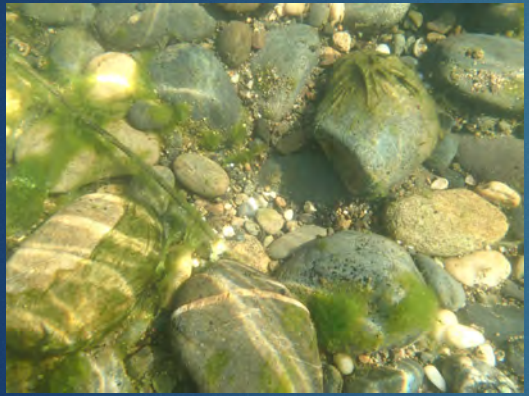
US EPA BENTHIC HABS DISCUSSION GROUP WEBINAR

October 17, 2023, 9:00am – 10:30am Pacific Daylight Time



GUEST SPEAKERS:

RAMESH GOEL, PROFESSOR, UNIVERSITY OF UTAH, USA

OTAKAR STRUNECKY, RESEARCHER, UNIVERSITY OF SOUTH BOHEMIA AND CZECH ACADEMY OF SCIENCE, CZECH REPUBLIC

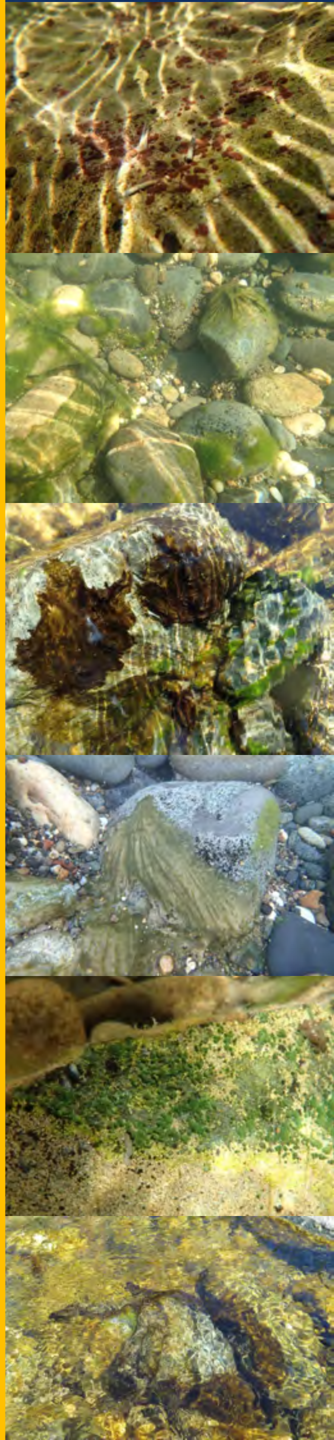
I. AGENDA

I Welcome, Agenda Overview, Announcements, and Introductions
Keith Bouma-Gregson, Margaret Spoo-Chupka, and Eric Zimdars

II Presentation: Benthic Cyanobacteria in Zion's National Park: Insight Using Omics Tools.
Guest Speaker – Ramesh Goel

III Presentation: *Phormidium* and Beyond – Practical Taxonomy of Filamentous Cyanobacteria
Guest Speaker – Otakar Strunecky

IV Wrap Up
Facilitators & Benthic HAB members



I. INTRODUCTIONS

Name	Affiliation	Contact Information
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Keith Bouma-Gregson	U.S. Geological Survey	Phone: 510-230-3691 Email: kbouma-gregson@usgs.gov
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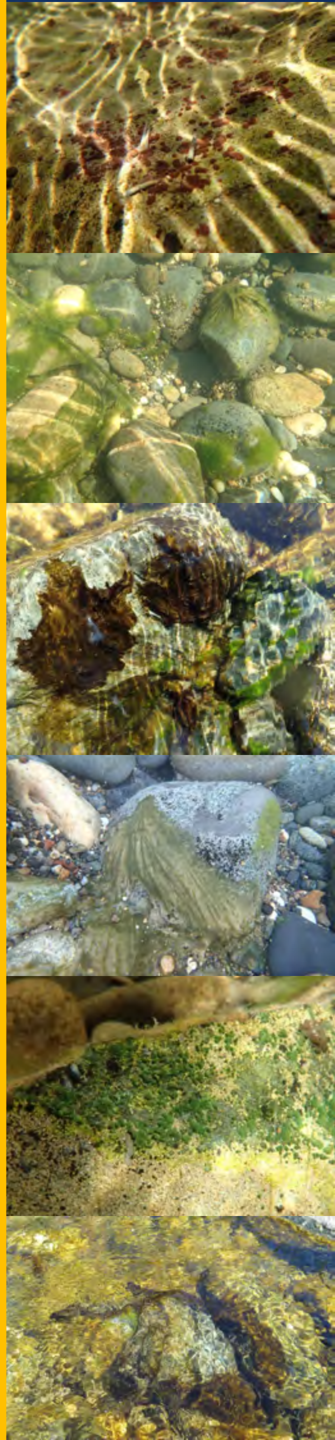
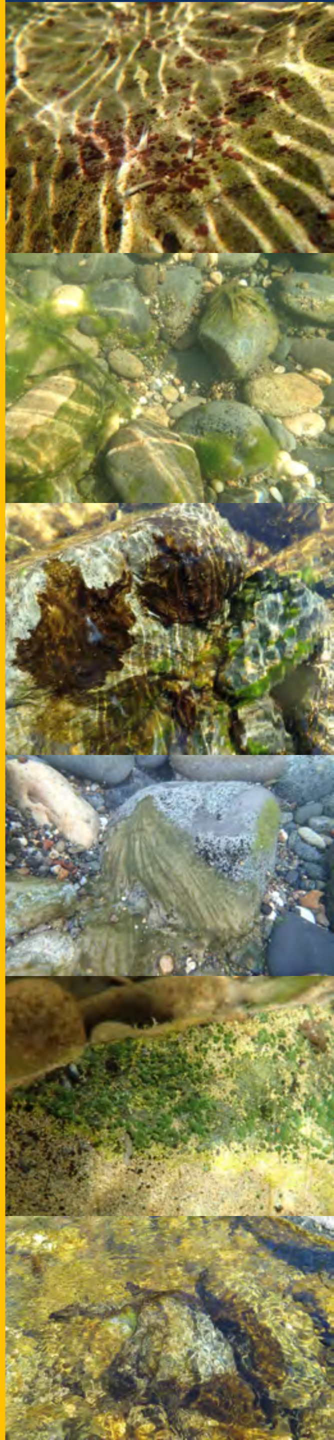
Webpage: https://www.epa.gov/cyanohabs/epa-newsletter-and-collaboration-and-outreach-habs#benthic



I. ANNOUNCEMENTS

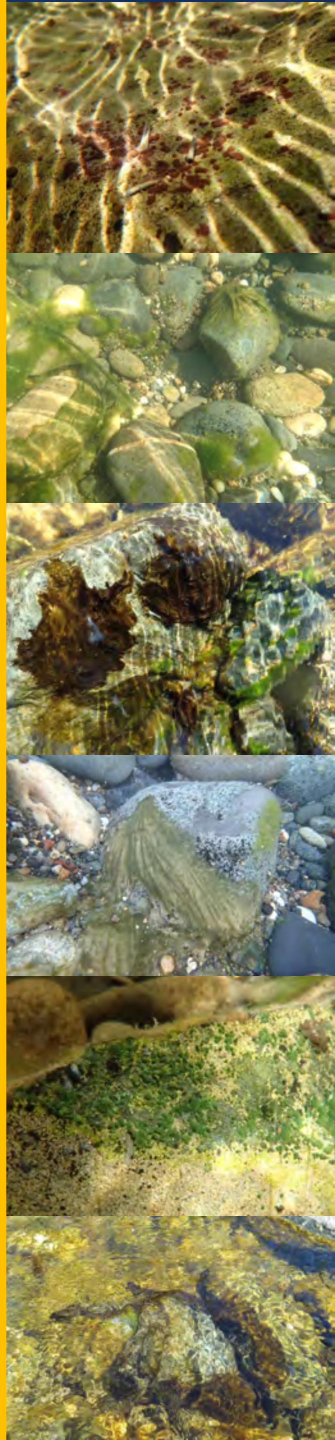
- Upcoming Meetings
- Recent Papers
  - Bauer, Franziska, et al. "Occurrence, Distribution and Toxins of Benthic Cyanobacteria in German Lakes." Toxics 11.8 (2023): 643.
  - McCarron, Pearse, et al. "Anatoxins from benthic cyanobacteria responsible for dog mortalities in New Brunswick, Canada." Toxicon 227 (2023): 107086.
  - Junier, Pilar, et al. "A ubiquitous Microcoleus species causes benthic cyanotoxic blooms worldwide." bioRxiv (2023): 2023-10.



ITEM II

GUEST PRESENTATION: BENTHIC CYANOBACTERIA IN ZION'S NATIONAL PARK: INSIGHT USING OMICS TOOLS

Ramesh Goel, University of Utah, USA



Benthic Cyanobacteria in Zion's National Park: Insight using omics tools.

Ramesh Goel

Professor, Civil & Environmental Engineering

University of Utah

October 17, 2023

Funding and Project Team

Funding: NSF’s Rule of Life Genotype

Dr. Ramesh Goel, U of U

Dr. Rosalina Christova, GMU

Dr. Robert Shriver, UN, Reno

Dr. Joanna Blaszczak UN, Reno

Dr. Hari Sunder, U of U

Project advisory and sampling

Dr. Sussane Wood, Cawthron Institute, New Zealand

Mr. Richard Fadness, California

Dr. Keith Bouma-Gregson, USGS

Robyn Henderek, Zion's National Park: Sampling Help and permitting

Planktonic versus Benthic

The planktonic cyanobacteria have the ability to regulate buoyancy in response to changing environmental conditions with the help of gas vacuoles

Community composition changes according to nutrient availability. Can move in the water column to combat nutrient stresses.

In general, planktonic cyanobacteria are well studied ranging from community composition to nutrient limitations.

Forms in thalweg (high velocity) and edges (low velocity)

Thick mats often experience diffusional limitations creating nutrient limited environments inside thick mats.

Can exhibit special gene expressions to combat environmental stresses.

N-fixer and non-fixers can co-exist in a single mat. Also, toxic and non-toxic genotypes co-exist in single mats.

Benthic Cyanobacterial Toxic Mats

- Different habitats including wetlands, littoral zones, shallow lakes, rivers and streams

- Temperature, nutrients, stream velocity, turbidity, and other factors.

- *Anabaena*, *Phormidium*, *Microcoleus* *Oscillatoria*, Lyngbya (now reclassified as *Microseira* and *Nodularia*,

Few Characteristics

- Mats produce a variety of toxins with Anatoxin being the most common one.

- Thick mats are often times a continuous source of toxins in flowing waters.

- Toxic and non-toxic cyanobacteria could co-exist in mats

- Cyanobacteria, other heterotrophs, and other phytoplankton co-exist in mats.

- Mats could form on a variety of substrates

- N-fixers and non-fixers could co-exist in mats

- Benthic cyanobacteria could employ a variety of physical and genomic strategies to acquire nutrients.

Microcoleus as a benthic Cyanobacteria

Previous research in rivers around the globe (e.g., northern California, New Zealand, Switzerland, and more has shown that *Microcoleus* benthic mats form on different substrates (e.g., sand, gravels) and are present in both the thalweg (i.e., high flow velocity) and edges (i.e., low flow velocity) of wetted stream and river channels.

Results suggest that toxic and non-toxic genotypes of *Microcoleus* co-exist in benthic mats but environmental factors contributing to the relative distribution of these genotypes are not clearly understood.

Metabolically, toxic and non-toxic strains of ***Microcoleus*** are quite different in terms of nutrient and carbon metabolism (Tee et al., 2021)

Our genome analysis of *M. anatoxicus* from Russian River suggest that this species is a non-heterocytous cyanobacterium and lacks *nitrogenase* enzyme, but experiment data (not shown) showed it thrives without N-source in culturing medium.

Different field Appearances of Microcoleus

Virgin River and Zion's

Virgin River-Zion's National Park

The Virgin River and its tributaries run through Zion National Park.

The North Fork of the Virgin River begins north of Zion at Cascade Falls, where it drains out of Navajo Lake at 9,000 feet above sea level

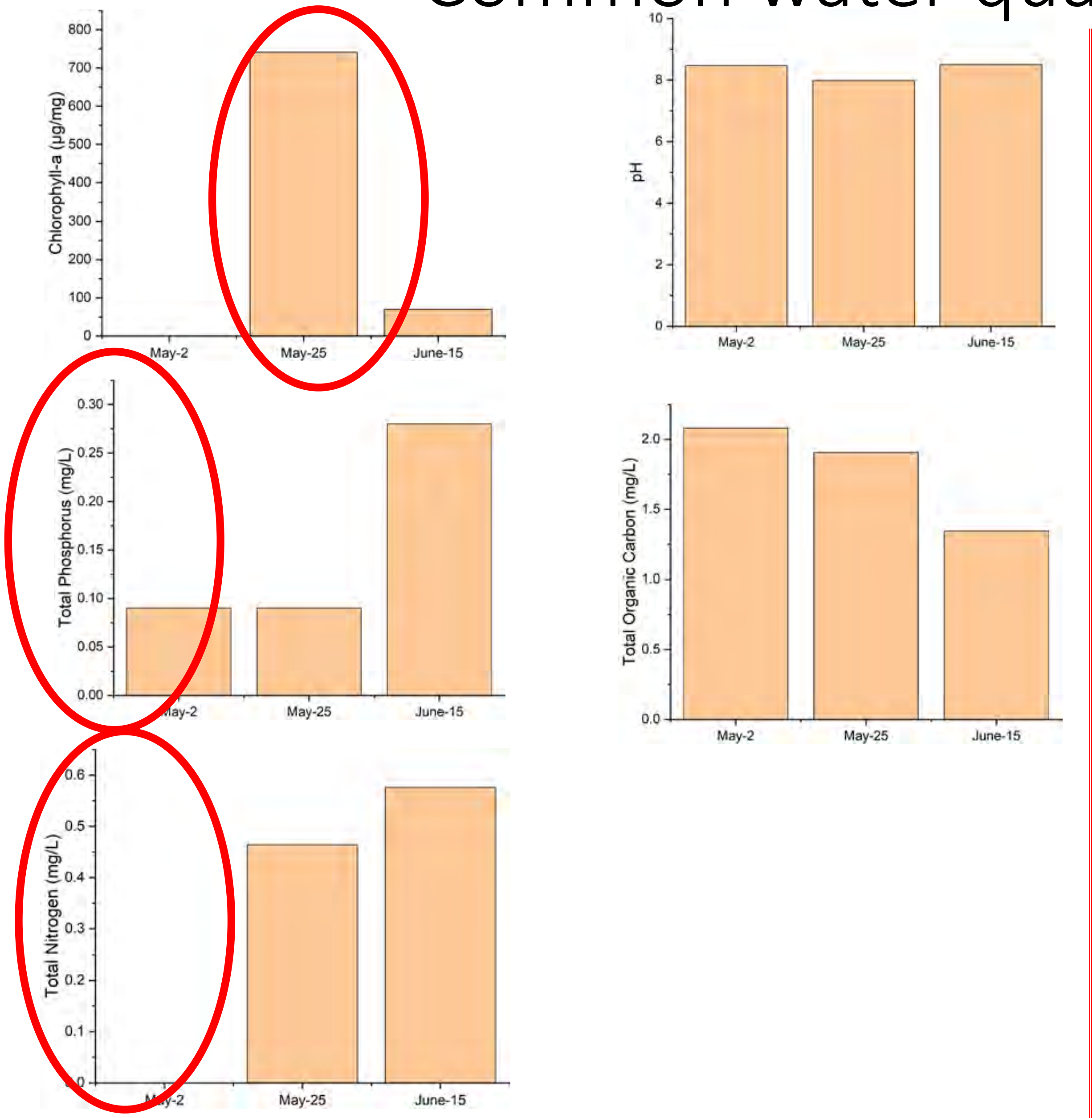
The East Fork of the Virgin River originates above Long Valley

Both the North and East Forks of the Virgin River run through the park and empty into Lake Mead at about 1000 feet above sea level, where it joins the Colorado River.

Though the Virgin River is relatively small, it is incredibly steep. The river drops roughly 7,800 feet in the 160 miles it travels

Benthic Outbreak in Zion's National Park

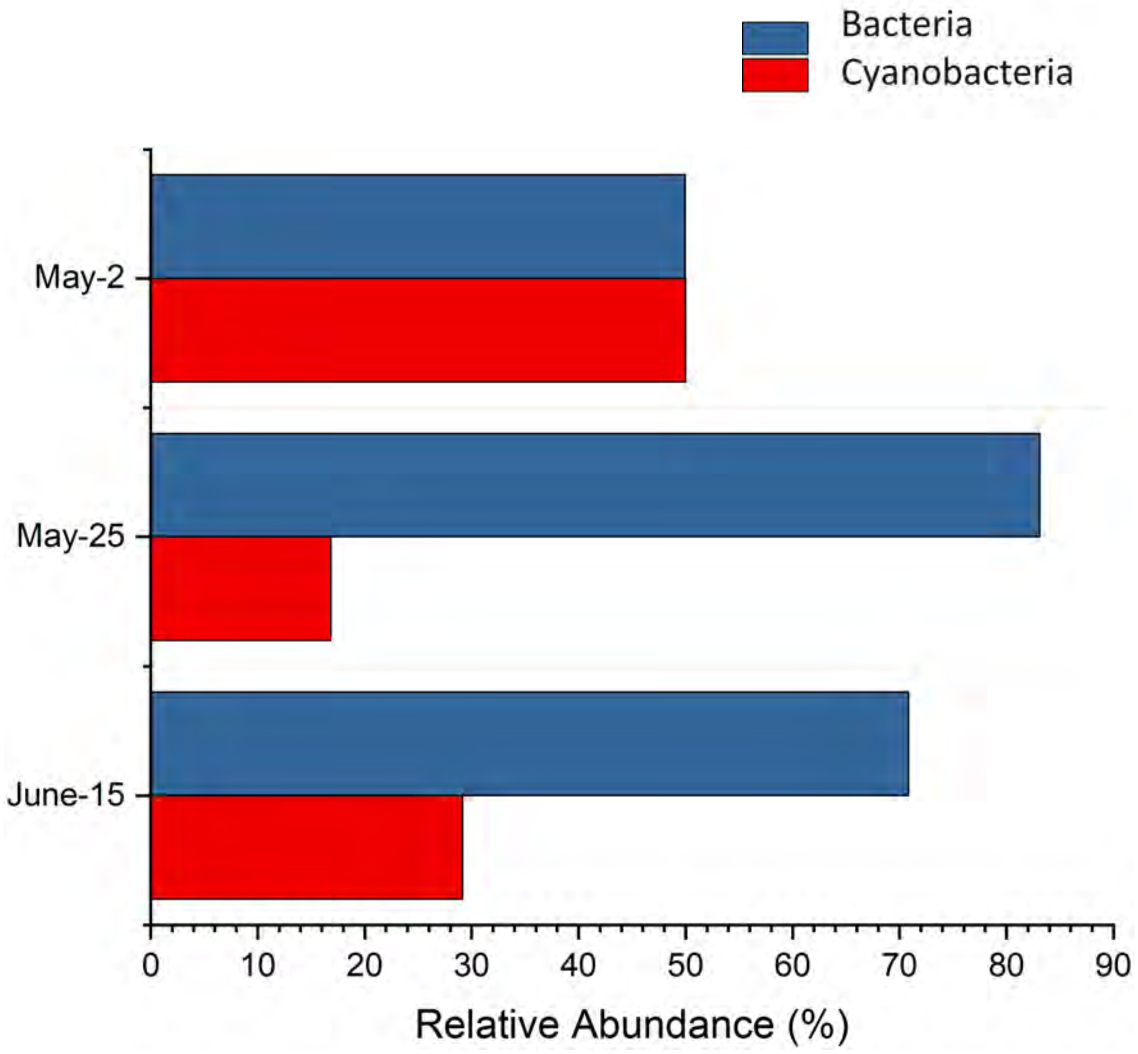
Common water quality parameters

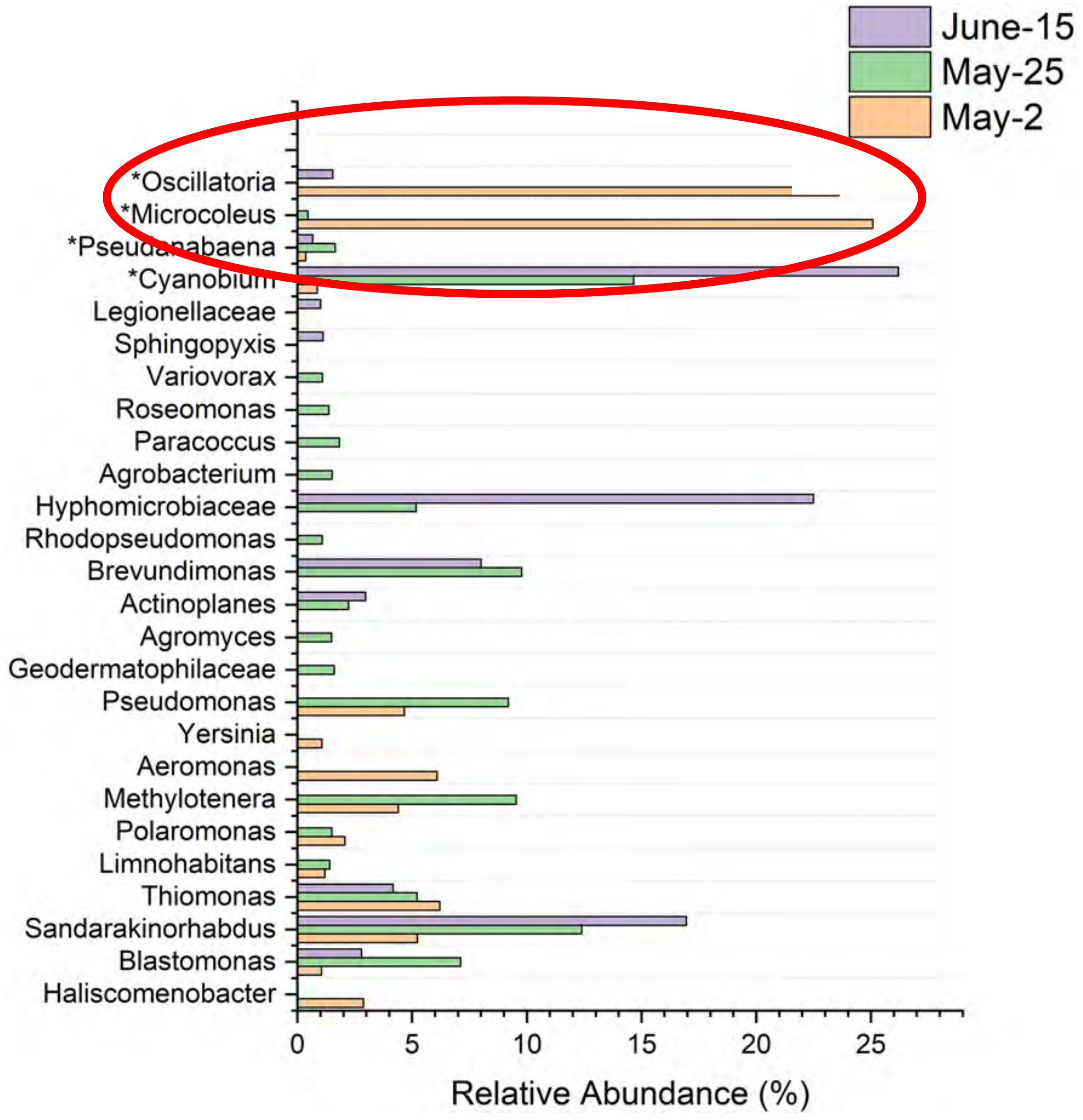


Visitor Center

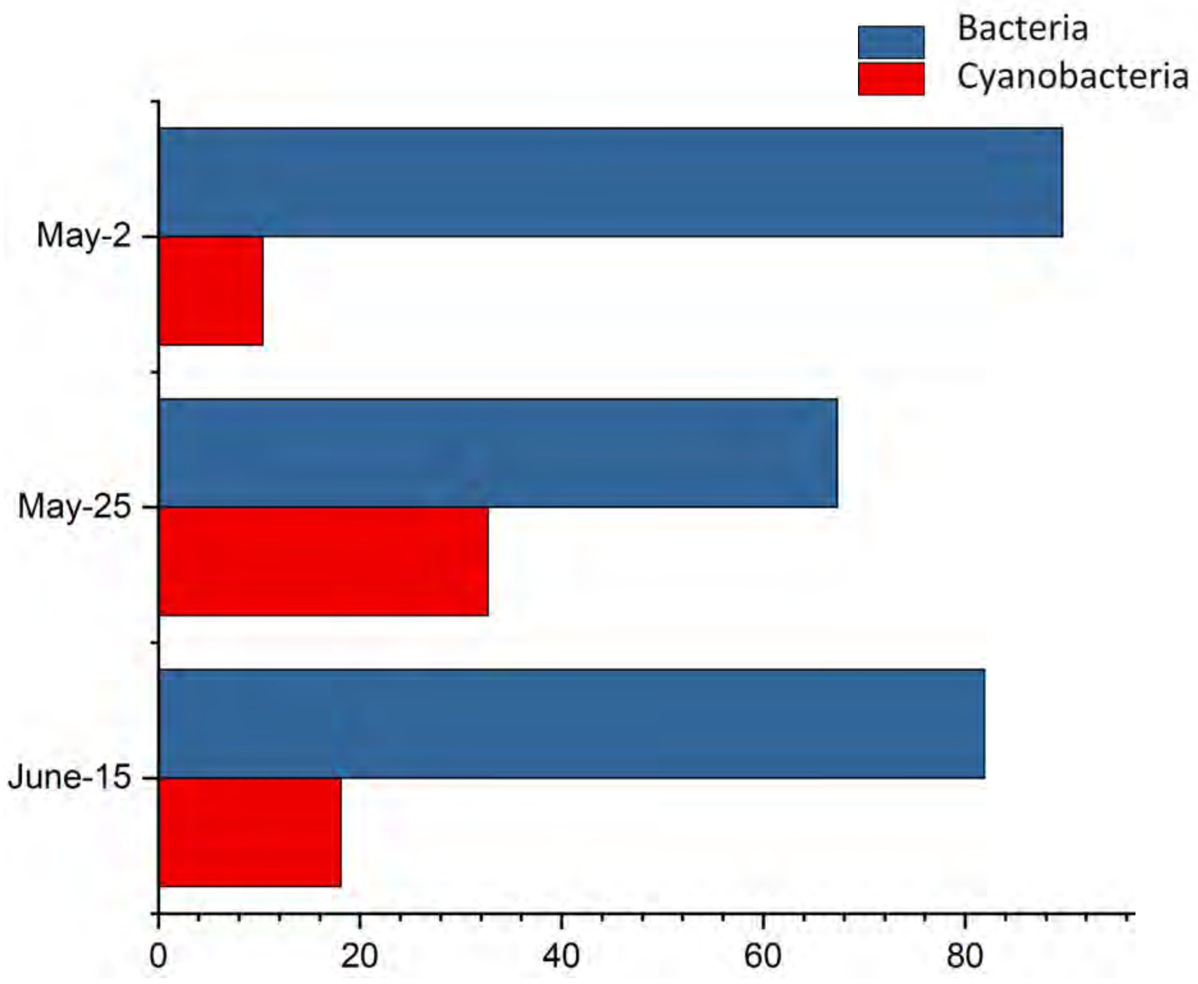
North Creek

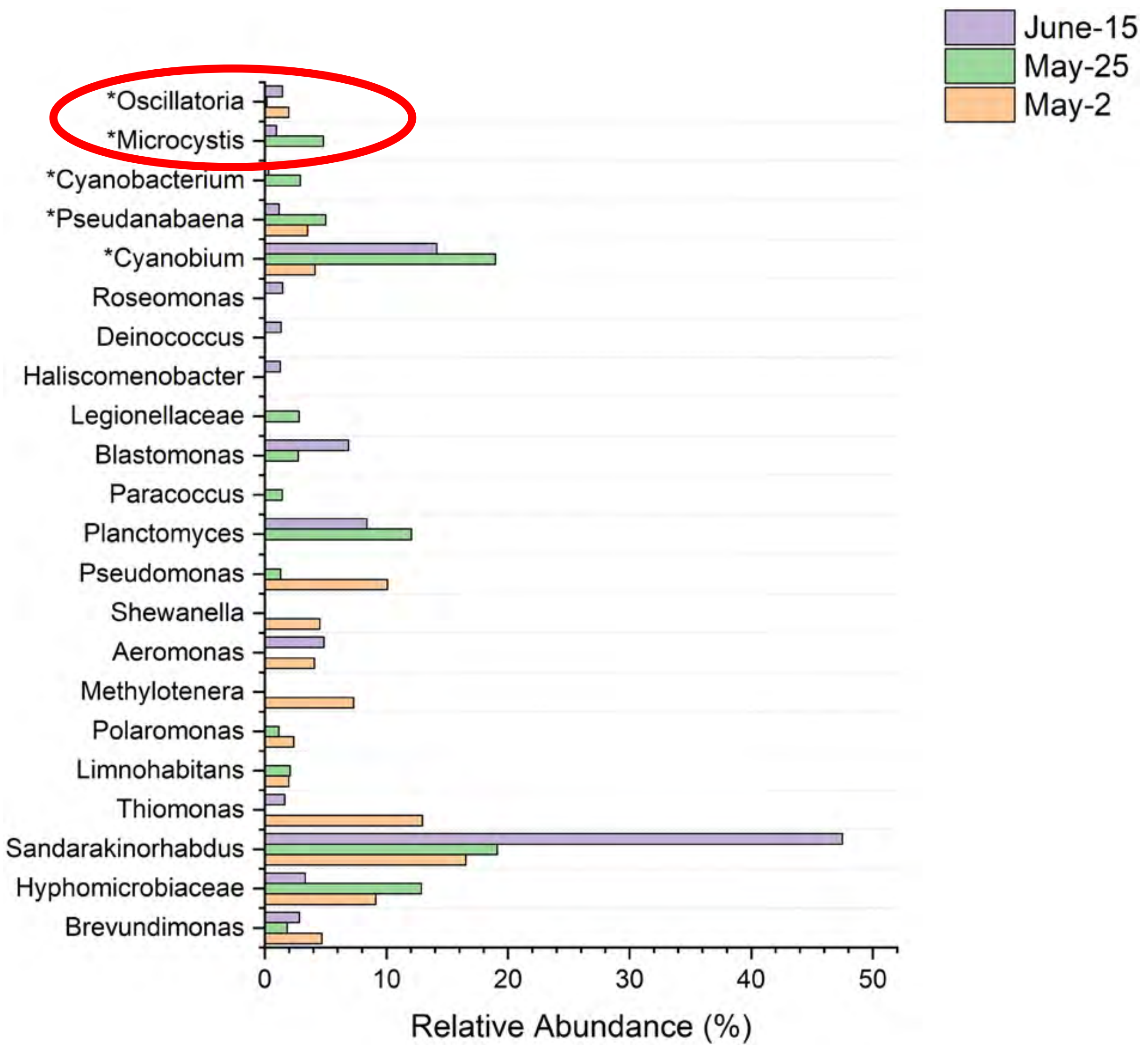
Overall microbial community- Visitor Center





Overall microbial community- North Creek





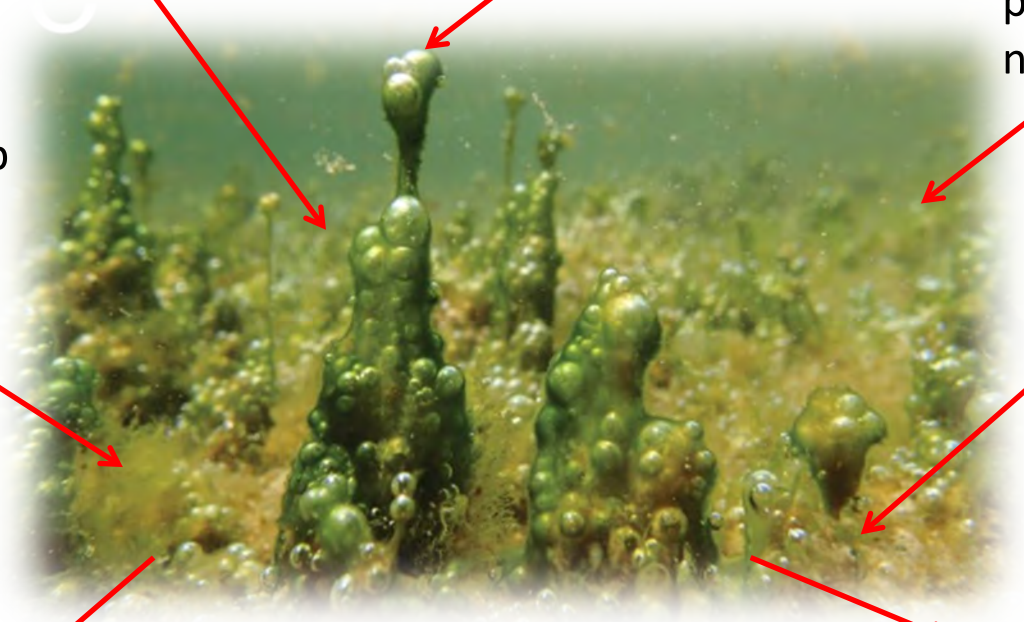
Toxic and Non-toxic *Microcoleus* in Benthic Mats

Toxic strains have smaller genome size and harbor fewer biosynthetic gene clusters and their non-toxic counterpart.

Filaments extends outside to capture settling P from the water column

Toxic strains have higher alkaline phosphatase activity then their non-toxic counterpart

Non-toxic strains can synthesize sucrose and thiamine and take up alkanesufonate as an alternative sulfur source.

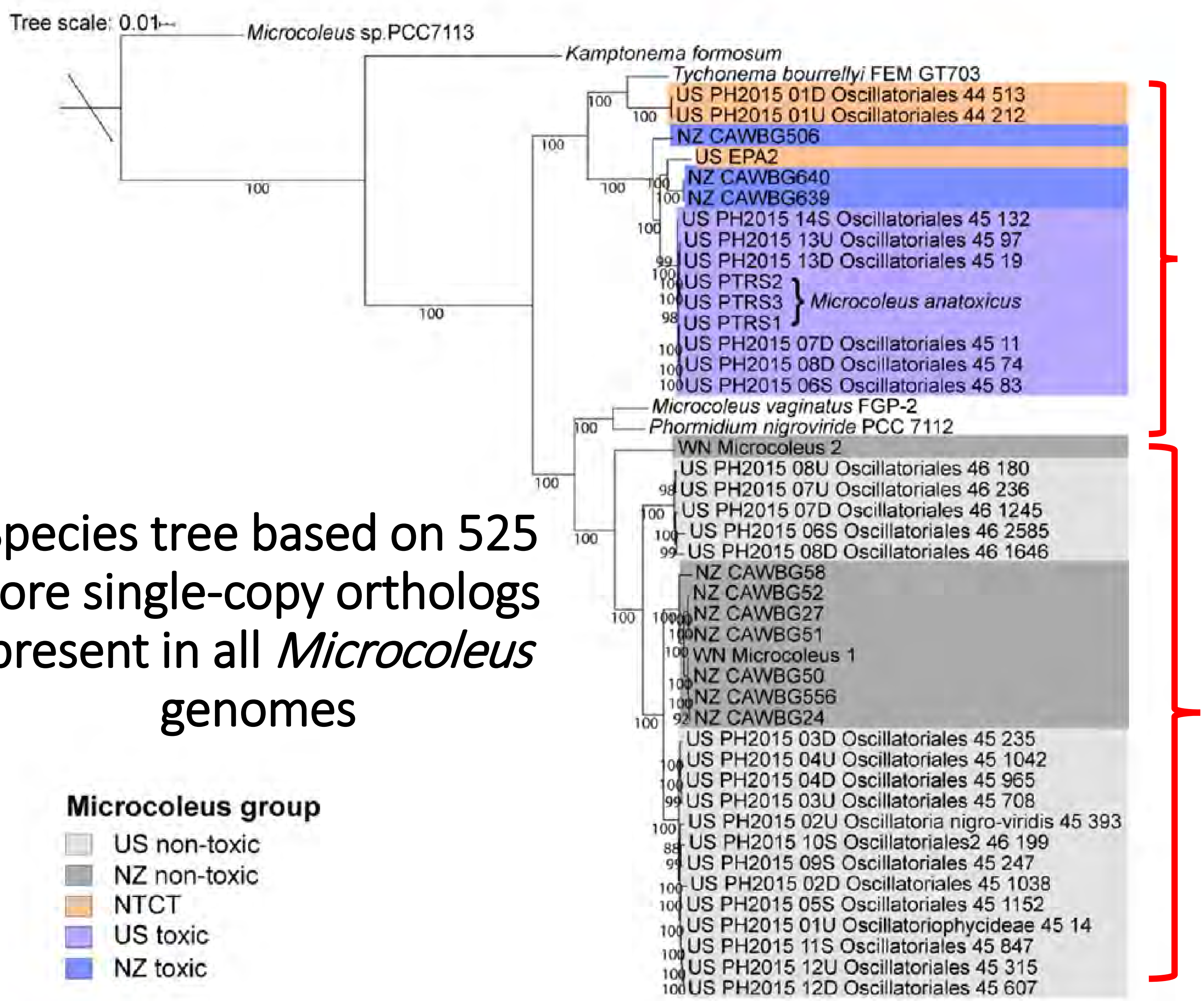


Non-toxic strains have better biofilm formation capacity due to higher growth rates and higher energy metabolism.

Toxic strains proliferate in nitrogen rich environment because they harbor an extra nitrate/sulfonate transport system

Microcoleus can do nitrogen assimilation using cyanophycin synthesis and catabolism by CphAB, which functions as temporary nitrogen/carbon storage. Non-toxic strains have an extra cyanophycin gene cluster making them tolerable to N fluctuations

Toxic and nontoxic *Microcoleus* are different species belonging to different clades

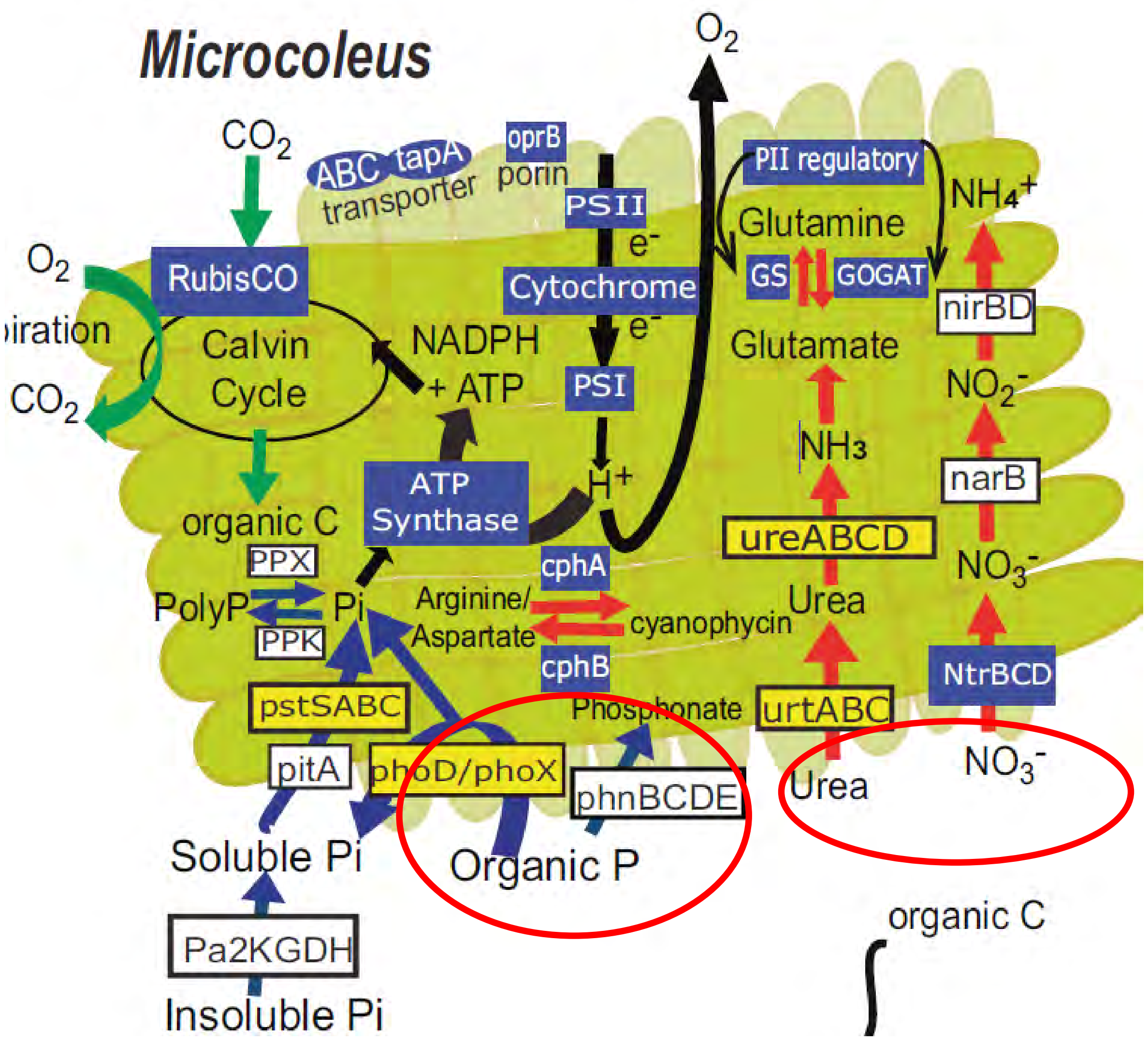


Species tree based on 525 core single-copy orthologs present in all *Microcoleus* genomes

Only 6 % of genes are shared across 42 genomes suggesting a high level of genetic divergence among *Microcoleus* strains.

Tee et al., 2022

Nutrient Acquisition by *Microcoleus* Sp.



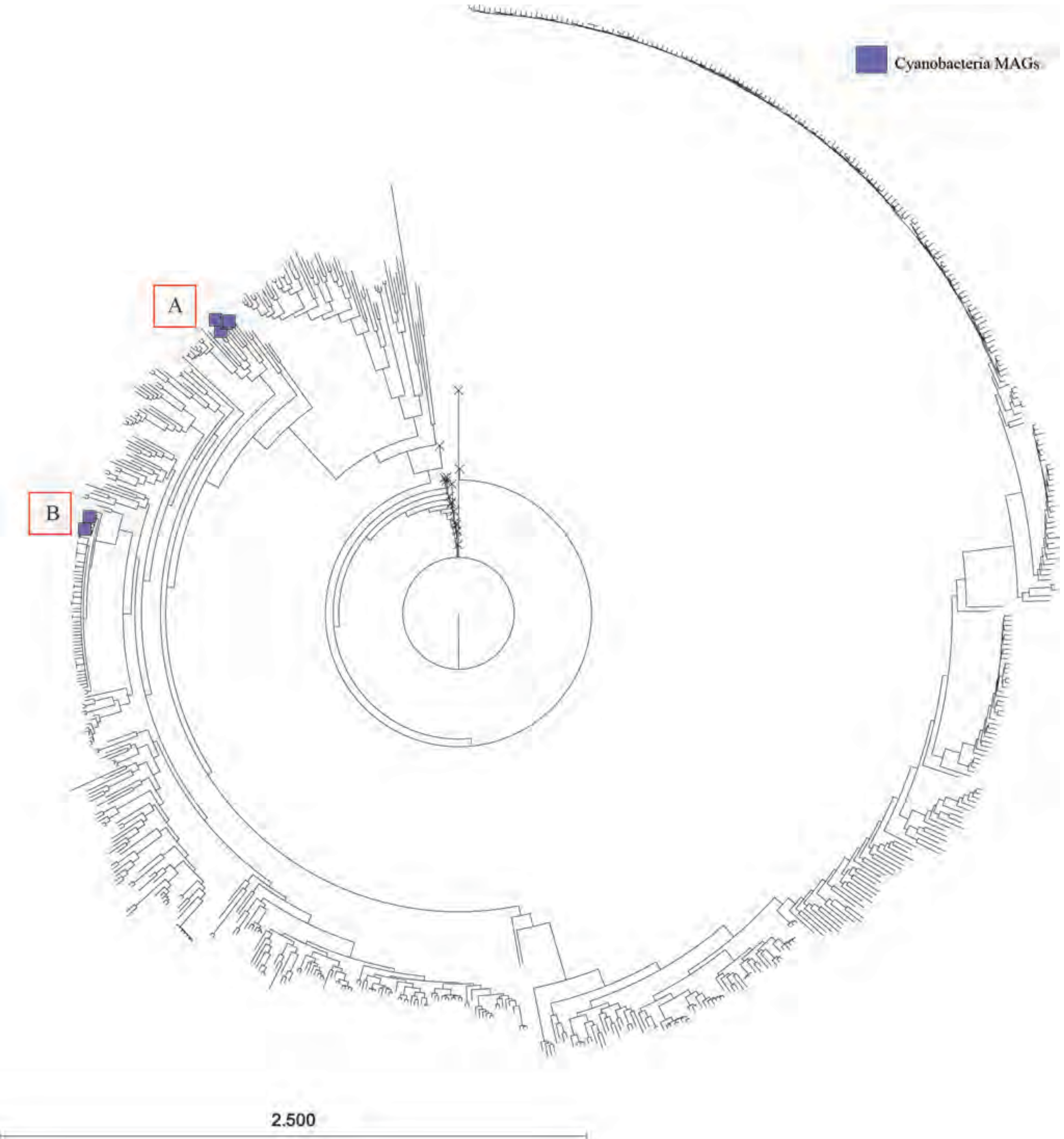
It tends to grow in systems with moderate dissolved inorganic nitrogen and very low dissolved reactive phosphorus.

It Lacks N-fixation genes.

It upregulates alkaline phosphatase activity in P deficient waters. Toxic strains exhibit higher Alkaline phosphatase activity then non-toxic counterparts.

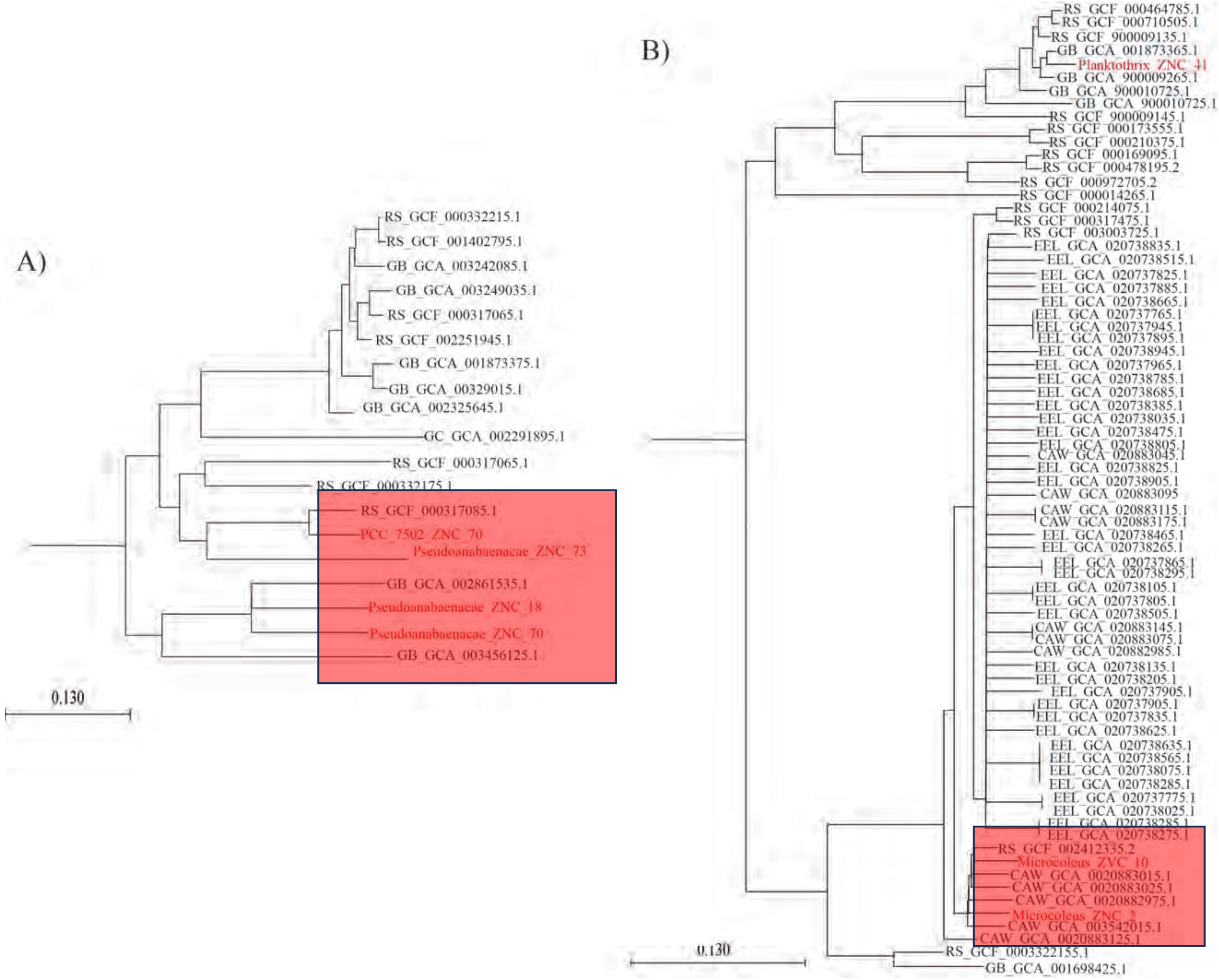
Non-toxic strains of *Microcoleus* have higher growth rate under nutrient deficient conditions

Metabolic pathways (adopted from Tee et al., 2020)

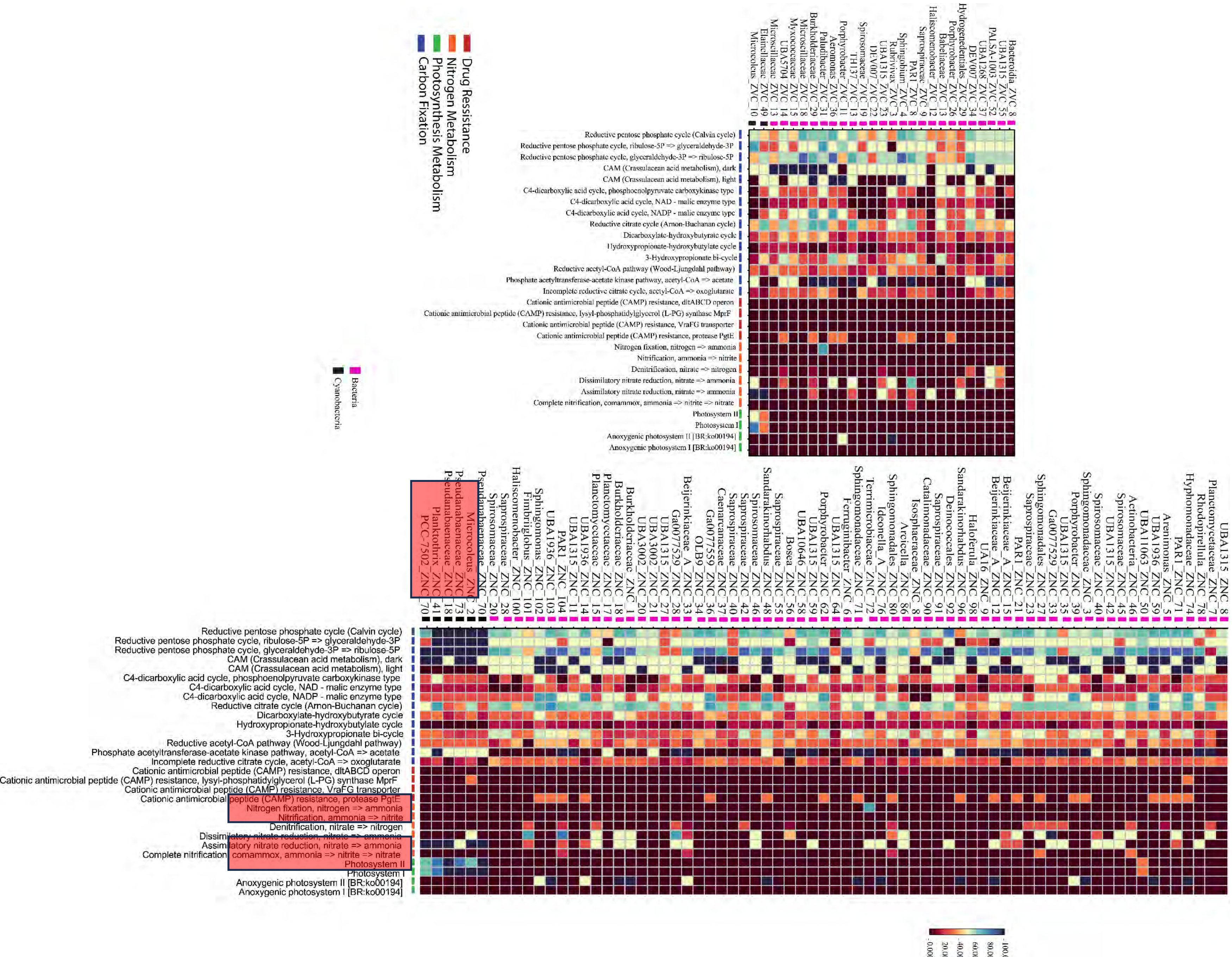


The complete phylogenetic tree as visualized on CLC Genomics Workbench 23 (QIAGEN)

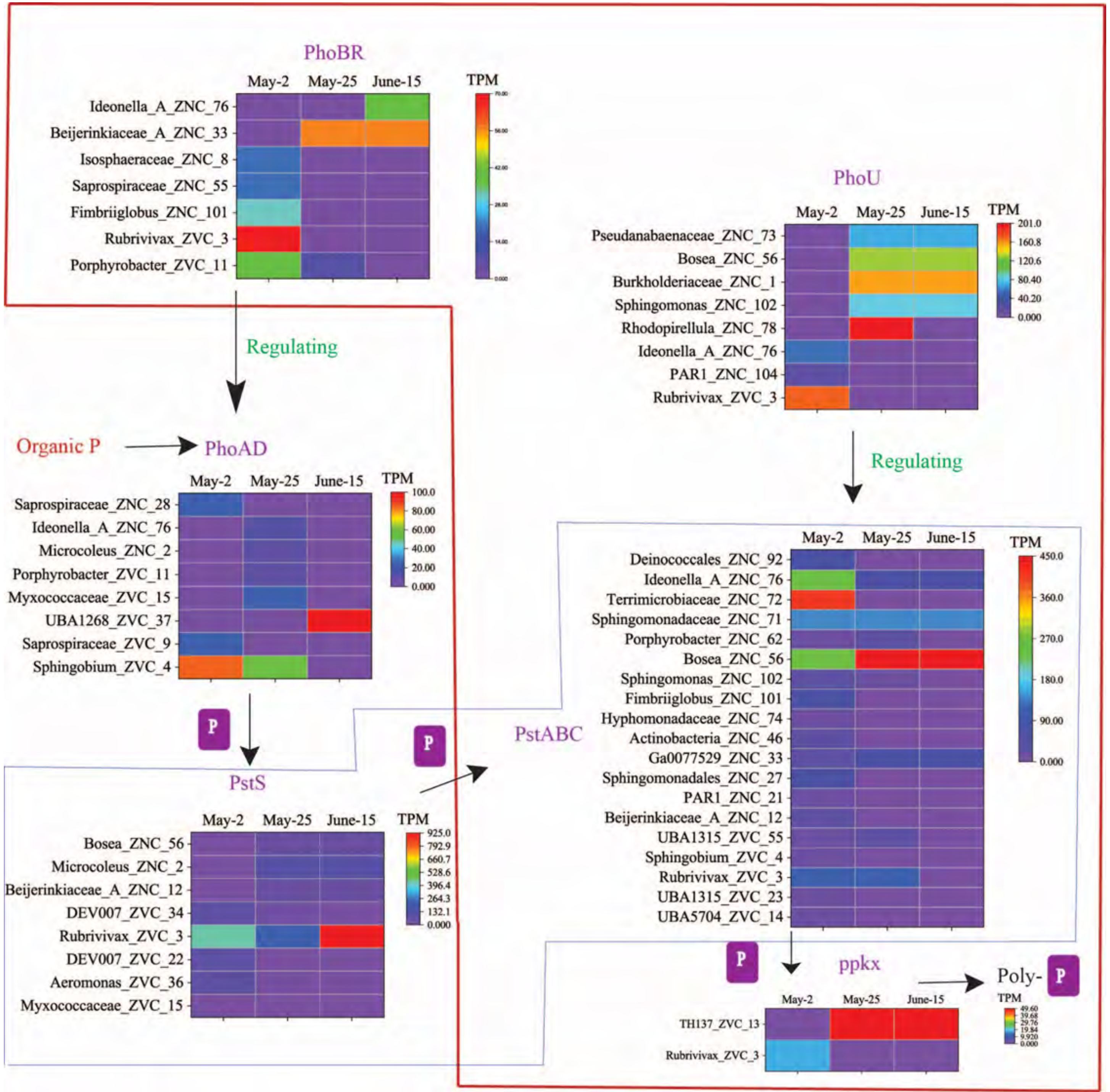
The complete phylogenetic tree from which the flanking regions of the MAGs of cyanobacteria were extracted. The MAGs of cyanobacteria are denoted by purple boxes in the tree. The plots A and B are enhanced and detailed in figure. 2.



The phylogenetic tree of MAGs of Cyanobacteria from Visitors Center and North Creek: Phylogenetic position of MAGs extracted from Vistor's Center and North Creek in Zions National Park. The MAGs of Cyanobacteria are color coded in red fonts.



The completeness of the genomic pathways in the MAGs of cyanobacteria and other bacteria: The KEGG module completeness of the MAGs of Bacteria and Cyanobacteria from Visitors Center(A) and North Creek(B) are represented by through two heatmaps. The pathways involved in nitrogen acquisition and storage, carbon fixation, photosynthesis, and drug resistance are color coded with orange, blue, green, and red rectangles respectively. Black and pink rectangles have been placed after the names of the MAGs of cyanobacteria and bacteria respectively.



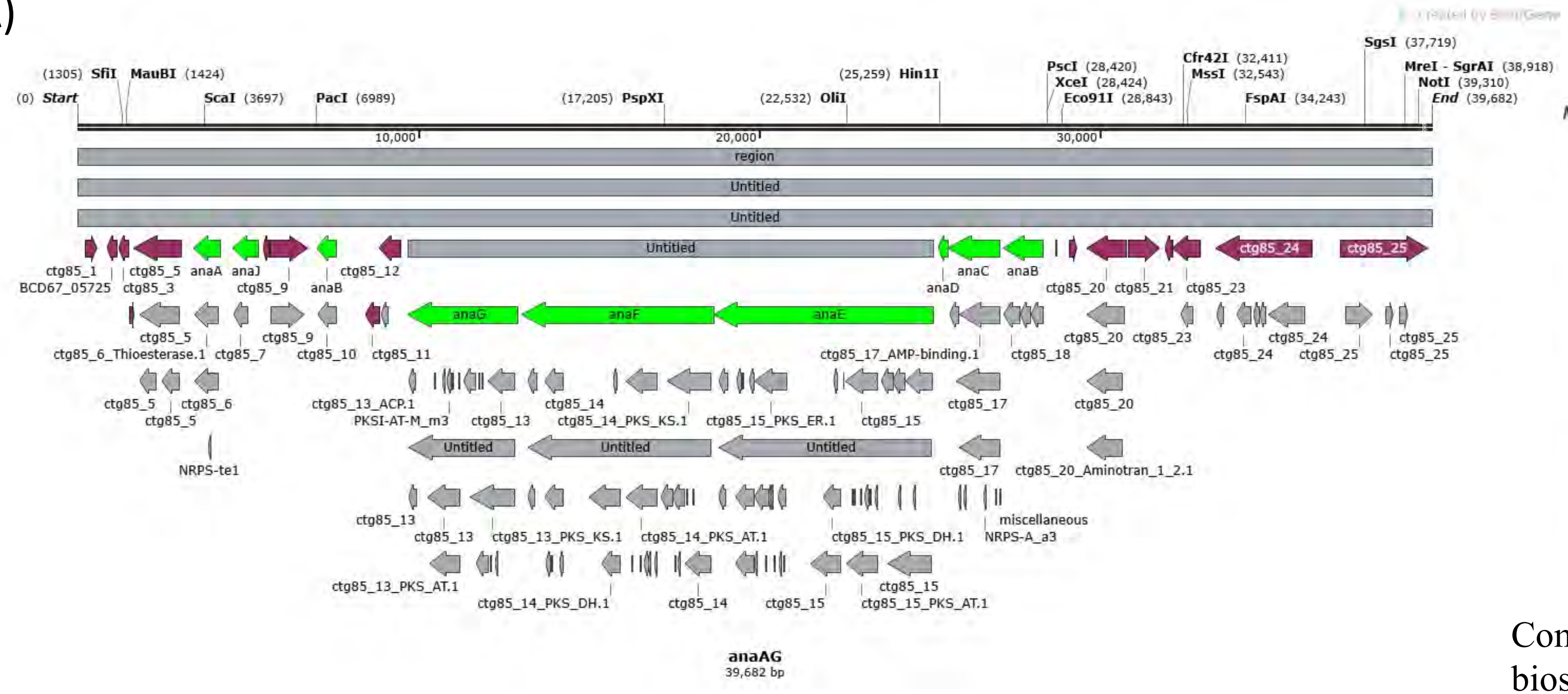
The Pathway of P metabolism and regulatory involved genes and the quantification of the transcripts.

The pathway of the genes that are related to the transport and assimilation of phosphate by cyanobacteria and bacterioplankton were depicted on the schematic map. During times of low Pi levels, the pstSABC genes are responsible for transporting Pi into the cell from the surrounding extracellular space. This process requires the activation of the PhoA gene. During the transition from organic P to Pi in an alkaline pH environment, the phosphate regulon sensor PhoR, the phosphate regulon response regulator PhoBR, and the alkaline phosphatase domains PhoA and PhoD were responsible. The TPM for genes implicated in the Pho regulon is depicted by the heatmaps before, during and after the phytoplanktonic bloom by MAGs of cyanobacteria and bacterioplankton.

MICROCOLEUS TOXICITY AT ZIONS NATIONAL PARK

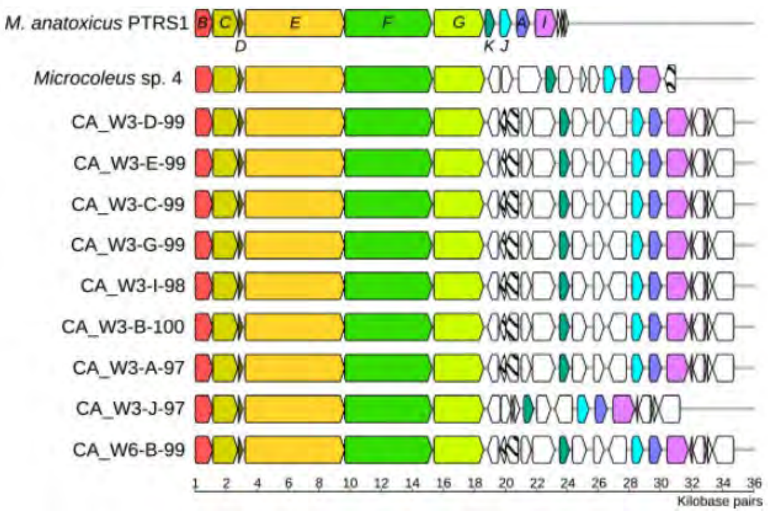
- The anatoxin gene cluster was found to have duplication of *anaB* gene and devoid of *anaHIK* gene.
- The absence of *anaK* gene causes the MAG of *Microcoleus* be incapable to produce homoanatoxin which has a lower LD_{50} concentration than anatoxin-a

A)

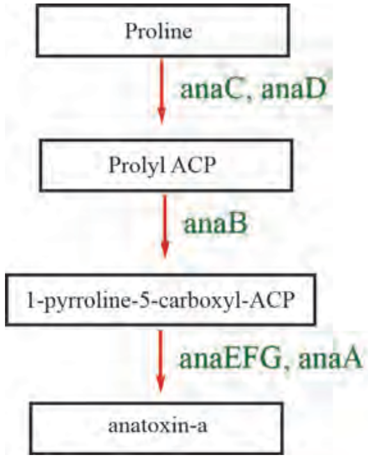


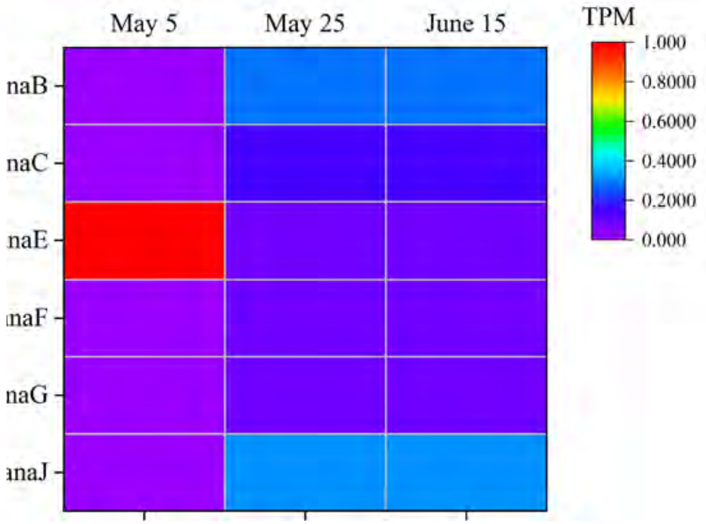
The architecture of anatoxin-a biosynthetic gene cluster in a MAG of a toxic *Microcoleus* assembled from the DNA extracted from the benthic community in Zions National Park.

B)

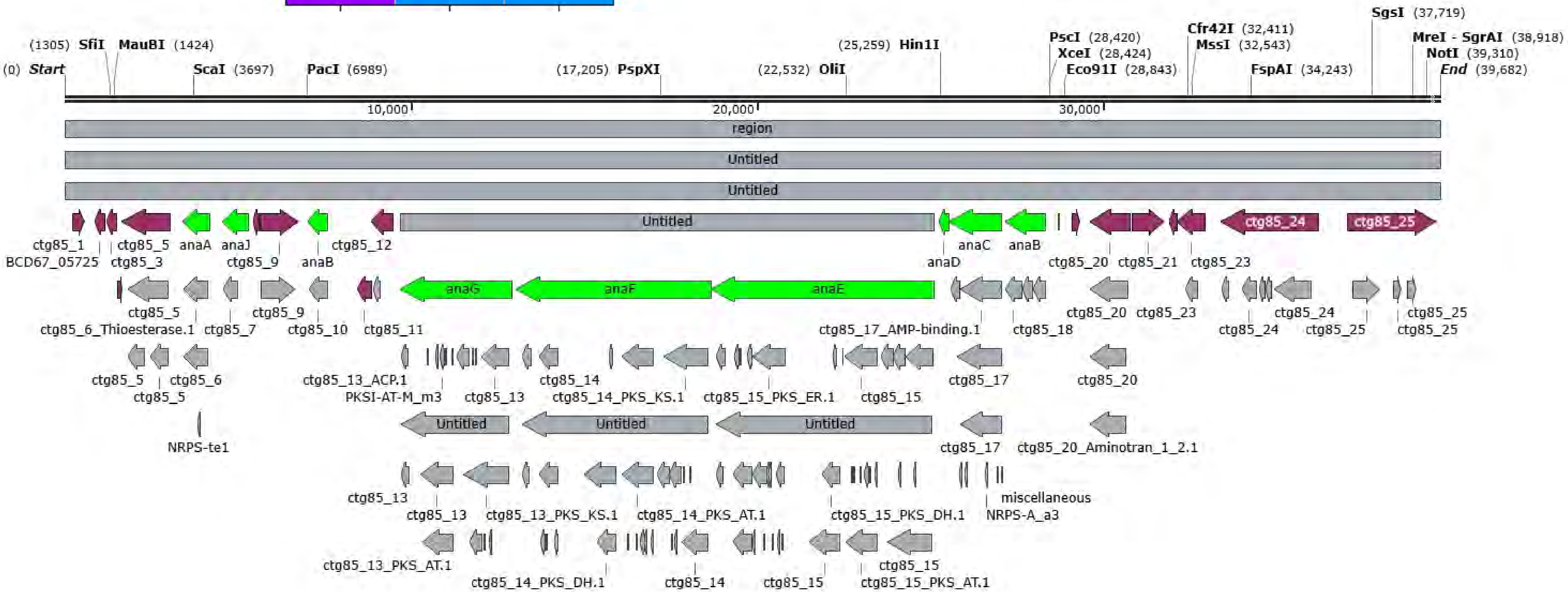


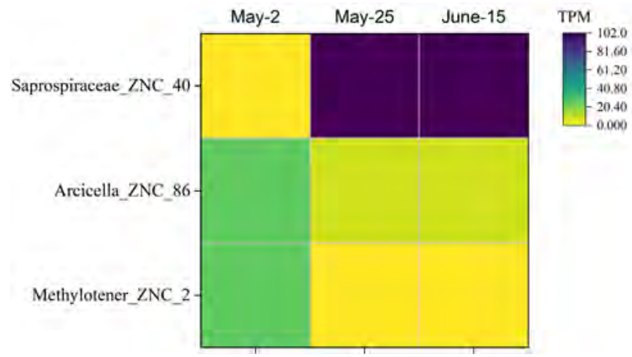
Comparative architecture of the anatoxin-a biosynthesis clusters from *M. anatoxicus* PTRS1 from California, *Microcoleus* sp. 4 (NZ_CAWBG639) from New Zealand and *Microcoleus* sp. Wq-II MAGs from the Wolastoq. (Valadez-Cano et al., 2023)





A)The pathway of the genes and the enzymes involved in producing the secondary metabolite anatoxin-a through the biosynthesis gene cluster (Méjean et al., 2014). B) The heatmap shows the trancripts per million reads of the ana operon throughout the sampling period. C)The arrangement of genes involved in anatoxin production is represented with green color. The restriction sites are denoted with bold letters on top of the gene cluster. The antiSMASH was able to annotate the genes *anaABCDESFGJ* required to produce anatoxin.





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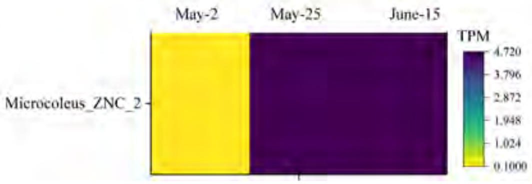
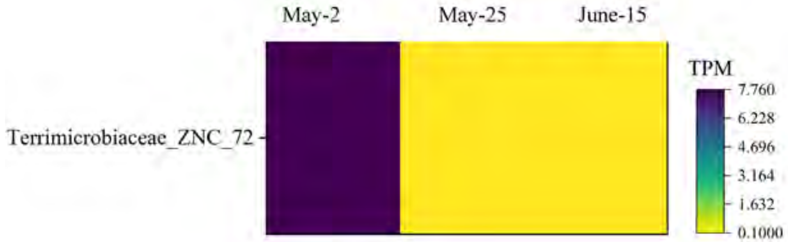
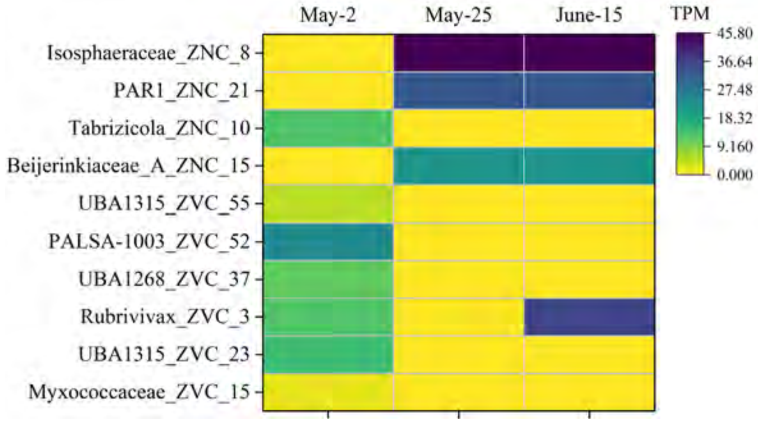


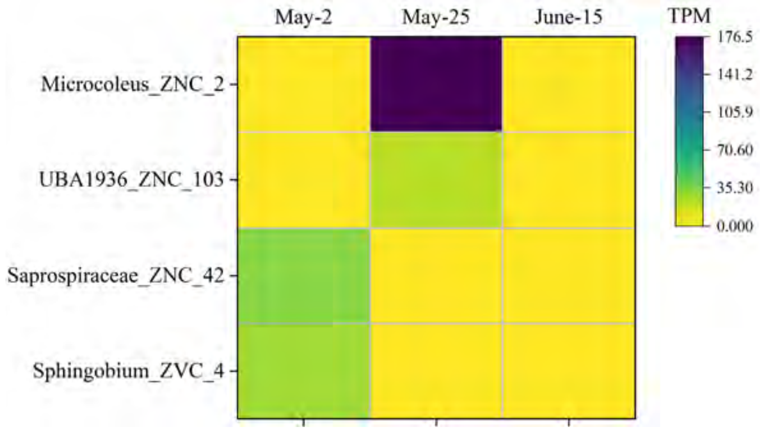
nirB,nrfA



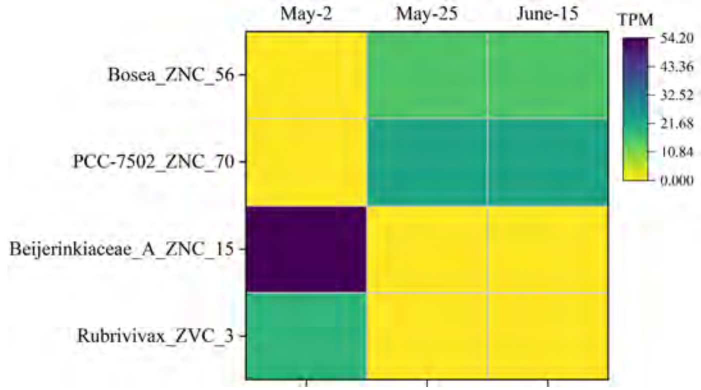
nifDHK



narG/Z, narH/Y



nosZ



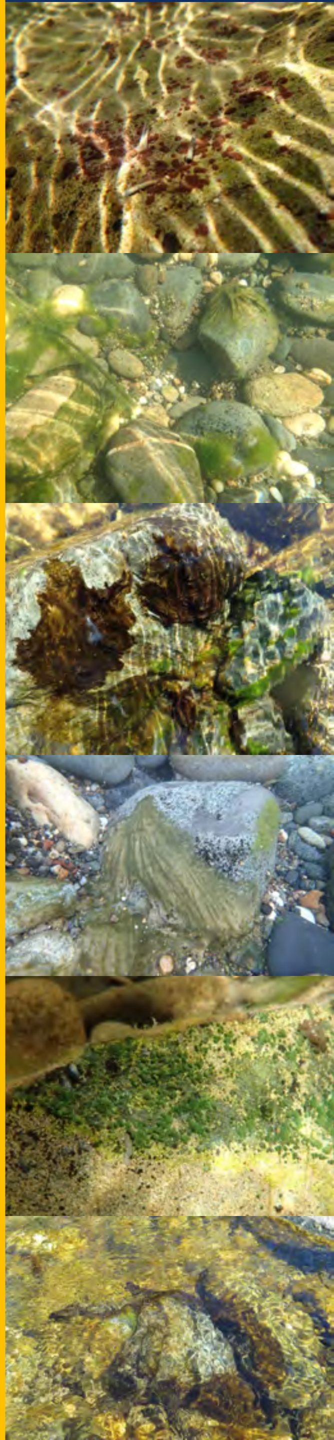
nrtA, nrtC

Thank You

ITEM III

Phormidium and beyond –practical taxonomy of filamentous cyanobacteria

Otakar Strunecky, Czech Academy of Sciences, Czech Republic



Phormidium and beyond – practical taxonomy of some filamentous cyanobacteria

Otakar Strunecký

University of South Bohemia
in České Budějovice
Faculty of Fisheries
and Protection
of Waters

Taxonomic rules – lawyerish but has a main goal – make things **clearer** and support **understanding**

- ***International Code of Nomenclature for algae, fungi, and plants*** **(ICN)** formerly ***International Code of Botanical Nomenclature*** (**ICBN**)

  TYPE: dried plant material and is usually deposited and preserved in a herbarium (image or a culture)

- **International Code of Nomenclature of Prokaryotes (ICNP)**
- The type strain is a living culture to which the scientific name of that organism is formally attached

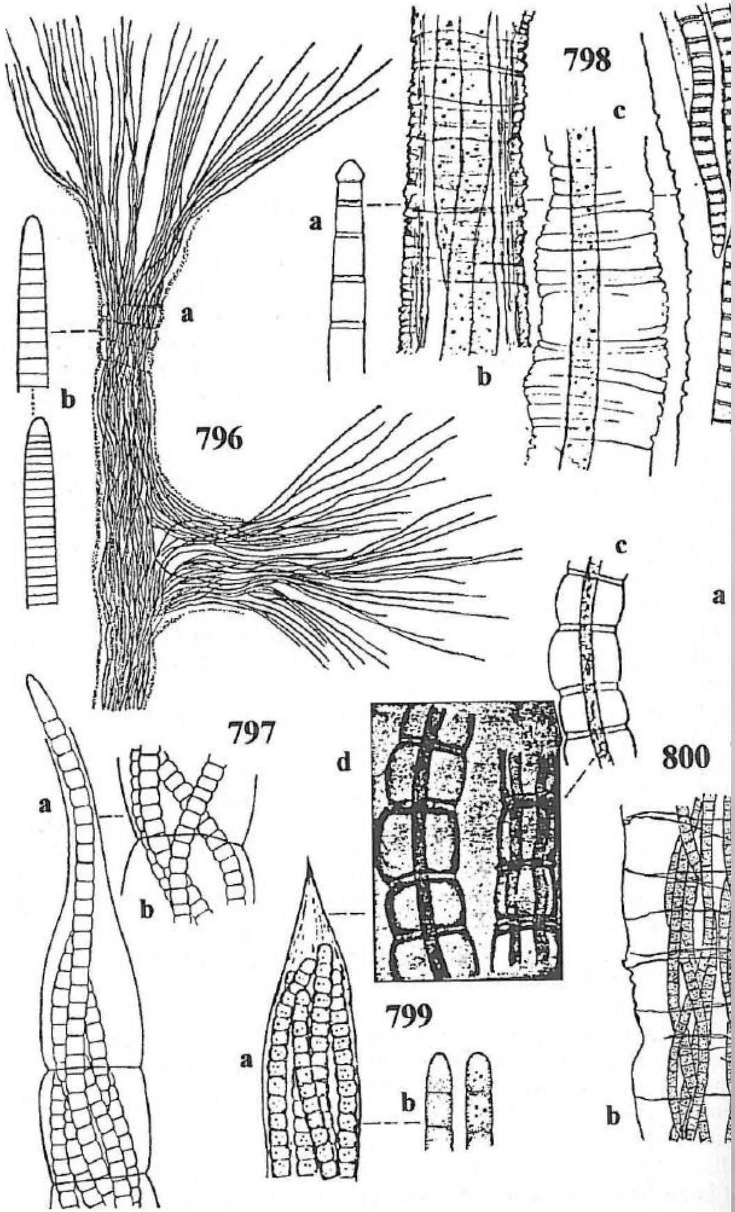


Fig. 796. *Sirocoleum kurzii*: **a** – after Frémy, **b** – after Gomont; (
Kosinskaja 1948).
Fig. 797. *Sirocoleum* ? sp.: **a-b** – after Novičkova from Starmach (
Hydrocoleum terrestre).

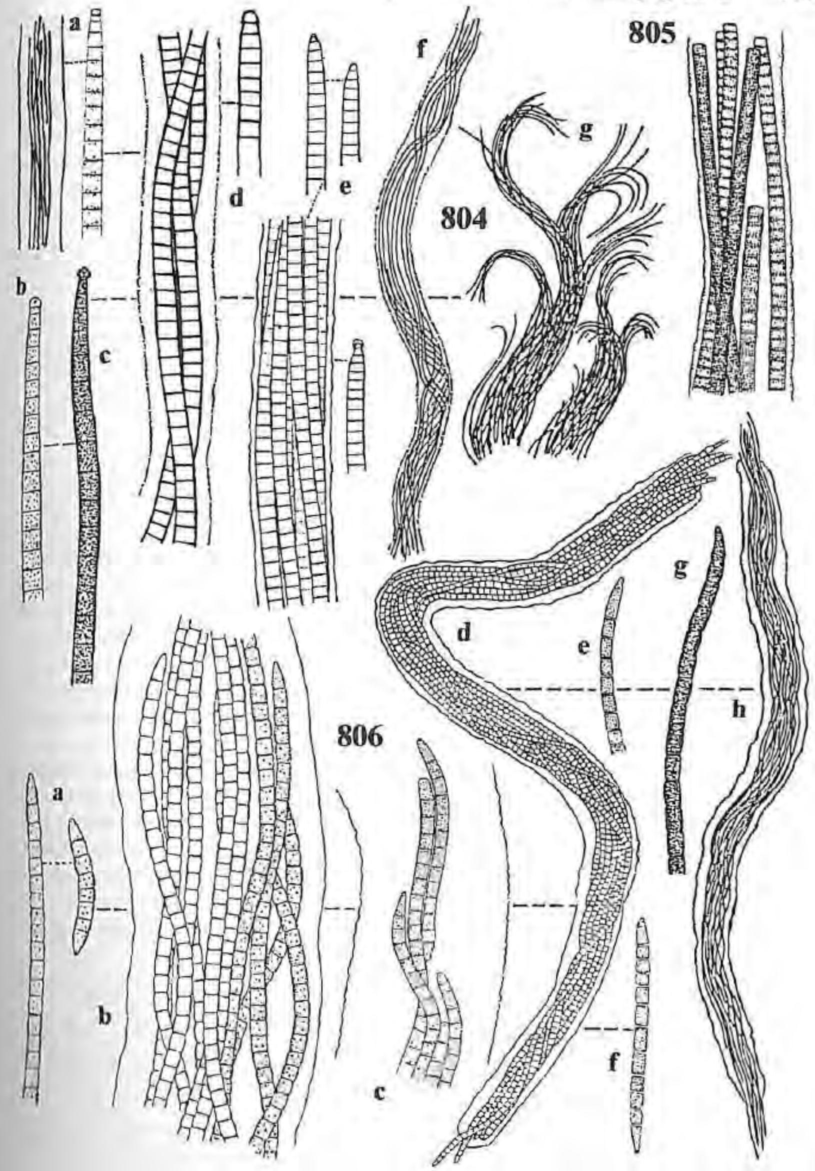
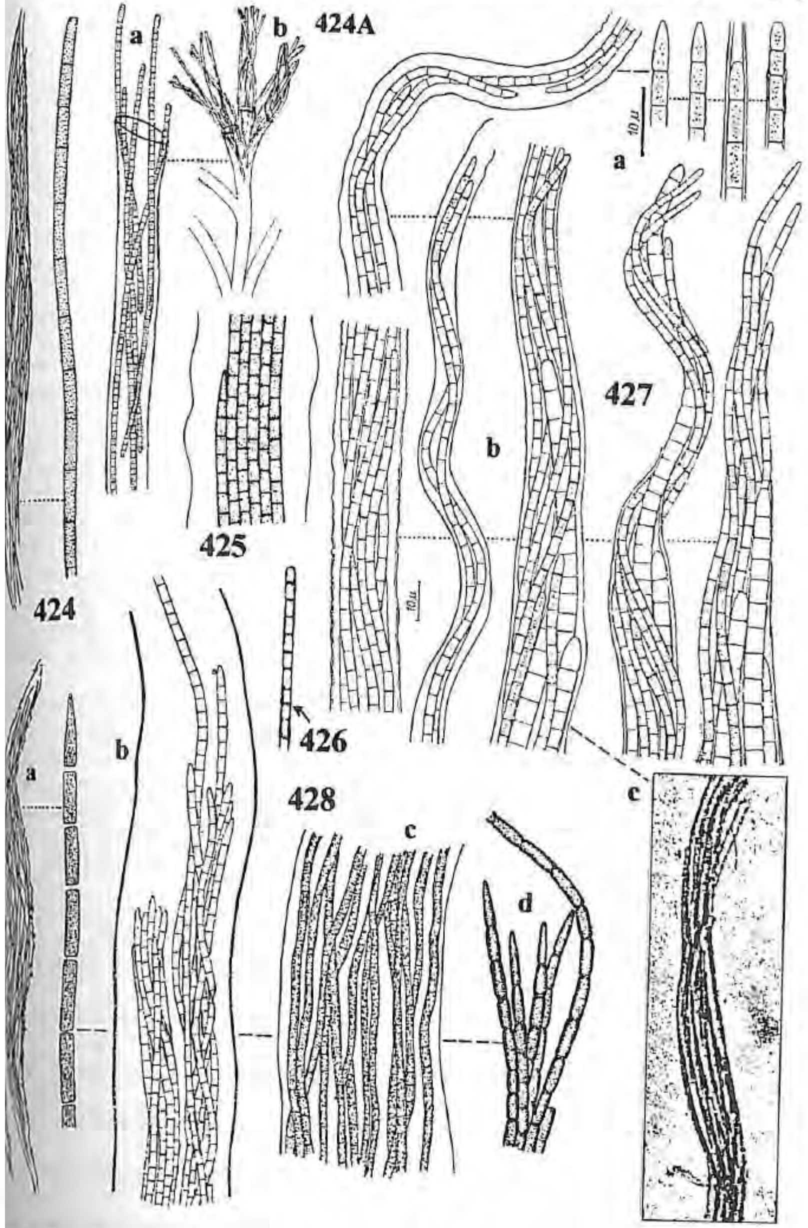


Fig. 804. *Microcoleus vaginatus*: **a** – after Komárek (1988), **b** – after Gomont from Starmach (1966), **c** – after Frémy (1930), **d** – after Kann (1978), **e,g** – after Starmach (1962), **f** – after Bourrelly (1970).
Fig. 805. *Microcoleus vaginatus* sensu Hirano (1964).
Fig. 806. *Microcoleus chthonoplastes*: **a-b** – after Kosinskaja (1948), **c-f** – after Gomont from Starmach (1966), **g-h** – after Frémy (1930).



ig. 428. *Trichocoleus sociatus*: **a** – after Frémy & Meslin (1928), **b** – after ... from Starmach (1966), **c** – after Palik (1949), **d** – after Behre (1953); (all ... *Microcoleus sociatus*).

So, w y is a there such a mess in naming? (stra B seqs., natural populations…)

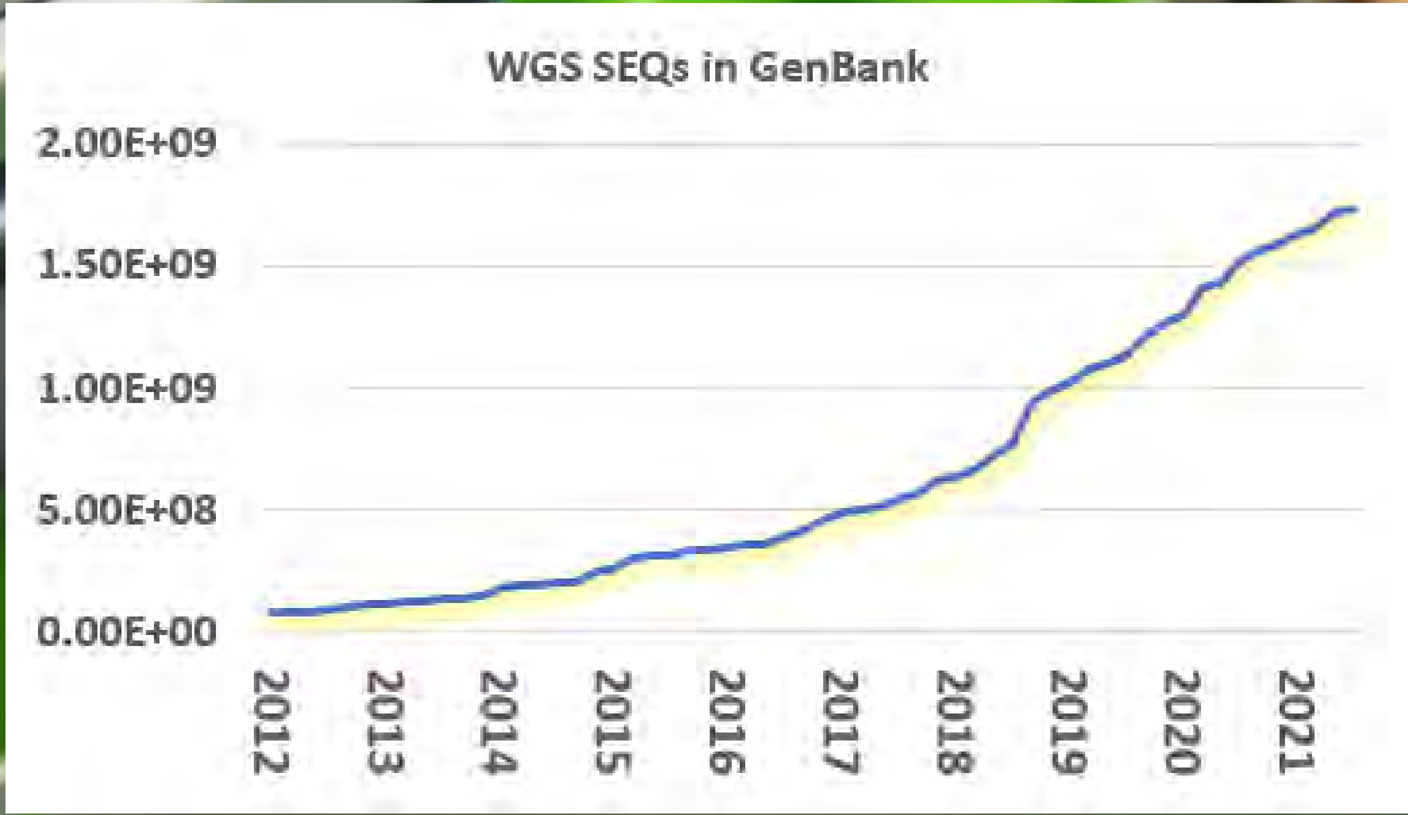
- Small numbe ical markers on bacteria
- Natural variability
- Historical background (sp ranging, selection from “old species”)
- Personal (team, country) pref
- Identical sequence in GB wins the p entum in strain naming)

➔ due to all above + the need of compari type species (+ pressure on publishing) many new species are

Huge development during last ~ 10 years (why?)

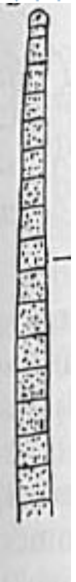
16S rRNA gene (+) genomic sequencing

280 new species
140 new genera
2014-2022



Laspinema Heidari et Hauer (2018)

*Microcoleus** (former *P. autumnale* + others)



Current name: *Microcoleus vaginatus* Gomont
On marginal plants, Hollowell Reservoir, Northampton UK. Collected by Rachel Carter. - 03 August 2006. C.F.Carter (chris.carter@6cvw.freeuk.com)

- *Oscillatoria vaginata* Vaucher 1803
- *Microcoleus vaginatus* Gomont 1892

* Was well defined (more consensual) soil species

- Relatively good diacritical features
- 16S rRNA formed clade with >100 strains with variable morphology and ecology

J. Phycol. **49**, 1167–1180 (2013)
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DOI: 10.1111/jpy.12128

MOLECULAR AND MORPHOLOGICAL CRITERIA FOR REVISION OF THE GENUS *MICROCOLEUS* (OSCILLATORIALES, CYANOBACTERIA)[1]

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and Josef Elster
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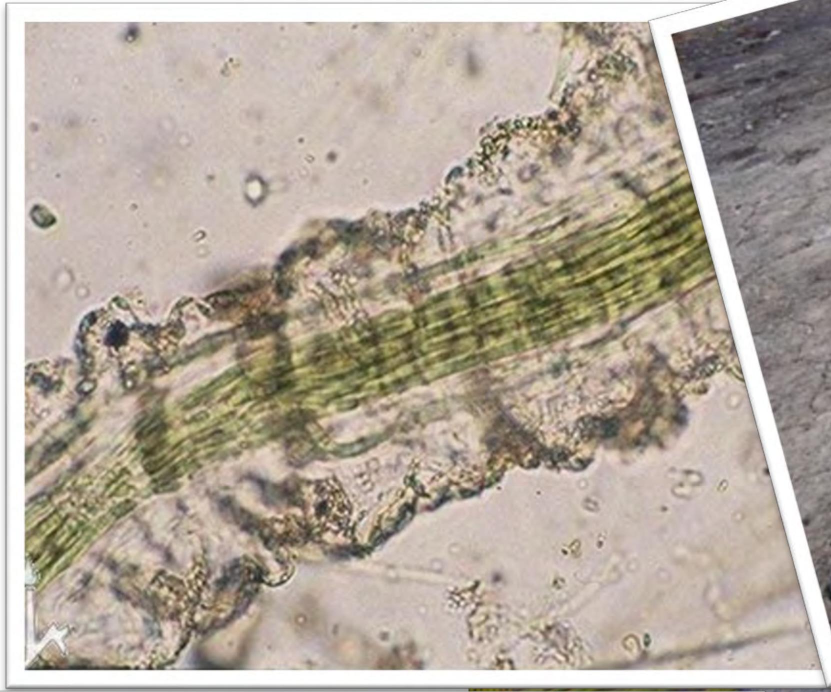
Centre for Polar Ecology, Department of Ecosystem Biology, Faculty of Science, University of South Bohemia, Branišovska 31, Ceske Budejovice 370 05, Czech Republic

ECOLOGY OF MICROCOLEUS

- Highly resistant to drying, freezing and desiccation
- Virtually everywhere where not outcompeted (N?) by other cyanobacteria, algae or plants

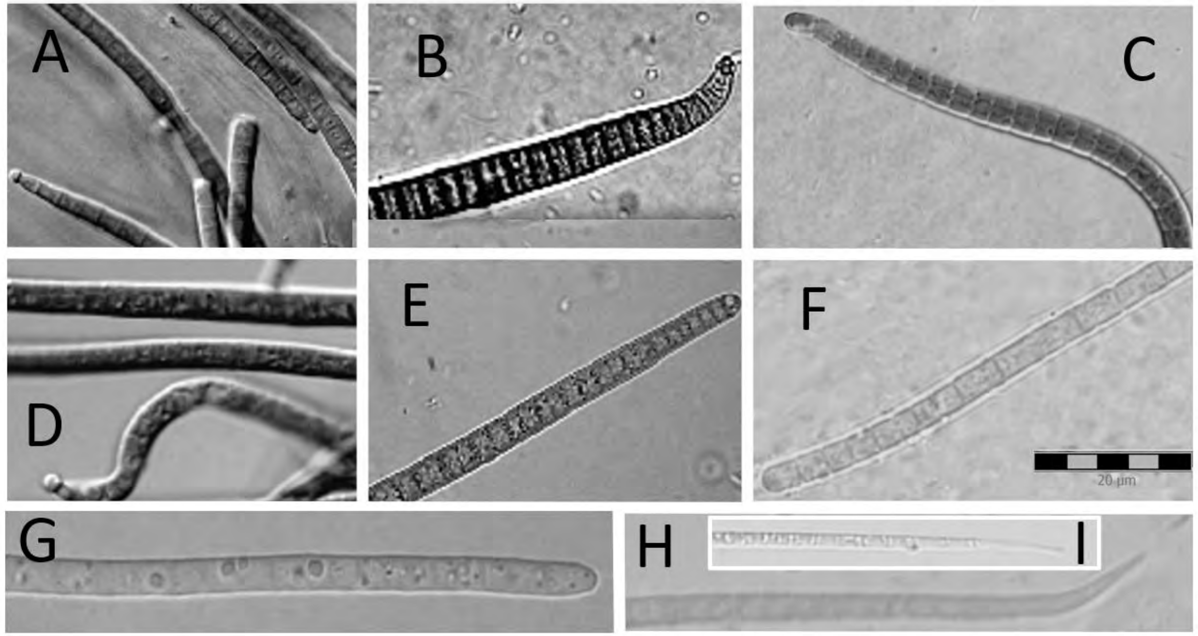
ECOLOGY OF MICROCOLEUS



ECOLOGY OF MICROCOLEUS

QUESTIONS REMAINS

- Is the New World different from the Old World?
- Is there higher diversity of particularly soil filamentous (bundles forming) species/genera in Americas?
- How many species are in *Microcoleus*?



Revised filamentous species: Microcoleus vaginatus (A) , M. autumnalis (B), Kamptonema formosum (C), M. fonticulus (D), M. attenuatus (E), Wilmottia murrayi (F), Anagnostidinema formosum (G), Oxynema thaianum (H), Geitlerinema splendidum (I)

Microcoleus

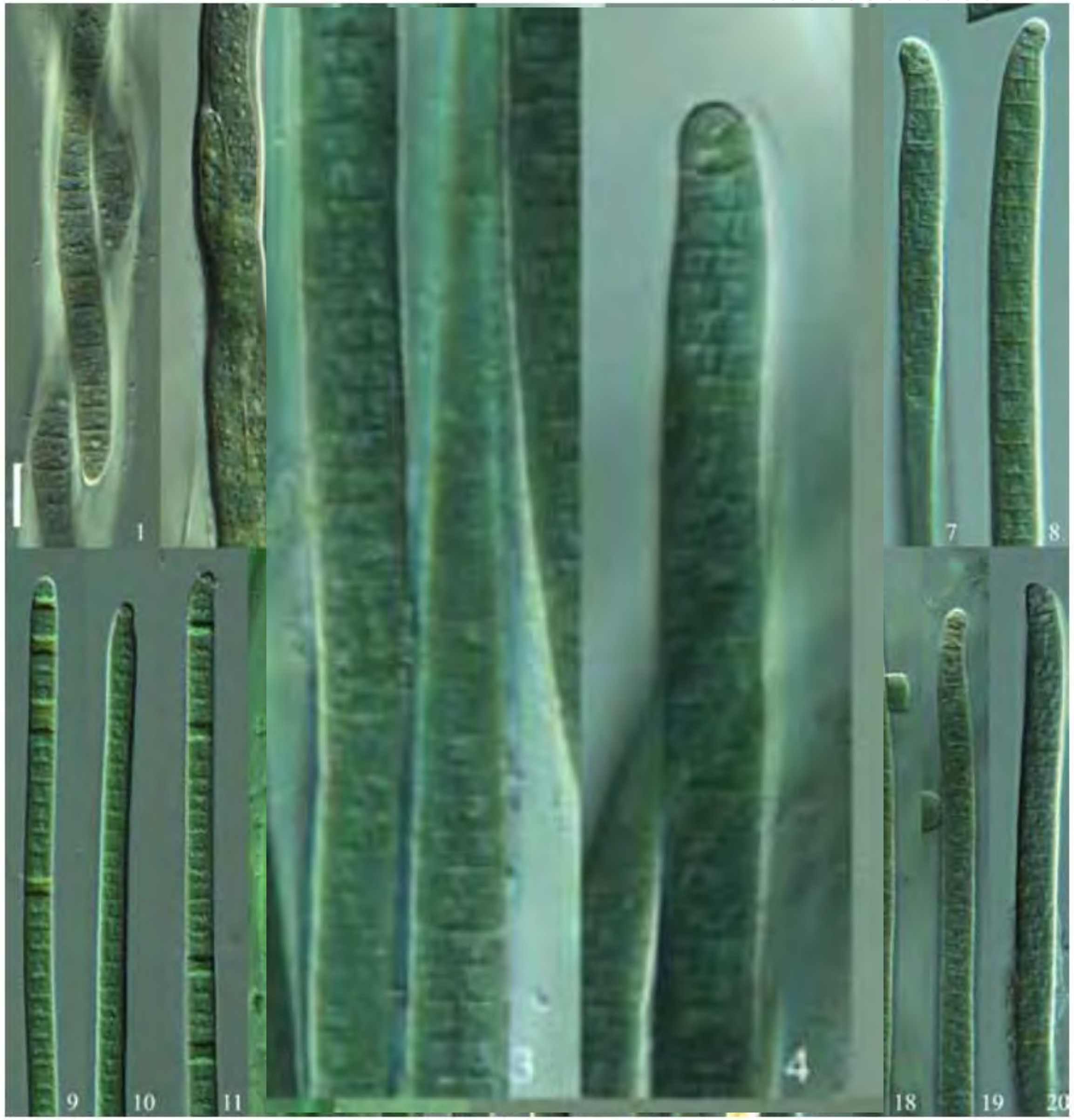
The common features: trichome width 4–10 μm, cells isodiametric, occasionally as short as 1/3 as long as wide, with cyanophycin bodies located close to cell walls between cells. *Microcoleus* have characteristic raft structure of thylakoids which can be also seen by optical microscopy as green field areas within the cells. Calyptra, motility and multiple trichomes in a common sheath facultative.

Fottea, Olomouc, 12(2): 341–356, 2012 341

Morphological and molecular study of epipelic filamentous genera *Phormidium*, *Microcoleus* and *Geitlerinema* (Oscillatoriales, Cyanophyta/ Cyanobacteria)

Petr Hašler [1*], Petr Dvořák [1], Jeffrey R. Johansen[2], Miloslav Kitner [1], Vladan Ondřej [1] & Aloisie Poulíčková [1]

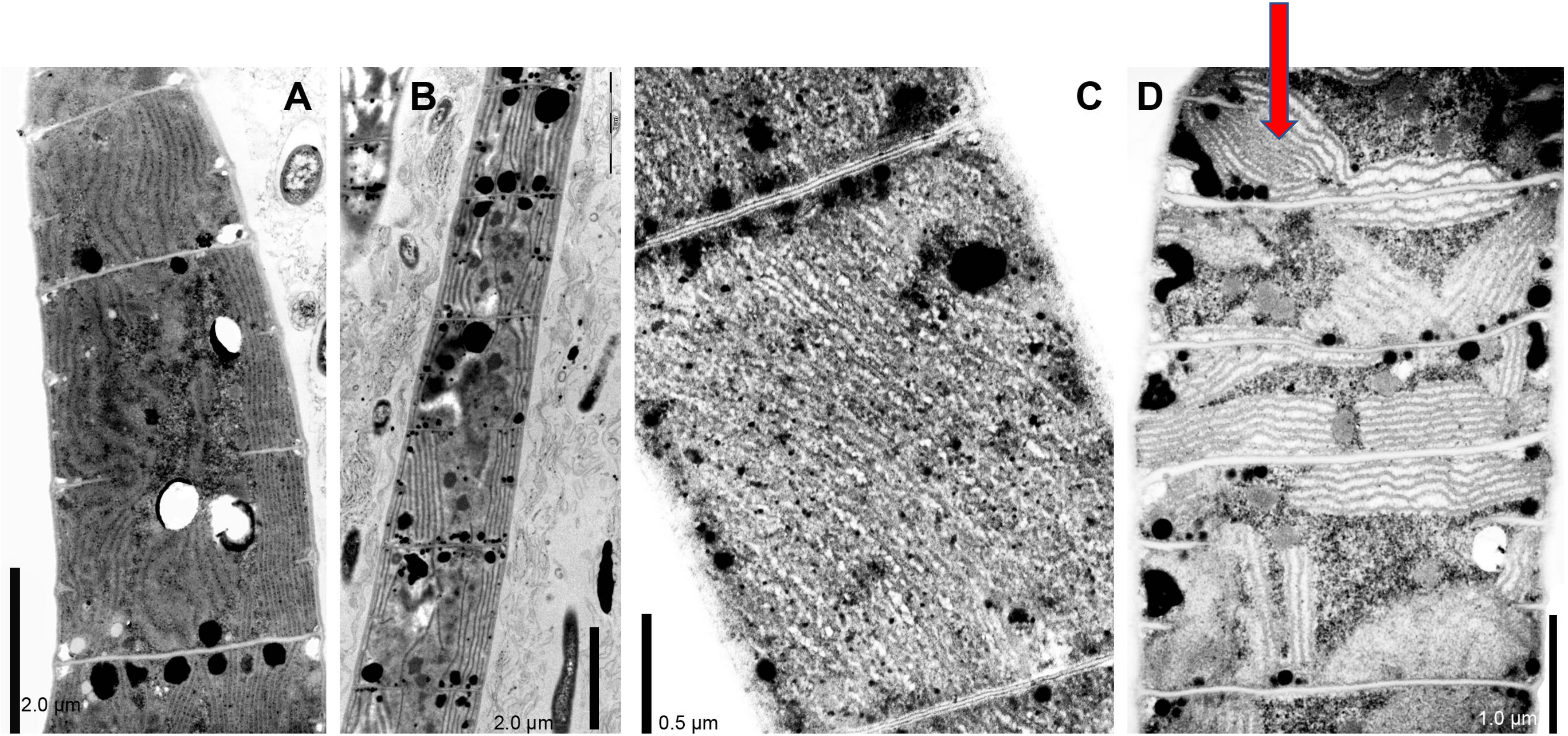
*[1] Department of Botany, Faculty of Science, Šlechtitelů 11, CZ–783 71 Olomouc, Czech Republic; *Corresponding author e–mail: petr.hasler@upol.cz*
[2] Department of Biology, John Carroll University, 20700 North Park Blvd., University Heights, Ohio 44118, USA



Figs 1–20. Variability of filamentous epipelic cyanobacteria: (1–2) *M. vaginatus*, strain P006; (3–4) *M. vaginatus*, strain P0R1; (5–6) *M. vaginatus*, strain P09; (7) *M. vaginatus*, strain P0B; (8) *M. vaginatus*, strain P0C; (9–11) *Ph. autumnale*, strain P00; (12–13) *M. vaginatus*, strain P007; (14–16) *Ph. autumnale*, strain P019; (17–20) *Ph. autumnale*, strain P012. Scale bar 10 mm.

Ultrastructure - *Microcoleus*

Width 4 – 10 μm , sheaths, thylakoids bundles



Did *Microcoleus* changed back to *Phormidium*?

[HTML] Hydrogen Peroxide Stress Induced in the Marine Cyanobacterium *Synechococcus aeruginosus* and ***Phormidium*** *valdarianum*

JM Hussain, P Muruganantham… - Applied Biochemistry and …, 2023 - Springer

… Synechococcus aeruginosus and **Phormidium** … and **Phormidium** valderianum, catalase in Synechococcus aeruginosus, peroxidase in Synechococcus aeruginosus and **Phormidium** …

☆ Uložit 99 Citovat Související články Všechny verze (počet: 3)

Statistical Optimization and Downstream Processing of C-Phycocyanin from ***Phormidium*** *valderianum*

MS Nair, R Rajarathinam, S Velmurugan… - Chemical …, 2023 - Wiley Online Library

… This study proved that **Phormidium** valderianum could serve as an alternative source of the pigment C-PC. The extraction of C-PC from **Phormidium** valderianum by ultrasonication was …

☆ Uložit 99 Citovat Počet citací tohoto článku: 2 Související články

[PDF] Roles of phytochrome, PixJ, and photosynthesis in photophobotaxis of the filamentous cyanobacterium **Phormidium** lacuna

T Lamparter, E Schwabenland, CJ Jelen, N Weber - 2023 - researchgate.net

Cyanobacterium **Phormidium** lacuna filaments move from dark to illuminated areas by twitching motility. Time-lapse recordings demonstrated that this photophobotaxis response was …

☆ Uložit 99 Citovat Všechny verze (počet: 3) »

[HTML] Complete Genome Sequence of **Phormidium** yuhuli AB48, Isolated from an Industrial Photobioreactor Environment

Y Qiu, AJC Noonan, K Dofher, M Koch… - Microbiology …, 2023 - Am Soc Microbiol

We report the genome of **Phormidium** yuhuli AB48, which includes a circular chromosome and a circular plasmid (4 747 469 bp and 51 599 bp, respectively). This is currently the only

Polyphasic characterisation of *Microcoleus autumnalis* (Gomont, 1892) Strunecky, Komárek & J.R.Johansen, 2013 (Oscillatoriales, Cyanobacteria) using a metabolomic approach as a complementary tool

Ivanka Teneva[‡], Detelina Belkinova[‡,§], Tsvetelina Paunova-Krasteva[|], Krum Bardarov[¶], Dzhemal Moten[‡], Rumen Mladenov[‡], Balik Dzhambazov[‡]

‡ Faculty of Biology, Plovdiv University "Paisii Hilendarski", Plovdiv, Bulgaria
§ Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, Sofia, Bulgaria
| The Stephan Angeloff Institute of Microbiology, Bulgarian Academy of Sciences, Sofia, Bulgaria
¶ InoBioTech Ltd., Sofia, Bulgaria

Corresponding author: Ivanka Teneva (teneva@uni-plovdiv.bg)

Academic editor: Christian Wurzbacher

- No, due to lack of the taxonomically valid prerequisites

Tychonema – to be solved

2. Tychonema tenue (Skuja) Anagnostidis et Komárek 1988 (fig. **521**)

Oscillatoria bornetii f. *tenuis* Skuja 1929

Trichomes greyish, solitary or in fine, brownish or olive-green mats, straight or slightly flexuous or curved, not constricted at cross-walls, cylindrical, not attenuated towards ends, 5.5–7 (8) µm wide. Cells ± isodiametric, distinctly granular at cross-walls, with distinctly keritomized, almost colourless content. Apical cells rounded with thickened cell wall, but without calyptra (?).
Occurrence: In swamps, among plants, secondary free-floating, mainly tychoplanktic, in clear, acidic and cold waters; Denmark, Estonia, Latvia, Norway, Sweden, recorded also from Romania (E Carpathians). Planktic populations possibly identical with *T. bourrellyi* (?).

- Tychonema bourrellyi (Lund) Anagnostidis et Komárek 1988
  Trichomes solitary, free-floating, grey to greyish-brown, straight or occasionally curved, to about 5 mm long, in the mass violet, pinkish … cells longer or shorter than wide, sometimes with 1 (2) small to large "vacuoles" (in fact widened thylakoids), almost colourless, 4-5 (6.3) µm wide

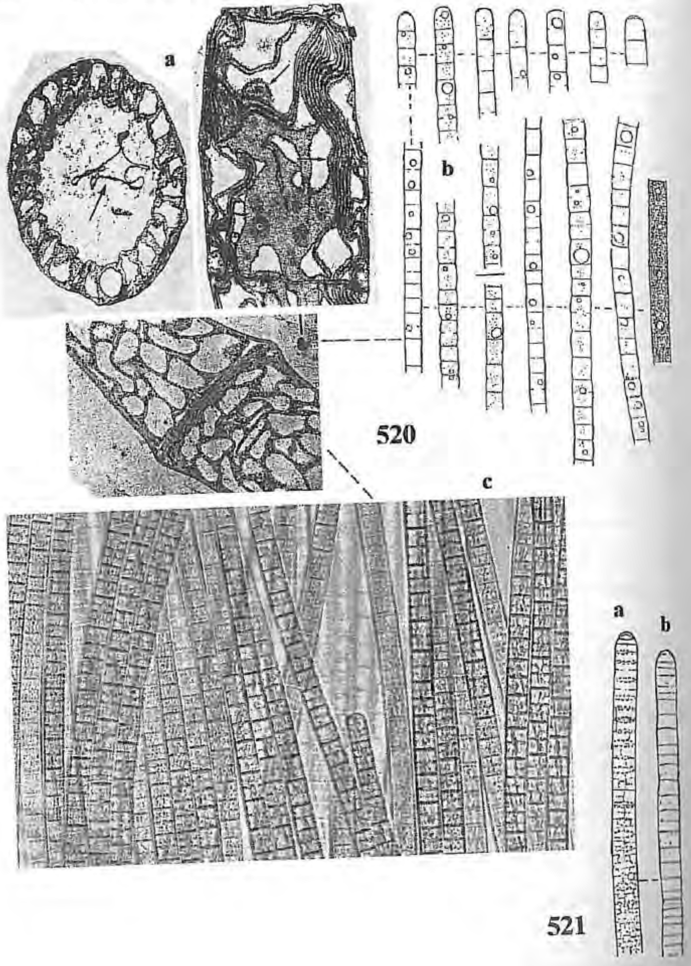


Fig. 520. *Tychonema bourrellyi*: **a** – ultrathin section through a cell with widened thylakoids, **b-c** – details of trichomes; **a** – after Komárek & Albertano (1994), **b** – after Lund (1955, sub *Oscillatoria bourrellyi*), **c** – from Canter-Lund & Lund (1995, sub *Oscillatoria bourrellyi*).
Fig. 521. *Tychonema tenue*: **a** – after Skuja (1929, sub *Oscillatoria bornetii* f. *tenuis*), **b** – redrawn from Skulberg (1977, sub *Oscillatoria* sp.).

Tychonema – early bird in Genbank

```
SOURCE      Tychonema bourrellyi CCAP 1459/11B
  ORGANISM  Tychonema bourrellyi CCAP 1459/11B
            Bacteria; Cyanobacteriota; Cyanophyceae; Oscillatoriophycideae;
            Oscillatoriales; Microcoleaceae; Tychonema.
REFERENCE   1
  AUTHORS   Suda,S., Watanabe,M.M., Otsuka,S., Mahakahant,A., Yongmanitchai,W.,
            Nopartnaraporn,N., Liu,Y. and Day,J.G.
  TITLE     Taxonomic revision of water-bloom-forming species of oscillatorioid
            cyanobacteria
  JOURNAL   Int. J. Syst. Evol. Microbiol. 52 (PT 5), 1577-1595 (2002)
   PUBMED   12361260
REFERENCE   2  (bases 1 to 1361)
  AUTHORS   Suda,S.
  TITLE     Direct Submission
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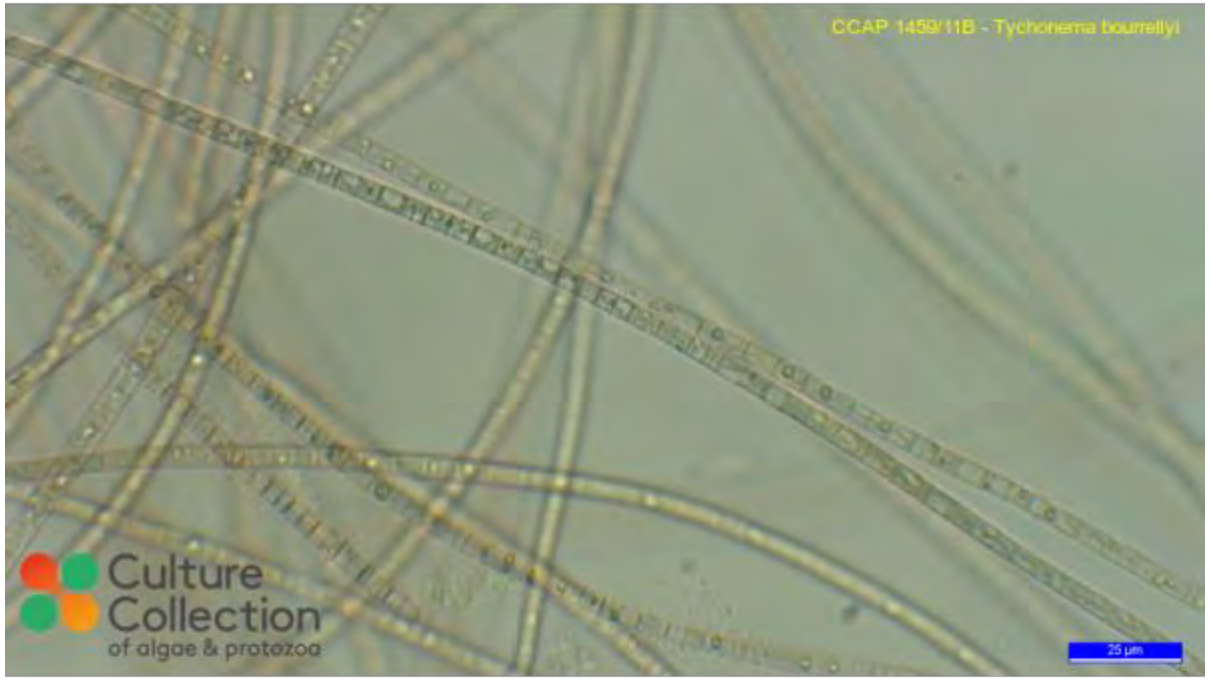

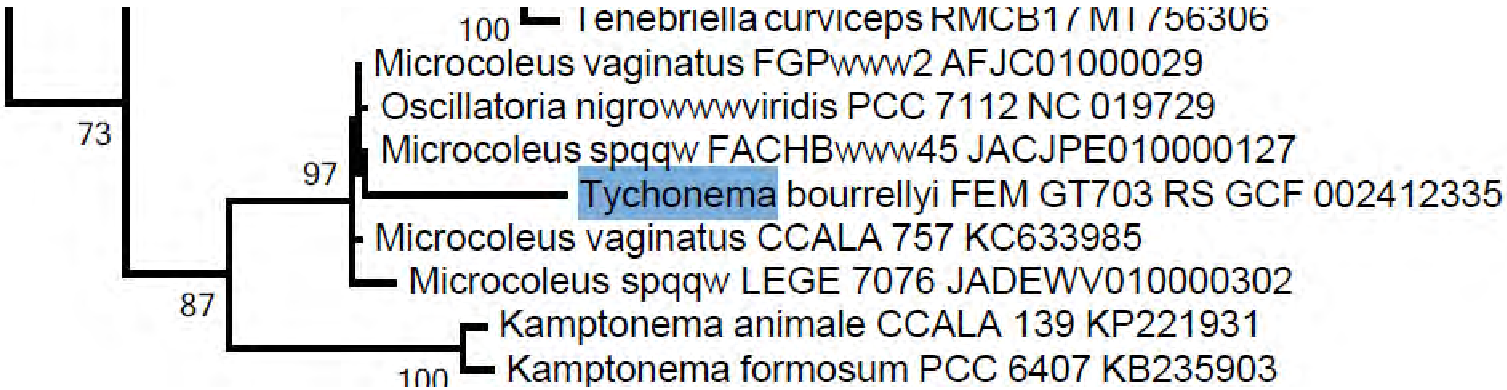

J. Phycol. 59, 12–51 (2023)

DOI: 10.1111/jpy.13304

REVIEW

AN UPDATED CLASSIFICATION OF CYANOBACTERIAL ORDERS AND FAMILIES BASED ON PHYLOGENOMIC AND POLYPHASIC ANALYSIS[1]

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and Jan Mareš [2]
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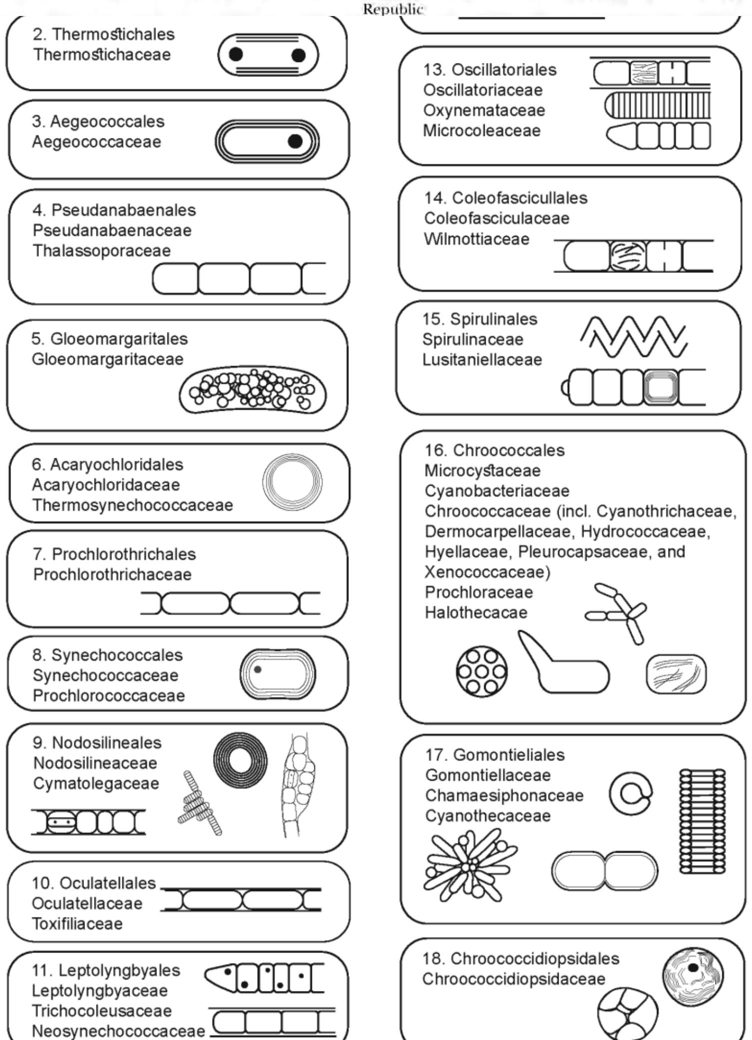
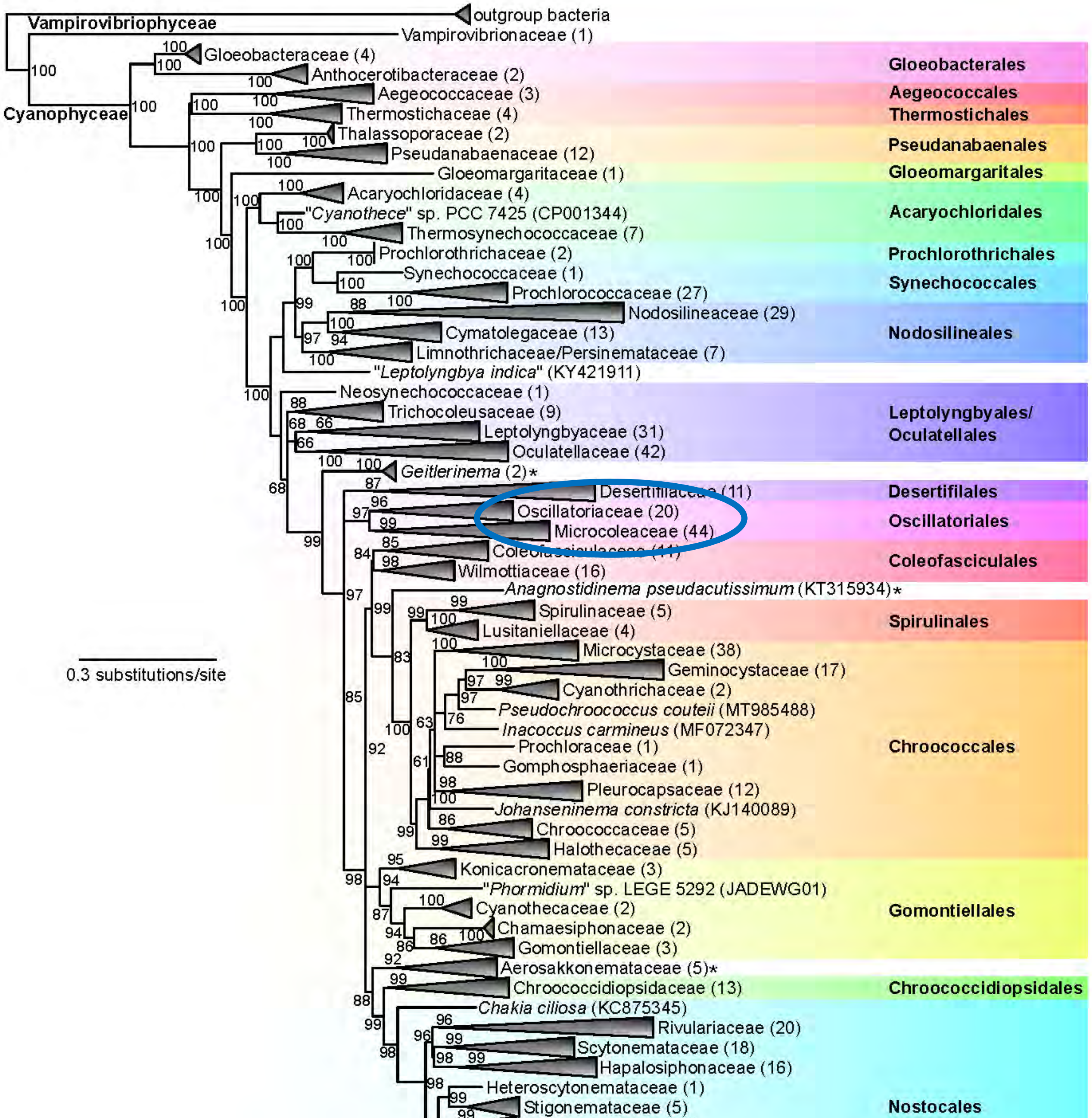
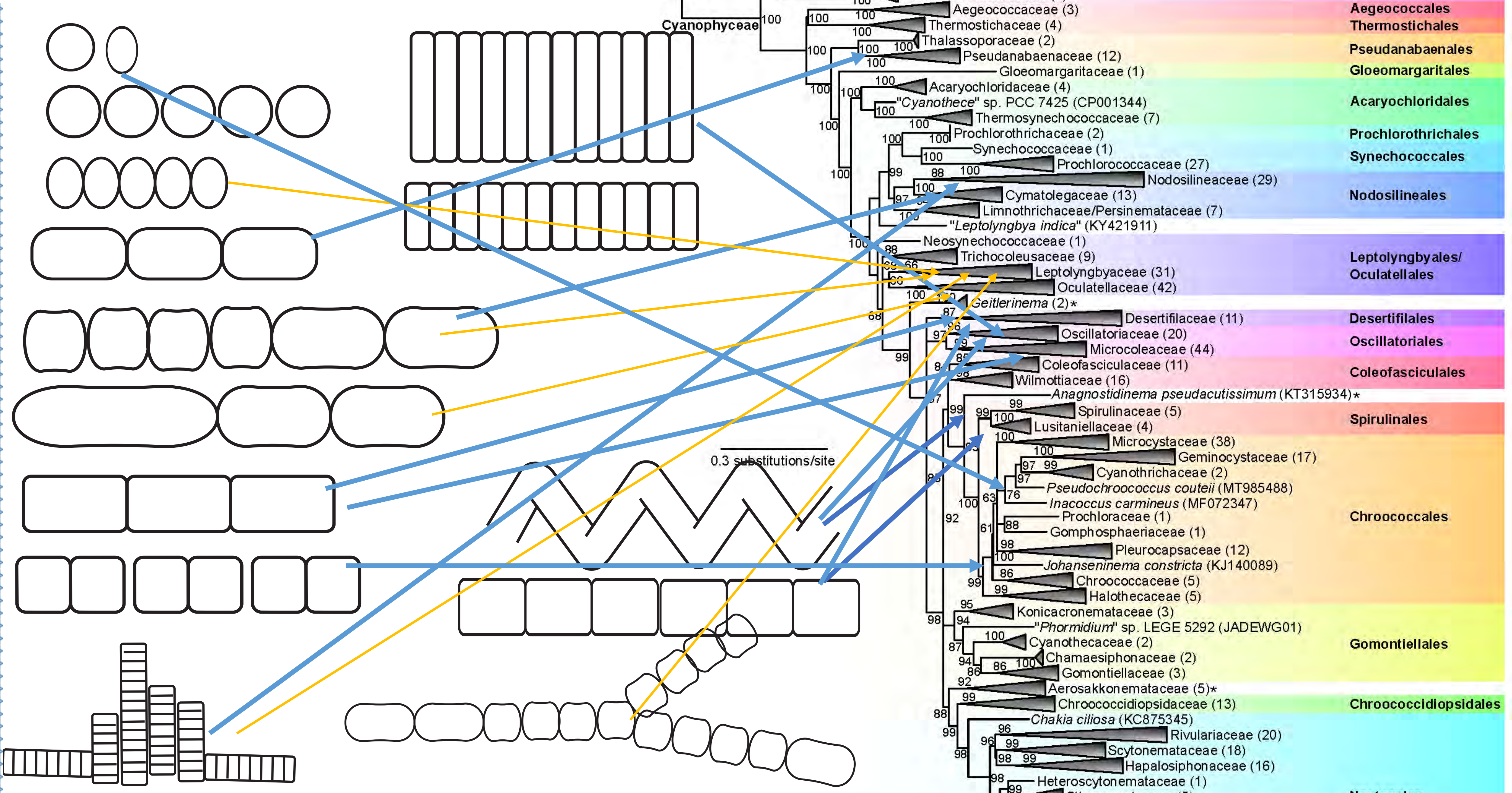
Faculty of Science, Department of Botany, University of South Bohemia, Branišovská 1760, 370 05 České Budějovice, Czech Republic







Morphological constraints

taxon	*type species*
Gloeobacterales Cavalier-Smith 2002	
Gloeobacteraceae Komárek et Anagnostidis 1995	
Gloeobacter Rippka et al. 1974 ex Mareš et al. 2013	*G. violaceu*
Anthocerotibacteraceae Strunecký et Mareš, fam. nov.	
Anthocerotibacter F. W. Li 2021	*A. panamer*
Thermostichales Komárek et Strunecký 2020	
Thermostichaceae Komárek et Anagnostidis 1995	
Thermostichus Komárek et Strunecký 2021	*T. vulcanus*
Aegeococcocales Strunecký et Mareš, ordo nov.	
Aegeococcaceae Strunecký et Mareš, fam. nov.	
Aegeococcus Konstantinou et Gkelis 2020	*A. anagnos*
Pseudanabaenales Komárek et Anagnostidis 1988	
Pseudanabaneaceae Anagnostidis et Komárek 1988	
Pseudanabaena Lauterborn 1915	*P. catenata*
Limnothrix Meffert 1988	*L. redekei*
Thalassoporaceae Strunecký et Mareš, fam. nov.	
Thalassoporum Konstantinou et Gkelis 2020	*T. komareki*

Oscillatoriales Schaffner 1922		
Oscillatoriaceae (Gray) Kirchner 1898		
Ammassolinea Hašler et al. 2014	*A. attenuata*	
Baaleninema Samylina et al. 2021	*B. simplex*	
Koinonema Buch et al. 2017	*K. pervagatum*	
Laspinema Heidari et Hauer 2018	*L. thermale*	
Oxynema Chatchawan et al. 2012	*O. thaianum*	
Oscillatoria Vaucher ex Gomont 1892	*O. princeps*	
Perforafilum Zimba et al. 2020	*P. tunnelli*	
Phormidium Kützing ex Gomont 1892	*P. lucidum*	**P**
Planktothricoides Suda et M.M.Watanabe 2002	*P. raciborskii*	
Sodalinema Cellamare et al. 2018	*S. komarekii*	
Microcoleaceae Komárek et al. 2014		
Affixfilum Lefler et al. 2020	*A. floridanum*	
Ammatoidea W.et G.S.West 1897	*A. normannii*	**P**
Ancylothrix Martins et Branco 2016	*A. rivularis*	
Arthrospira Stizenberger ex Gomont 1892	*A. jenneri*	
Blennothrix Kützing ex Anagnostidis et Komárek 1988	*B. vermicularis*	**P**
Capilliphycus Caires et al. 2019	*C. salinus*	
Dapis Engene et al. 2018	*D. pleousa*	
Dasygloea Thwaites ex Gomont 1892	*D. amorpha*	**P**
Homoeothrix (Thuret) Kirchner 1898	*H. juliana*	**P**
Hydrocoleum Kützing ex Gomont 1892	*H. homoeotrichum*	**P**
Kamptonema Strunecký et al. 2014	*K. animale*	
Leibleinia (Gomont) Hoffmann 1985	*L. baculum*	**P**
Leptochromothrix Berthold et al. 2021	*L. valpauliae*	**P**
Limnoraphis Komárek et al. 2013	*L. hieronymusii*	
Limnospira Nowicka-Krawczyk, Mühlsteinová et Hauer 2018	*L. fusiformis*	
Lyngbya C. Agardh ex Gomont 1892	*L. confervoides*	**P**
Lyngbyopsis Gardner 1927	*L. willei*	**P**
Microcoleus Desmazières ex Gomont 1892	*M. vaginatus*	
Neolyngbya Caires et al. 2018	*N. maris-brasilis*	
Okeania Engene et al. 2013	*O. hirsuta*	
Ophiophycus Berthold et al. 2021	*O. aerugineus*	**P**
Phormidiochaete Komárek in Anagnostidis 2001	*P. nordstedtii*	**P**
Planktothrix Anagnostidis et Komárek 1988	*P. agardhii*	
Plectonema Thuret ex Gomont 1892	*P. tomasinianum*	**P**
Polychlamydum W. et G.S.West 1897	*P. insigne*	**P**
Porphyrosiphon Kützing ex Gomont 1892	*P. notarisii*	**P**
Proterendothrix W. et G.S.West 1897	*P. scolecoidea*	**P**

Tabularised system

ng data are missing and/or their phylogenetic placement is ambiguous

Oscillatoria

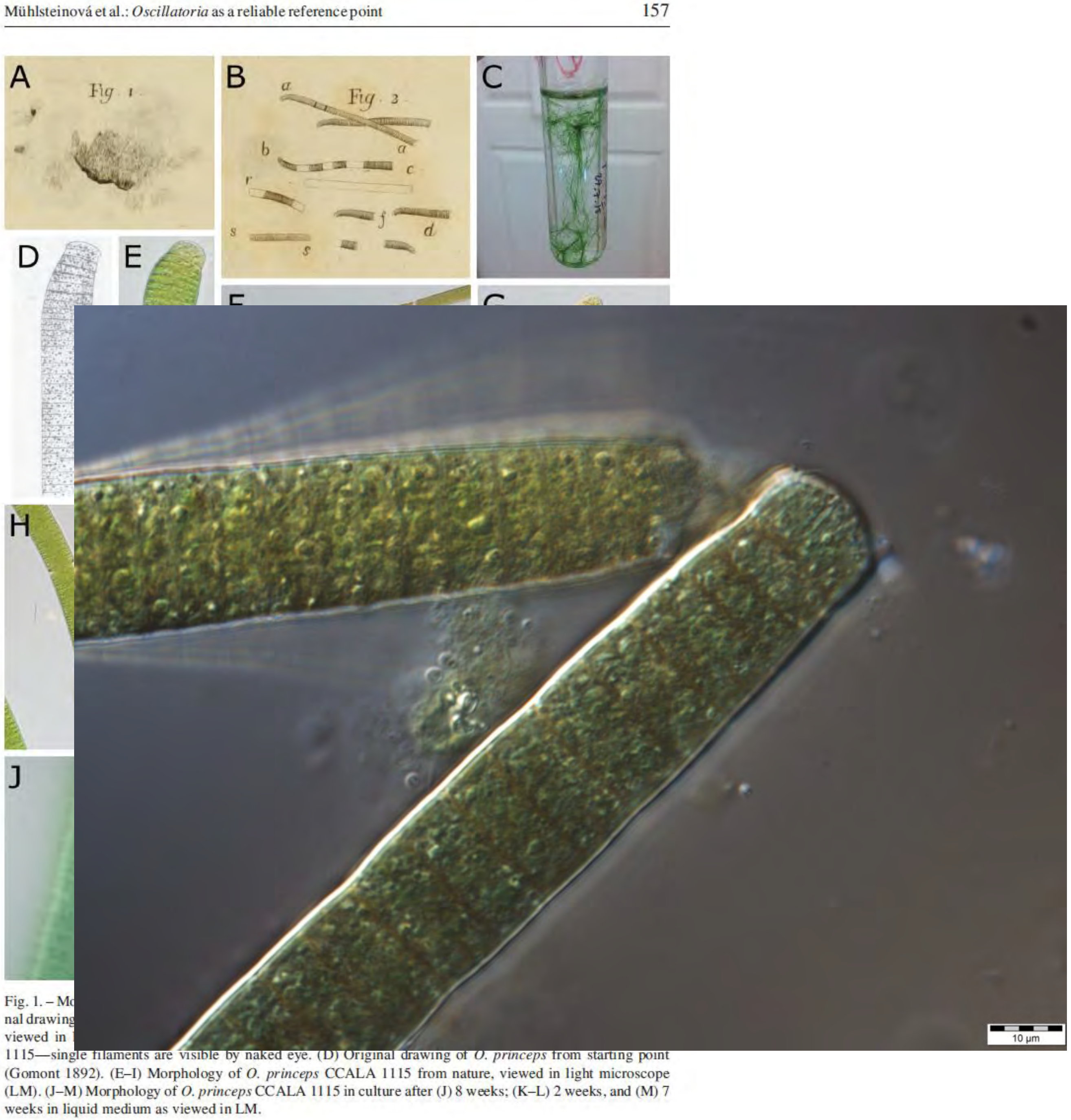
Preslia 90: 151–169, 2018 151

Seeking the true *Oscillatoria*: a quest for a reliable phylogenetic and taxonomic reference point

Hledání fylogenetického a taxonomického referenčního bodu pro rod *Oscillatoria*

Radka Mühlsteinová[1,2], Tomáš Hauer[1,2], Paul De Ley[3] & Nicole Pietrasiak[4]

[1]*Department of Botany, Faculty of Science, University of South Bohemia, Branišovská 31, České Budějovice, Czech Republic, CZ-370 05, e-mail: radka.muhlsteinova@gmail.com;* [2]*The Czech Academy of Sciences, Institute of Botany, Centre for Phycology, Dukelská 135, CZ-379 82, Třeboň, Czech Republic, e-mail: tomas.hauer@prf.jcu.cz;* [3]*Department of Nematology, University of California Riverside, Riverside, California 92521, USA, e-mail: paul.deley@ucr.edu;* [4]*Department of Plant and Environmental Science, New Mexico State University, Skeen Hall, Box 30003 MSC 3Q, Las Cruces, New Mexico 88003, USA, e-mail: npietras@nmsu.edu*



Tenebriella

Contents lists available at ScienceDirect

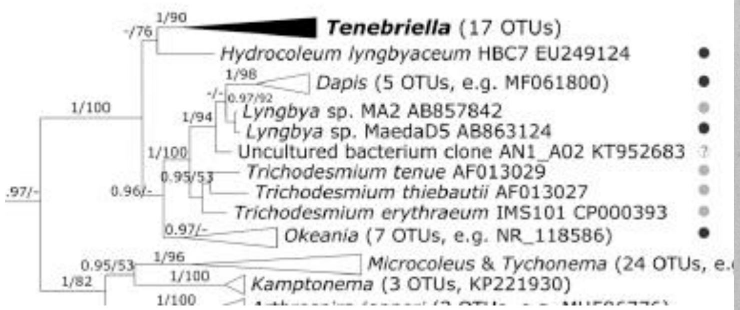
Molecular Phylogenetics and Evolution

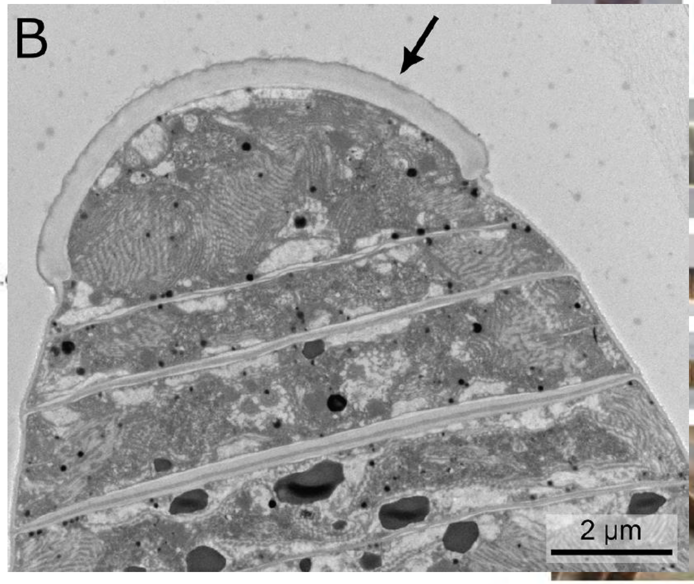
journal homepage: www.elsevier.com/locate/ympev

Tenebriella gen. nov. – The dark twin of *Oscillatoria*

Radka Hauerová[a,b,*], Tomáš Hauer[a], Jan Kaštovský[a], Jiří Komárek[a,c], Olga Lepšová-Skácelová[a], Jan Mareš[a,d]

[a] University of South Bohemia, Faculty of Science, Branišovská 1760, 370 05 České Budějovice, Czech Republic
[b] Biology Centre of the Czech Academy of Sciences, Institute of Soil Biology, Na Sádkách 702/7, 37005 České Budějovice, Czech Republic
[c] The Czech Academy of Sciences, Institute of Botany, Centre for Phycology, Dukelská 135, 379 82 Třeboň, Czech Republic
[d] Biology Centre of the Czech Academy of Sciences, Institute of Hydrobiology, Na Sádkách 702/7, 37005 České Budějovice, Czech Republic





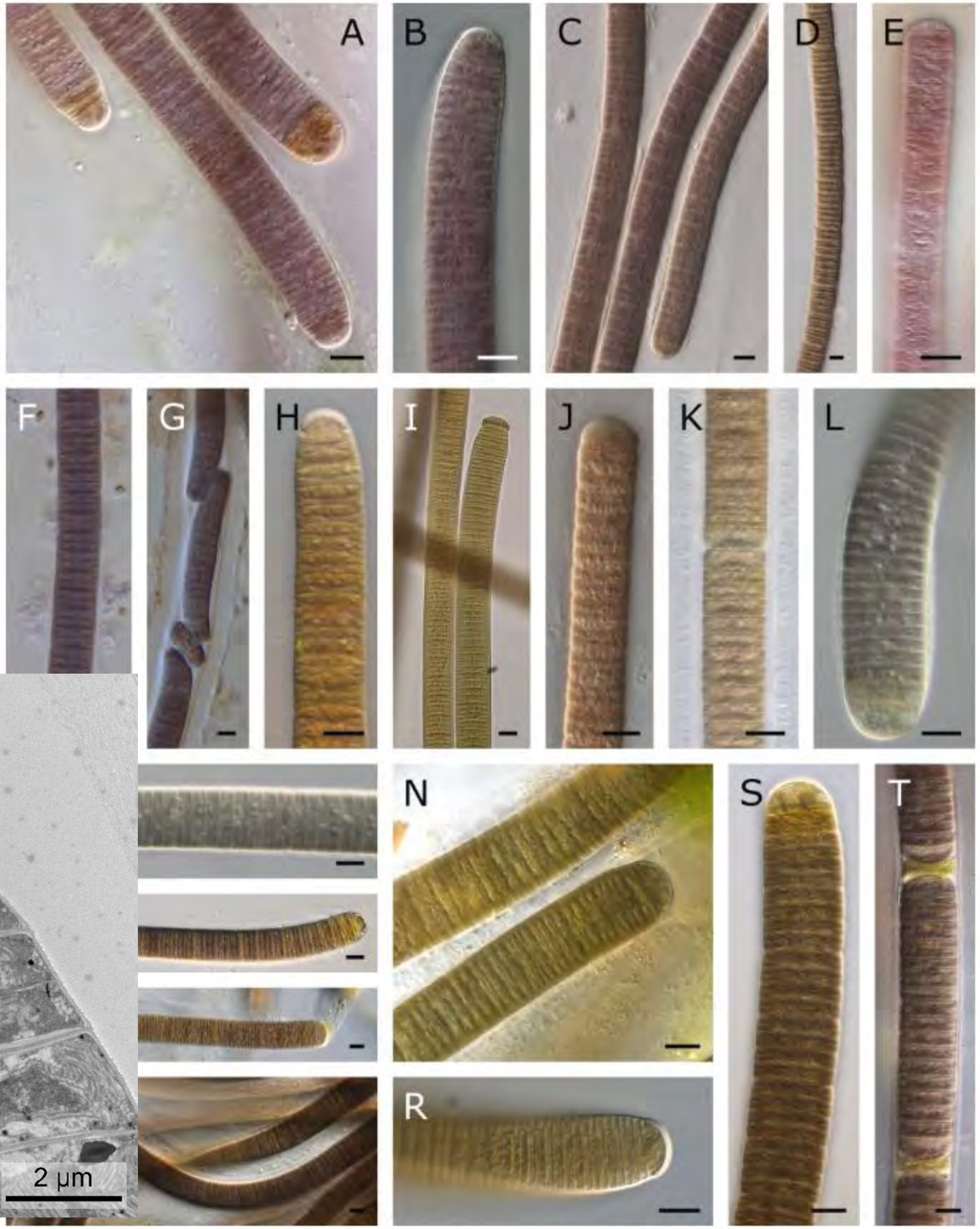
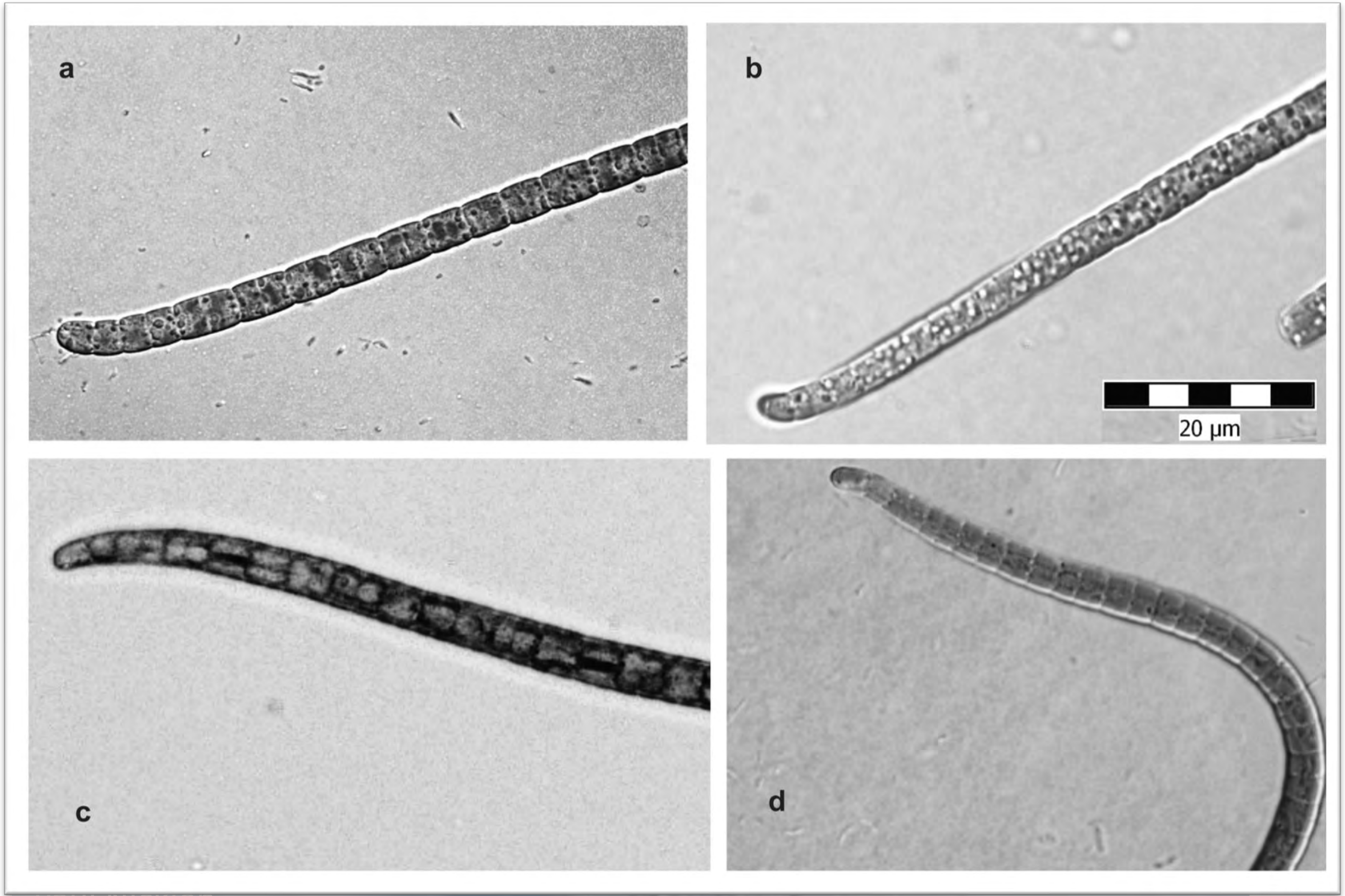


Fig. 1. The morphology of *T. amphibia* visualized by light microscope. A–E strain CCALA 1132; F–G Sicily Cemetery; H – RMCB18; I–K RMCB21, L–M Ute Lake; N – JM72/15; O–Q RMCB19; R – JM90-15; S–T RMCB16. The length of the scale bar is 10 µm.

Oscillatoria curviceps
Agardh ex Gomont 10-17 um

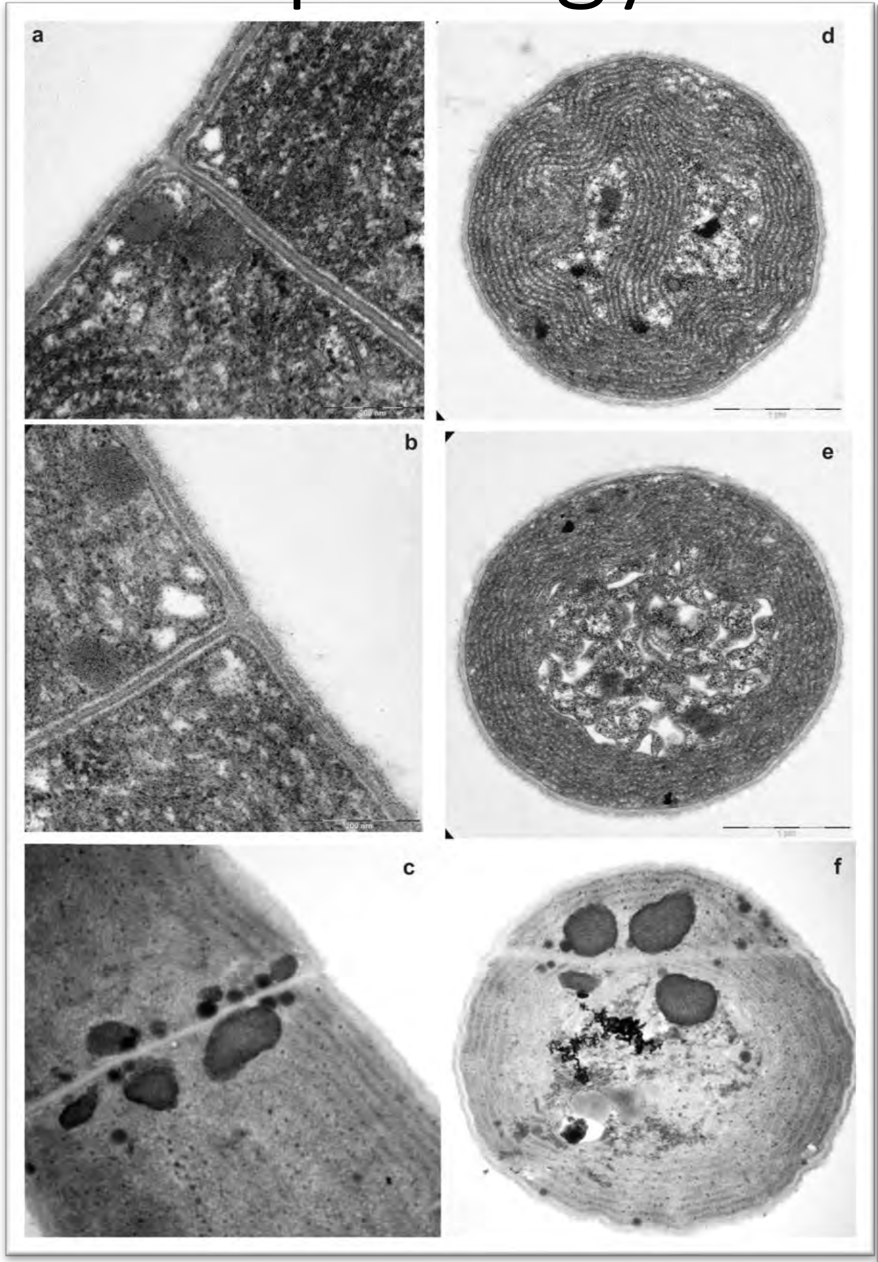
Kamptonema

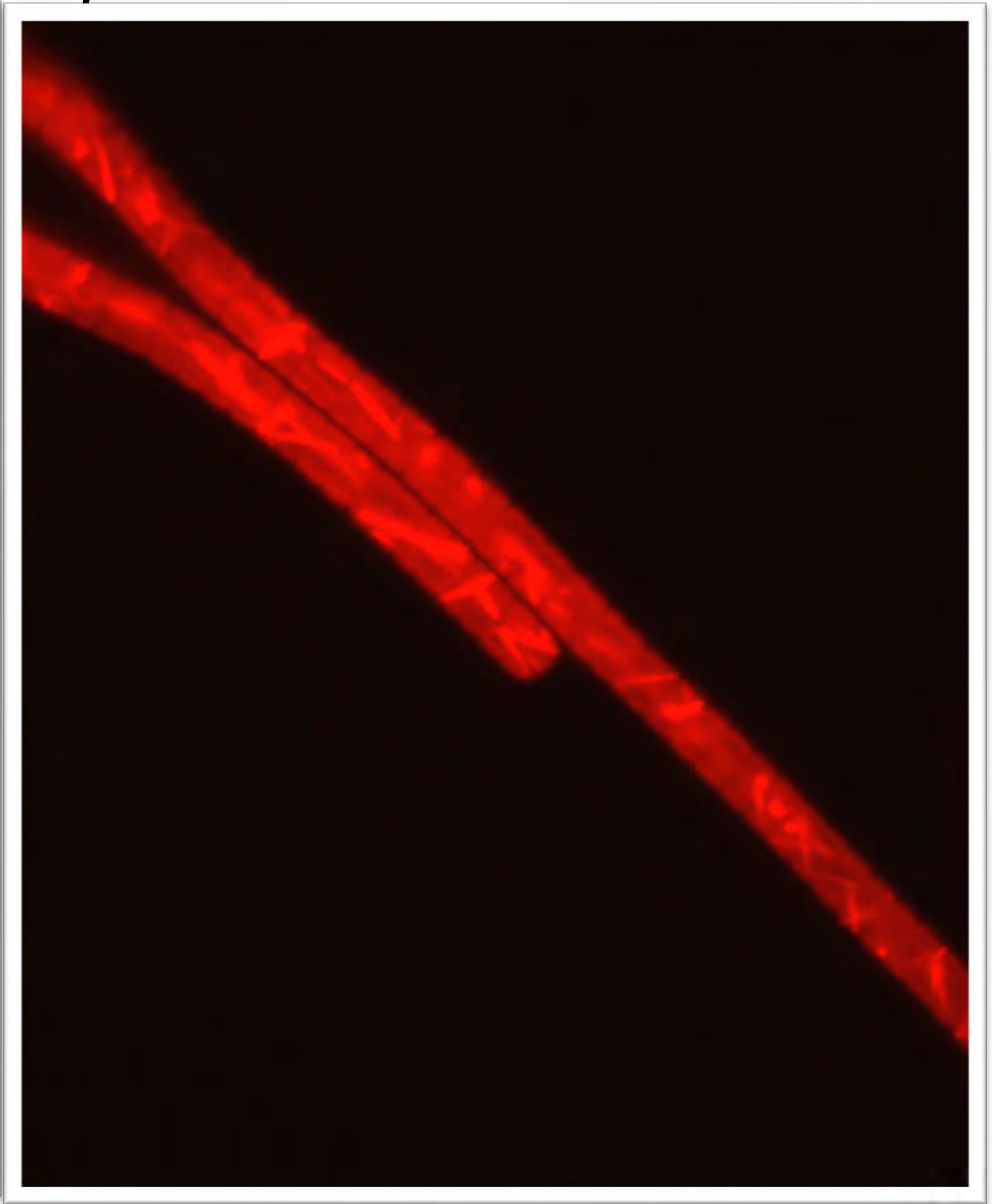
= Bending filament



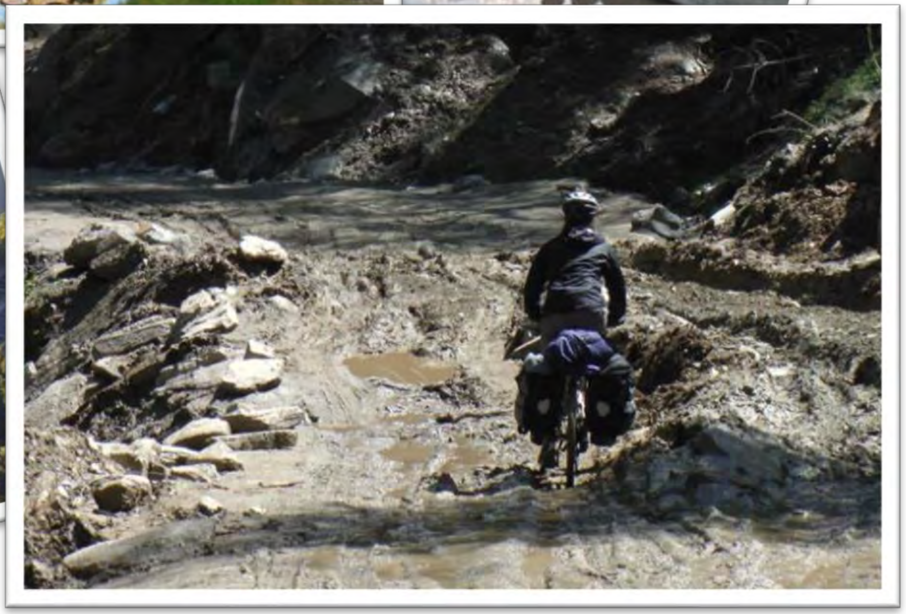
Paul Nicklen

Morphology - *Kamptonema*



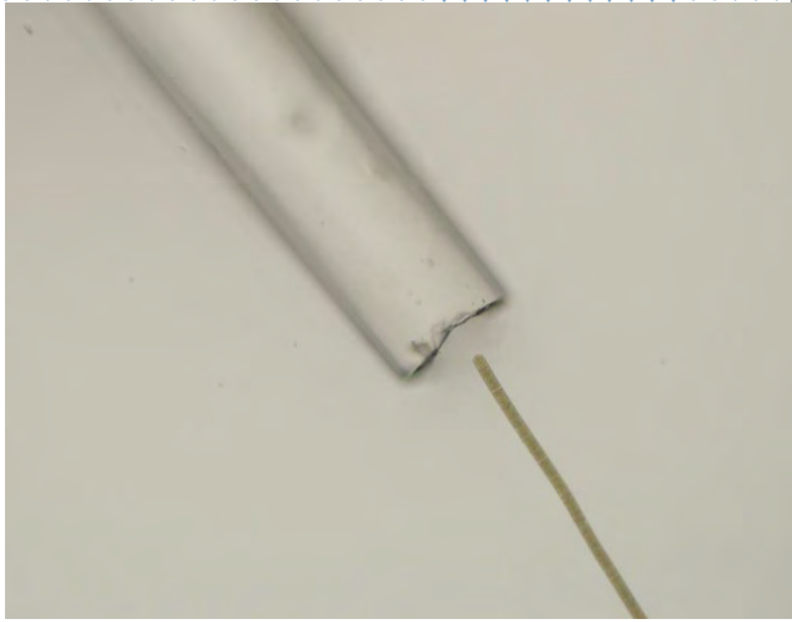


Ecology - *Kamptonema*



Conclusions:

- Optical microscopy remains quick, easy and reliable method
- But to be 100% sure and publish usable data connected with particular strain (population) the 16S rRNA is even better



Thank you for your attention

ITEM IV
Wrap Up

Facilitators & Benthic HAB members