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Compsopogon prolificus sp. nov. (Compsopogonaceae, Rhodophyta) from Allahabad, Uttar Pradesh in India

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A new species of the genus *Compsopogon*, *C. prolificus* (Rhodophyta) from an outlet of a tube-well at Allahabad, Uttar Pradesh in India is described. This species resembles *C. coeruleus*, *C. iyengarii* and *C. hookeri* in having more than one layers of cortical cells, however, differs from *C. coeruleus* in having constricted and curled fronds and from *C. iyengarii* in the number of microspores formed in a cluster. Besides, this species differs from the above-mentioned taxa in having knot-like structures which serve for vegetative propagation.

Key Index Words: Compsopogon prolificus sp. nov., *freshwater Rhodophyta*; *India*; *taxonomy*.

Thirteen taxa of the genus *Compsopgon* have been described, but only five taxa have been reported from India by many authors such as BRUEHL and BISWAS (1923, 1927), KRISHAMURTHY (1953, 1957, 1962), SINGH (1964), PATEL (1965), VAIDYA (1968), PATEL and FRANCIS (1969), PANDEY *et al.* (1973, 1976) and YADAVA and PANDEY (1980). SHYAM and SARMA (1980) suggested for a need of comparative morphological study both in nature and culture to decide which characters consistently and reliable to distinguish various taxa of the genus *Compsopogon*. YADAVA and PANDEY (1977) reproted an interesting taxon of *Compsopogon* from Allahabad in India. This report was for an unnamed species of *Compsopogon*, whose fronds showed twisting and later developed into knot-like structures. Subsequent comparative study in nature and culture conditions has shown this taxon of *Compsopogon* to be a new species. In the present paper this new species is described in more detail, a holotype for the species is determined.

Locatity and Habitat

The present alga was found growing in an outlet of a water channel of a tube-well (Fig. 2), lying at latitude 25°30′N, longitude 81°40′E at Allahabad (Fig. 1) in the State of Uttar Pradesh in India. During the period of the present study, the water temperature ranged from 16°C to 27°C and the value of pH was 6.5. The present alga is perenial and was growing throughout the year, therefore, the observations were also able to continue throughout the year. The present alga grows epiphytically on the filaments of *Cladophora* sp. on bricks and also on muddy beds in the water channel, where the other algae such as *Oscillatoria* spp. and *Spirogyra* sp. were growing associated with it.

Materials and Methods

It was collected twice in every month and observations were constantly carried out for one year, 1978-1979. A comparative study on the development in nature and

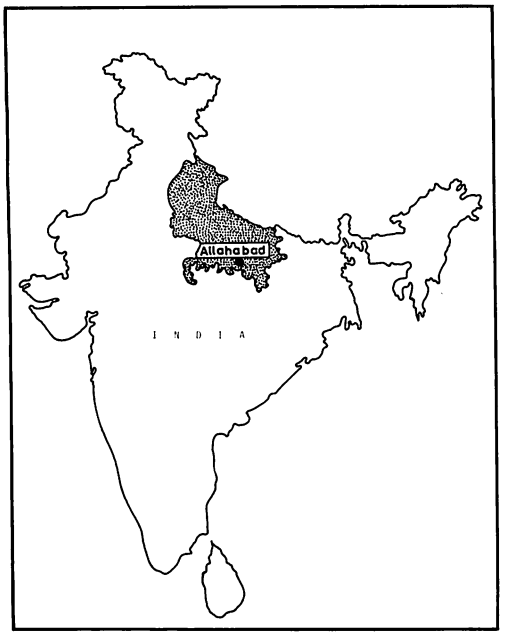


Fig. 1. Map of India showing Allahabad.

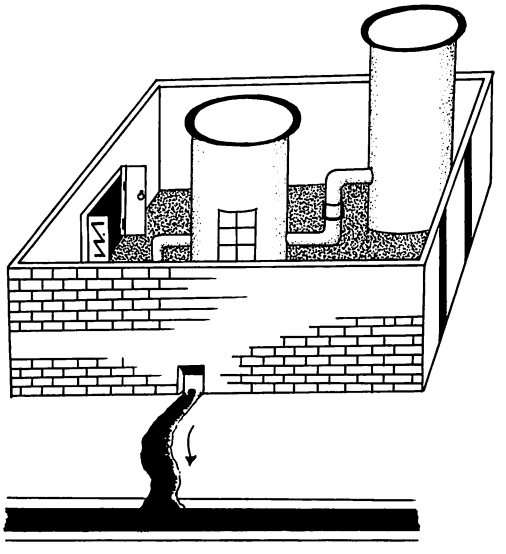


Fig. 2. A tube-well.

culture conditions was undertaken. The alga was isolated in a unialgal culture, a single filament was repeatedly washed in sterilized tap water and struck on solid and liquid BOLD's medium (1949). Monospores were also used to initiate such an inoculum on agar plates, which were incubated in a culture chamber at 25°C, provided with 16 hours light period receiving an intensity of approximately 1,000 lux.

Observations

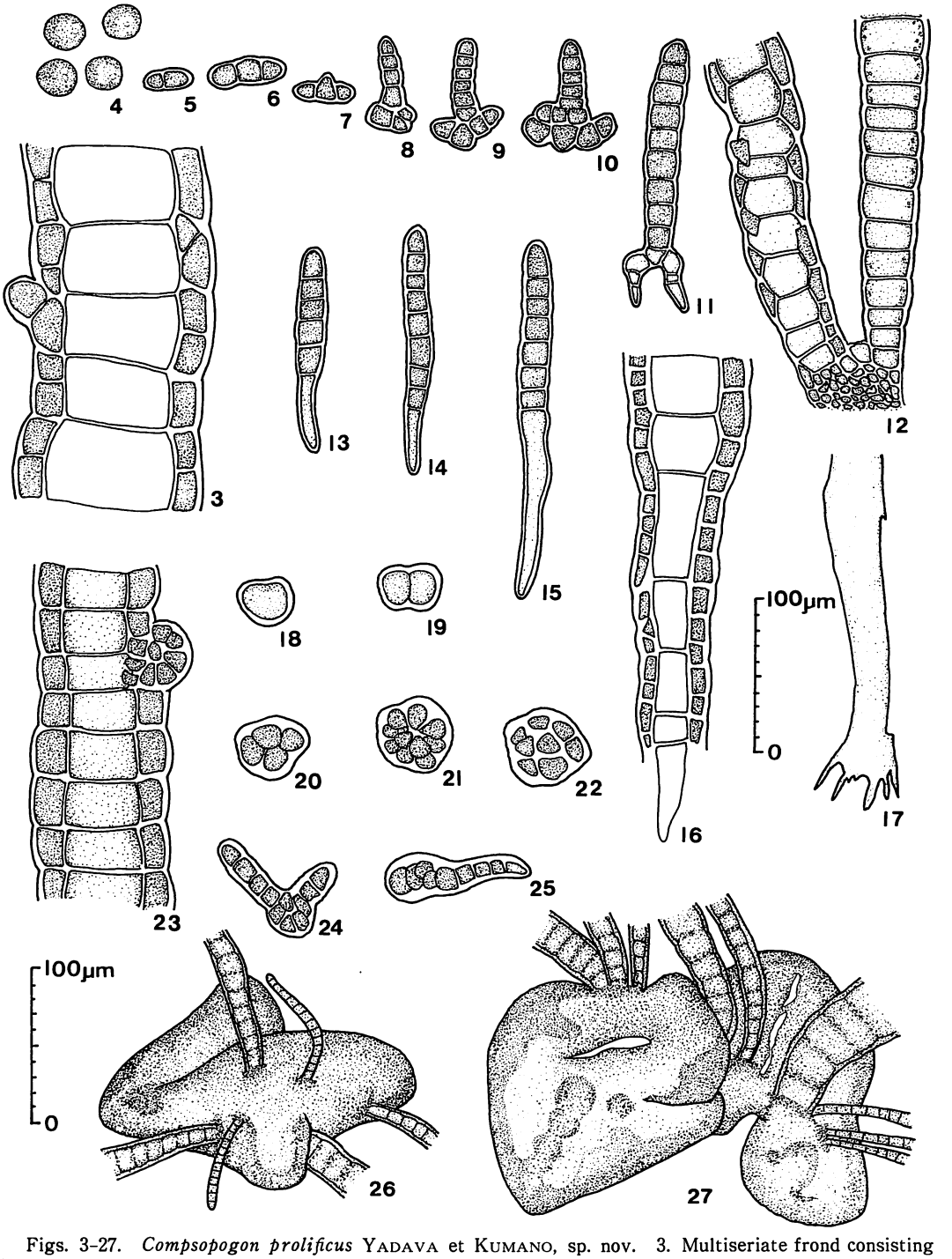
The present alga was first spotted in the middle of May in 1978. The luxuriant growth of fronds is observed in May and June. In natural habitat, the present alga is heterotrichous, consisting of a small prostrate system and a few erect filaments; fronds are up to 0.2 mm wide, 42 cm long, coarsely or profusely branched (Fig. 28). Mature portions of fronds are brittle, nodulated and constricted at irregular intervals (Fig. 30). Profuse branches arise at angle of 30°-70° to the main branch. Apical cells of the main branch have rounded ends. The main branches as well as the mature portions of the multiseriate branches are composed of central cells and cortical cells. The central cells are 10-18 μm wide, 16-30 μm long and single layered, while multilayered in the main branches (Fig. 29).

Reproductive Organs

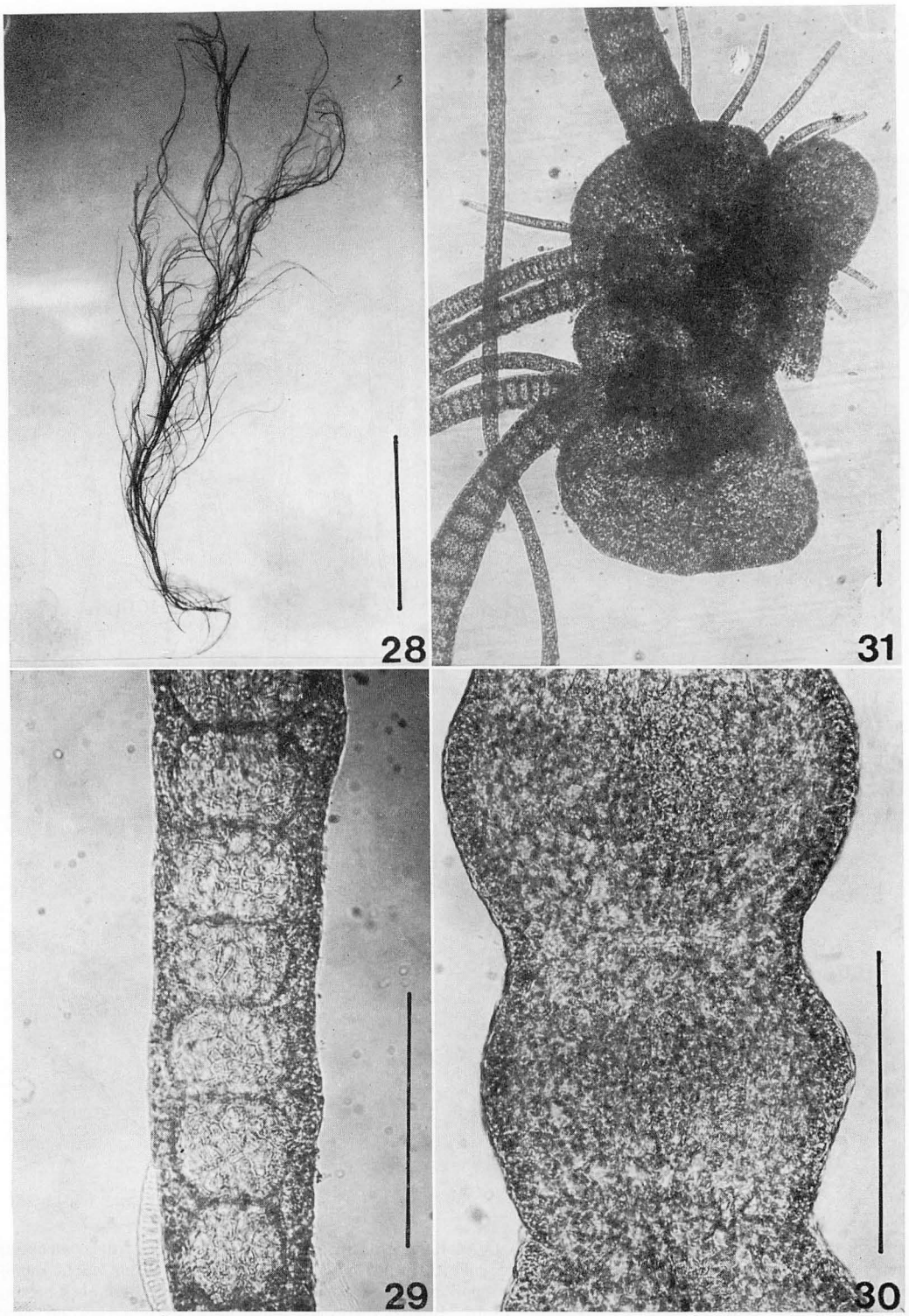
Two types of monosporangia have been described as monosporangia which originate singly and microsporangia formed in group or sorus. These two types of monosporangia are also observed in the present alga.

1. Monosporangia; In natural habitat, monosporangia are frequently observed from May to September. Monosporangia occur both in uniseriate and multiseriate fronds. In uniseriate fronds, an axial cell is divided by an oblique wall resulting in a central cell and a monosporangium; a monosporangium is formed by an unequal division of an axial cell. In multiseriate fronds, a monosporangium is formed by a unequal division of a cortical cell.

Fronds were brought into the laboratory of University of Allahabad, washed and kept in the sterilized tap water, the liberation of a large number of monospores was observed early in the next morning. Liberated mono-



Figs. 3-27. *Compsopogon prolificus* YADAVA et KUMANO, sp. nov. 3. Multiseriate frond consisting of central cells and cortical cells in a single layer; 4. Liberated monospores; 5-11. Germination of monospores on filaments of *Cladophora* sp. forming a small prostrate system; 12. Two erect filaments arising from a small disc type of prostrate system; 13-16. Bipolar type of monospore germination on agar plates; 17. Tubular rhizoids originating from the lowermost segments of the erect filament; 18-23. Microsporangia forming in cortical layer; 24-25. Microspores germination in *situ*. 26-27. Knot-like structures which help in the vegetative propagation.



Figs. 28–31. *Compsopogon prolificus* YADAVA et KUMANO, sp. nov. 28. Habit of whole frond; 29. An erect filament showing central cells and cortical cells of 2–3 layers; 30. Main branch showing nodulation; 31. Knot-like structures of vegetative discs. (Scale: 10 cm for Fig. 28, 100 μm for Figs. 29–31).

spores lie within a mucilaginous mass, they are spherical in shape, range from 16 to 20 μm in diameter and contain a fairly prominent nucleus and several chloroplasts. Among the monospores transferred to agar plates for culture, only those with dense cytoplasmic contents are able to germinate after a week or so, while the rest are regenerated. Monospores are able to germinate epiphytically. The germination of monospores on the filaments of *Cladophora* sp. is observed (Figs. 4-11). The naked monospores (Fig. 1) soon acquire thick hyaline cell walls and elongate on the substratum. The settled monospore is divided unequally by a wall at right angle to the substratum into a smaller cell and a bigger cell (Fig. 5). The bigger cell is divided again into two cells unequally by further transverse wall, resulting in a slightly bigger central cell and two smaller peripheral cells (Fig. 6). The peripheral cells are further divided and resulted into a prostrate system, while the bigger central cell is an initial cell of an erect filament, divided and resulted into an erect filament (Figs 7-11). Apart from this type of development, monospores seem to be able to germinate in a bipolar manner to produce two-celled structure, one of which gives rise to an erect filament, while another elongates to form an unbranched rhizoid (Figs 13-16).

2. Microsporangia: In natural habitat, microsporangia in sorus are observed throughout the year. On a 15-days-old agar plate, the formation of microsporangia was initiated in the cortical cells. An initial of sorus became prominently dark brown, thick-walled and up to about 50 μm in diameter. After about one week, an initial cell of microsporangial sorus was divided vertically. At right angle to the first division, the second division follows to form four cells a few days latter. They were further divided oblique to form a group of microsporangia, which are usually 8 up to 16 and trianglar or polygonal because they are compressed each other (Figs 19-23). After liberation, microspores become globose in shape and up to 10-18 μm in diameter. After about one week since such microsporangia were formed on fronds on agar plates, microspores may germinate in *situ* (Figs 24-25). Among such microspores, a few are able to germinate, while the rest are regenerated. During the early stages in development, microspore is divided transversely to form a small filament composed of a series of discoid cells (Figs. 24-25), developed up to 1.5 cm in length in culture condition. An uniseriate filament consists of a series of axial cells formed by successive transverse divisions of a dome-shaped apical cell. Under cultural conditions several branches are developed by an oblique division of an axial cell prior to the formation of cortical cells. The cortical intials are formed by an oblique longitudinal division of an axial cell, resulting in the formation of peripheral segments, which subsequently transform into a single layer of cortical cells. Further anticlinal and longitudinal divisions take place the formation of 2-3 layers of cortical cells.

Formation of Knot-like Structures (Figs. 26-27, 31):

Mature fronds have commonly twisted or curled portions, which become thicker due to an increase in number of surrounding cortical cells. Fronds become curled and formed a U-shaped structure. After a few days, an arm of the U-shaped frond crosses over another arm to form an α-shaped structre the a knot-like structure, sometimes a double knot is developed. Such knot-like structures slowly grow into large discs, from which a number of small branches or young erect filaments derived from microspores germinating in *situ* are emerged in clusters (Figs 26-27, 31). One to three such discs may occur in a frond, and later they become up to 390-600 μm$\times$930-1,500 μm. These fronds break up at the side portions of such discs, and anchored on the substratum. Thus these discs may serve as accessory organs for the vegetative propagation. In the natural habitat, these discs commonly occur in June, become more frequent in

August and most frequent in September.

Discussions

SHYAM and SARMA (1980) emphasized that among characteristics which they examined the number of erect filaments per prostrate system, the number of cortical layers and the angle between the lateral branches and the main branches were found to be somewhat constant under both natural and culture conditions. In the present study, some of the above-mentiond characteristics are dealt with.

Mature fronds of the present alga are composed of the central cells and the cortical cells of 2-3 layers, this characteristic is reported to be that for *C. coeruleus*, *C. iyergarii* and *C. hookeri*. Branches in the present alga arise at wide range of angles from 30° to 70° to the main branch. It is reported that branches in *C. coeruleus*, *C. oishii* and *C. hookeri* arise at an angle of more than 45° to the main branch, while in *C. aeruginosus*, *C. indicus*, *C. cortinaldi* and *C. iyergarii* branches arise at an angle less than 45° to the main branch.

Monosporangia and microsporangia are observed in the present alga as reported for *C. coeruleus* (THAXTER 1900, KRISHNAMURTHY 1962, NICHOLS 1964), *C. aeruginosus* (PATEL and FRANCIS 1969, NAKAMURA and CHIHARA 1983), *C. aeruginosus* var. *catenatum* (YADAVA and PANDEY 1980), *C. hookeri* (BRÜHL and BISWAS 1923, 1927, NAKAMURA and CHIHARA 1983), *C. iyergarii* (PANDEY *et al.* 1976) and *C. minutus* (SETO and JAO personal communication).

Germination of monospores for the present alga is similar to the process as described for *Compsopogon coeruleus* (NICHOLS 1964), *Compsopogon* sp. (SHYAM and SARMA 1980), *C. corticrassus* (CHIHARA and NAKAMURA 1980) and *Compsopogonopsis japonica* (NAKAMURA and CHIHARA 1977). Bipolar type of monospore germination for the present alga is also found on agar plates. Unfortunately, the subsequent stage in the development of monospores could not be followed in the present cultural study. Besides the disc type of the basal system, the tubular rhizoid type of holdfast originating from the lowermost segment of the erect filament is observed growing on the loose substratum such as the muddy bed in the water channel. From these observations, it is suggested that the present alga exhibits two types of monospore germinations and the basal attachment systems depending on the nature of the substrata. In both types, a single, rarely two, erect filaments seem to arise from the basal system derived from a single monospore. KRISHNAMURTHY (1962) reported that a single erect filament arises from the basal system in *C. hookeri*, however, many erect filaments from the basal system reported by NAKAMURA and CHIHARA (1983). One or more than one erect filaments arise in *C. chalybens*, *C. iyengarii* and *C. cornaldii*. *C. coeruleus* is thought to be similar to *C. hookeri* concerning the basal system, from which a single erect filament arises, however, PANDEY *et al.* (1973) showed more than one erect filaments.

Mature fronds of the present alga commonly possess knot-like structures which slowly grow into large vegetative discs. Fronds soon fall to pieces of such vegetative discs, from which a number of small branches or erect filaments probably derived from the monospores germinating in *situ*. These discs help in the vegetative propagation for the present alga. Such discs have not been reported in any other taxa of the genus *Compsopogon*.

As mentioned above, the present alga could be compared with *C. coeruleus*, *C. iyengarii* and *C. hookeri* in having more than one layers of cortical cells. The present alga also resembles *C. hookeri* and *C. coeruleus* in having one rarely two erect filaments arising from the basal system. However, the present alga differs from *C. coeruleus* in having prominently constricted and curled fronds, and from *C. iyengarii* in the size of fronds and the number of microspores; the microspores for the present alga occur in smaller clusters from 4 to 16, while those for

C. iyengarii appear in larger numbers from 4 to 128. Besides, the present alga differs from the above-mentioned three taxa on having the knot-like structures, which slowly grow into large vegetative discs.

The foregoing considerations and comparisons have shown the present alga to be an undescribed taxon, therefore, the holotype for the present alga is determined and the specific name, *C. prolificus*, is given.

Description of the Species

Compsopogon prolificus YADAVA et KUMANO, sp nov.

Thalli heterotrichi, e systematibus prostratis et filamentis erectis constantes, atrovanenti. Systema prostratum polymorphum, disciforme vel tubuliforme secundum sbst--ratum; 1-2 filamentae erectae e systema prostrato orientes. Filamenta erecta 0.2 mm crassa, 42 cm longa, grosse profuseque ramosa. Rami sub angulo 30-70° axi principali orientes. Cellulae centrales in filamentis maturis 44-50 μm crassae, 58-70 μm longae. Cellulae corticales 6-16 μm crassae, 16-30 μm longae, unistratae in filamentis yuvenibus, tristratae in filamentis maturis. Monosporangia ex cellulis corticalibus per divisiones inaequales producentia; monosporae sphaericae, 15-20 μm diametro. Microsporangia ex cellulis corticalibus producentia, octna sedienaque aggragata; microsporae globosae, 10-18 μm diametro. Structrae gangliiformes in filamentis maturis pro propagationibus vegetativis facientes.

Thalli heterotrichous, consisting of prostrate system and erect filaments, dark blue-green. Prostrate systems polymorphous, disc-shaped and tubular rhizoids depending the substratum; 1-2 erect filaments arising from a prostrate system. Erect filament 0.2 mm wide, 42 cm long, coarsely and profusely branched. Branches arising at angles of 30-70° to main branches. Central cells in mature filaments 44-50 μm wide, 58-70 μm long. Cortical cells 6-16 μm wide, 16-30 μm long, one layered in young filaments, while about three layered in mature ones. Monosporangia produced from cortical cells by unequal divisions; monospores spherical, 15-20 μm in diameter. Microsporangia produced from cortical cells, grouping in 8-16; microspores globose, 10-18 μm in diameter. Knot-like structures in mature filaments produced for vegetative propagation.

Holotype: YADAVA (D. C. P. No. 38), 15/V 1978, Herbarium of Botany Department, Allahabad University, India.

Type Locality: An outlet of a water channel from a tube-well at Allahabad, Uttar Pradesh, India.

Distribution: Known only from the type locality.

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R.N. ヤダバ*・熊野 茂：**
インド，ウタルパラデシユ州，アラハバド産の1新種 *Compsopogon prolificus*（淡水産紅藻，オオイシソウ科）について

東北インドのアラハバドにある井戸からの小流中に産するオオイシソウ属の1新種 *Compsopogon prolificus* が記載された。産地の小流の水温は 16～27°C, pH は 6.5 であった。本種の藻体の長さは 42 cm, 1～3層からなる皮層細胞をもつ。生殖細胞として単胞子と小胞子とが観察された：単胞子は着生基物によって異る発芽形式を示し，小胞子の母藻上での発芽も観察された。栄養繁殖の役目をする結節構造と，それに由来する盤状体の形成が9月に最も多く認められた。本種は1～3層の皮層細胞をもつことで *C. hookeri*, *C. coeruleus* および *C. iyengarii* に似るが，彎曲しくびれの多い藻体をもつ点で *C. coeruleus* と区別でき，*C. iyengarii* とは形成される小胞子の数が異る。その上，栄養繁殖の役目をする盤状体をもつ点で上記の種と区別できる。(*インド ビハル州 バガルプル，バガルプル大学植物学研究科 **657 神戸市灘区六甲台町 1-1 神戸大学理学部生物学教室)