IRANIAN JOURNAL OF BOTANY 24 (1), 2018
DOI: 10.22092/ijb.2018.110713.1160

COMPSOPOGON CAERULEUS, A NEW RECORD OF RHODOPHYTA FOR ALGAL FLORA OF IRAN

R. Taghavizad

Received 2017. 06. 22; accepted for publication 2018. 05. 23

Razieh Taghavizad, 2018. 06. 30: *Compsopogon caeruleus*, a new record of Rhodophyta for Algal flora of Iran. *-Iran. J. Bot. 24 (1): 84-90.* Tehran.

A freshwater red algae, *Compsopogon caeruleus* was collected from current water canal on south of Tehran, Iran for the first time. It lives as epiphyte on *Cladophora* sp. (green algae) in cold water canal at a temperature of 8-10°C and at high speed at a depth of 30-50 cm. Thallus was macroscopic filamentous, grey to greyish–green, in the growing season abundantly branched. Branches made an acute angle with the axis (about, 20-70°). Thallus is 180-1000 µm in diameter and 2-10 cm long. In mature thallus, cortex had 1–2 polygonal or irregular cell layers with short spine-like branchlets. Cortical cells were established in regular or irregular rows. Chloroplasts were parietal. Monosporangia were cortical and semi-spherical to irregular.

Razieh Taghavizad, (correspondence <ra_taghavizad@yahoo.com>), Department of Biology, Yadegar -e- Imam Khomeini (RAH) Shahre-Rey Branch, Islamic Azad University, Tehran, Iran.

Key words: *Compsopogon caeruleus*, epiphyte, freshwater algae, monosporangia, polygonal, spine-like branchlets

Compsopogon caeruleus، گزارش گونه جدیدی از جلبکهای قرمز برای فلور جلبکی ایران

راضیه تقوی‌زاد: استادیار،گروه زیست‌شناسی، واحد یادگار امام خمینی (ره) شهرری، دانشگاه آزاد اسلامی، تهران، ایران

یک جلبک قرمز آب شیرین به نام Compsopogon caeruleus برای اولین بار از کانال آب جاری در جنوب تهران جمع‌آوری شد. این گیاهان به طور اپی‌فیت روی جلبک سبز .Cladophora sp در کانال آب جاری سرد در دمای°C ۱۰–۸ و سرعت زیاد در عمق cm ۵۰–۳۰ زندگی می‌کردند. تال رشته‌ای ماکروسکوپی، خاکستری تا سبز مایل به خاکستری، در فصل رشد به فراوانی منشعب شده هستند. انشعابات با محور اصلی، زاویه حاده (حدود° ۷۰–۲۰) می سازند. تال، µm۱۰۰۰–۱۸۰ قطر و cm۱۰–۲ طول دارد. در تال بالغ کورتکس ۲–۱ لایه سلول چندگوش یا بی‌نظم با انشعابچه‌های کوتاه خار مانند دارد. سلول‌های سطحی در ردیف‌های منظم یا نامنظم قرار دارند. کلروپلاست‌ها جانبی هستند. مونوسپورانژیا سطحی و نیمکروی تا بی‌نظم هستند.

INTRODUCTION

Compsopogon Montagne (1846) is a typical Rhodophyta algae genus that inhabits freshwater (Kumanoa 2002). *Compsopogon* is a Periphyton filamentous red algae which make slimy coating and grows on the beds of streams and rivers. The genus is an essential component of stream ecosystems (Bigs & Kilroy 2000). However a few species have been reported from cold to temperate region of the world but recent phylogenetic studies have revealed that the genus is monospecific and *Compsopogon caeruleus* (Balbis ex C.Agardh) Montagne is the only valid specific name in the genus (Necchi & al. 2013; Nan & al. 2016; Guiry & Guiry 2018). Morphological features of the species delineations in this genus include the type of the thallus basal portion, the branching pattern and the number of cortical layers. However, these characteristics are widely variable both within and among populations at different environmental conditions (Necchi & al. 1999). Kitayama (2011) has considered that size of monospore and monosporangia is not enough useful as a taxonomic character for

Compsopogon.

In Europe, specimens of this genus were found only in rather restricted areas in some specific environments, often only in tropical aquaria, in botanical gardens and in polluted canals, where they were probably introduced (Kwandrans & Eloranta 2010). Of great interest is that *C.cf. aeruginosus* was recently found in Skryjský Brook (Czech Republic), downstream from the cooling water effluent from the Dukovany Nuclear Power Plant in the Jihlava River basin, which has also experienced temperature changes due to pollution (Žáková & al. 2013). *Compsopogon caeruleus* (Syn. *C. aeruginosus*) has cosmopolitan distribution and is well known from North America (Withford & Schumacher 1963). *Comsopogon caeruleus* (Syn. *C. aeruginosus*) extract has been studied in order to understand the usefulness as a foodstuff as well as cosmetic products (Chankaew & al., 2016).

Geographical distribution

Asia: China (Hu & Wei 2006), Japan (Kitayama 2011), Indonesia (Johnston & al. 2014), Malaysia (Johnston et al. 2014), Vietnam (Nguyen & al. 2013); *Europe*: Britain (Sheath & Sherwood 2011), Germany (Täuscher 2011); *North America*: Florida (Taylor 1960), Louisiana (Taylor 1960); *South America*: Brazil (Nan & al. 2016); *Australia*: Australia (Eloranta, Kwandrans & Kusel-Fetzmann 2011); *Pacific Islands*: Hawaiian Islands (Sherwood 2006).

There were no other reports of this genus from Iran. In this study *Compsopogon caeruleus* is reported for the first time in Iran.

MATERIALS AND METHODS

Compsopogon caeruleus was collected from current water canal on southern Tehran, Iran with longitude of 51°, 21′, 49″ and latitude of 35°, 33′, 34″ and 1038 m a.s.

Samples of algae were collected and placed in a 4% formaldehyde solution for fixing, and were stored in special glass bottles in phycology laboratory in Yadegar-e Imam Khomeini, Shahre-Rey Branch of Islamic Azad University. The microscopic observations were done by light microscope. *Compsopogon caeruleus* samples were morphologically and anatomically studied. The identification procedure and terminology used followed Kitayama (2011), Ratha & al. (2007), Stoyneva & al. (2006), Ceschin & al. (2013), Bigs & Kilroy (2000), Eloranta & al. (2011), Žáková & al. (2013) and Nan & al. (2016).

Physicochemical analysis

Environmental factors and chemical factors such as Nitrate and phosphorus in water were measured and are shown in table 1. Water of the area where the algae lived was collected in a 3-liter reservoir and immediately transferred to the water analysis laboratory and physicochemical analysis was made. In these studies, the electrical conductivity of water (EC), the concentration of nitrate, and elements of phosphorus (P), iron (Fe) and heavy metals including lead (Pb), cadmium (Cd), copper (Cu) and zinc (Zn) were measured. The temperature, pH and water depth of the place where plant lived were also measured. To comply with the permissible limits of elements, the standards published by US water standards and health advisories (EPA, 2012) and U.S. Environmental Protection Agency (EPA, 1994), were used (table 1). In order to accurately identify the species, the length and diameter of the algae and the angle between the branches with the main axis were calculated.

RESULTS

Systematic position

Phylum: Rhodophyta
Class: Rhodophyceae
Order: Compsopogonales
Family: Compsopogonaceae
Genus: *Compsopogon*
Compsopogon caeruleus (Balbis ex C.Agardh) Montagne (1846)

Compsopogon caeruleus was observed in water canals around farmlands of city of Tehran in autumn and winter. In the collected specimens, these plants color were gray and sometimes greyish-green. The algae thallus was epiphyte on green algae, *Cladophora* sp. grown in cold water canals at a temperature of 8-10°C, pH=7 and at high speed at a depth of 30-50 cm.

The results of water physicochemical studies are shown in table 1. In this research the nitrate measured (23.5 mg/l) and phosphorus (0.021 mg/l) were high. Therefore, the habitat of *C. caeruleus* was contaminated with nitrate. Water EC was at about 0.96 dS/m and since it is less than 1.5 dS/m, it is classified in the category of freshwaters. Heavy metals including Zn, Cu, and Cd were insignificant. Fe was higher than the permissible limits (0.3 mg/l) i.e. 1.2 mg/l. The concentration of Pb was much higher than the permissible limits (0.015 mg/l), i.e. 0.16 mg/l. Tolerance to high levels of Pb is another feature of this species of algae (table 1).

Table1. Comparison of some physicochemical parameters of collecting water from *Compsopogon caerulus* habitat with permissible limits.

Physicochemical parameters	water channel in south of Tehran	permissible limits
pH	7	6.5-8.5
Water temperature (°C)	8-10	-
Electerical conductivity (dS/ m)	0.96	-
Concentration of Fe (mg/l)	1.2	0.3
Concentration of Cu (mg/l)	nil	1.0
Concentration of Zn (mg/l)	nil	5
Concentration of Cd (mg/l)	nil	0.005
Concentration of Pb (mg/l)	0.16	0.015
Nitrate (mg/l)	23.5	10
P (mg/l)	0.021	-

Morphological and anatomical studies

Thallus is filamentous, abundantly branched, 180-1000 µm in diameter, 2-10 cm long. Most lateral branches are on one side and are rarely alternate arise from the main (fig. 1-B) and secondary axis, making an acute angle with the main axis (about, 20-70°), branches attenuated with rounded apices (figs. 1-A, B, 2-C). Branches become loose and hung after elongation. Each cell contained only one nucleus and chloroplasts are lateral, small, dark green to greenish blue (fig. 3-C). Growing region consisted of a number of barrel-shaped cells and was formed followed by a basal conical cell (holdfast) (figs. 2-A, B). Holdfast was connected by the rhizoidal section to the surface of *Cladophora* sp. green algae (fig. 2-B). Lateral young branches are uniseriate with barrel shaped cells (figs. 2-A, B, C). Axial developed branches have contained central large clear cells which corticated with several rows of polygonal cells and rarely monosporangia scattered among cortical cells (figs. 3-A, B). Monosporangia irregular to semi-spherical (fig. 3-B). Cortex with 1–2 layers of polygonal or irregular cells. Main axis constricted at the base, basal holdfast conical (fig. 2- B). Secondary and latter layers thallus cortex originates from a single-layer cell from the main axis. By the further development of thallus, the cell division gradually increases and several rows of cells form peripherally around a cylindrical axis (2-A, D). At the beginning of development, the cells are irregular and become gradually polygonal (figs 1-B, 3-B). Immature thallus is a single-layer and mature thallus has spine-like branchlets (figs. 1-B, 3-A).

Fig. 1. A, Unisereate branches originated from the main axis; most branches are on one side and are rarely alternate. B, Thallus round tip (greed arrowhead). The younger sections of thallus are composed of unisereate cells (red arrowhead); the unisereate cells of thallus with thick walls which led to growth and development of cortex layer (blue arrowhead). The old parts of thallus are composed of irregular multisereate to polygonal cells (black arrowhead).

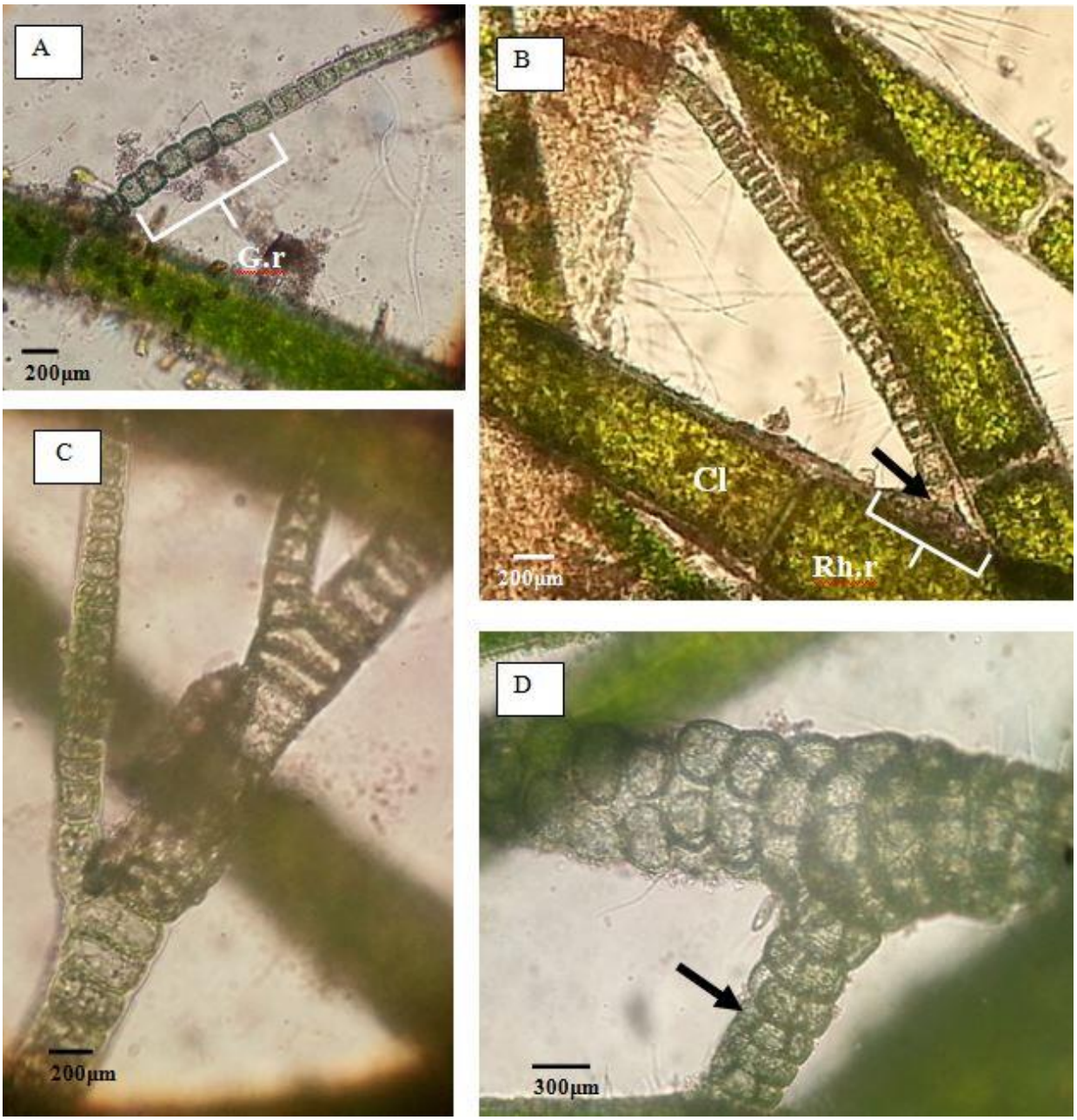

Fig. 2. A, Growing region (G. r.) with unisereate filament composed of barrel-shaped cells; B, Rhizoidal region (Rh. r.) is placed on *Cladophora* (Cl) sp. and a conical cell (holdfast) is on the base of thallus (arrowhead); C, Young branches of thallus composed of unisereate cells which form an acute angle with the main axis; D, Old branches of thallus have developed cortex layer which is composed of multisereate cells (arrowhead).

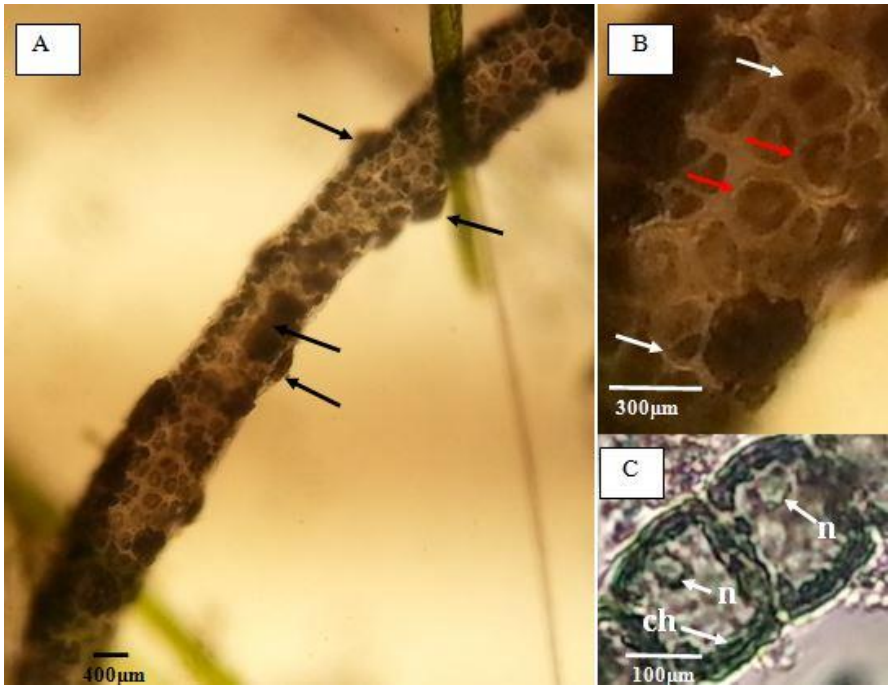

Fig. 3. A, B, Spine-like branchlets in cortical layer (cortex) which are composed of differentiated cells (black arrowheads); B, Polygonal cells (red arrowheads) and monosporangia (white arrowheads) in cortex; C, barrel-shaped cells in the place of growth of thallus. Each cell has one nucleus and parietal chloroplasts, which are small and dark green to greenish blue (white arrowhead).
n=nucleus, ch= chloroplast

DISCUSSION

This report is the first record of *Compsopogon caeruleus* in Iran which was collected from steppe area in south of Tehran in autumn and winter at the water temperature of 8-10°C.

Several researchers including Žáková & al. (2013) suggested *C. Caeruleus* as a native species from tropical and subtropical regions. They also found this species in cold water river of Jihlava in Czech Republic and concluded that nitrate pollution is the main reason for presence of the red algae species in cold water. Kwandrans & Eloranta (2010) also reported the species in polluted water canals in Europe.

In our study Nitrate level was high (23.5 mg/l) that perhaps is one of the reasons of presence of this algal species. Žáková & al. (2013) also reported high nitrate level (16.4 mg/l) in the habitat *C. Caeruleus.*

According to our observations, *C. Caeruleus* appears in gray to greyish-green color. So, it has little pigment content. This corresponds with the findings of Zucchi & Necchi (2001) who suggested that optimum growing conditions will not increase the pigments level.

The presence of this species in polluted canals and its tolerance to high level of nitrate is of great importance. It seems that the species can be considered as an indicator of high nitrate level in polluted waters. Therefore, it is worthy to conduct research on its role in water ecosystems

ACKNOWLEDGEMENTS

I appreciate the help of Dr. Hassan Nazarian, associate professor of Imam Khomeini Higher Education Center for advising me during the preparation of the manuscript and editing the paper. Also I wish to thank the authorities of Yadegar-e-Imam Khomeini (RAH), Shahr-e-Rey Branch, Islamic Azad University authorities for their support.

REFERENCES

Bigs, B .J .F. & Kilroy, C., 2000: Stream Periphyton Monitoring Manual. Identification guide to common periphyton. Published by: NIWA, P.O. Box 8602, Christchurch. New Zealand.

Ceschin, S., Ricci, S., Abati, S., Bisceglie, S., Minciardi, M.R. & Zuccarello, V., 2013: Distribution and ecology of red algae in Italian Rivers. -Fundamental and Applied Limnology, 17: 1-15.

Chankaew, W., Luaelae, W. & Phromhom, S., 2016: Diversity and Screening of Biological Activity of Red Macroalgae from Trang Watershed Area, Thailand. - Journal of Agricultural Technology, 12 (7.2): 2113-2122.

Eloranta, P., Kwandrans, J. & Kusel-Fetzmann, E., 2011: Rhodophyta and Phaeophyceae. Xll. -Fl. of Cent. Eur. 7: 156 p. 343 illus.

Epa (Environmental Protection Agency), 1994: Hydrology of the Black Hills Area, South Dakota, Office of Water U.S. Environmental Protection Agency, Ground-Water Characteristics. - https://pubs.usgs.gov/wri/wri024094 /pdf/mainbodyofreport-3.pdf.

Epa (Environmental Protection Agency), 2012: Edition of the Drinking Water Standards and Health Advisories, Office of Water U.S. Environmental Protection Agency Washington, DC, 822-S-12-001.- https://www.epa.gov.

Guiry, M. D. & Guiry, G. M., 2018: Compsopogon caeruleus (Balbis ex C.Agardh) Montagne. Algae Base. World-wide electronic publication, National University of Ireland, Galway. -http://www.algaebase.org.

Hu, H. & Wei, Y., 2006: The freshwater algae of China. Systematics, Taxonomy and Ecology, China. 1023 pp.

Johnston, E. T., Lim P-E. Buhari, N., Keil, E. J., Djawad, M. I. & Vis M. L., 2014: Diversity of freshwater red algae (Rhodophyta) in Malaysia and Indonesia from morphological and molecular data. -Phycologia, 53 (4): 329–341.

Kitayama, T., 2011: First Record of *Compsopogon caeruleus* (Balbis ex C.Agardh) Montagne (Compsopogonaceae, Rhodophyta) from Ogasawara Islands, Japan. - Bull. Natl. Mus. Nat. Sci., Ser. B, 37(4): 169–174.

Kumanoa, S., 2002: Freshwater red algae of the world. -Biopress Ltd., Bristol, 375 pp.

Kwandrans, J. & Eloranta, P., 2010: Diversity of freshwater red algae in Europe. – Oceanol. Hydrobiol. Stud. 39 (1): 161–169.

Nan, F., Feng, J., LV, J., Liu, Q. & Xie, S., 2016: Evolutionary history of the monospecific *Compsopogon* genus (Compsopogonales, Rhodophyta). Algae. 31(4): 303-315.

Necchi, O., Jr. Branco, C. C. Z. & Gomes, R. R.V., 1999: Microhabitat and plant structure of *Compsopogon coeruleus* (Compsopogonaceae, Rhodophyta) populations in streams from São Paulo State, southeastern Brazil. -Cryptogam. Algol. 20:75-87.

Necchi, O. Jr., Fo, A.S.G. Salomaki, E.D., West, J. A., Aboal, M. & Vis, M.L., 2013: Global sampling reveals low genetic diversity within *Compsopogon* (Compsopogonales, Rhodophyta). - European Journal of Phycology. 48 (2): 152-162.

Nguyen, T. V., Le, N. H., Lin, Sh-M., 2013: Frederique Steen and Olivier De Clerck Checklist of the marine macroalgae of Vietnam. -Botanica Marina. 56 (3): 207–227.

Ratha, SK., Jena, M., Rath, J. & Adhikary, S. P., 2007: Three Ecotypes of *Compsopogon coeruleus* (Rhodophyta) from Orissa State, East Coast of India. -Algae. 22 (2): 87-93.

Sheath, R. G. & Sherwood, A. R., 2011: Rhodophyta (Red Algae). In: The freshwater algal flora of the British Isles. An identification guide to freshwater and terrestrial algae. -Second edition. (John, D.M., Whitton, B. A. & Brook, A. J. Eds), pp. 159-180. Cambridge: Cambridge University Press.

Sherwood A. R., 2006: Stream Macroalgae of the Hawaiian Islands: A Floristic Survey. -Pacific Science. 60 (2): 191–205.

Taylor, W.R., 1960: Marine Algae of the Eastern Tropical and Subtropical Coasts of the Americas. - The University of Michigan Press, Ann Arbor. Xi-870 pp.

Täuscher, L., 2011: *Compsopogon* Montagne in Bory et Durieaux 1846. pp. [2]. Germany (Unpublished report).

Withford, L. A. & Schumacher J. G., 1963: Cummunities of algae in North Carolina of streams and their seasonal relations. -Hydrobiologia. 22: 96-133.

Žáková, Z., Pum, M., Sedláček, P., Mlejnková, H., & Hindák, F. 2013: Oceanological and Hydrobiological Studies. -Int. J. of Oceanogr. Hydrobiol. 42 (4): 412-419.

Zucchi, M. R. & Necchi, O. Jr., 2001: Effects of temperature, irradiance and photoperiod on growth and pigment content in some freshwater red algae in culture. -Phycol. Res. 49 (2): 103–114.

https://www.googlemap.com

www.algaebase.org