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Two New Members of Freshwater Red Algae in Taiwan: *Compsopogon tenellus* Ling *et* Xie and *C. chalybeus* Kützing (Compsopogonaceae, Rhodophyta)

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ABSTRACT: Two freshwater red algae, *Compsopogon tenellus* Ling *et* Xie and *C. chalybeus* Kützing, are first reported to the freshwater algal flora of Taiwan. In this study, we describe in detail the morphology of them and compare the ecological differences of their habitats. Both of them were found in clear, warm (24-27 °C) and running stream in low altitude plain areas of southern Taiwan.

KEY WORDS: ***Compsopogon*, Freshwater red algae, New record, Taiwan.**

INTRODUCTION

Most of the freshwater algal studies in Taiwan were focused on the microalgae (Yamagishi, 1992; Moriwaka and Chyi, 1996; Wang and Chen, 2000; Wang *et al.*, 2002), and few studies were engaged in the macroscopic freshwater red algae (Wu, 1999, 2001). Freshwater red algae were reported to only appear in clear, high oxygen concentration and low nutrient aquatic environment (Sheath and Hambrook, 1990). To present knowledge, in Taiwan, rhodophytes are not common in freshwater mass, but spread extensively in marine environment (Chiang, 1962, 1973; Chiang and Wang, 1987; Huang, 1990, 1999; Wang and Chiang, 2001). Recently, Wu (1999, 2001) reported three genera and five species of freshwater red algae from Taiwan. In this study, we collected two freshwater red algae from southern Taiwan. Morphological observations suggest that they belong to genus *Compsopogon* Montagne (1846) and are new to the freshwater algal flora of Taiwan. Furthermore, the genus *Compsopogon* is a new record for Taiwan.

MATERIALS AND METHODS

The materials were collected from southern Taiwan in 2003 from clear, well-aerated and moderate agitate stream with a depth ranged bwtween 20-50 cm. The pH, dissolved oxygen (mg/L) and conductivity (μS/cm) of water at the localities were immediately measured by pH meter, DO (dissolved oxygen) meter and conducometer *in situ*, respectively. About 1000 ml water sample was stored at 0-4°C in the refrigerator and transported to the laboratory. The measurements of dissolved inorganic nitrogen (DIN, including NO_2^- + NO_3^- + NH_3) and dissolved inorganic phosphate (DIP, PO_4^{-3}) were done with a $SMART_{Spectro}$ spectro-photometer (LaMotte, Maryland, USA). All of materials examined were preserved in 5-10% formalin solution or dried as herbarium specimens. Free-hand sections were done to observe the vegetative and reproductive structures under light microscope (Zeiss Axioskop 2) or dissecting microscope (Zeiss Stemi SV11). Specimens were deposited at the Department of Biology, National Changhua University of Education, Taiwan.

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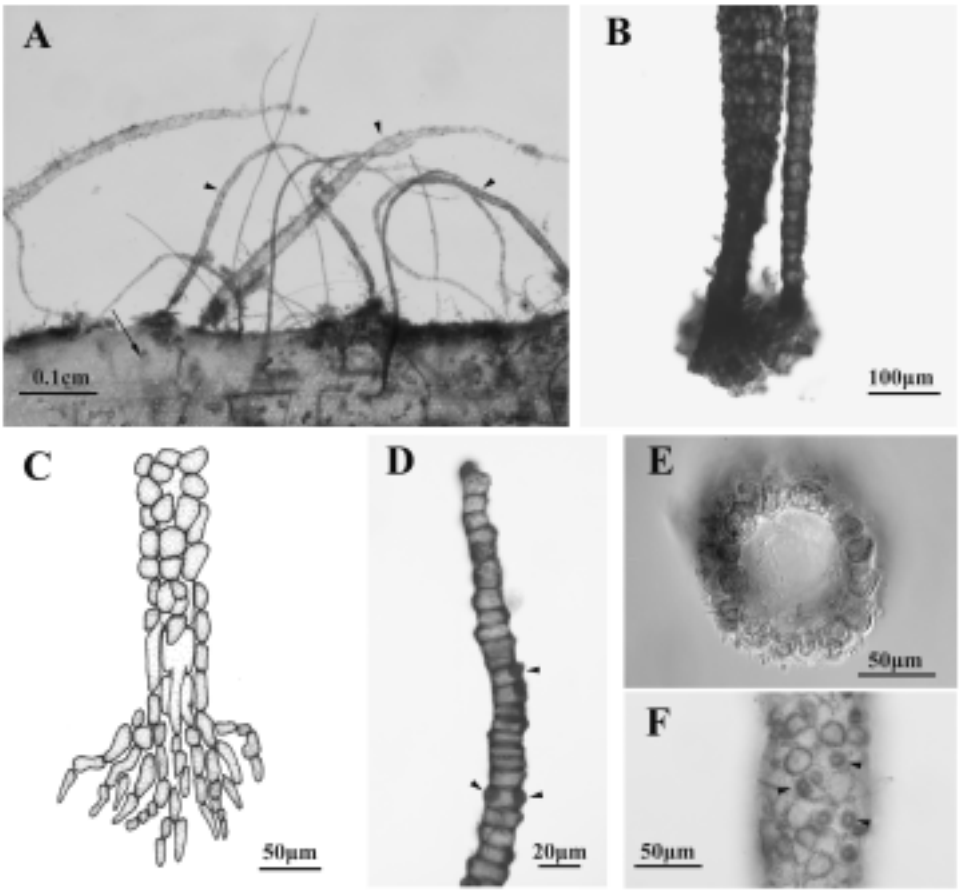

Fig. 1. *Compsopogon tenellus* Ling *et* Xie. A: The habit of plants (arrowheads) attaching on the water vascular macrophyte, *Najas* sp. (arrow). B-C: The lower portion of plants showing the disk-like holdfast which is formed by the rhizoid filaments. D: The apical portion of young branch showing the initial division of cortical cell (arrowheads). E: Cross-section of thallus showing 1-layered cells of cortex. F: The surface of old branch showing numerous 1-layered polygonal cortical cells and pigmented monosporangia (arrowheads).

DESCRIPTIONS OF SPECIES

Key to species of *Compsopogon*

1. Thallus 0.5-1 cm high, diameter 50-150 μm, with 1-layered cortex ……...……..…… *Compsopogon tenellus*
1. Thallus 2-15 cm high, diameter 120-320 μm, with 2-3-layered cortex ……..…….. *Compsopogon chalybeus*

Compsopogon tenellus Ling *et* Xie in Xie and Ling, 1998: 136, figs 1, 2A-2J, 3A-3L, 4A-4C.
Kumano, 2002: 27, pl. 13, figs 1-9. Figs. 1A-1F

Plant is macroscopic, green, few branched and very small. It is 0.5-1 cm high and 50-150 μm in diameter (Fig. 1A). Holdfast is conical or hemispherical (Figs 1B-1C). Young branches consist of large-celled main axes without covering cortical cells (Fig. 1D). The main axes of branches are about 100 μm in diameter. Cortex consists of 1-layered cells (Fig. 1E). Cortical cells are polygonal or ovoid, 17-30 μm in width and 22-40 μm in length (Fig. 1F). Pigmented monosporangia are rarely produced from cortical cells of proximal portion of thallus. It is spherical or ovoid in shape and 16-22 μm in diameter (Fig. 1F).

Type locality: Taiyuan, Shanxi, China.

Specimen examined: Liuchung river, Paiho, Tainan County (N23°19’28’’, E120°26’56’’), coll. Liao, C.-C. and J.-Y. Chou, Cote920901, 13.ix.03.

Habitat: Plants are epiphytic on the aquatic vascular macrophytes, *Najas* sp. (Fig. 1A), in well-aerated, moderate flow speed, clear stream (Table 1).

Table 1. A comparison of some physical-chemical parameters at the collecting localities in Taiwan.

Physical-chemical parameters	*C. tenellus*	*C. chalybeus*
pH	7.6	8.2
Conductivity (μS/cm)	676	201
Water temperature (°C)	24.5	27.0
Dissolved oxygen (mg/L)	10.1	9.0
Dissolved inorganic nitrogen (ppm)	2.01	1.75
Dissolved inorganic phosphate (ppm)	0.18	0.05

Compsopogon chalybeus Kützing, 1849: 432. Kumano, 2002: 27, pl. 11, figs 1-2, 6-8. Figs. 2A-2I

Synonym: Lemanea corinaldii Meneghini, 1841: 186; *Compsopogon corinaldii* (Meneghini) Kützing, 1857: 35, tab. 88, fig. Ia, a’-b, b’.

Plant is macroscopic, sparsely branched and greenish in color. It is 2-15 cm in height and 120-320 μm in diameter (Fig. 2A). Holdfast is conical or hemispherical in shape (Figs. 2B, 2C). Young branches have a main axial cell row without forming the cortical cells. The apical portion of branch has two types: gradually attenuating toward apex without obvious tumid basal corticated portion (Fig. 2D) or with obvious cortication (Fig. 2E). Old branches have numerous constricted rings in appearance (Fig. 2F). Depending on the age of branches, the main axes of branches are 62-225 μm in diameter. Branchlet departs from main axes and gradually attenuates toward apex (Fig. 2G). Cortex consists of 2-3 layers of cells (Fig. 2H). Cortical cell is polygonal in shape, 8-15 μm in width and 8-25 μm in length (Fig. 2I). Pigmented monosporangia is spherical or ovoid in shape and 12-18 μm in diameter (Fig. 2I).

Type locality: Cayenne, French Guianain South America.

Specimen examined: Wukoushui, Neipu, Pingtung County (N22°35’51’’, E120°35’20’’), coll. Liu, S.-L. and W.-L. Wang, Coch921001, 18.x.03.

Habitat: Plants are epiphytic on the aquatic vascular macrophytes, *Hygrophila difformis* (Linn. f.) E. Hossain (Fig. 2A), or epilithic on the benthic stones in well aerated, moderate flow speed, and clear stream (Table 1).

DISCUSSION

According to Kumano (2002), we can easily distinguish theses two freshwater red algae of *Compsopogon* in this study. He distinguished the species of *Compsopogon* mainly based on the size of thallus diameter, the size of monosporangia diameter and the number of cortical layer. Comparing these characters, we summarized the differences between *C. tenellus* and *C. chalybeus* as shown in Table 2. From the taxonomic keys of Kumano (2002), the thallus diameter of *C. tenellus* is less than 200 μm and its monosporangia diameter is large than 20 μm, whereas thallus diameter of *C. chalybeus* is large than 200 μm and its monosporangia

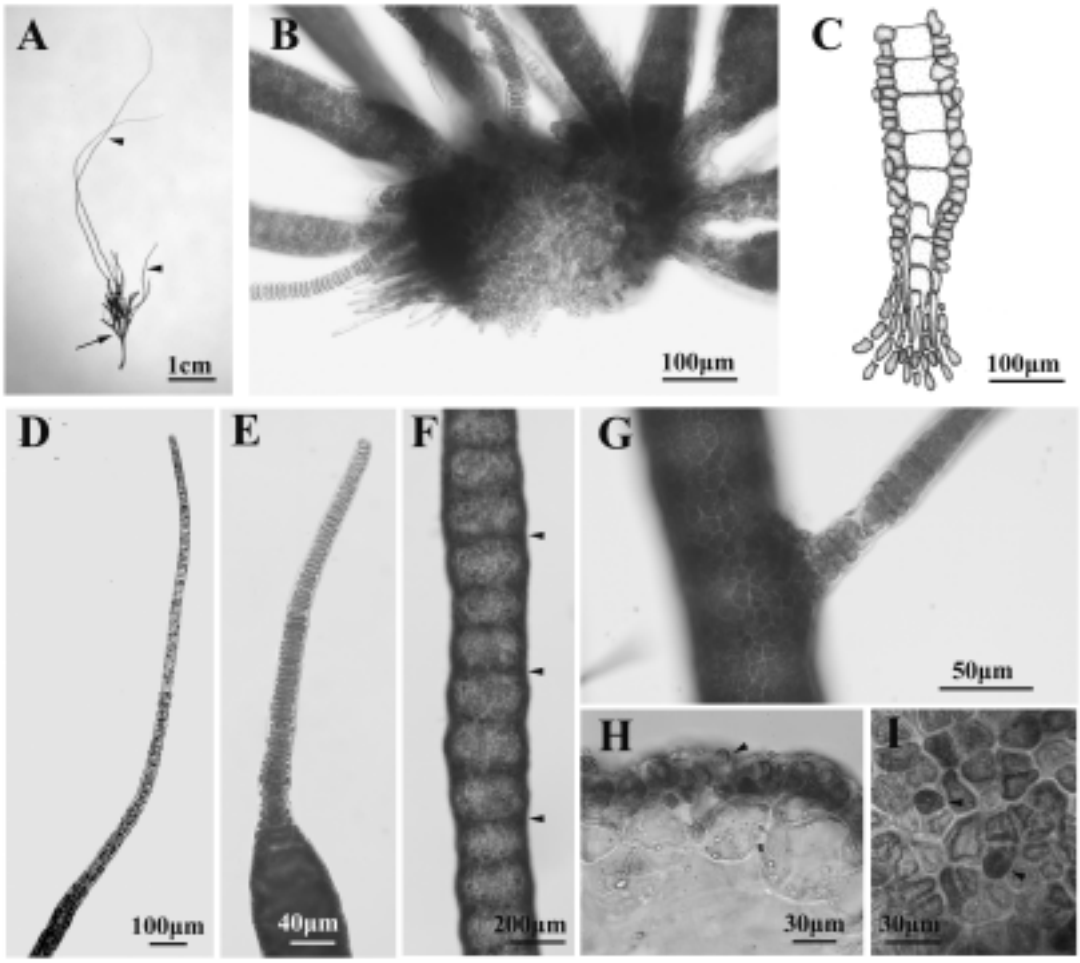

Fig. 2. *Compsopogon chalybeus* Kützing. A: The habit of plants (arrowheads) attaching on the water vascular macrophyte, *Hygrophila difformis* (Linn. f.) E. Hossain (arrow). B-C: The lower portion of plants showing the disk-like holdfast formed by the rhizoid filaments. D-E: The apical portion of plants showing two different types: gradually attenuating toward apex without obvious tumid basal corticated portion D or with obvious one E. F: Old branch showing the constriction rings (arrowheads) in appearance. G: Branchlet departing from the main axes. H: Cross-section of thallus showing 2-3 layered cells of cortex and the release of monospore (arrowhead). I: The surface of old branch showing numerous polygonal cortical cells and pigmented (deep colored) monosporangia (arrowheads).

diameter is less than 20 µm. Those features in our two materials pertain to the descriptions of Kumano and can be distinguishable based on those characteristics. Based on the comparisons, these two entities should be easily separated (Table 2). Besides, when we examined the *C. tenellus* population in Liuchung river, Paiho, Tainan County, we could not find any plants higher than 1 cm and with more than 1-layered cortex. Due to above morphological comparisons, we believed that the small thallus species, *C. tenellus*, should not be a young stage of the large species, *C. chalybeus*. *C. tenellus* can be distinguished from *C. chalybeus* by having smaller plant size (0.5-1 cm), larger monosporangia diameter (16-22 µm), only 1-layered cortex and smaller thallus diameter (50-150 µm).

The water quality of the habitats among these two species show that they inhabit in high oxygen concentration, warm and alkaline aquatic environment (Table 1). According to Wehr and Sheath (2003), *Compsopogon* is largely distributed from tropical to warm temperate

streams because they can tolerate warm (13-27°C) and alkaline (pH 7.3-8.6, specific conductance 46-1880 μS) environment in North America. Hence, it could explain why these two species of *Compsopogon* are found in warmer plain areas (this study), unlike other members of freshwater red algae that inhabit in colder mountain area in Taiwan (Wu, 1999, 2001).

Compsopogon tenellus prefers higher conductivity and higher nutrient concentration, while *C. chalybeus* prefers lower conductivity and lower nutrient concentration. Obviously, *C. tenellus* can endure higher polluted environment. However, like other members of freshwater rhodophytes (Wu, 1999, 2001), these two species of *Compsopogon* require clear water and high oxygen concentration.

Table 2. A morphological comparison of *C. tenellus* and *C. chalybeus*.

Characters	*C. tenellus*	*C. chalybeus*
Thallus height	0.5-1 cm[a]	2-15 cm
	(1-2 cm)[b]	(*)
Diameter of thallus	50-150 μm	120-320 μm
	(90-120 μm)	(100-250 μm)
Diameter of monosporangia	16-22 μm	12-18 μm
	(10-25 μm)	(12-16 μm)
The number of cortical layers	1-layered	2-3-layered
	(1-layered)	(up to 3-layered)

[a] this study; [b] the values in parenthesis were obtained from Kumano (2002); * not mentioned.

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台灣兩種新紀錄淡水紅藻 *Compsopogon tenellus* Ling *et* Xie 和 *C. chalybeus* Kützing

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摘　　要

本文報導美芒藻屬 2 種台灣新紀錄淡水紅藻 *Compsopogon tenellusc* Ling *et* Xie 和 *C. chalybeus* Kützing。此兩藻種分布於南台灣低海拔平原微污染溪流，棲地含氧量高、水溫暖且清澈。本文除對此兩藻種形態作詳細描述外，並對其棲地水質進行比較。

關鍵詞：美芒藻屬、淡水紅藻、新紀錄、台灣。

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