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Distribution of Epiphytic Cyanobacteria on Lichens from Eastern Ghats of Tamil Nadu, India

R. Shyam Kumar[1,3]*, Fahad M.A. Al-Hemaid[1], Naif Abdullah Al-Dhabi[2], C. Muthukumar[1], M. Ajmal Ali[1] and N. Thajuddin[4]

[1]Department of Botany and Microbiology, College of Science, King Saud University, Riyadh - 11451, Saudi Arabia.
[2]Department of Botany and Microbiology, Addiriyah Chair for Environmental Studies, College of Science, King Saud University, P.O. Box 2455, Riyadh 11451, Saudi Arabia
[3]Department of Biotechnology, Kamaraj College of Engineering and Technology, Virudhunagar - 626 001, India.
[4]Department of Microbiology, Bharathidasan University, Trichirapalli - 620 024, India.

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Lichens and cyanobacteria of forest and other environmental conditions often enhance the growth and essential elements uptake to associated herbs and they also enhance the fertility of soil and maintain the nitrogen content. Thus, cyanobacteria and lichens including cyanolichens plays significant role in mineralization, maintenance of soil texture, etc. Hence, the present study focused on the subsistence of epiphytic cyanobacteria on lichens collected from Yerkaud and Kolli Hills region of Eastern Ghats, Tamil Nadu, India. There were 17 genera and 29 species belongs to 6 families of cyanobacteria identified from lichens such as species of *Chroococcus*, *Gloeocapsa, Synechococcus, Microcystis, Aphanocapsa, Dermocarpa, Myxosarcina, Xenococcus, Oscillatoria, Phormidium*, *Lyngbya, Nostoc, Anabaena, Plectnema*, *Scytonema* and *Microchaete*. Among these *Phormidium* and *Chroococcus* species was widely distributed on different lichens as an epiphytic.

Key words: Lichens, cyanobacteria, cyanolichens, epiphytic.

Lichens are complex organisms involved in symbiotic relationship between a phycobiont (Cyanobacteria or Green alga or both) and a mycobiont (a fungus). Lichens have a worldwide distribution, occurring in the highest, hottest, coldest, wettest and driest habitats[1]. The first lichens probably developed around 440 million years ago, and preceded even the first plants[2]. There are number of cyanobacterial species associated with lichen as symbiotic and epiphytic forms. Approximately 10 genera of cyanobacterial (blue–green) phycobionts have been recorded from lichens. There were inadequate studies on epiphytic cyanobacteria of lichens. Cyanobacteria that are originally referred as blue - green algae, a unique group of gram negative, prokaryotic organisms bridging bacteria and algae are very much akin to chloroplast of plants, whose distribution around the world delegated only by bacteria. Particularly, in the last quarter of this century, there has been such an information explosion about these hitherto neglected organisms, that today they seem to be neck to neck with bacteria in biotechnology race, with every promise of over taking them by the turn of the century due to their twin potential of fixing atmospheric carbon and nitrogen[3].

Cyanobacteria are an ancient, morphologically diverse group of prokaryotes with an oxygenic photosynthesis. Many cyanobacteria also possess the ability to fix atmospheric N_2,

* To whom all correspondence should be addressed.
E-mail: kingshyam2003@yhaoo.co.in

although well suited to an independent existence in nature. Some cyanobacteria occur in symbiosis with a wide range of hosts (protists, animals, and plants)[4]. With these N_2 fixing symbiosis involving heterocystous cyanobacteria particularly *Nostoc* as cyanobiont, a given host species associates with only a particular cyanobiont genus and specifically does not extend to the strain level. The cyanobiont is located under micro aerobic environment in a variety of host organs and tissues (bladder, thalli and cephalodia in fungi; cavities in gametophytes of horn worts and liver worts or fronds of the *Azolla* sporophyte, coralloid roots in cycads; stem glands in *Gunnera*). The dualistic nature of the lichen thallus was known for more than 100 years ago. But lichenologists all through the period have concentrated their attention only on the mycobiont, while the algal partner received the least attention. This is especially true of the taxonomic study of lichen phycobionts[5]. At world level, the photobionts have been identified up to species level, only at 2% of known lichens. As for as Indian lichens are concerned photobionts have not been identified up to species level not even in one case[6]. Hence, as part of an ecophysiological study on cyanobacteria and lichens, this work presents some results intending to draw more interest to this group of organisms, their taxonomy and ecology in the tropics.

MATERIALS AND METHODS

Collection of samples

The present study is based on intensive collection of lichens at various altitudes and across the Yerkaud (Shervaroy Hills) and Kolli Hills (Kollimalai). Field trips were made from January 2000 to February 2001 in both areas. On locating lichens, samples were collected in polyethylene bags of appropriate sizes. Crustose, foliose, and fruticose lichens on tree barks (corticolous), rocks, (saxicolous) and on soil (terricolous) were collected along with substratum using sharp knife. Much care was taken to collect the specimen without any damage to the thallus margin. Fruticose lichens were collected with their holdfasts intact on the substratum. The specimens were cleaned by careful removal of debris, sun dried and deposited in the herbaria of Department of Microbiology, Bharathidasan University, Trichirapalli.

Identification of Lichens

A morphological feature was studied using powerful field lenses and trinocular zoom dissection microscope (Meiji optics, Japan). Cross sections were made by the use of sharp knives and microtomes in various planes at a thickness upto 15mm blocks were made using paraffin wax and teased out preparations were also made to examine asci and ascocarp for some samples. K, C, KC and P tests[7] which are important for identification of lichens were made. Micro crystal tests[8] were also carried out for some specific samples. Thin layer chromatography (TLC) analysis was carried out using procedures outlined in Culberson[9] and Culberson and Kristinsson[10]. With the help of data obtained after analyzing the specimens through the methods mentioned above classification was done as per the taxonomic system of Hale[11].

Isolation and identification of epiphytic cyanobacteria from lichen

A section of lichen thallus was rinsed with 5 ml volume of sterile distilled water. The 0.1 ml rinsed water directly placed over BG11 medium containing 1.5% agar[12, 13] and incubated at 20° C under continuous light at 2,000 lux (Osram, universal white, fluorescent light, 40 W). After growth, different colonies of cyanobacteria were grown in fresh BG 11 agar plates and incubated under the same conditions. Colonies of the cyanobacteria were identified using the taxonomic publications of Geitler[14], Desikachary[15] and Starmach[16].

RESULTS

In the present work was an attempt on study of epiphytic cyanobacterial forms in lichens of Yerkaud and Kolli Hills of Eastern Ghats, India located in Tamil Nadu region. There were 11 and 9 collecting sites in Yerkaud and Kolli Hills respectively selected for lichen sample collection and identified with reference to Shyam Kumar et al. [17, 18]. More than six hundred lichens samples were collected from above locations and restricted lichens samples used for isolation of epiphytic cyanobacteria (exclusions of lichens species repetition). Thus, our observations mainly rely on studies of epiphytic cyanobacteria over lichens. The epiphytic cyanobacteria isolates were belong

Table 1. Epiphytic cyanobacterial diversity on lichens from tropical forest of Eastern Ghats

S.No	Name of cyanobacteria	Lichen genus/ species
Family: Chroococcaceae		
1	*Chroococcus minutes* (Kutz.) Näg.	*Leptogium milligranum* Sierk, *Leptogium chloromelum* (Swartz ex Ach.) Nyl., *Phyllopsora parvifolia* (Pers) Mull. Arg., *Phaeographis platycarpa* Mull. Arg.
2	*Chroococcus monotanus* Hansgirg	*Brigantia ionoexipula* (Patw. & Makh.) Awasthi in Awasthi & Srivasthawa
3	*Chroococcus minor* (Kutz.) Näg.	*Cryptothecia subnidulans* (Stirton), *Heterodermia isidiopora* (Vainio) Awas., *Lecanora tropica* (Zaluosh)., *Leptogium chloromelum* (Swartz ex Ach.) Nyl., *Parmotrema. nilgherrense* (Nyl) Hale.
4	*Gloeocapsa crepidinum* Thuret.	*Collema auriforme*(With.) Coppins and J.R. Laundon., *Usnea stigmatoides*G.Awasthi, *Rimelia clavulifera* (Ras.) Kurok.
5	*Gloeocapsa granosa* (Berk.) Kutz.	*Letrouitia domingensis* (Pers.) Haf. & Bellem. *Myriotrema desquamans* (Mull. Arg.) Hale., *Parmeliella wallichiana* (Taylor) Elix & Hale.
6	*Gloeothece* sp.	*Heterodermia cosmosa* (Eschw.) Follm & Redon., *Cryptothecia subnidulans* (Stirton), *Heterodermia speciosa* (Wulfer) Trevisan,
7	*Synechococcus* sp.	*Leptogium milligranum* Sierk, *Parmeliella wallichiana* (Taylor) Elix & Hale., *Usnea orientalis* (Mot.)
8	*Microcystis* sp.	*Rimelia clavulifera* (Ras.) Kurok., *Phyllopsora parvifolia* (Pers) Mull. Arg.,
9	*Aphanocapsa delicatissima* W. et. G.S.West	*Heterodermia diatamata* (Taylor) Awasthi., *Haematomma puniceum* (Sm. Ex. Ach.) Mascal, *Chrysothrix chlorina* (Ach.) Laundan.
10	*Aphanocapsa banaresensis* Bharadwaja	*Cryptothecia subnidulans* (Stirton),
11	*Aphanocapsa elachista* E.et.G.S.West.	*Cryptothecia subnidulans* (Stirton), *Heterodermia hypocasia* (Yasuda) Awasthi., *Heterodermia cosmosa* (Eschw.) Follm & Redon.
12	*Aphanothece microscopica* Näg.	*Graphina sp., Usnea aciculifera* Vainio, *Brigantia ionoexipula* (Patw. & Makh.) Awasthi in Awasthi & Srivasthawa.,
Family: Dermocarpacea		
13	*Dermocarpa* sp.	*Pertusaria concinna* (Erichsan), *Parmotrema. nilgherrense* (Nyl) Hale., *Parmeliella wallichiana* (Taylor) Elix & Hale.
Family: Pleurocapsaceae		
14	*Myxosarcina spectabilis* Geitler	*Pseudocephallaria argyracea* (Bory.) Vainio., *Pyxine cocoes* (Swartz) Nyl.,
15	*Myxosarcina concinna* Printz	*Phyllopsora santensis* (Tuck.) Krog.,
16	*Xenococcus* sp.	*Pseudocephallaria argyracea* (Bory.) Vainio., *Parmotrema andian* (Mull. Arg.) hale.,
Family: Oscillatoriaceae		
17	*Oscillatoria tenuis* Ag. Ex. Gomont.	*Heterodermia Leucomela subsp. Boryi* (Fee) Swinse & Krog., *Caloplaca malaensis* (Rasanen) Awasthi., *Heterodermia dentritica* (Pers.) Poelt, *Usnea aciculifera* Vainio
18	*Phormidium tenue* (Menegh.) Gomont.	*Heterodermia isidiopora* (Vainio) Awas., *Leptogium chloromelum* (Swartz ex Ach.) Nyl., *Lepraria soridiata., Heterodermia angustiloba* (Mull. Arg.) Awas., *Ramalina sinensis* (Jatta)., *Usnea undulata* Stirton., *Usnea orientalis* (Mot.)
19	*Phormidium corium* (Ag.) Gomont.	*Usnea orientalis* (Mot.)., *Graphina* sp., *Rimelia clavulifera* (Ras.) Kurok., *Teloschistes flavicans* (Swartz) Norm.
20	*Lyngbya lutea* (Ag.) Gom.	*Leptogium milligranum* Sierk., *Phyllopsora parvifolia* (Pers)

		Mull. Arg., *Letrouitia domingensis* (Pers.) Haf. & Bellem.
21	*Lyngbya martensiana* Menegh. Ex Gomont.	*Heterodermia speciosa* (Wulfer) Trevisan, *Pyxine cocoes* (Swartz) Nyl., *Cladonia cartilaginea* Mull. Arg. *Dirinaria confluence* (Fr.) Awasthi
22	*Nostoc* sp.3	*Parmotrema nilgherrense* (Nyl.) Hale., *Pseudocephallaria arggraceae* (Bory.) Vainio.
23	*Nostoc* sp.4	*Pseudocephallaria arggraceae* (Bory.) Vainio.,
24	*Nostoc* sp.5	*Parmotrema. nilgherrense* (Nyl) Hale., *Parmeliella wallichiana* (Taylor) Elix & Hale.
25	*Anabaena* sp.	*Rimelia clavulifera* (Ras.) Kurok.,
Family: Scytonemataceae		
26	*Plectonema gracillimum*(Zopf) Hansgrig	*Pseudocephallaria argyracea* (Bory.) Vainio., *Leptogium milligranum* Sierk., *Leptogium chloromelum* (Swartz ex Ach.) Nyl., *Letrouitia domingensis* (Pers.) Haf. & Bellem. *Canoparmelia texana* (Tuck.) Elix & Hale., *Chitodecton leptosporum* (Mull. Arg).
27	*Plectonema* sp.	*Haematomma puniceum* (Sm. Ex. Ach.) Mascal., *Phaeophyscia* sp., *Lecanora* sp., *Usnea undulata* Striton
28	*Scytonema schmidtii* Gom.	*Cryptothecia dispersa* Makh. & Patw., *Heterodermia japonica* (Sato.) Swinsc. & Krog
Family: **Microchaetaceae**		
29	*Microchaete tenera* Thuret ex Born. Et, Flah.	*Parmotrema tinctorum* (Nyl.) Hale., *Parmotrema praesorediosum* (Nyl.) Hale.

to 17 genera of 6 families (Table 1; Figure 1-3). There were about 16 species of cyanobacteria were unicellular remaining species were filamentous. Majority of the species comes under Chroococcacea family. Of these 29 species of epiphytic cyanobacteria, 3 species, *Chroococcus, Nostoc,* and *Plectonema* and 2 species such as *Lyngbya* and *Synechococcus* were considered as predominant and codominant forms on various lichens.

DISCUSSION

According to earlier report of Budel et al.[19], 23 species of cyanobacteria were observed as epilithic community from Inselberg. In their investigation, cyanobacteria were found to be predominant on all rock surfaces as epilithic and endocryptolithic forms. Fritsch[20] also reported that factors responsible for abundance and development for growth and survival were predominantly moisture and optimal temperature. Similarly lichen also provides specific conditions for existence of cyanobacterial species as epiphytes.

Climatic factors were also said to be responsible for the abundance of cyanobacteria on exposed environments. Cyanobacteria attain increased abundance in all climatic regions, which could be positively correlated with rainfall. Even in Antarctica and region, particularly in La Gorce Mountain 6 cyanobacterial species were reported[21]. In desert climate, i.e. in hot arid region, cyanobacterial species contribute significantly in terms of primary productivity and nitrogen fixation[22]. Cyanobacteria were found to favour the harshest sites, while lichens dominated intermediate sites[23]. In most extremely arid desert of the world Atacana and Namib, crusts dominated by cyanobacteria and cryptobiotic crusts were reported[24, 25]. These observations indicate that soil characteristics determine specific groups of cyanobacteria[26]. Cyanobacterial crusts generally dominate poor sandy soil. Lichens increase proportionately with carbonates, gypsum and silt content of the substrate[27]. Although several reports are there on the epiphytic cyanobacteria on rice plants, and other eukaryotic algae[28], there were limited studies reported on epiphytic cyanobacteria on lichens.

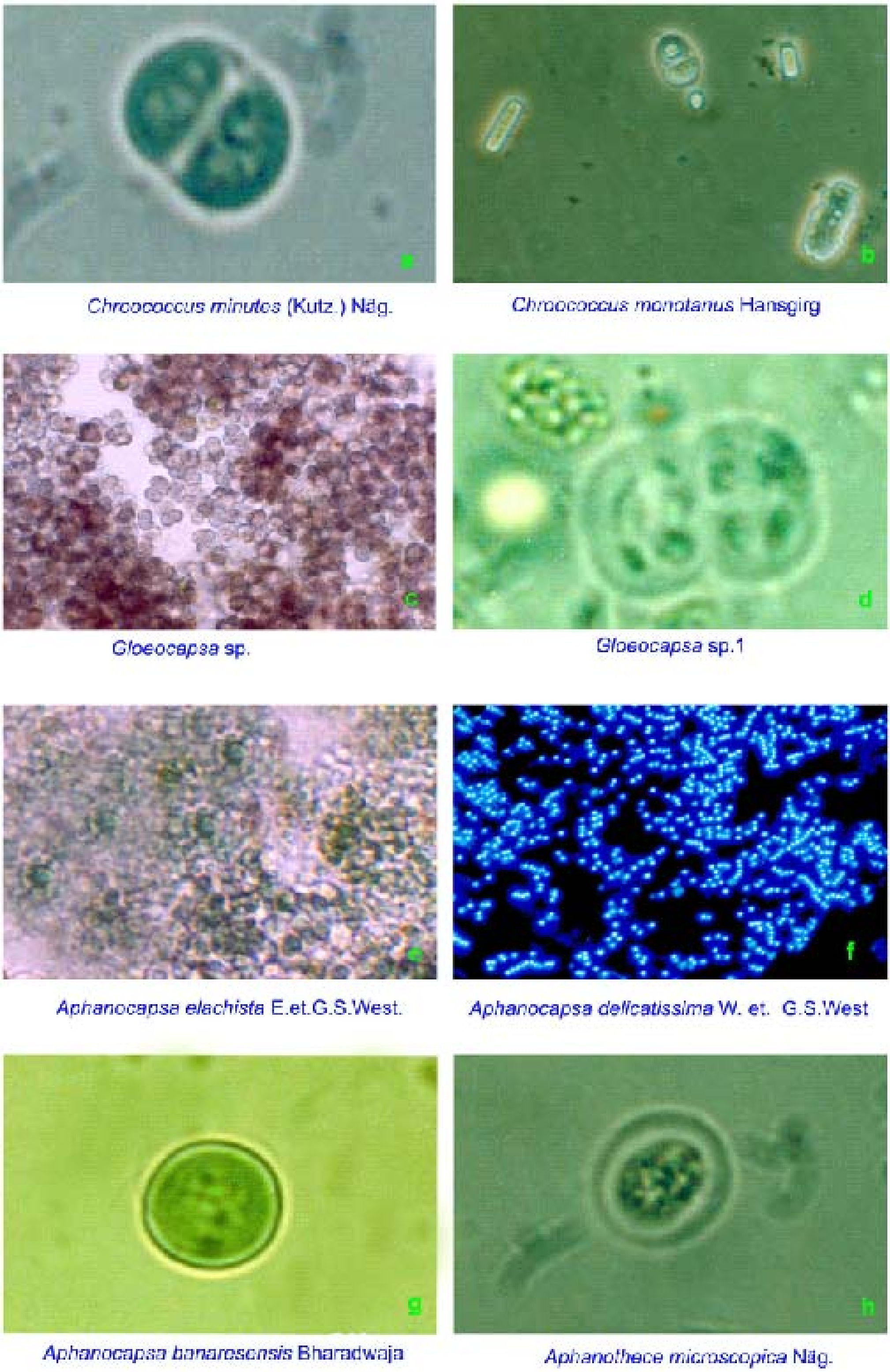

Chroococcus minutes (Kutz.) Näg.
Chroococcus monotanus Hansgirg
Gloeocapsa sp.
Gloeocapsa sp.1
Aphanocapsa elachista E.et.G.S.West.
Aphanocapsa delicatissima W. et. G.S.West
Aphanocapsa banaresensis Bharadwaja
Aphanothece microscopica Näg.

Fig. 1.

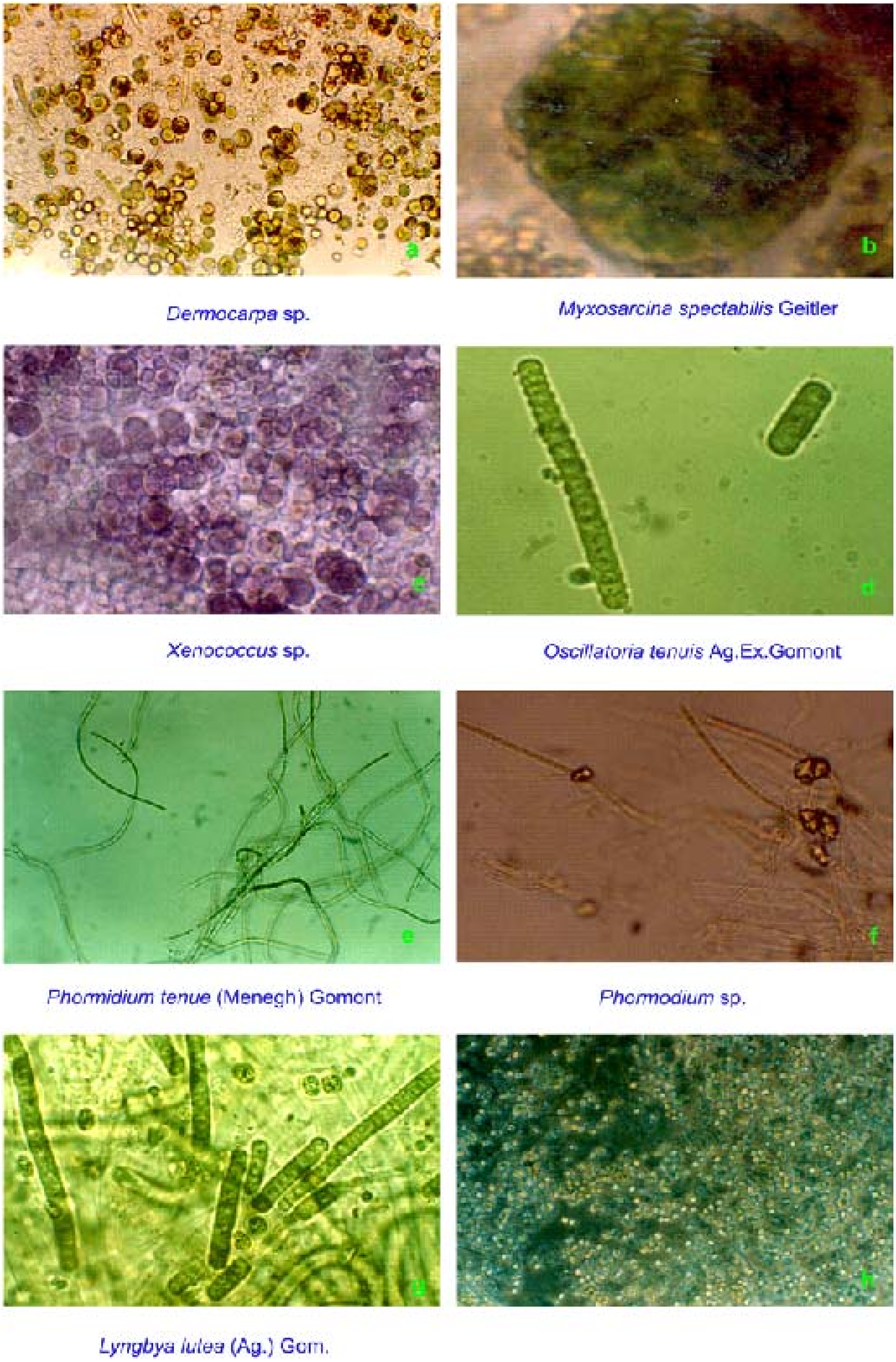
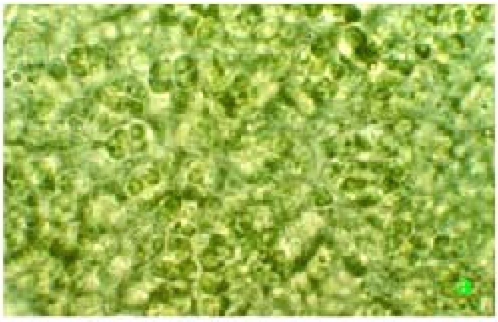
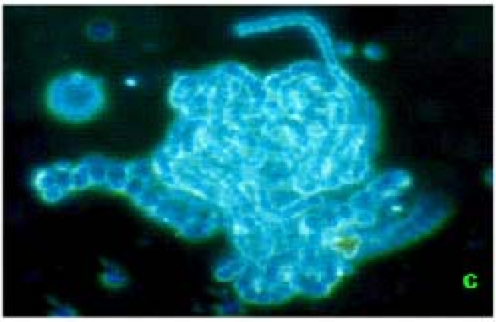

a
b
Dermocarpa sp.
Myxosarcina spectabilis Geitler
c
d
Xenococcus sp.
Oscillatoria tenuis Ag.Ex.Gomont
e
f
Phormidium tenue (Menegh) Gomont
Phormodium sp.
g
h
Lyngbya lutea (Ag.) Gom.

Fig. 2.

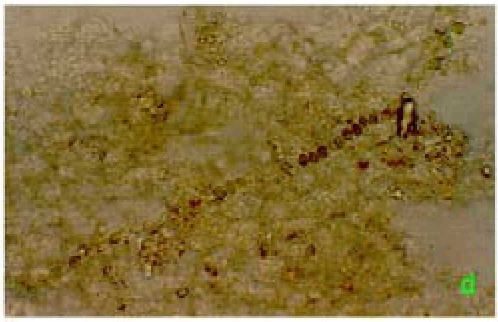


Nostoc sp.2

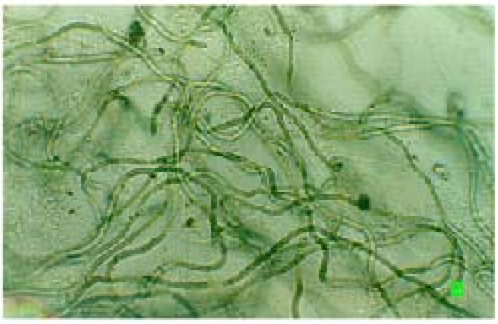
Nostoc sp.3



Nostoc sp.4



Nostoc sp.5



Plectonema gracillimum (Zopf) Hansgrig.

Plectonema sp.

Scytonema schmidtii Gom.

Microchaete tenera Thuret ex Born. Et, Flah.

Fig. 3.

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