

## Reappraisal of some taxa of the genera *Compsopogon* and *Compsopogonopsis* (Compsopogonaceae, Rhodophyta)

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Seto, R. and Kumano, S. 1993. Reappraisal of some taxa of the genera *Compsopogon* and *Compsopogonopsis* (Compsopogonaceae, Rhodophyta). Jpn. J. Phycol. 41: 333–340.

Based on the examinations of the type specimens deposited in the herbarium at Rijksherbarium, Leiden, and in the herbaria of Hokkaido University, Kobe University and the National Science Museum of Japan, Tokyo, we proposed that the specific descriptions of selected species of the Compsopogonales should be revised, namely: *Compsopogon aeruginosus*, *C. chalybeus* [= *C. corinaldii*], *C. coeruleus* [= *C. oishii*, *C. minutus*], *Compsopogonopsis leptoclados*, *Cs. japonica* and *Cs. fruticosa* (Compsopogonaceae, Rhodophyta).

*Key Index Words:* Compsopogon—Compsopogonopsis—freshwater Rhodophyta.

Montagne (1846) established the genus *Compsopogon* and proposed *Compsopogon coeruleus* to accommodate the type species. The genus *Compsopogonopsis* was established by Krishnamurthy (1962) who proposed *Compsopogonopsis leptoclados* to accommodate the type species.

Krishnamurthy (1962) reviewed the genus *Compsopogon* and *Compsopogonopsis*, without giving text figures, including not only type specimens but also all of the specimens which he examined. Some authors such as Okamura (1915), Jao (1941), Das (1963), Pujals (1967), Chihara and Nakamura (1980) and Yadava and Kumano (1985) have described their new species without the examinations of the type specimens.

Recently Vis et al. (1992) recognized only two species of the genus *Compsopogon* and one species of the genus *Compsopogonopsis* based on the examinations of nine type specimens and other collections. However, we feel that their proposal was too radical to accept. In the present study, some species of the genus *Compsopogon* and *Compsopogonopsis* were reappraised based on the examinations of the type specimens and other collections of these taxa.

### Type and herbaria specimens examined

#### 1. Type specimens examined

Genus *Compsopogon*: 1) *Compsopogon aeruginosus* (J. Ag.) Kuetzing, L No. 940284410; 2) *Compsopogon chalybeus* Kuetzing, L No. 940284409; 3) *Compsopogon corinaldii* (Meneghini) Kuetzing, L No. 940285098; 4) *Compsopogon coeruleus* (Balbis) Montagne, L No. 940284413; 5) *Compsopogon oishii* Okamura, SAP No. 46132; 6) *Compsopogon minutus* Jao, SC No. 1010; 7) *Compsopogon corticrassus* Chihara et Nakamura, TNS No. Al-35602.

Genus *Compsopogonopsis*: 1) *Compsopogonopsis leptoclados* (Montagne) Krishnamurthy, L No. 940284405; 2) *Compsopogonopsis japonica* Chihara, TNS No. Al-24051; and 3) *Compsopogonopsis fruticosa* (Jao) Seto, SC No. 1145.

#### 2. Herbaria specimens examined

Genus *Compsopogon*: 1) *Compsopogon aeruginosus* (J. Ag.) Kuetzing: UPO 27, NKT River Bareilly, India, Feb. 2, 1992; UPO 30, Shahjhpur, India, Mar. 2, 1992, collected by M. Khan, growing on aquatic plants; 2) *Compsopogon chalybeus* Kuetzing: R. S. 391,

Miyara River, Ishigaki Island, Okinawa, Japan, Apr. 5, 1977; R. S. 394, Ohsato, Ito-man, Okinawa Island, Apr. 6, 1977, collected by R. Seto, growing on pebbles in river and on the concrete walls surrounding a spring; No. 32, Pulau Tioman, Malaysia, May 24, 1974, collected by M. Ratnasabapathy, UPO 21, BHC, Golwaghat, India, Jan. 29, 1992, collected by M. Kumar, growing on aquatic plants; 3) *Compsopogon coeruleus*: UPO 16, Lelly Pond, ALD, India, Jan. 25, 1992, collected by M. Khan, growing on aquatic plants.

Genus *Compsopogonopsis*: 1) *Compsopogonopsis leptoclados*: UPO 33, Gharra River, India, Mar. 2, 1992, collected by M. Kumar, growing on aquatic plants.

### Examinations of the type specimens

Genus *Compsopogon*

1. *Compsopogon aeruginosus* (J. Ag.) Kuetzing 1849.

[=*Pericystis aeruginosa* J. Agardh 1847]

The isotype specimen, L No. 940284410, was deposited in the Rijksherbarium, Leiden. It was collected near Havana, Cuba, by Liebman.

The isotype specimen, L No. 940284410, deposited in the Rijksherbarium and those of two other type specimens, PC No. 12408 and PC No. 12409, at the Muséum National d'Histoire Naturelle, Paris, were collected from the same locality, and by the same collector, Liebman.

Krishnamurthy (1962) used two specimens of syntypes of *Pericystis aeruginosa*, PC No. 12408 and PC No. 12409, in the Muséum National d'Histoire Naturelle, Paris, (Agardh's herbarium), as the basis for his description.

Kuetzing (1849) may have used the above-mentioned three specimens for his description of the new combination. In other words, Agardh (1847) did not designate the holotype for the original description of *Pericystis aeruginosa*, consequently these two type specimens and the isotype specimen are to be considered the syntype specimens.

2. *Compsopogon chalybeus* Kuetzing 1849.

One of the syntype specimens, L No. 940284409, was deposited in the Rijksherbarium, Leiden. It was collected by Leprieur, from near Cayenne, French Guiana.

The specimen, L No. 940284409, of *Compsopogon chalybeus*, deposited in the Rijksherbarium, and two specimens, PC No. 1102 and PC No. 828, in the Muséum National d'Histoire Naturelle, were carry the same habitat and collector. Kuetzing (1849) did not designate the holotype in the original description of *C. chalybeus*, therefore, these three specimens, just enumerated, are considered to have an equal value as the syntype.

3. *Compsopogon corinaldii* (Meneghini) Kuetzing 1857.

[=*Lemanea corinaldii* G. Meneghini 1841]

The duplicate of the holotype specimen, L No. 940285098, was deposited in the Rijksherbarium, Leiden. It was collected by J. Corinaldi and from Piza, Italy, (Kuetzing's herbarium).

Krishnamurthy (1962) used the specimen of *Lemanea corinaldii* Meneghini in the Muséum National d'Histoire Naturelle, Paris, as the type for his description, and he also mentioned that there was an additional specimen, L No. 940285098, in the Rijksherbarium, Leiden, and this was probably the specimen that Kuetzing (1857) employed on making the new combination. Therefore, it is considered by us that this specimen deposited in the Muséum National d'Histoire Naturelle, Paris, is the lectotype used by Kuetzing.

4. *Compsopogon coeruleus* (Balbis) Montagne 1846.

[=*Conferva coerulea* Balbis in Agardh C. 1824]

The type specimen, L No. 940284413, of *Conferva coerulea* Agardh C., was deposited in the Rijksherbarium, Leiden. It was collected by Bertero in Port Ricco, Antilles, (Balbis's Herbarium).

Montagne (1846) established genus *Compsopogon* and proposed *Compsopogon coeruleus* as a new combination based on mainly the specimen collected from La Calle, Algeria.

At the same time, he cited as a synonym *Conferva coerulea* Balbis in Agardh (1824), which was based on the same specimens.

The specimen, L No. 940284413, of *Conferva coerulea* C. Agardh deposited in the Rijksherbarium, Leiden was labelled as collected by Bertero in Port Ricco, Antilles, (Balbis's Herbarium), so that, the Leiden specimen of *Conferva coerulea* is considered by us as the type specimen of *Conferva coerulea* Balbis in Agardh (1824).

5. *Compsopogon oishii* Okamura 1915.

The holotype specimen, SAP No. 46132, was deposited in the Hokkaido University in Sapporo. It was collected by Oishi, from Yanokuchi, Tama River, Tokyo Prefecture in Japan, growing on the leaves and stems of *Valisneria*, on gravel and on wood in a spring brook.

6. *Compsopogon minutus* Jao 1941.

The duplicate of the holotype specimen, SC No. 1010, was deposited in Kobe University in Japan. It was collected by Jao and from Hua-kai-shan, Kiangtsin, Szechwan, China, growing on submerged roots and leaves in a mountain stream.

7. *Compsopogon corticrassus* Chihara et Nakamura 1980.

The holotype specimen, TNS No. Al-35602, was deposited in the National Science Museum of Japan. It was collected by Hasei, from Minuma-yosui River, Gyoda, Saitama prefecture, Japan, growing on the concrete bed in a riffle.

Genus *Compsopogonopsis*

1. *Compsopogonopsis leptoclados* (Montagne) Krishnamurthy 1962.

[= *Compsopogon leptoclados* Montagne 1850]

The isotype specimen, L No. 940284405, was deposited in the Rijksherbarium, Leiden. It was collected from near Cayenne in French Guiana, from a freshwater stream.

2. *Compsopogonopsis japonica* Chihara 1976.

The holotype specimen, TNS No. Al-

24051, was deposited in the National Science Museum of Japan. It was collected by Hashimoto and from Tone River, Sakai, Gunma Prefecture, Japan, from a small man-made pond.

3. *Compsopogonopsis fruticosa* (Jao) Seto 1987.  
[= *Compsopogon fruticosus* Jao 1941]

The duplicate of the holotype specimen, SC No. 1145, was deposited in Kobe University, Kobe, Japan. It was collected by Jao and from Kan-tungtze, Pehpei, Szechwan, China, growing on the concrete wall of a mill dam.

The available characters (Table 1)

1. The mode of the formation of cortical cells

The mode of the formation of cortical cells is recognized as a reliable, taxonomic character for distinguishing *Compsopogonopsis* from *Compsopogon* as proposed by Krishnamurthy (1962) and is supported by many authors among which are Vis et al. (1992). *Compsopogonopsis leptoclados* (Montagne) Krishnamurthy (1962), *Cs. japonica* Chihara (1976) and *Cs. fruticosa* (Jao) Seto (1987) can be distinguished from each other by the mode of the rhizoidal, cortex formation.

2. The occurrence of the spinous short branchlets

Vis et al. (1992), agreeing with Yadava and Pandey (1980), concluded that the spinous short branches were a young stage in lateral branch development and were not a reliable taxonomic character. However, the isotype specimen of *Compsopogon aeruginosus* is mainly characterized by many spinous branchlets on older portions of the thallus, which were observed by Krishnamurthy (1962) on the type specimens PC No. 12408 and PC No. 12409 of *Pericystis aeruginosa* J. Agardh 1847, collected near Havana, Cuba. Moreover, *Compsopogon aeruginosus* is distinguished from *C. coeruleus* and the other taxa of the genus *Compsopogon* by the occurrence of many short spinous branchlets on older portions of the mature thallus (Krishnamurthy 1962). Patel

Table 1. Available characters

specimens	rhizoidal cortex	spinous branchlets	monospores ( $\mu\text{m}$ )	cortical layers	outermost cortical cells ( $\mu\text{m}$ )
1.					
<i>Compsopogon aeruginosus</i>	—	+	11–17	1–2	16–37
Imd. UPO 27, 30	—	+	8–15	2	15–49
2.					
<i>Compsopogon chalybeus</i>	—	—	10–16	2	12–35
Jap. RS 391	—	—	12–16	2	18–44
Jap. RS 394	—	—	12–16	1–2	19–36
Mal. UPO 32	—	—	12–17	2	19–29
<i>Compsopogon corinaldii</i>	—	—	12–16	1–2	16–27
Ind. UOP 21	—	—	13–18	2	9–21
3.					
<i>Compsopogon coeruleus</i>	—	—	(16–)20–23	2	13–39
Ind. UPO 16	—	—	20–26	2	17–35
<i>Compsopogon oishii</i>	—	—	17–22	2–3	15–39
<i>Compsopogon minutus</i>	—	—	15–25	1–(2)	13–47
4.					
<i>Compsopogon corticrassus</i> *	(–)	(–)	(16–22)	(3–4–(5))	(14–36)
1.					
<i>Compsopogonopsis leptoclados</i>	+	—	12–16	1	9–31
Ind. UPO 33	+	—	16–22	1	14–32
2.					
<i>Compsopogonopsis japonica</i> *	(+)	(–)	(17–23)	(2)	(30–50)
3.					
<i>Compsopogonopsis fruticosa</i>	+	—	15–22	2	14–55

\* Characters for *Compsopogon corticrassus* and *Compsopogonopsis japonica* are cited from original protologues.

and Francis (1969) reported the spinous short branchlets in mature thalli of *C. aeruginosus* from India. Nakamura and Chihara (1983) also found many spinous short branchlets on the old thalli of *C. aeruginosus* from Japan. Thus, this character is very useful to distinguish *Compsopogon aeruginosus* from the other taxa of the genus *Compsopogon*.

### 3. The size of monospores

The size range of the monospores from taxon to taxon often overlaps one another. Vis et al. (1992) considered the sizes of monospores to have minor specific importance. However, this character has been regarded by other authors as one of the more invariable characters. For example, we have observed that some taxa can be roughly divided into two groups on the basis of the size of monospores, one with monospores larger than 20  $\mu\text{m}$  in diameter, another with smaller than 20  $\mu\text{m}$ . The diameter of the monospores has been used to distinguish the taxa by many authors such as Nakamura and Chihara

(1983) who distinguished *C. aeruginosus* from the other taxa of the genus by employing this character.

### 4. The number of cortical layers

The number of cortical layers varies from one to two occasionally more than three layers. This character is important for specific identification and has been used as such by many authors. For example, Kuetzing (1857) described the number of cortical layers on *Compsopogon corinaldii*, *C. coeruleus*, *C. aeruginosus*, *C. chalybeus* and *C. leptoclados* with the figures of cross section of branches. For the duplicate of the holotype specimen of *Compsopogon corinaldii*, we clearly observed one or two cell layers of cortex, although Kuetzing (1857, Tab. Phyc., tab. 88, fig. I a'-b, b') illustrated two to three cell-layered cortex in his figures. Krishnamurthy (1962) reported single cell-layered cortex based on the observation of the type specimens (PC No. 1102 and PC N. 828) of *Compsopogon chalybeus* collected from near Cayenne, French Guiana.

However, the type specimen, L No. 940284409, collected by Leprieur from near Cayenne, French Guian, has distinctly two cell-layered cortex in the mature, corticated portions of the branches. For *Compsopogon corticrassus* Chihara and Nakamura (1980) considered the number of cortical layers to be very important and for other taxa it may be of equal importance, especially when used with other selected characters.

5. The size of the outermost cortical cells

The size range of outermost cortical cells from taxon to taxon often overlaps one another. But for some taxa this character is also useful. According to Chihara (1976) *Compsopogonopsis japonica* is distinguished from *Cs. leptocladus* in having the diameter of the outermost cortical cells larger in size than those of the latter. Thus, in some cases, the diameter of of the cortical cells may be useful in specific identification.

**Taxonomic proposals and revised descriptions**

Key to the genera of the family Compsopogonaceae

- 1. Rhizoidal filaments restricted to the basal part of the thallus ..... *Compsopogon*
- 1. Rhizoidal filaments appeared throughout the thallus, constructing the cortex ..... *Compsopogonopsis*

Revised descriptions of taxa of the genus *Compsopogon*

Description of Genus *Compsopogon*

Thallus filamentous, cylindrical, often profusely branched; juvenile erect filaments uniseriate and mature filaments becoming multiseriate consisting of the cortex and central cells; the cortex consisting of one or more layers of cells; axial cells forming linear, large central cells; reproduction mostly by monospores sometimes by microspores produced from uniseriate axial cells as well as from the outermost cells of the cortex; sexual reproduction unknown.

Key to the species of the genus *Compsopogon*

- 1. Spinous short branchlets occurred on mature thallus  
..... *Compsopogon aeruginosus*
- 1. Spinous short branchlets absent on mature thallus.....2
- 2. Monospores smaller than 20 μm in diameter ..... *Compsopogon chalybeus*  
[= *Compsopogon corinaldii*]
- 2. Monospores larger than 20 μm in diameter.....3
- 3. Cortex consisting of two to three layers of cells  
..... *Compsopogon coeruleus*  
[= *C. oishii*, *C. minutus*]
- 3. Cortex consisting of up to five layers of cells  
..... *Compsopogon corticrassus*

Discriptions of the taxa of the genus *Compsopogon*

- 1. *Compsopogon aeruginosus* (J. Ag.) Kuetzing 1849, Species Algarum, Lipsiae, 432.  
Homotypic synonyms [= *Pericystis aeruginosa* J. Agardh 1847, Öfvers Förhandl. Kangl. [Svenska] vetrnskops. -Akad. 4: 5-17]

Rhizoidal filaments restricted to the basal part of the thallus. The main branches 60-250 μm in diameter, nodulated, with many short spinous branchlets from cortical cells of main axis on older part of the thallus. The fully developed cortex consisting of one to two layers of cells; the outermost cortical cells 16-37 × 9-21 μm in size. Monospores 11-17 μm in diameter.

- 2. *Compsopogon chalybeus* Kuetzing 1849, Species Algarum, 432; Kuetzing 1849, Tab. Phycol., VII: tab. 89, fig. II.  
Heterotypic synonym [= *Compsopogon corinaldii* (Meneghini) Kuetzing 1857, Tab. Phycol. VII: 35, tab. 88, fig. I. a, a'-b, b', *Lemanea corinaldii* G. Meneghini 1841, Giron. Toscano Sci. Med. Fis. e nat. (Piza) 1841, 1: 186-189]

Rhizoidal filaments restricted to the basal part of the thallus. The main branches 140-250 μm in diameter. The fully developed cortex consisting of two layers of cells; the outer-

most cortical cells  $12-35 \times 8-24 \mu\text{m}$  in size. Monospores  $10-16 \mu\text{m}$  in diameter.

3. *Compsopogon coeruleus* (Balbis) Montagne 1846, Flore d'Algérie 1: 154-156.

Homotypic synonym [= *Conferva coerulea* Agardh C. 1824, Systema Algarum, 122]

Heterotypic synonyms [= *Compsopogon oishii* Okamura 1915, Icones of Japanese Algae. III, N. VII, Tokyo, *Compsopogon minutus* Jao 1941, Sinensia 12: 245-279]

Rhizoidal filaments restricted to the basal part of the thallus. The main branches  $250-750 \mu\text{m}$  in diameter. The fully developed cortex consisting of two layers of cells; the outermost cortical cells  $13-39 \times 8-25(-30) \mu\text{m}$  in size. Monospores  $(16-20-23 \mu\text{m})$  in diameter.

4. *Compsopogon corticrassus* Chihara et Nakamura 1980, Journ. Jap. Bot. 55: 136-144.

Rhizoidal filaments restricted to the basal part of the thallus. The main branches  $2000-3000 \mu\text{m}$  in diameter. The fully developed cortex consisting of three to four rarely five layers of cells; the outermost cortical cells  $14-36 \times 7-20 \mu\text{m}$  in size. Monospores  $16-22 \mu\text{m}$  in diameter.

Revised descriptions of taxa of the genus *Compsopogonopsis*

The genus *Compsopogonopsis* was separated from the genus *Compsopogon* by the characteristic formation of cortex and established by Krishnamurthy (1962) based on the type specimen of *Compsopogon leptoclados* Montagne deposited in the Muséum National d'Histoire Naturelle in Paris. Distribution of this species has been known to restrict only in Cayenne, French Guiana. However, Chihara (1976) described *Compsopogonopsis japonica*, which differed from *Cs. leptoclados* in having the outermost cortical cells larger than the latter.

Description of the genus *Compsopogonopsis*

Thallus filamentous, cylindrical, profusely branched; the cells of cortex initiated by means of rhizoidal filaments arising from the

uniseriate filaments; the fully developed cortex consisting of one layered generally, occasionally two layered of cells; cortical cells almost globular; reproduction by monospores produced from uniseriate axial cells as well as from outermost cells of the cortex; sexual reproduction unknown.

Key to the species of the genus *Compsopogonopsis*

1. Outermost cortical cells up to circa  $30 \mu\text{m}$  in size and with one cortical layer ..... *Compsopogonopsis leptoclados*
1. Outermost cortical cells up to circa  $50 \mu\text{m}$  in size and with two cortical layers ..... 2
2. Rhizoidal filaments initiated from the segments on both side of the axial cells ..... *Compsopogonopsis japonica*
2. Rhizoidal filaments initiated from the tubular outgrowths on the axial cells ..... *Compsopogonopsis fruticosa*

Descriptions of the taxa of the genus *Compsopogonopsis*

1. *Compsopogonopsis leptoclados* (Montagne) Krishnamurthy 1962, J. Linn. Soc. (Bot.) 58: 372, 207-222.

Homotypic synonym [= *Compsopogon leptoclados* Montagne 1850, Ann Sci. Nat. bot. (3 sér) 14: 283-309.

Rhizoidal filaments appeared throughout the thallus, constructing the cortex. The main branches  $130-400 \mu\text{m}$  in diameter. The fully developed cortex consisting of one layers of cells; the outermost cortical cells  $9-31 \times 4-15 \mu\text{m}$  in size. Monospores  $12-16 \mu\text{m}$  in diameter.

2. *Compsopogonopsis japonica* Chihara 1976, Journ. Jap. Bot. 51: 289-294.

Rhizoidal filaments appeared throughout the thallus, constructing the cortex. The main branches  $500-1000 \mu\text{m}$  in diameter. The fully developed cortex consisting of two layers of cells; the outermost cortical cells  $30-50 \times 25-40 \mu\text{m}$  in size. Monospores  $17-23 \mu\text{m}$  in diameter.

3. *Compsopogonopsis fruticosa* (Jao) Seto 1987, Jpn. J. Phycol. 35: 265-267.

Homotypic synonym [= *Compsopogon fruticosus* Jao 1941, Sinensia 12: 245-279]

Rhizoidal filaments appeared throughout the thallus, constructing the cortex. The main branches 200-500  $\mu\text{m}$  in diameter. The fully developed cortex consisting of two layers of cells; the outermost cortical cells 14-55  $\times$  12-35  $\mu\text{m}$  in size. Monospores 15-22  $\mu\text{m}$  in diameter.

### Acknowledgments

The authors express their thanks to Dr. W. Prud'Homme van Reine, the Rijksherbarium, Leiden, the Netherlands, Dr. T. Yoshida, Hokkaido University and Dr. J. Tanaka, the National Science Museum of Japan for the loan of the type specimens, to Dr. M. Ratnasabapathy for providing Malaysian specimens and to Dr. M. Khan and Dr. A. Kumar, Aligarh Muslim University for providing Indian specimens. They are also indebted to Dr. F. D. Ott, the Boys' Latin School of Maryland for critically reading and proofing the manuscript and supplying copies of some papers, and to Prof. T. Izumi of Osaka Gakuin University for translations of French papers.

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## 瀬戸良三\*・熊野 茂\*\*：オオイシソウ科数種の再評価

最近, M. L. Vis, R. G. Sheath and K. M. Cole (1992) はオオイシソウ科 9 種の基準標本と, 北米産の標本に基づいて, 従来と同科の種を検討し, オオイシソウ属を 2 種に, オオイシソウモドキ属を 1 種に纏めるといふ, 思い切った見解を示したが, 従来分類体系に大きな改変を加えるこの見解に従うことは出来ない。今回, 我々は, ライデン国立標本館, 北海道大学, 神戸大学, 国立科学博物館所蔵のオオイシソウ属 7 種, オオイシソウモドキ属 3 種の基準標本と日本・マレーシア・インド産の標本に基づいて, オオイシソウ科 2 属を, これまで用いて来た有効な形質により比較検討し, 以下の種についての記載の修正を報告する。 *Compsopogon aeruginosus*, *C. chalybeus* (= *C. corinaldii*), *C. coeruleus* (= *C. oishii*, *C. minutus*), *C. corticrassus*, *Compsopogonopsis leptoclados* *Cs. japonica*, *Cs. fruticosa*. (\*662 西宮市岡田山4-1 神戸女学院大学家政学部・\*\*657 神戸市灘区六甲台1-1 神戸大学理学部生物学教室)

(Received April 14, 1993; Accepted October 15, 1993)