Review of the cyanoprokaryotic genus *Romeria*

**Přehled cyanoprokaryotního rodu *Romeria***

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**Abstract**

The cyanoprokaryotic genus *Romeria* is traditionally classified as the simplest filamentous cyanobacterium, occurring scarcely in freshwater reservoirs. Three species were described originally, which are known from the temperate zone, and which are usually cited in all identification manuals of this cyanoprokaryotic group. However, other species were found recently, also in other biotopes (benthos, cryoseston, marine plankton), and now the number of registered species increased to 19. The problem is, that they were not yet isolated in culture, and nothing is known about ultrastructure and molecular characters of any *Romeria* species. Recently, two mass developments of two planktic species were found in freshwater reservoirs in Brazil and in Czech Republic, which enabled, at least, the study of their morphological variability and cell structure. It was found, that *Romeria* is evidently very interesting cyanobacterium with close relations to other simple filamentous species, as well as to simple coccoid types living in solitary, rod-like cells. The review of the whole genus, which is included in this article, is necessary for further research of this important cyanobacterial type.

**Introduction**

The genus *Romeria* KOCZW. ex GEITL. 1932 with the type species *R. leopoliensis* (RACIB.) KOCZW. ex GEITL. 1932 comprises only 3-5 species in traditional identification books (GEITLER 1932, HUBER-PESTALOZZI 1938, HOLLERBACH & al. 1953, STARMACH 1966, KONDRA TEVA 1968, BOURRELLY 1985). However, 19 species were described up to now and two of them were found as important components in phytoplankton of eutrophic, man-made reservoirs recently (KOMÁREK & al. 2001, HAUER 2001). The species occurring in Czech Republic and in neighbouring regions respectively, are listed in Table 1. The taxonomic status of this genus is a little problematic. It was classified by almost all mentioned authors into the order Oscillatoriales in respect to short, irregular “filaments”, which are characteristic to this genus, and in modern manuals into the family Pseudanabaenaceae (ANAGNOSTIDIS & KOMÁREK 1988). Only KOMÁREK (1970, 1976) discussed the very similar cell morphology and cell-division like in the coccoid genera *Synechococcus* and particularly...
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*Rhabdoderma*, and described differences in their life cycles (Fig. 1). *Romeria* is not yet in culture and all species are known only from natural populations. Quite recently, the almost identical thylakoid arrangement was found in several *Aphanothece*–types (from the subg. *Anathece*), in several *Synechococcus* species, in *Romeria* and in simple *Pseudanabaenaceae* (Fig 2). The systematic position of *Romeria* should be therefore revised respecting this fact. Of course, the final solution can be derived only after molecular evaluation of all mentioned types.

The ultrastructural generic features of *Romeria* are summarised and discussed in Komárek & Sulek (in press). The connections of cells in pseudofilaments of two studied species are in Fig. 3. The review of all phenotype species of this genus described up to date is presented in this article. Instead of the identification key are included the Tables 2 and 3. In the Table 3 are explicitly designated species, which do not correspond with the generic diagnosis, and which should be revised. In characteristics of taxa the diacritical features are only presented, not the full descriptions. The original illustrations are cited, for comparison see the drawings in Table 3. The description with drawings will be included in the prepared 2nd part of cyanoprokaryotes in the 2nd edition of the compendium Süsswasserflora von Mitteleuropa (Anagnostidis & Komárek in prep.).

Taxonomic review


Generic phenotype characters:
- Trichomes free-living, solitary, or few in irregular mucilaginous clusters.
- Trichomes short, usually (1)2-12(23)-celled, exceptionally with more (up to >60) cells, frequently fragmentating.
- Trichomes usually irregularly wavy or coiled, rarely almost straight, or irregularly screw-like, 0.6-3 µm wide.
- Trichomes constricted at cross-walls (species without constrictions belong probably to other genera (genotypes); it concerns particularly *R. austriaca* and *R. cryophila*. Characteristical is the occasional shift of neighbouring cells within trichomes.
- Trichomes enveloped by fine, colourless, diffuse mucilaginous envelopes (in all species?). Sheaths are lacking.
- Cell cylindrical, always longer than wide. In few species the Y-shaped cells were found.
- Cell division cross-wise, sometimes asymmetrical. Heterocellular trichomes occur.
- Terminal cells do not differ from other cells, capable to divide.
- Thylakoids arranged parietally in cylindrical cells.
- Cell connected by gelatinous matrix of various width; pores in connecting cross-walls are lacking (always?).
- Gas vesicles lacking.
- Reproduction by trichome fragmentation.

Species review:
Note: Species marked by asterisk do not correspond exactly to generic diagnosis and their taxonomic classification must be revised.

1. **Romeria minima** (LEMM.) KOM. comb. nov.
Trichomes solitary or few in mucilaginous colourless colonies, (1)-4-celled, constricted et cross-walls. Cells 1.5-3 x 0.7-0.8 \( \mu m \), pale greyish blue-green. – Metaphytic in small clear streams; Czech Republic (Beskydy Mts.), Italy.

2. **Romeria alascensis** (HORTOB. et HILLIARD) KOM. comb. nov.
Trichomes in small mucilaginous clusters, (1)2-4(8)-celled, clearly constricted et cross-walls, arcuated. Cells 3.7-8.3 x 0.6-0.8 \( \mu m \), pale blue-green. – Planktic in oxidation pond; USA (Alaska).

   Trichomes disintegrating (numerous solitary cells in population), irregularly coiled, solitary in diffuse, indistinct slime, 1-4(12)-celled, constricted et cross-walls. Cells 1-12.8 x 0.7-1 \( \mu m \), pale greyish blue-green. – Planktic in meso- to eutrophic reservoirs; tropical, Brazil (state Pernambuco).

Trichomes solitary, arcuated, very short (“few-celled”), not constricted et cross-walls, but disintegrating and composed from few segments with constrictions, mucilage?. Cells 1.5-2.5 x ± 1µm, yellow-green. – Benthic, epipelic in lakes with muddy bottom; Czech Republic, Denmark, northern Germany.

Trichomes irregularly wavy, solitary, with numerous cells, but disintegrating, with wide mucilaginous envelopes, constricted at cross-walls. Cells short, cylindrical, 1-1.5 x ± 1µm, yellow-green or pale blue-green. – Planktic in eutrophic ponds; Slovakia.

   Trichomes very short, arcuated, 2-3-celled, more in gelatinous mass, constricted at cross-walls. Cells long cylindrical, ± 6 x 1 µm, pale blue-green. – Subaerophytic, epiphytic on wet mosses; tropical species, Costarica.

   Syn.: Arthrospira leopoliensis RACIB. Phycol. polon. 9; Kosmos 35: 82, 1910. 
   Trichomes solitary, short, irregularly arcuated, (1)2-4(8)-celled, with very fine and indistinct diffuse slime, slightly constricted at cross-walls. Cells cylindrical, 3-6 x 0.8-1.2 µm, pale blue-green. – Planktic in ponds and lakes; known mainly from central Europe, probably over the whole temperate zones.

   Syn.: Raciborskia gracilis KOCZW. Kosmos 53: 104, 1929. 
   Trichomes solitary, irregularly wavy to coiled, 2-18-celled, with very fine, colourless, mucilaginous envelopes, constricted at cross-walls. Cells short cylindrical to almost barrel-shaped, 3.5-4.6 x 1.2-1.5 µm, pale blue-green. – Planktic in ponds and lakes; cosmopolitan (?) .

Trichomes solitary, very irregularly coiled, 12-24-celled, with mucilaginous, diffuse envelopes, constricted at cross-walls. Cells long cylindrical, 4.5-9.2 x 1-1.3 µm, pale blue-green. – Planktic in small eutrophic ponds and pools; tropical species (?), Brazil (São Paulo state).

Trichomes solitary, almost straight or slightly arcuated, 8-16-celled, with mucilaginous envelopes, not constricted at cross-walls. Cells cylindrical, 1-3 x 1-1.5 µm, pale blue-green. – Kryosestic; Poland (High Tatra Mts.). - Generic identification problematic.

Trichomes solitary, slightly wavy to almost straight, 4-16-celled, constricted at cross-walls. Cells cylindrical, 4-12 x ± 1.2-1.6 µm, pale blue-green; sometimes Y-formed cells occur. – Planktic in eutrophic village ponds; Slovakia.

Trichomes solitary, wavy to coiled, (1)2-18-celled, but sometimes with numerous cells (up to > 60), slightly constricted at cross-walls. Cells cylindrical, 4.5-9(13) x ± 1.5 µm, pale greyish blue-green. – Planktic in lakes and large reservoirs; tropical species – central, east and southern Africa.

Trichomes solitary, always irregularly wavy, 2-12-celled, with diffuse, colourless mucilaginous envelopes, slightly constricted at cross-walls. Cells cylindrical, (2.5?)3-9 x (1?)1.3-2 µm, pale glue-green. – Planktic in ponds, lakes and rivers; known mainly from temperate Eurasia, but recorded also from India; cosmopolitan (?).

   Syn.: *Romeria elegans* var. nivicola KOL Amer. J. Bot. 28: 190, 1941.
Trichomes solitary, irregularly wavy to coiled, facultatively with very diffuse and indistinct slime, usually with up to 12, rarely with numerous cells, constricted at cross-walls, usually heterocellular. Cells cylindrical, (3.5)4-14 x ±
2 µm, pale greyish blue-green. – Kryosectic; coastal Antarctica, Japan, USA (mountains).

Trichomes solitary, almost straight to slightly wavy, with indistinct mucilaginous envelopes, 2-23-celled, constricted at cross-walls, heterocellular. Cells cylindrical, 2.6-8.2 x (1.4)2.2-2.8 µm, pale blue-green. – Planktic and metaphytic in large reservoirs; tropical species, Brazil (São Paulo state).

Trichomes solitary, short, almost straight or arcuated, usually 6-celled, not constricted at cross-walls, cylindrical, to 10 µm long, with diffuse slime envelopes. Cells ± isodiametric or shorter (!) than wide, ± 2.3 µm wide, pale blue-green. – Benthic in shallow lakes; eastern Austria. – Generic identification is problematic (cell morphology, not constricted trichomes).

Trichomes solitary, slightly wavy, with narrow, indistinct mucilaginous envelopes, 2-4(12)-celled, constricted at cross-walls. Cells cylindrical to sausage-shaped, 3-5(7) x (2)2.5-2.8 µm, greyish to pale blue-green; Y-shaped cells occur. – In summer plankton of fishponds; Slovakia.

* Spirulina okensis* (MEYER) GEITL. Rabenh.’s Krypt.-Fl. 14: 924, 1932.  
Trichomes solitary, irregularly to almost regularly screw-like coiled, with diffuse mucilaginous envelopes, up to 27-celled, constricted at cross-walls. Cells cylindrical, arcuated, 5.2-12 x 2-3 µm, pale blue-green. – Planktic in eutrophic ponds, reservoirs and large rivers; Czech Republic, Hungary, Russia, Slovakia, Ukraine.

19. *Romeria mexicana* (ROUCHIJ.) KOM. comb. nova  
Trichomes solitary, slightly wavy, 2-8-celled (sometimes with more cells?), constricted at cross-walls, heterocellular, sometimes attached by one end to floating microscopic particles. Cells long cylindrical, 8-48(80!) x 2-3 µm, pale greyish blue-green. – Marine, planktic; Mexico gulf.
Discussion

The following main questions remain open in the genus Romeria:

1. The proof of genotype separation of this genus and its homogeneity (monophyly) by molecular methods.
2. The proof of presence or absence of pores between cells (taxonomic classification in coccoid or filamentous cyanobacteria).
3. The examination of relations of Romeria to coccoid Aphanothece-types and filamentous Pseudanabaena-types, as representants of one evolutionary line.
4. The taxonomic revision of species conspect (mainly if all described Romeria species belong to one and the same genotype – genus).
5. Toxicity of various strains and species.
6. The distribution of various species (eko- and morphotypes).

Acknowledgement

The study was supported by the grant AS CR no A6017803.

References


Fig. 1. Comparison of life-cycles in genera *Rhabdodera* (Chroococcales, Synechococcaceae), and *Romeria* (Oscillatoriales, Pseudanabaenaceae). – (From Komárek 1970).
Fig. 2. Example of thylakoid arrangement in coccoid and simple filamentous cyanoprokaryotes: a = Aphanothece stratus, b = Romeria caruaru, c = R. leopoliensis, d = Pseudanabaena sp. (after GUGLIELMI & COHEN-BAZIRE 1984), e = Geitlerinena unigranulatum (after KOMÁREK & AZEVEDO 2000); t = thylakoids.
Fig. 3. Thylakoid position in cells (cross and length-wise sections) and connections of cells in pseudofilaments (arrows) in two species, tropical *R. caruaru* and temperate *R. leopoliensis* (type species).
**Romeria species from Czech Republic**

  - = *Romeria minima* (Lemm.) comb. nova
- *Arthrospira okensis* Meyer Arb. Oka Station, p.40, 1926

**Other possible species:**

*Romeria austriaca* – benthic in lakes, eastern Austria
*Romeria chlorina* – benthic (epipelic) in shallow lakes in Denmark
*Romeria crassa* – in eutrophic fishponds, Slovakia
*Romeria cryophyla* (?) – kryosestic, High Tatra Mts.
*Romeria cylindrocellularis* – eutrophic ponds, Slovakia
*Romeria simplex* – village ponds, Slovakia

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**Table 1.** *Romeria* species occurring in Czech Republic. The drawings are from Geitler 1932 (original drawings of authors of corresponding species; KOCZWARA, LEMMERMANN and MEYER).
## Table 2. Review of species – identification key.

### I. Non constricted trichomes; [non planktic species]
- **chlorina**
  - epipelic, benthic
  - cells: 1.5-2.5 x ± 1 µm
  - yellow-green
  - Denmark, Germany

- **cryophyla**
  - cryosestic
  - cells: 1-3 x 1-1.5 µm
  - cylindrical trichomes
  - High Tatra Mts.

- **austriaca**
  - benthic in lakes
  - cells: ± 2.3 x 2.3 µm
  - cylindrical arcuated trichomes
  - eastern Austria

### II. Constricted trichomes:

#### Marine
- **mexicana**
  - cells: 8-80 x 2-3 µm
  - Mexico Gulf

#### Not marine
- Cells distinctly narrower than 1 µm (max. to 1 µm wide):

<table>
<thead>
<tr>
<th>Cells</th>
<th>minima</th>
<th>metaphytic in clear streams</th>
<th>Italy, CZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5-3 x 0.7-0.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.7-8.3 x 0.6-0.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-12.8 x 0.7-1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cells ± 1 µm wide (0.8-1.3 µm):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cells</td>
</tr>
<tr>
<td>1.5 x ± 1</td>
</tr>
<tr>
<td>3-6 x 0.8-1.2</td>
</tr>
<tr>
<td>4.5-9.2 x 1-1.3</td>
</tr>
<tr>
<td>6 x 1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cells 1.2-1.6 µm wide:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cells</td>
</tr>
<tr>
<td>4-12 x ± 1.2-1.6</td>
</tr>
<tr>
<td>3.5-4.6 x 1.2-1.5</td>
</tr>
<tr>
<td>4.5-13 x 1.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cells to 2 µm wide (± 1.6 – 2.2 µm):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cells</td>
</tr>
<tr>
<td>3-9 x 1.3-2</td>
</tr>
<tr>
<td>4-14 x ±2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cells &gt; 2 µm wide (2-3 µm):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cells</td>
</tr>
<tr>
<td>5.2-12 x 2-3</td>
</tr>
<tr>
<td>3-7 x 2-2.8</td>
</tr>
<tr>
<td>2.6-8.2 x 1.4-2.2</td>
</tr>
</tbody>
</table>
Table 3A

<table>
<thead>
<tr>
<th>Species</th>
<th><em>minima</em></th>
<th><em>alascensis</em></th>
<th><em>caruraru</em></th>
<th><em>chlorina</em></th>
<th><em>cylindrocell.</em></th>
<th><em>westii</em></th>
<th><em>leopoliensis</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cells</td>
<td>(1)2 - 4(more?)</td>
<td>2 - 4(8)</td>
<td>1 - 4(12)</td>
<td>several</td>
<td>many</td>
<td>3</td>
<td>1 - 4(8)</td>
</tr>
<tr>
<td>Dimensions (µm)</td>
<td>1.5 - 3 x 0.7 - 0.8</td>
<td>3.7 - 8.3 x 0.6 - 0.8</td>
<td>1 - 12.8 x 0.7 - 1</td>
<td>1.5 - 2.5 x ± 1</td>
<td>1 - 1.5 x ± 1</td>
<td>6 x 1</td>
<td>3 - 6 x 0.8 - 1.2</td>
</tr>
<tr>
<td>Constrictions</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+?</td>
<td>(+)</td>
</tr>
<tr>
<td>Colour</td>
<td>pale blue-gray</td>
<td>pale blue-green</td>
<td>pale blue-grey</td>
<td>yellow green</td>
<td>yellow green or pale blue-green</td>
<td>blue-green</td>
<td>pale blue-green</td>
</tr>
<tr>
<td>Notes</td>
<td>colonies with 1-4 short trichomes</td>
<td>many solitary cells</td>
<td>disintegrated, indistinct cross-walls</td>
<td>in gelatinous mass</td>
<td>usually in trichomes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ecology</td>
<td>metaphyton, clear small streams</td>
<td>oxidation pond</td>
<td>planktic in reservoirs</td>
<td>benthic, epipelic on organic mud</td>
<td>planktic in eutrophic ponds</td>
<td>epiphytic on mosses</td>
<td>planktic in ponds &amp; lakes</td>
</tr>
<tr>
<td>Distribution</td>
<td>Italy, Czech Republic</td>
<td>USA (Alaska)</td>
<td>tropical – Brazil (PB)</td>
<td>Denmark, N Germany</td>
<td>Slovakia</td>
<td>tropical – Costarica</td>
<td>temperate</td>
</tr>
</tbody>
</table>

Table 3 (A – C). Review of species – main diagnostical characters.
Table 3B.

<table>
<thead>
<tr>
<th>Species</th>
<th>gracilis</th>
<th>hieroglyphica</th>
<th>cryophyla</th>
<th>simplex</th>
<th>victoriae</th>
<th>elegans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cells</td>
<td>2 – 18</td>
<td>12 - 24</td>
<td>8 - 16</td>
<td>4 - 16</td>
<td>(1)2 - 18 (→ 60)</td>
<td>2 - 12</td>
</tr>
<tr>
<td>Dimensions (µm)</td>
<td>3.5 – 4.6 x 1.2 - 1.5</td>
<td>4.5 - 9.2 x 1 - 1.3</td>
<td>1 - 3 x 1 - 1.5</td>
<td>4 - 12 x ± 1.2 - 1.6</td>
<td>4.5 – 9(13) x 1.5</td>
<td>(2.5?)3 - 9 x (1?)1.3 - 2</td>
</tr>
<tr>
<td>Constrictions</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Colour</td>
<td>pale blue-green</td>
<td>pale blue-green</td>
<td>pale blue-green</td>
<td>pale blue-green</td>
<td>pale blue-grey</td>
<td>pale blue-green</td>
</tr>
<tr>
<td>Notes</td>
<td></td>
<td></td>
<td>Y-formed cells present</td>
<td>± straight trichomes</td>
<td>always ± wavy</td>
<td></td>
</tr>
<tr>
<td>Ecology</td>
<td>planktic in ponds &amp; lakes</td>
<td>small ponds &amp; pools</td>
<td>cryosestic</td>
<td>planktic in eutrophic village ponds</td>
<td>planktic in large reservois &amp; lakes</td>
<td>planktic in ponds &amp; rivers</td>
</tr>
<tr>
<td>Distribution</td>
<td>cosmopolitan?</td>
<td>tropical – Brazil (SP)</td>
<td>High Tatra Mts.: Poland, Slovakia</td>
<td>Slovakia</td>
<td>tropical-Africa: Victoria lake, Mozambique</td>
<td>temperate Eurasia, India</td>
</tr>
</tbody>
</table>
Table 3C.

<table>
<thead>
<tr>
<th>Species</th>
<th><em>nivicola</em></th>
<th><em>heterocellul.</em></th>
<th><em>crassa</em></th>
<th><em>okensis</em></th>
<th><em>mexicana</em></th>
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</thead>
<tbody>
<tr>
<td>Number of cells</td>
<td>12 (- many)</td>
<td>2 - 23</td>
<td>2 - 4(12)</td>
<td>-27</td>
<td>2 - 8 (more?)</td>
</tr>
<tr>
<td>Dimensions (µm)</td>
<td>4 - 14 ± 2</td>
<td>2.6 - 8.2 (1.4)2.2 - 2.8</td>
<td>3 - 5(7) x 2.5 - 2.8</td>
<td>5.2 - 12 x 2 - 3</td>
<td>8 - 48(80) x 2 – 3</td>
</tr>
<tr>
<td>Constricted</td>
<td>(+) to +</td>
<td>+</td>
<td>+</td>
<td>(+) to +</td>
<td>+</td>
</tr>
<tr>
<td>Colour</td>
<td>pale blue-grey</td>
<td>pale blue-green</td>
<td>pale blue-green or greyish</td>
<td>pale blue-green</td>
<td>pale blue-grey</td>
</tr>
<tr>
<td>Notes</td>
<td>heterocellular trichomes</td>
<td>heterocellular trichomes</td>
<td>Y-formed cells present</td>
<td>± regulary coiled trichomes</td>
<td>attached to planktic particles</td>
</tr>
<tr>
<td>Ecology</td>
<td>cryosestic</td>
<td>planktic and metaphytic in large reservoirs</td>
<td>planktic in fishponds (in summer)</td>
<td>planktic in eutr. ponds &amp; rivers</td>
<td>marine, planktic</td>
</tr>
<tr>
<td>Distribution</td>
<td>USA, Japan, coastal Antarctica</td>
<td>tropical – Brazil (SP)</td>
<td>Slovakia</td>
<td>Czech Rep., Hungary, Russia</td>
<td>Mexico Gulf</td>
</tr>
</tbody>
</table>