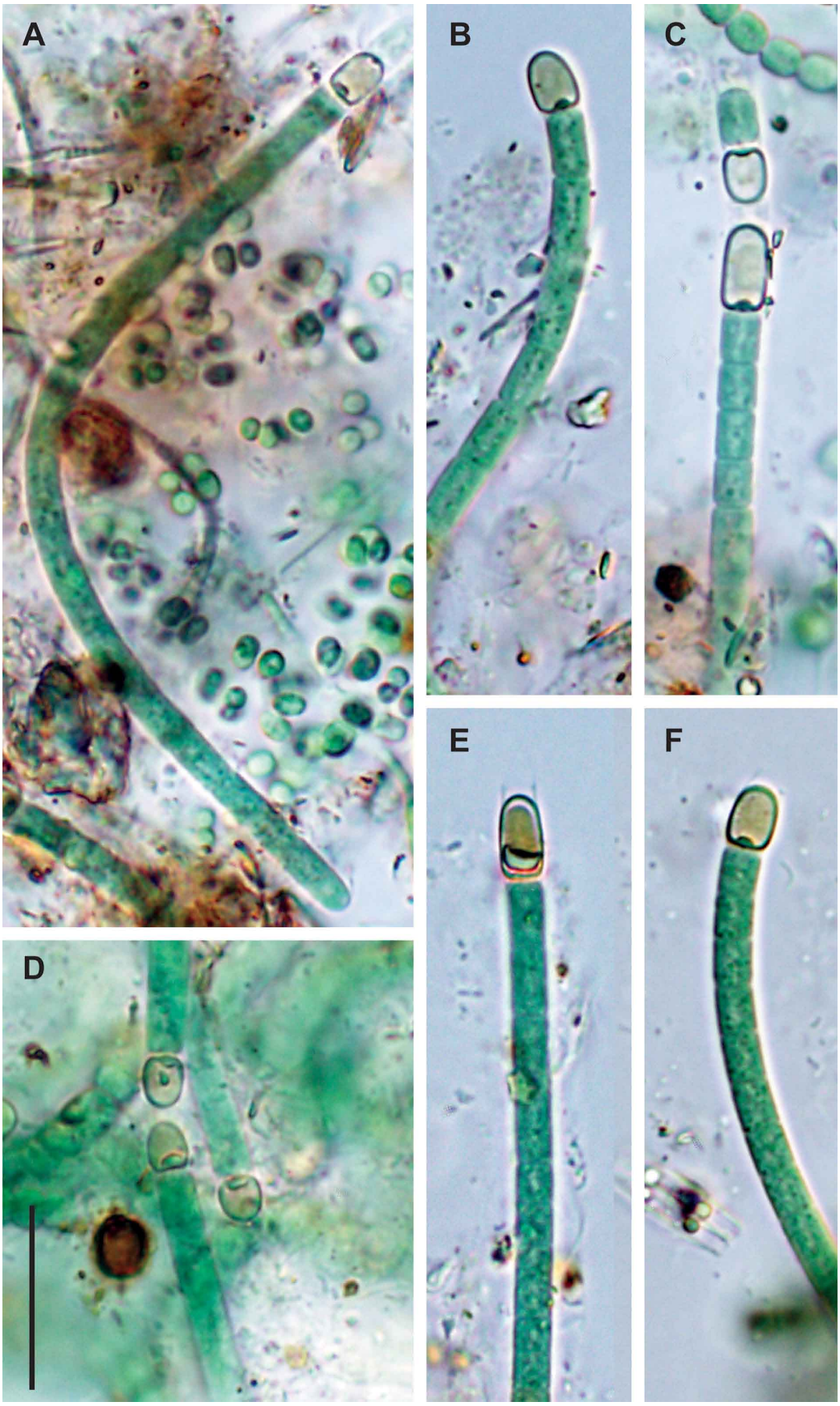

FIGURE 64. A–F *Microchaete* sp. B. Scale bars = 20 µm

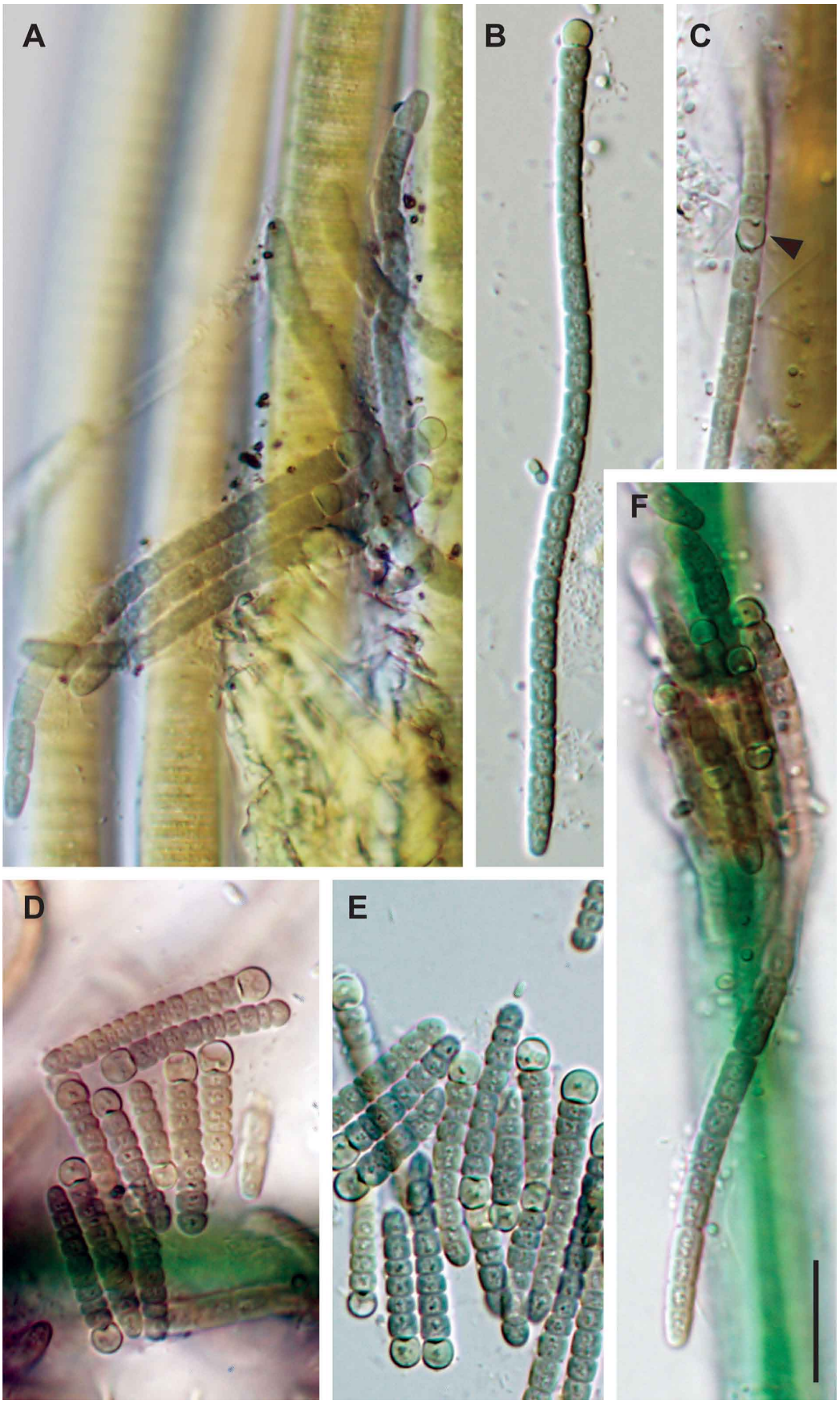

FIGURE 65. A–F *Microchaete* sp. C. Scale bars = 20 µm

FIGURE 66. A–E *Rivularia aquatica*. Scale bars = 20 µm

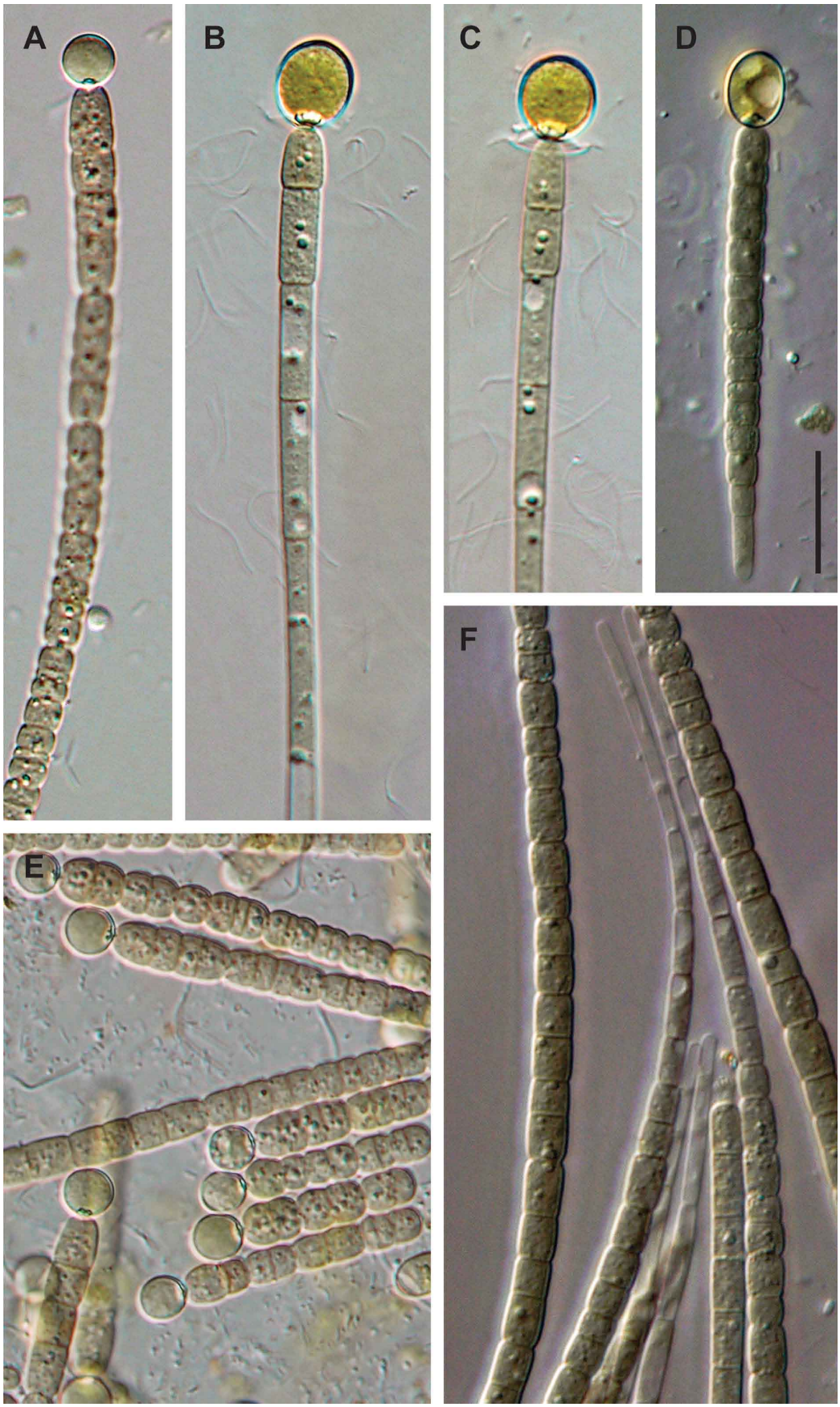

FIGURE 67. A–F *Rivularia beccariana*. Scale bars = 20 µm

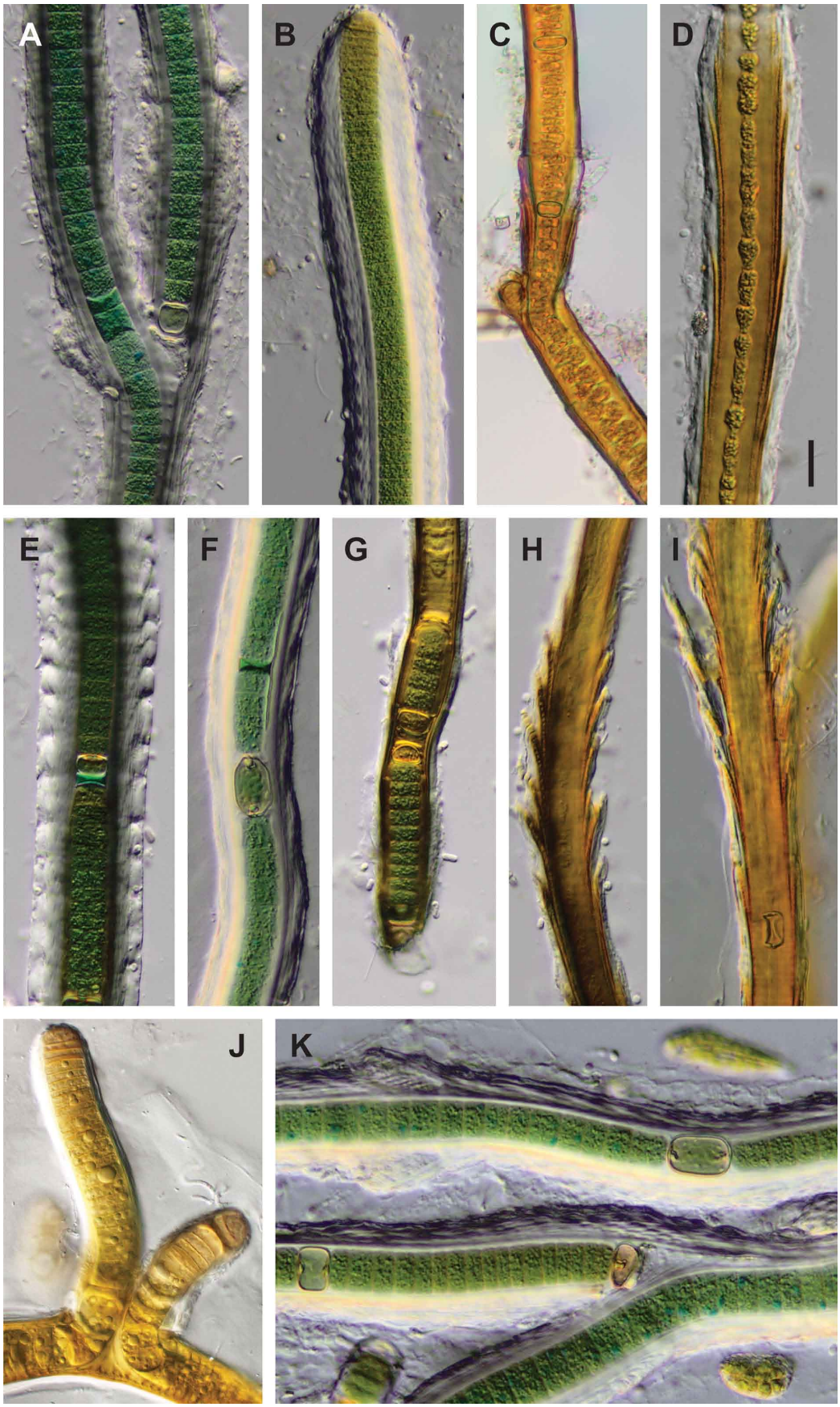

FIGURE 68. A–K *Ewamiania thermalis*. Scale bars = 20 µm

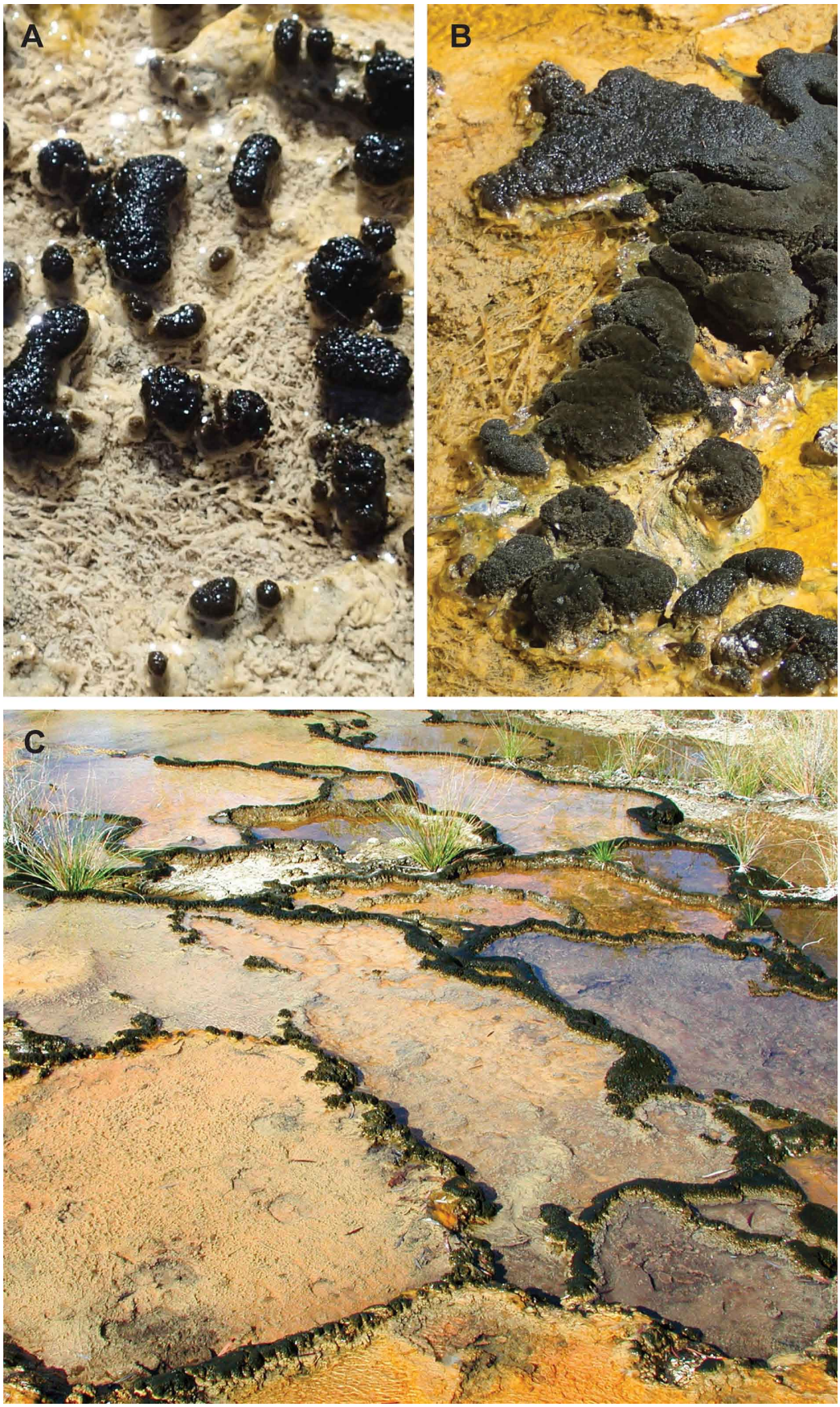

FIGURE 69. A–C Colonies of *Ewamiania thermalis* growing along the crests of minidams just above the thermal waters discharging from the springs.

FIGURE 70. A–E *Iningainema pulvinus*. Scale bars = 20 µm

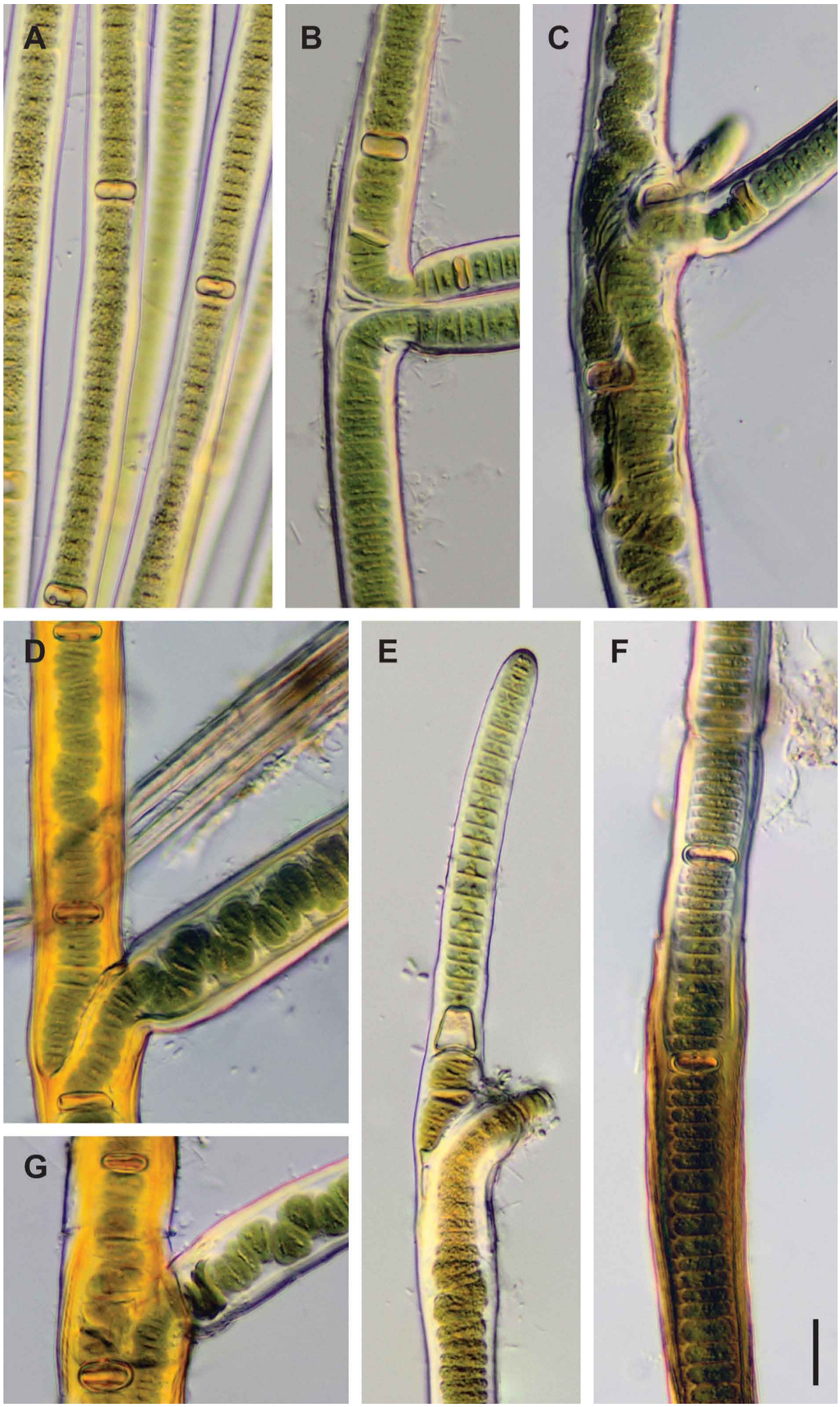

FIGURE 71. A–F *Iningainema pulvinus*. Scale bars = 20 µm

FIGURE 72. Colonies of *Iningainema pulvinus* growing on the benthos in shallow wetlands.

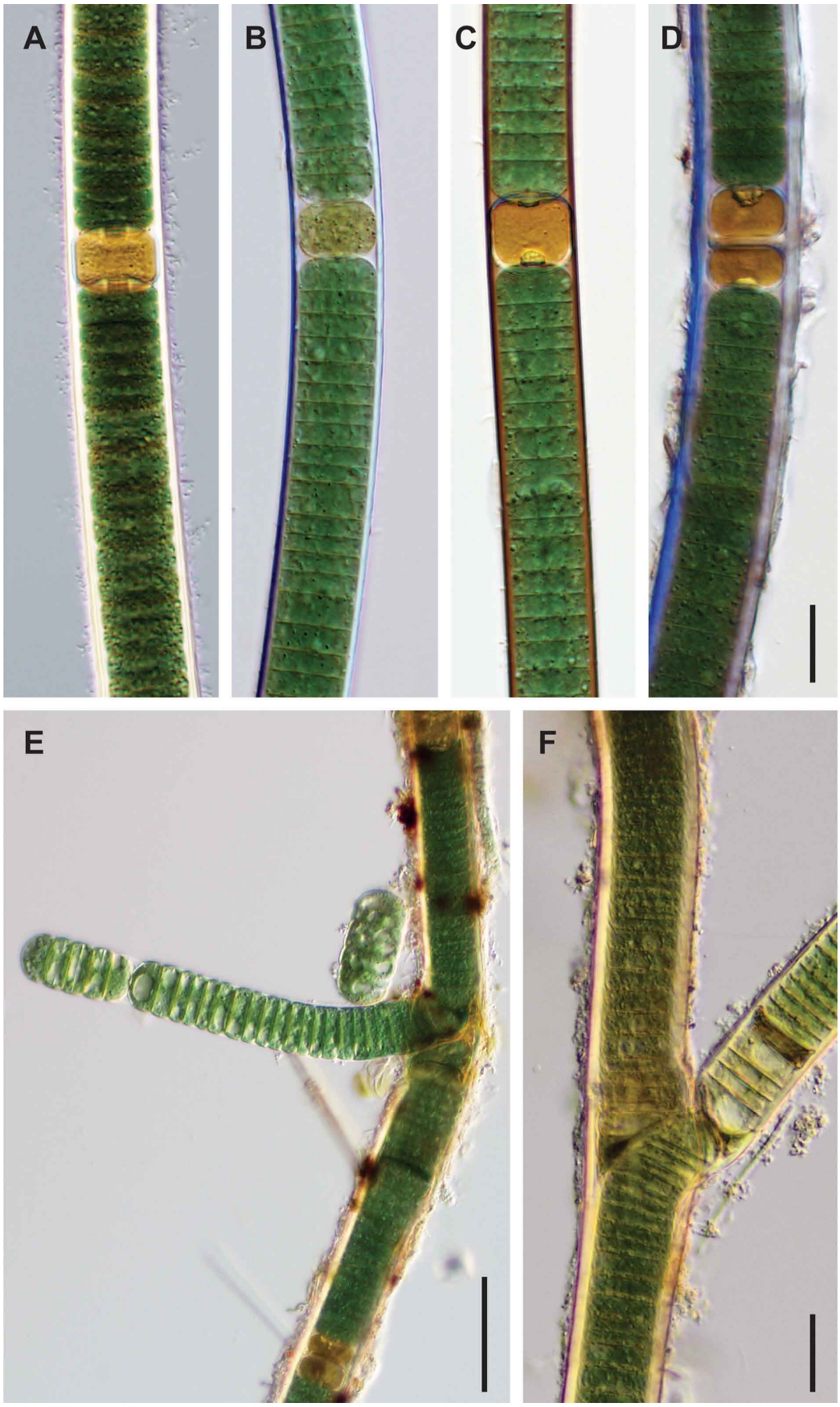

FIGURE 73. A–F *Heteroscytonema crispum*. Scale bars A–D, F = 20 µm, E = 50 µm

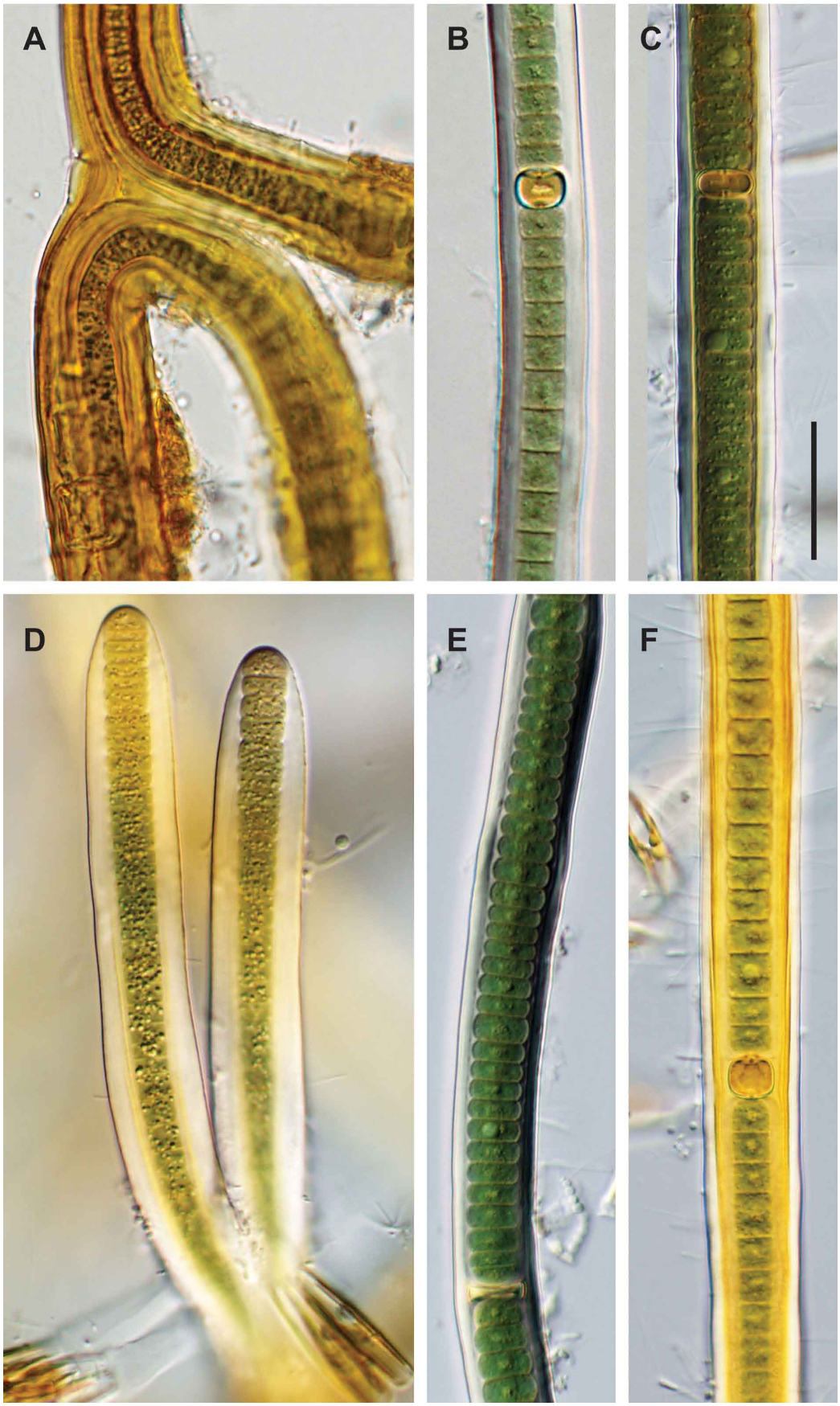

FIGURE 74. A–F *Scytonema coactile*. Scale bars = 20 µm

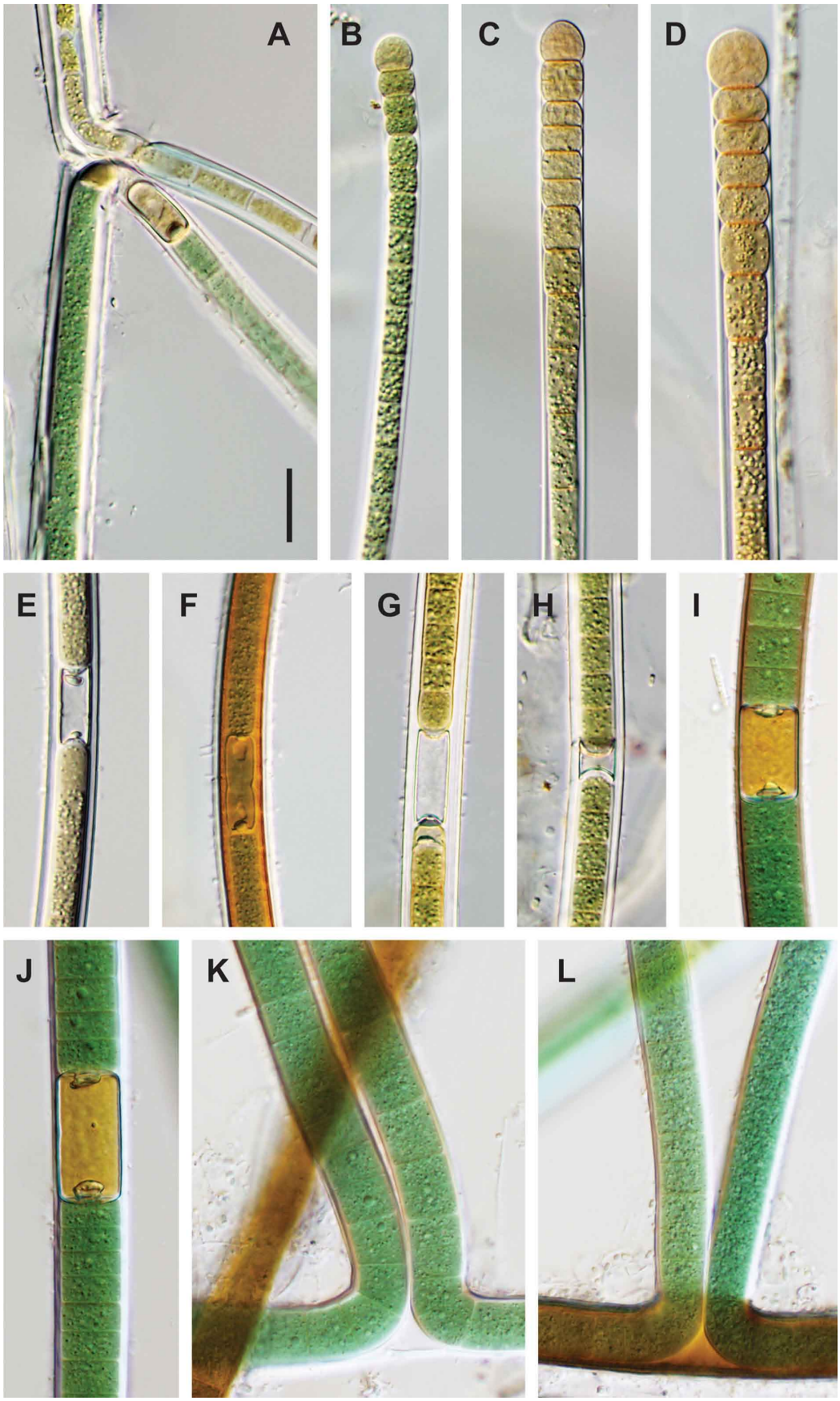

FIGURE 75. A–L *Scytonema mirabile*. Scale bars = 20 µm

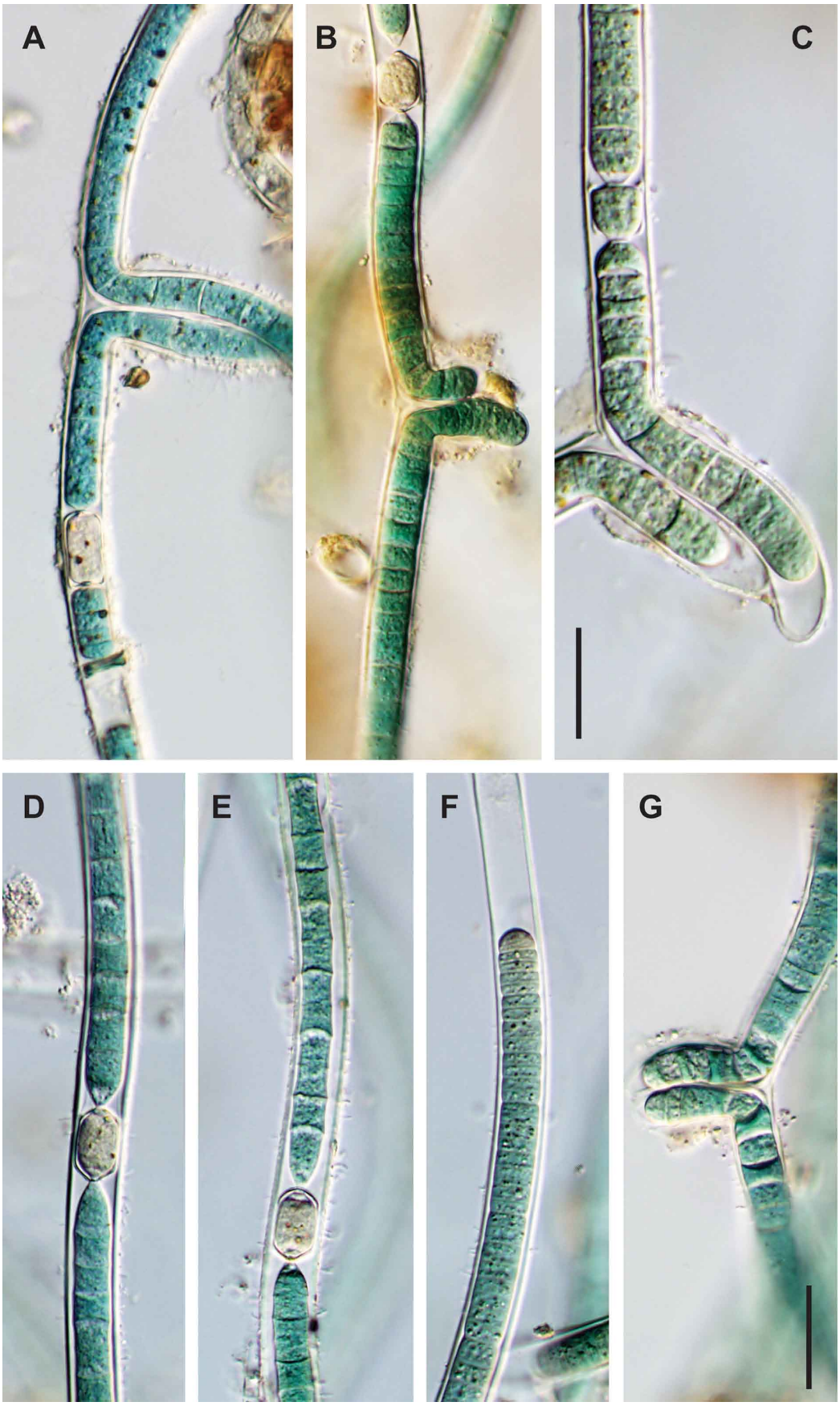

FIGURE 76. A–G *Scytonema* cf. *sanpaulense*. Scale bars = 20 µm

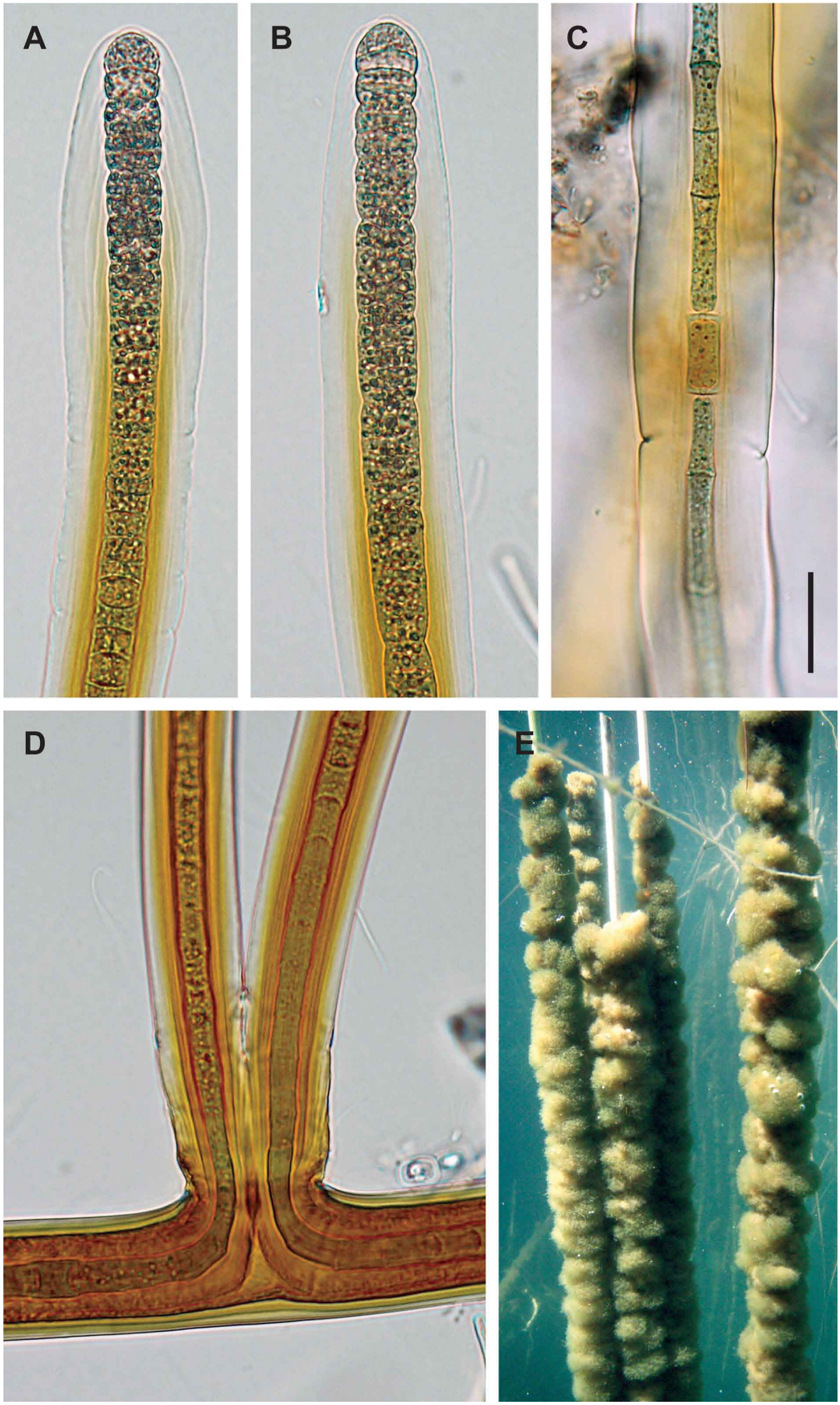

FIGURE 77. A–E *Scytonema subtile*; E Colonies periphytic on the culms of the emergent sedge *Lepironia articulata*. Scale bars = 20 µm

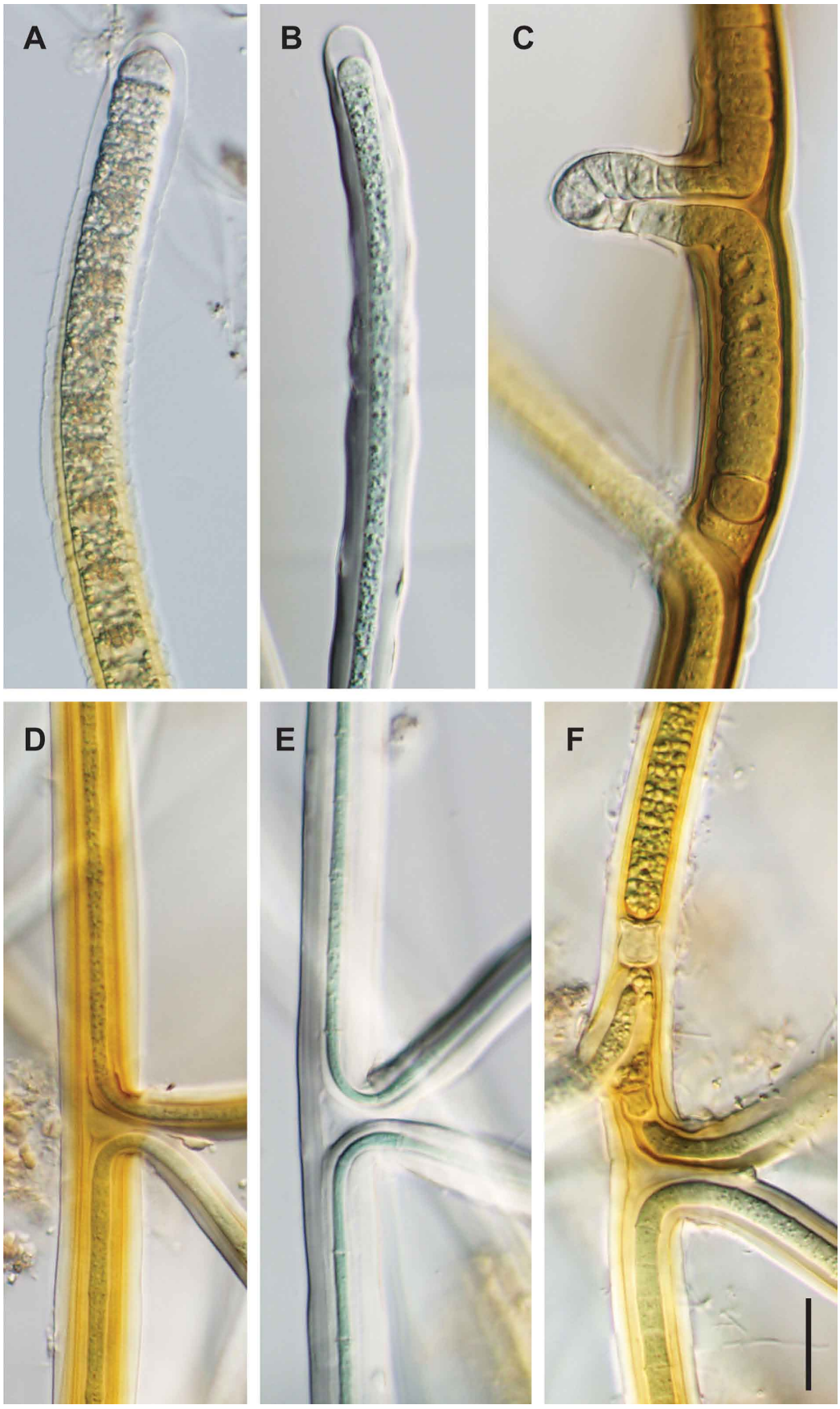

FIGURE 78. A–F *Scytonema subtile*. Scale bars = 20 µm

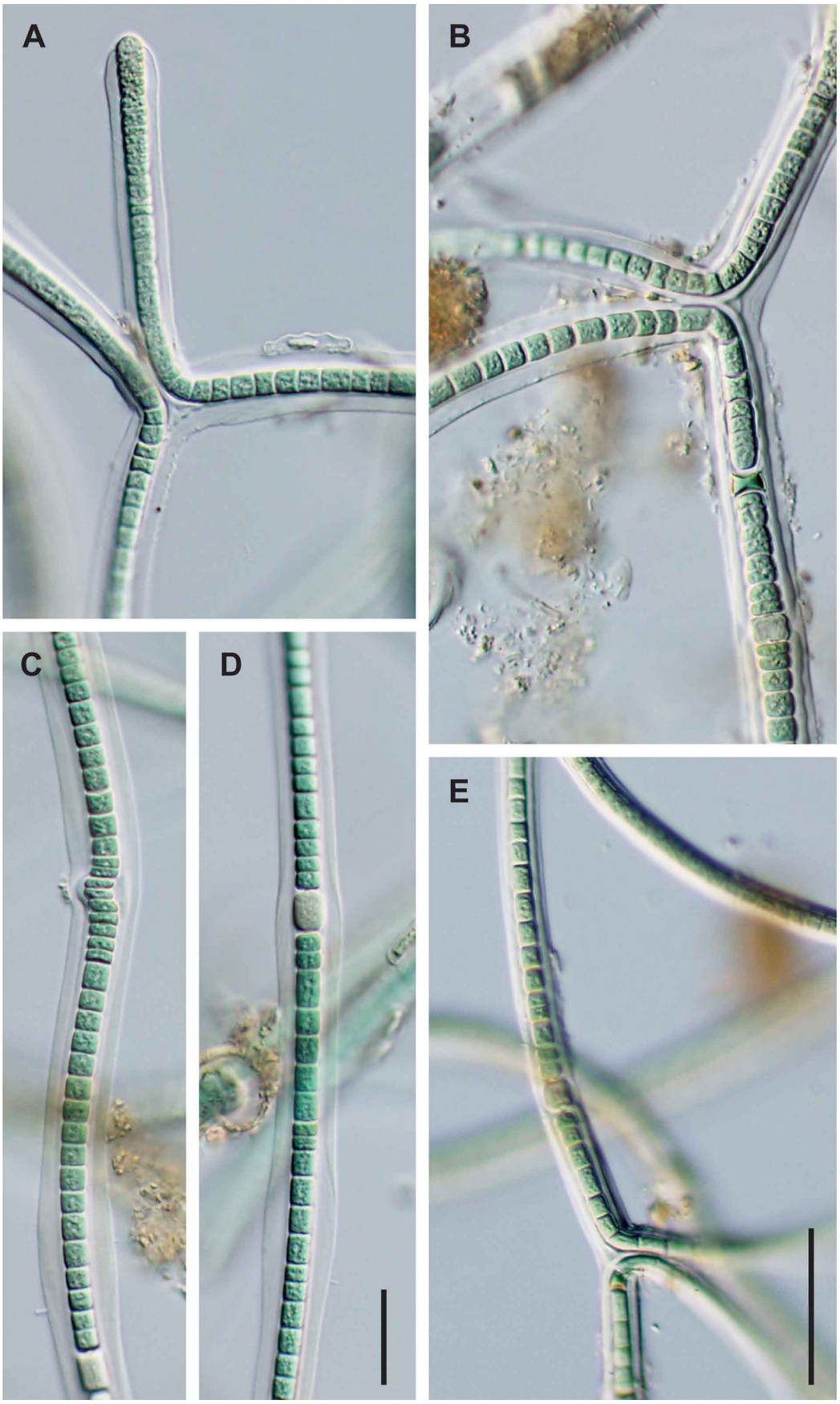

FIGURE 79. A–E *Scytonema tolypothrichoides*. Scale bars = 20 µm

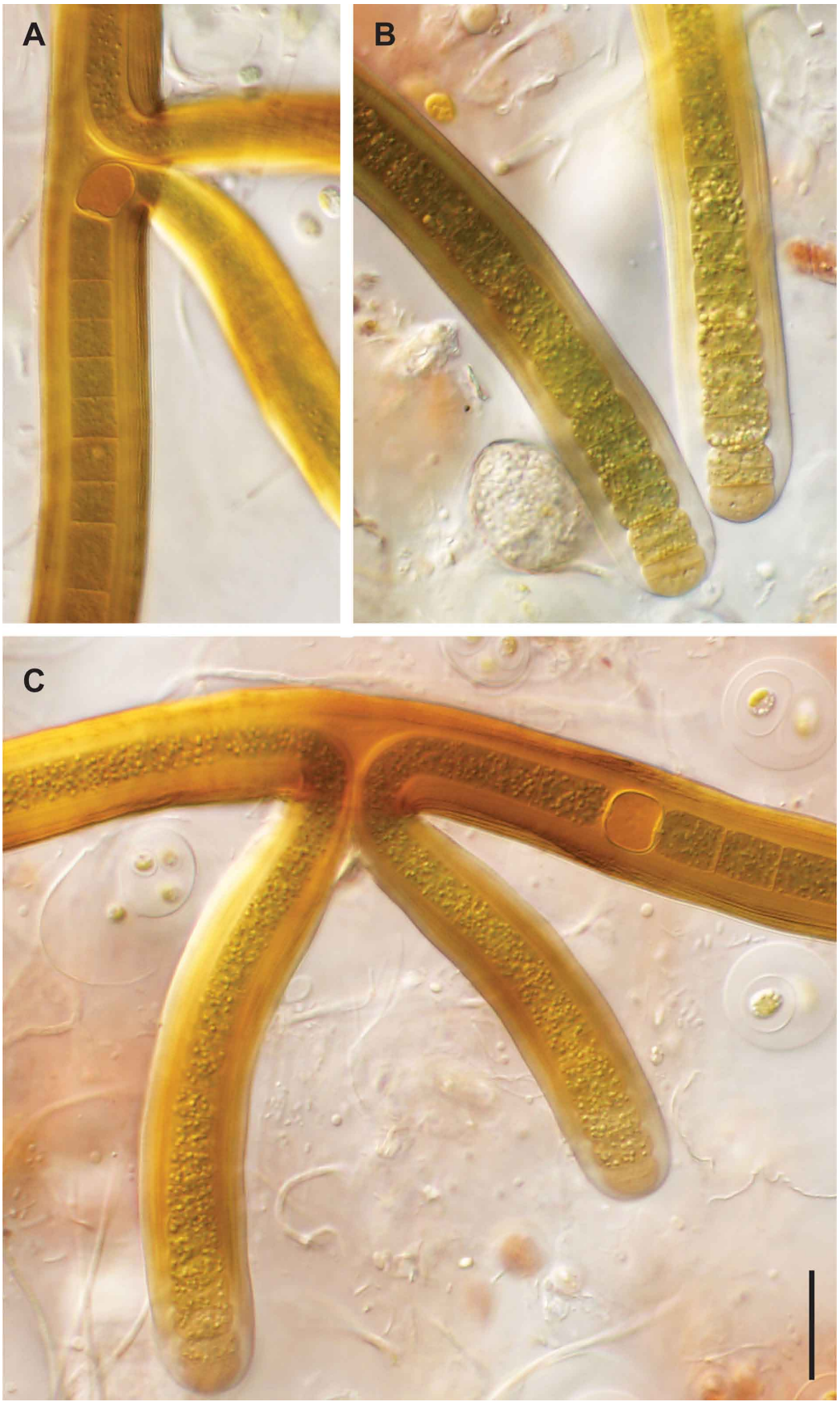

FIGURE 80. A–C *Scytonema* sp. A. Scale bars = 20 µm

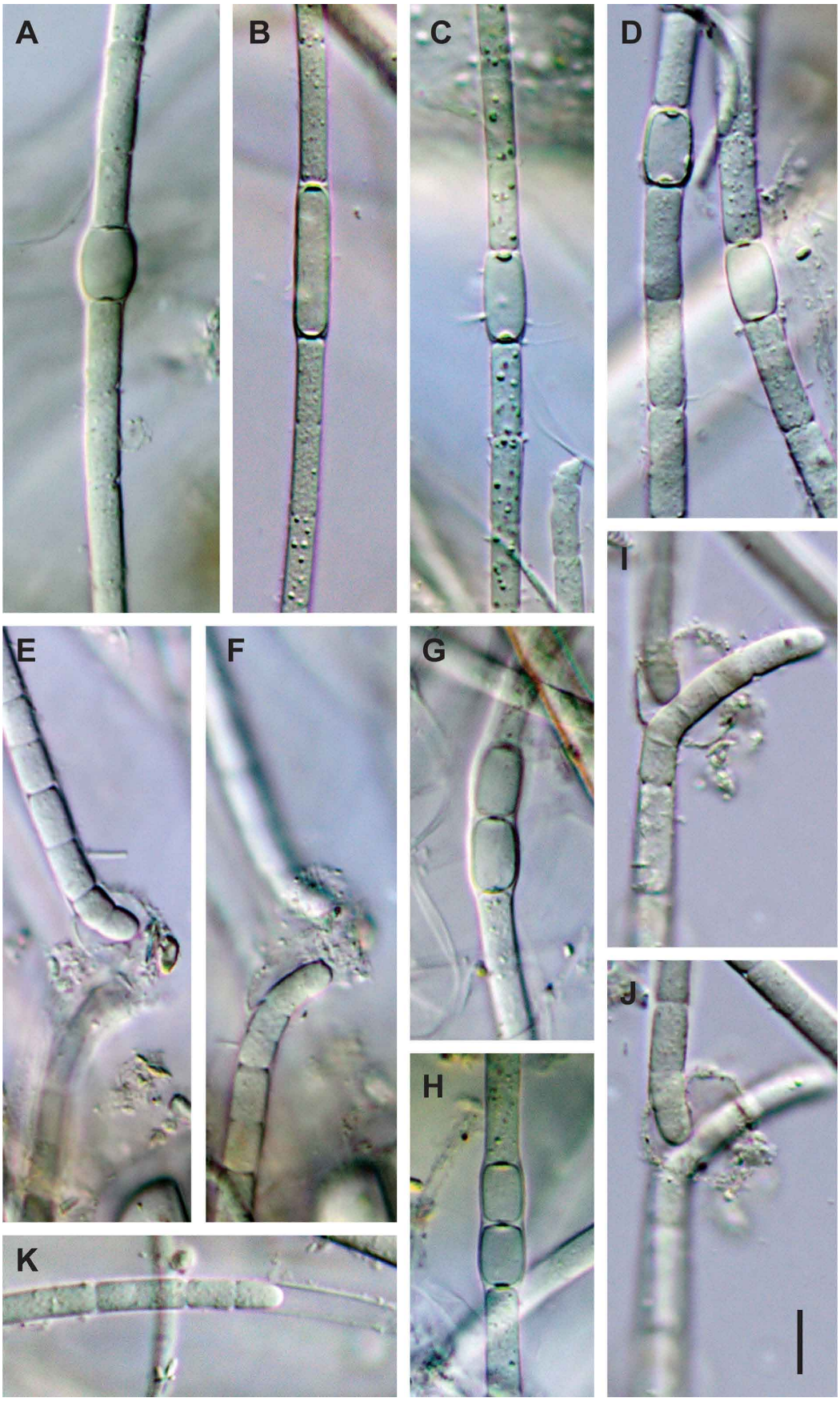

FIGURE 81. A–J *Scytonematopsis kashyapii*. Scale bars = 10 µm

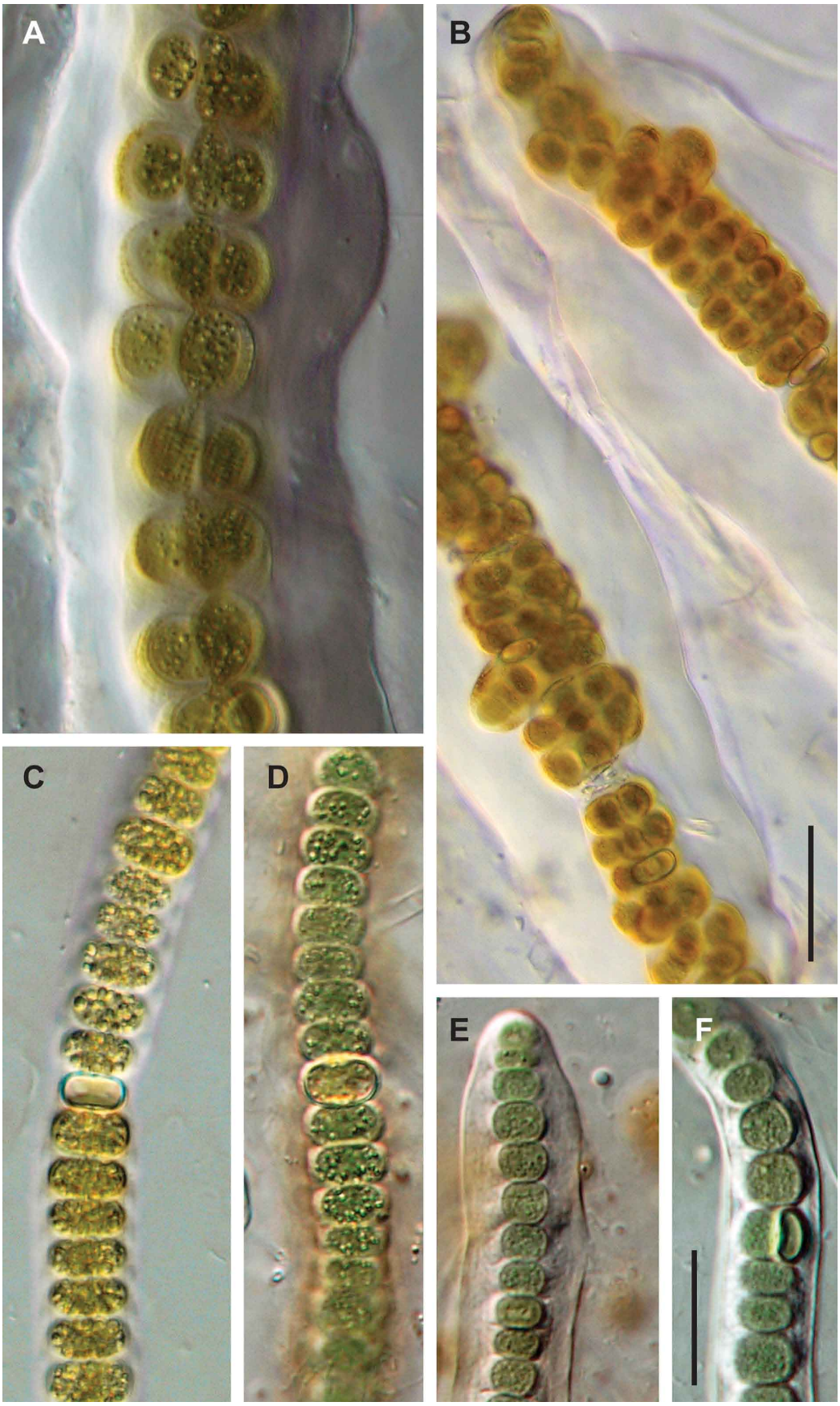

FIGURE 82. A–F *Stigonema eliskae*. Scale bars = 20 µm

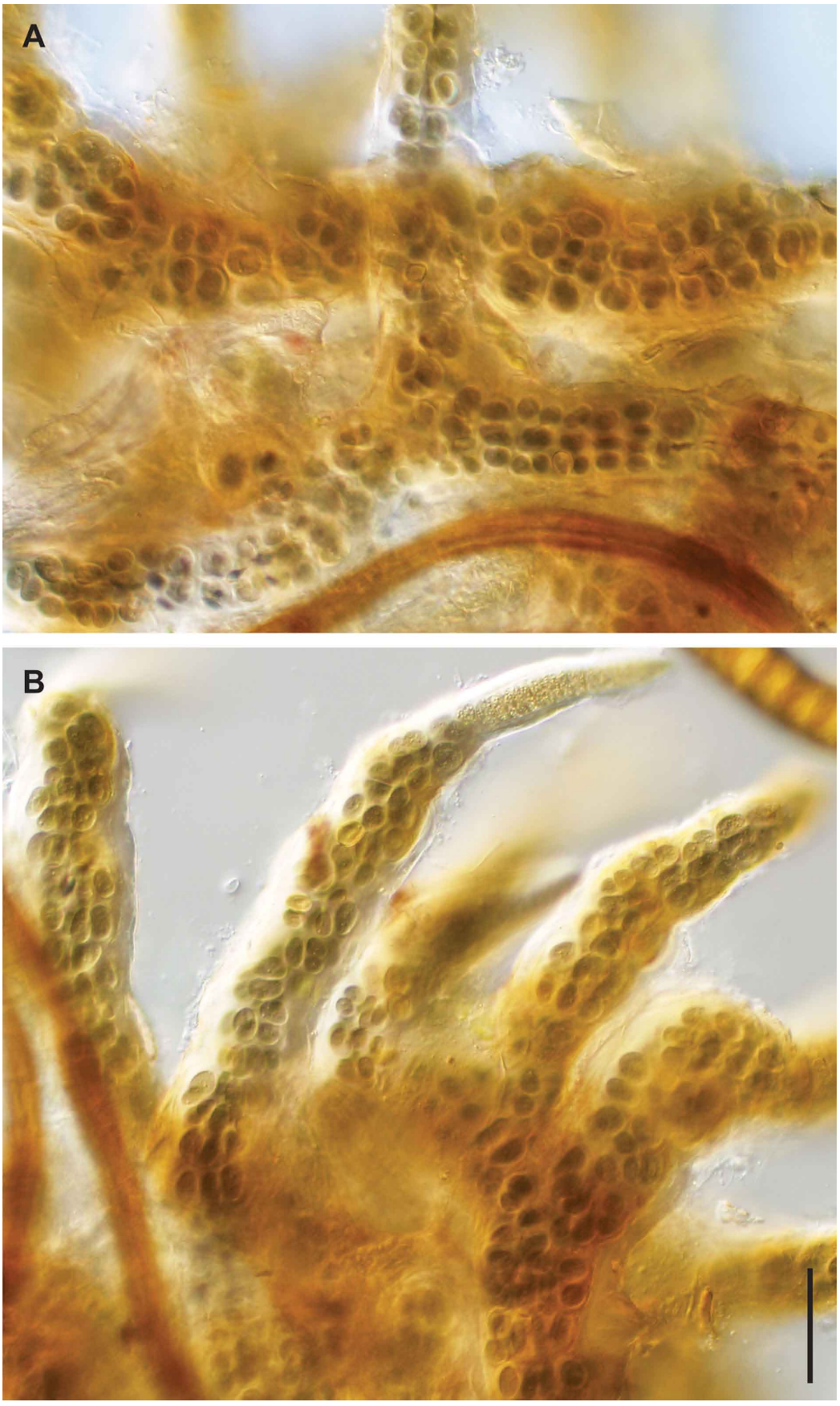

FIGURE 83. A–B *Stigonema informe*. Scale bars = 20 µm

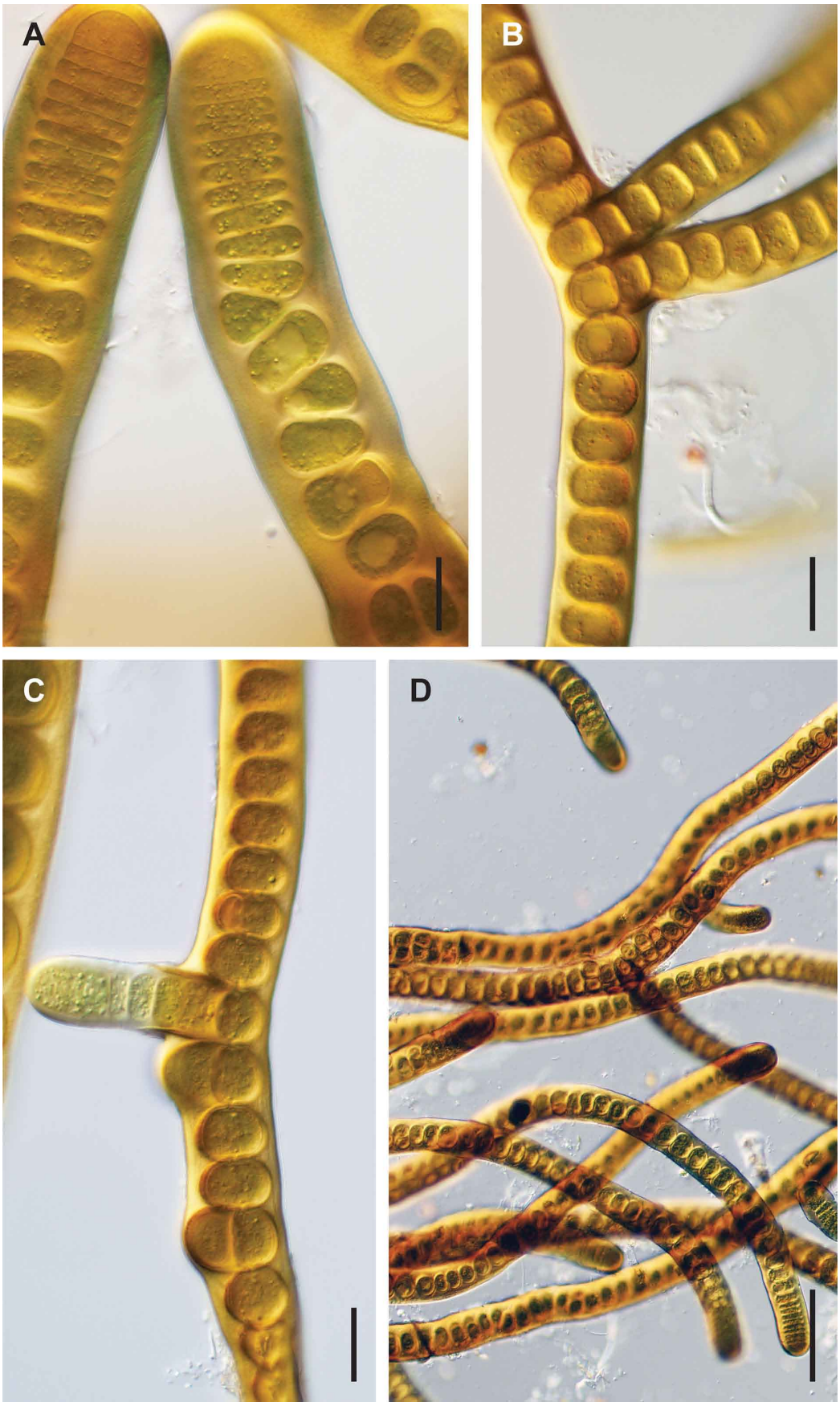

FIGURE 84. A–D *Stigonema ocellatum*. Scale bars = A–C 20 µm, D 50 µm

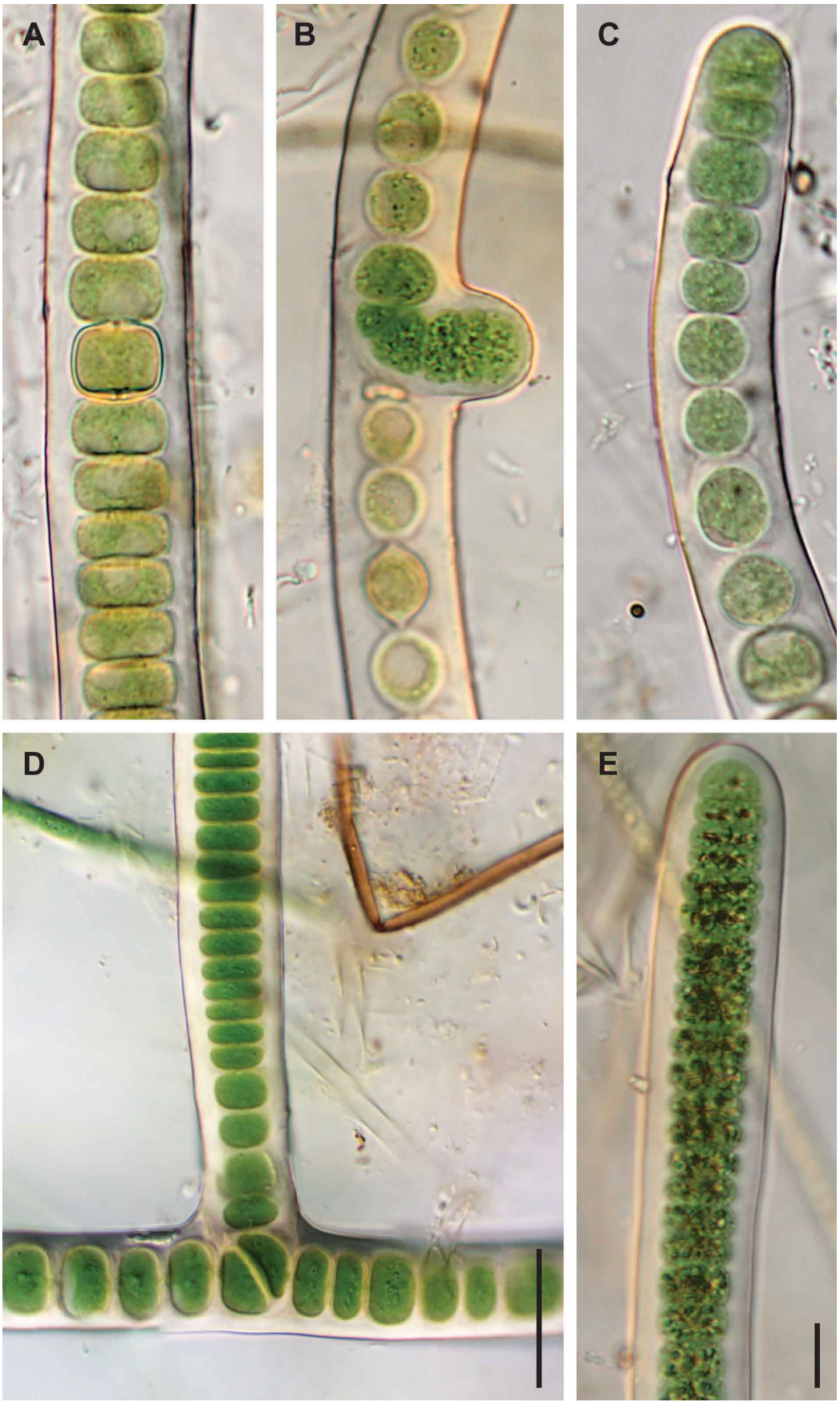

FIGURE 85. A–E *Stigonema ocellatum*. Scale bars = 20 µm

FIGURE 86. A–F *Symphyonema kaboorum*. Scale bars = 20 µm

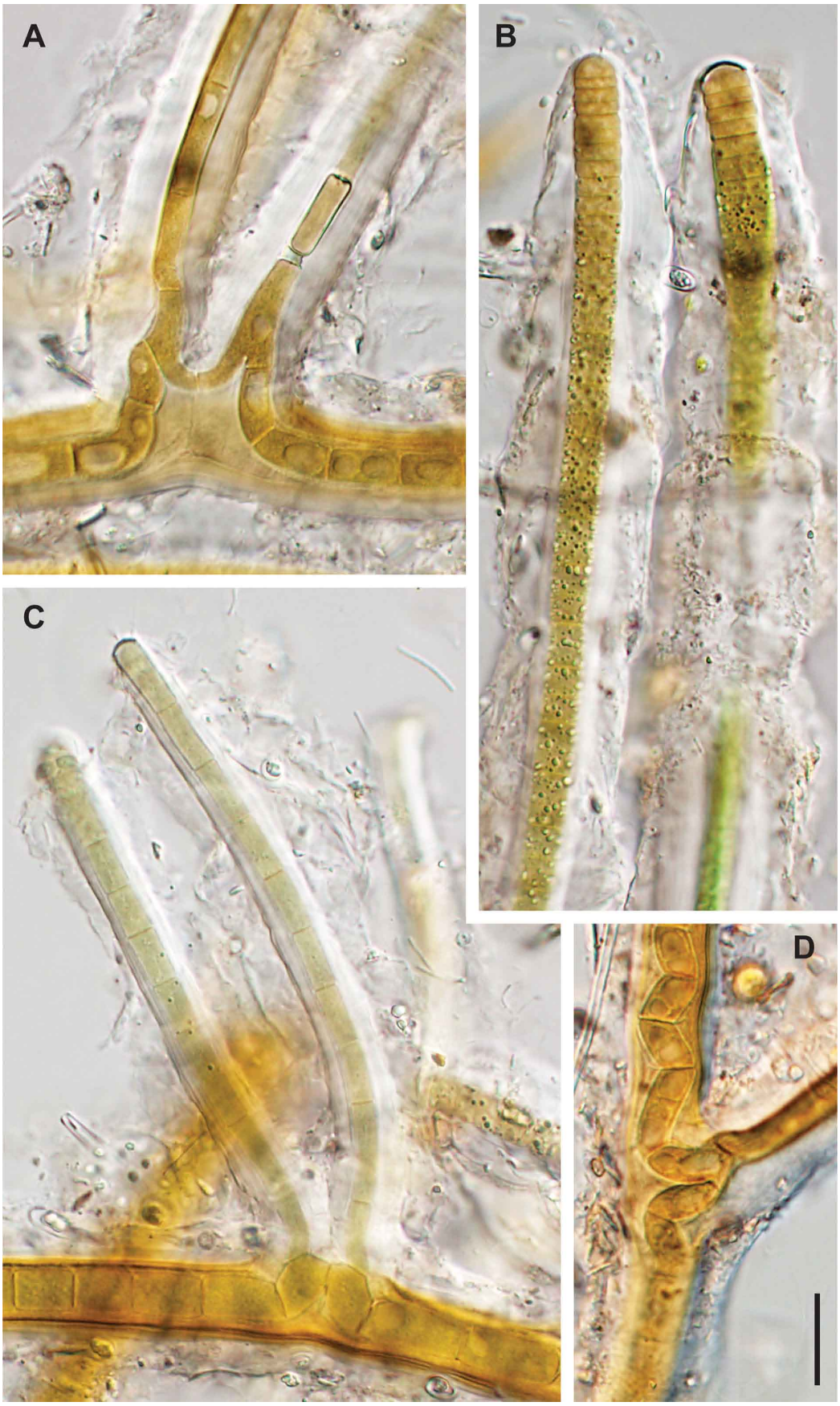

FIGURE 87. A–D *Symphyonema kaboorum*. Scale bars = 20 µm

FIGURE 88. A–D *Symphyonema kaboorum*. Scale bars = 20 µm

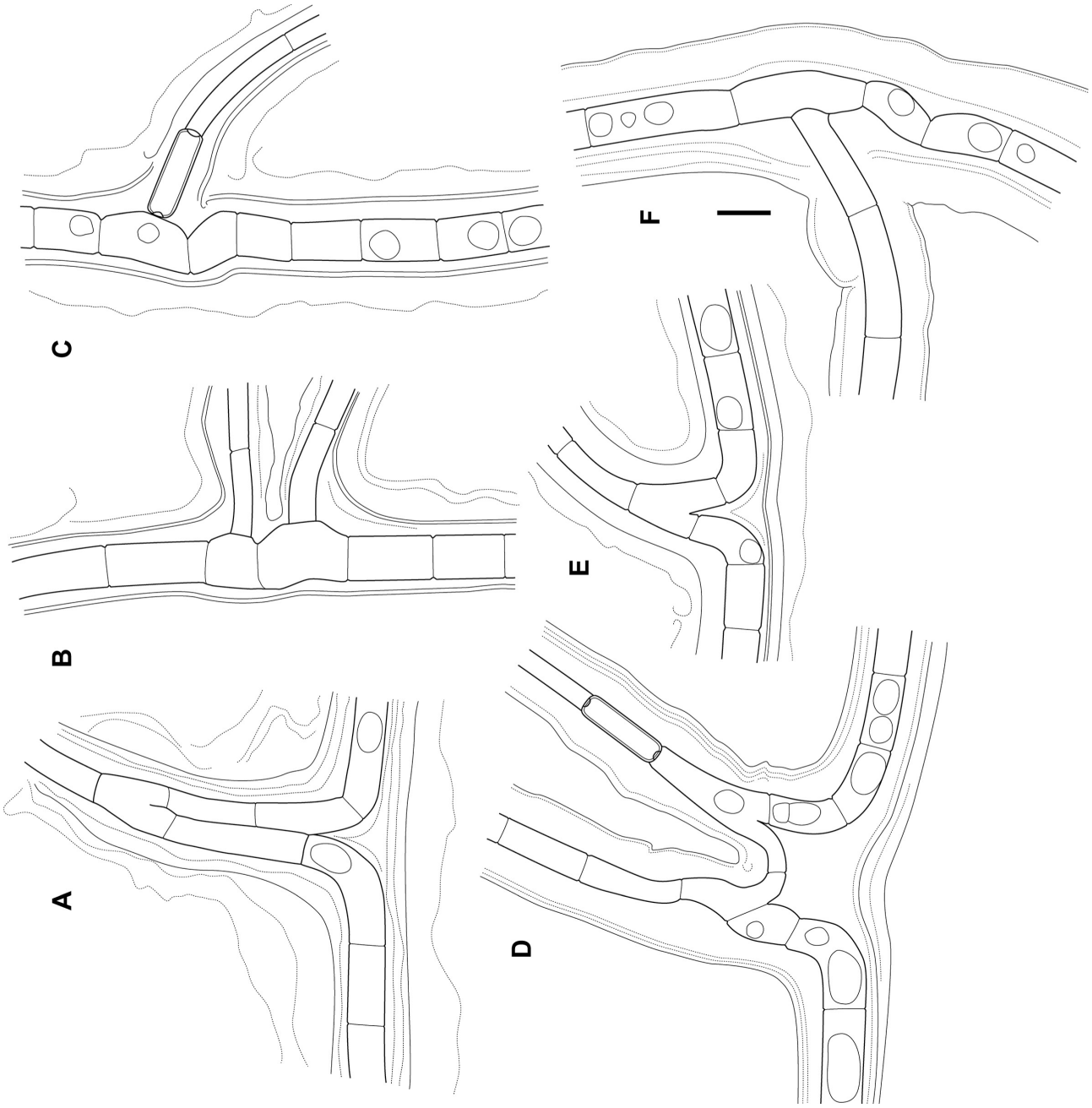

FIGURE 89. A–F Illustrations of true-branching types in *Symphyonema kaboorum*. Scale bars = 20 µm

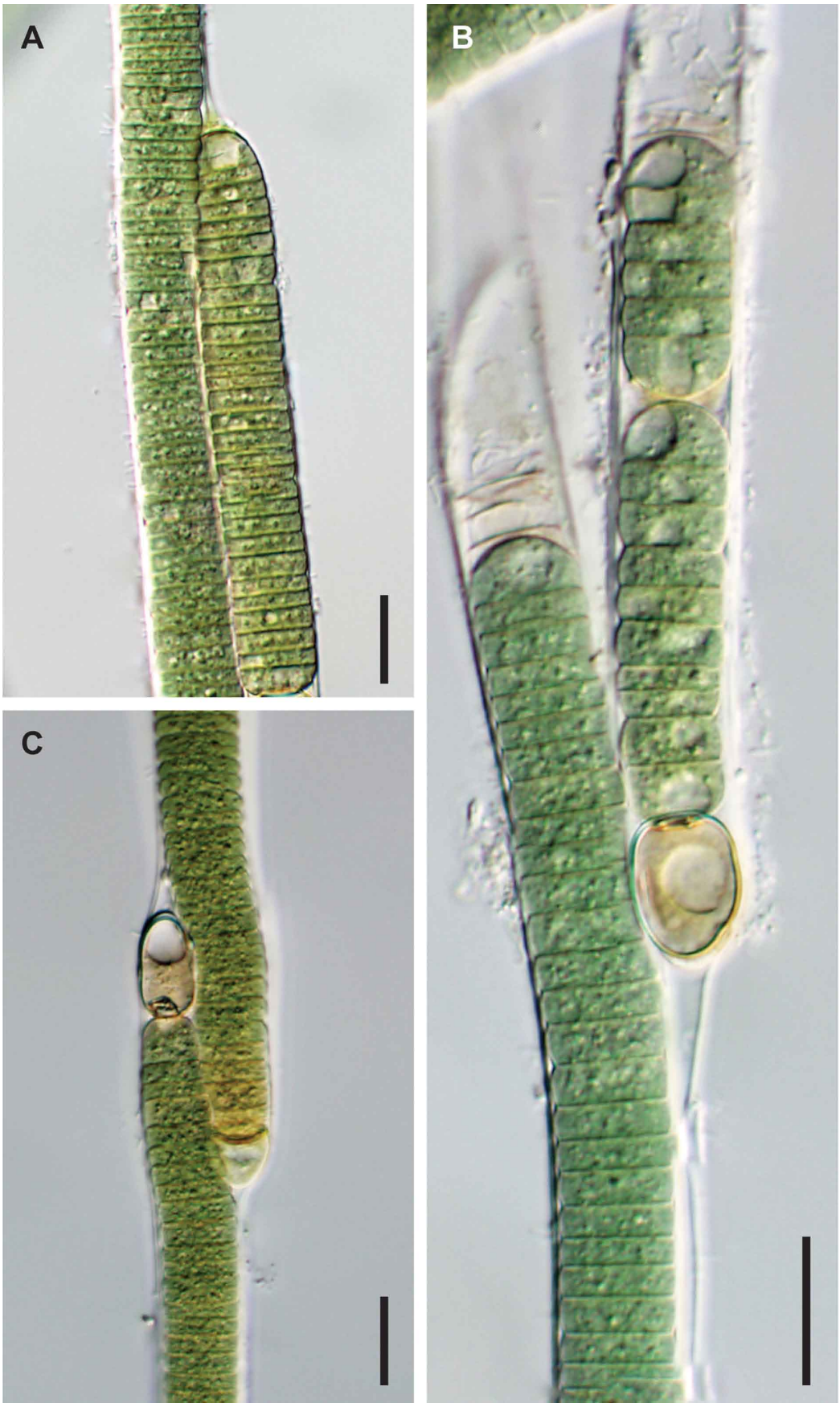

FIGURE 90. A–C *Coleodesmium* sp. A. Scale bars = 20 µm

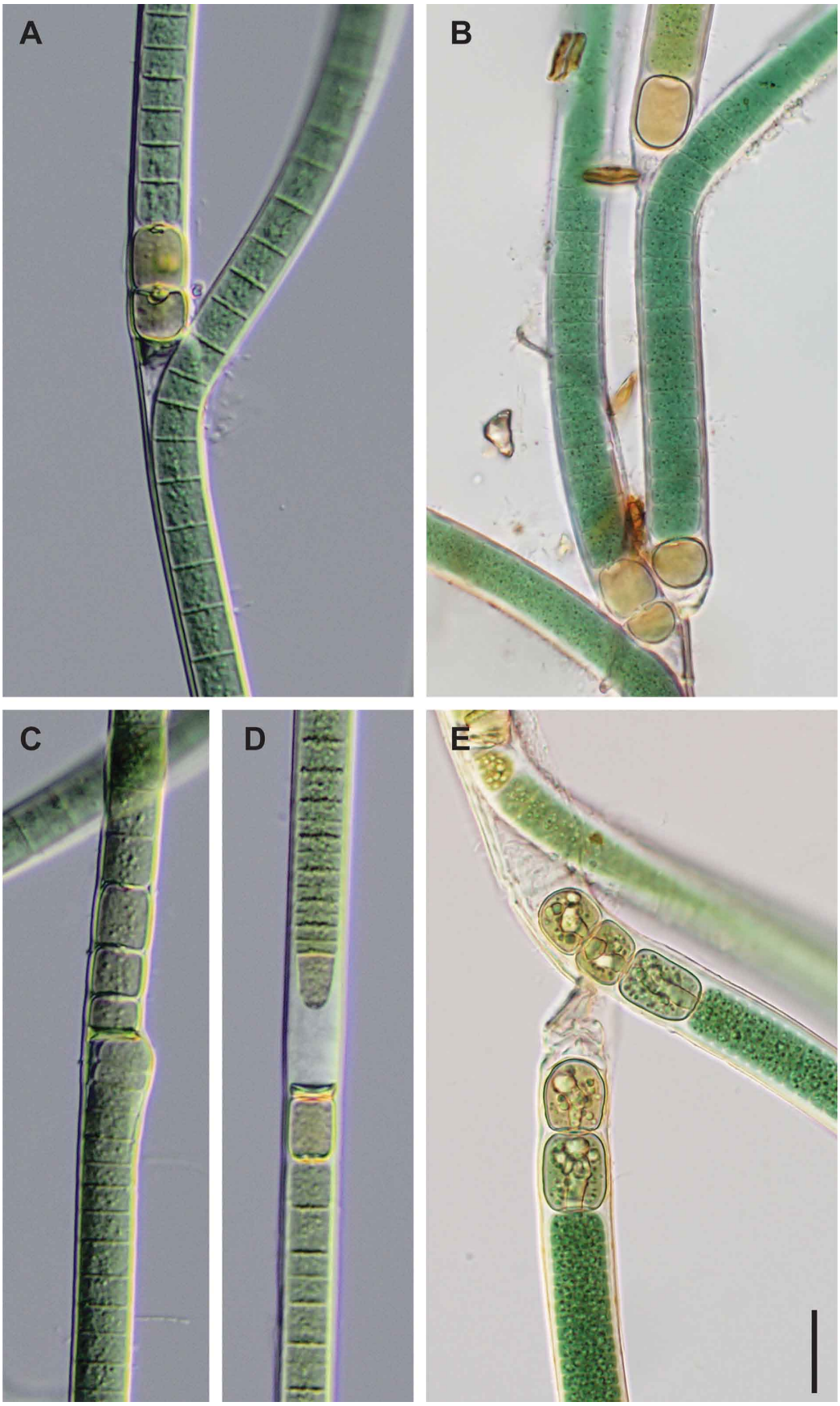

FIGURE 91. A–E *Tolypothrix lanata*. Scale bars = 20 µm