Biodiversity of the genus *Lyngbya* (Nostocophyceae, Cyanophyta) in the northern areas of Pakistan

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**ABSTRACT**

Specimens of the blue-green alga, *Lyngbya* C.A. Agardh have been collected from various freshwater habitats in the districts of Gujranwala, Jauharabad, Jhang, Lahore, Pasrur, Sheikhupura and Sialkot in the province of the Punjab, from water bodies at Bahrain and Kalam in N.W.F.P. (Pakistan) as well as from Neelum Valley in Azad Kashmir during December 1996 – July 1999 in different seasons. They were taxonomically investigated and found to belong to 16 species.

**Key Words**: Blue-green algae, taxonomy, morphology, distribution, ecology.

**INTRODUCTION**

*Lyngbya* C.A. Agardh is a commonly occurring blue-green alga (Oscillatoriaceae, Nostocales, Nostocophyceae; *fide* Shameel, 2001) in the marine as well as freshwater habitats. It has been recorded from Indian Ocean but not reported from the coast of Pakistan (Silva *et al*., 1996). There are a few reports of the occurrence of this genus from freshwater habitats of Pakistan (Faridi *et al*., 1981; Jahangir *et al*., 2000, 2001; Leghari *et al*., 2000, 2001, 2002; Mahar *et al*., 2000), but no detailed taxonomic investigation was carried out. A large collection of blue-green algae was made from various districts of the Punjab, certain areas of NWFP and Azad Kashmir (Naz *et al*., 2003) and detailed taxonomic study was carried out (Naz *et al*., 2004a,b). The present work is a continuation of that study, which describes the taxonomy of *Lyngbya* growing in the northern areas of Pakistan.

**MATERIALS AND METHODS**

Collections were made from various freshwater habitats of the districts of Gujranwala, Jauharabad, Jhang, Lahore, Pasrur, Sheikhupura and Sialkot in the province of the Punjab, from water bodies at Bahrain and Kalam in N.W.F.P. (Pakistan) as well as from Neelum Valley in Azad Kashmir during January 1996 – July 1999. The methods used for the collection and studies of the materials were the same as described previously (Naz *et al*., 2004a). The specimens were taxonomically identified with the help of standard literature (Gomont, 1892; Forti, 1907; Tildén, 1910; Frémy, 1929, 1933; Satchell and Gardner, 1930; Geitler, 1932; Feldmann, 1937; Desikachary, 1959; Starmach, 1966; Islam, 1976).

**RESULTS AND DISCUSSION**

On the basis of their morphological and cytological characteristics the following 16 species of *Lyngbya* have been identified and taxonomically described, which were found to grow in the northern regions of Pakistan.

*Lyngbya* C.A. Agardh

Trichomes single or free in a thin or very massive thick, firm sheath; sheaths mostly colourless, seldom coloured, yellow to brown or red, blue to purple red; filaments sometimes spirally coiled or attached at the base or in the middle or the entire filament attached, mostly without such attachment or free-swimming or forming free thallus. It included following species, which may be distinguished as follows:

1. Filaments attached by the base........................................... *L. lachneri* (8)
   Filaments not so attached..................................................... 2
2. Filaments attached by the middle...................................... *L. polysiphoniae* (11)
   Filaments not attached by any regular manner....................... 3
3. Filaments free floating..................................................... 4
   Filaments associated with other algae................................... 5
4. Filaments more than 20 μm broad ........................................... \( L. \) birgei (2)  
Filaments less than 20 μm broad ........................................... \( L. \) hieronymusii (7)
5. Trichomes with coloured sheaths ........................................... 6  
Trichomes with hyaline sheaths ........................................... 7
6. Sheath red ........................................................................... 8  
Sheath yellow to brown ........................................... 9
7. Filaments less than 5 μm broad ........................................... \( L. \) scotti (13)  
Filaments more than 5 μm broad ........................................... 10
8. Trichomes more than 7 μm broad ........................................... \( L. \) ceylanica (3)  
Trichomes less than 7 μm broad ........................................... \( L. \) rubida (12)
9. Trichomes up to 10 μm broad ........................................... 11  
Trichomes more than 10 μm broad ........................................... \( L. \) dendrobia (6)
10. Occurring in salt water ........................................... 12  
Occurring in freshwater ........................................... 13
11. Cross-walls granulated ........................................... \( L. \) connectens (5)  
Cross-walls not granulated ........................................... \( L. \) truncicola (16)
12. Trichomes more than 16 μm broad ........................................... \( L. \) majuscula (10)  
Trichomes less than 16 μm broad ........................................... \( L. \) confervoides (4)
13. Trichomes less than 6 μm broad ........................................... \( L. \) aerugineocoerulea (1)  
Trichomes more than 6 μm broad ........................................... 14
14. Trichomes less than 12 μm broad ........................................... 15  
Trichomes more than 12 μm broad ........................................... \( L. \) taylorii (15)
15. Cells longer than broad ........................................... \( L. \) martensiana (9)  
Cells very short ........................................... \( L. \) stagnina (14)

1. \( L. \) aerugineocoerulea (Kützing) Gomont  
(Gomont, 1892: 146; Forti, 1907: 281; Frémy, 1929: 190; Geitler, 1932: 1062; Desikachary, 1959: 315)

**General characters:** Filaments single or more rarely forming a dark or dull blue-green expanded thallus, flexuous; sheath firm; trichomes 5-7 μm broad without sheath, 6-8 μm broad with sheath, not constricted at the cross walls, sometimes granulated; apex of the tichome broadly rounded; cells 1½ as long as broad, 2-4 μm long, blue-green; end cells conical or broadly rounded, with or without slightly thickened outer membrane (Fig. 1).

**Geographical distribution:** India, Myanmar, Pakistan.

**Locality:** Lahore: Ravi Park.

**Remarks:** It has been collected in massive quantity from the inner walls of the tube-well and around its house during June, 1997. The area around the tube-well house mostly remains wet due to leakage of pipelines, which provides a suitable habitat for blue-green algae to grow. Therefore, in the presence of abundant water and favourable season this species showed massive growth.

2. \( L. \) birgei G.M. Smith  
(Smith, 1916: 482; Geitler, 1932: 1048; Desikachary, 1959: 296)

**General characters:** Filaments straight, 20-24 μm broad; sheath firm, colourless, mostly unlamellated, 4-5 μm thick; trichomes not constricted at the cross walls, 19-24 μm broad; end rounded, not attenuated, not capitate; cells shorter than broad, 2-3 μm long; gas vacuoles present (Fig. 2).

**Geographical distribution:** India: Travancore (Parakutty, 1940), Mumbai (Gonzalves and Joshi, 1946); Pakistan.

**Localities:** Gujranwala District: Chendali Village, Kamokeyl Tehsil.

**Remarks:** The specimens were collected during December 1998, where the pH of water was near about 8, temperature was 25°C and it was raining from time to time. Mostly blue-green algae are found at high temperature but this species occurred at low temperature.
3. *L. ceylanica* Wille
(Wille, 1915: 161; Frémy, 1929: 184; Geitler, 1932: 1054; Desikachary, 1959: 299)

**General characters:** Thallus olive green; filaments 10.0-11.5 \( \mu m \) broad, straight; sheath thin, colourless, when old often red, not coloured violet by chlor-zinc-iodide; trichomes blue-green, unconstriicted at the cross walls, not attenuated at the end, 8-9 \( \mu m \) broad; cross walls not granulated; cells quadrate, end cell rotund, without calyptra (Fig. 3).

**Geographical distribution:** Myanmar: Kaisseraing Island (Ghose, 1927); India: Assam (Biswas, 1932), Benaras (Rao, 1937); Pakistan.

**Locality:** Lahore: Badshahi Mosque.

**Remarks:** The specimens were collected from fountain water in September 1997. During this month temperature remains high and it rains from time to time. This type of environment is favourable for the growth of blue-green algae and therefore, it showed luxuriant growth. Fountains of historical places mostly remain closed and open only on special occasions. So main source of fountain water was rain.

4. *L. confervoides* C.A. Agardh ex Gomont

**General characters:** Thallus caespitose, yellowish brown or dull green; filaments 10-19 \( \mu m \) broad; cells 2-4 \( \mu m \) long; trichomes may or may not be constricted at the cross walls, straight; sheath colourless, lamellated, much projected; cross walls slightly granulated; end cell rounded, calyptra absent, tip conical (Fig. 4).

**Geographical distribution:** India: Krusudai Island (Iyengar and Desikachary, 1944), Chilka (Biswas, 1932), Benaras (Rao, 1937); Pakistan.

**Localities:** Gujranwala District: Nandipur; Jhang District: Trimmu Head Works; NWFP: between Bahrain and Kalam (Swat).

**Remarks:** It has been collected during June as well as December 1996. It occurred in free floating state in running water in low quantity during winter. During summer it was found in stagnant water in large quantity. It appears that low temperature and water stream conditions are not suitable for its growth.

5. *L. connectens* Brühl et Biswas
( Brühl and Biswas, 1923: 4; Geitler, 1932: 1053; Feldmann, 1937: 161; Desikachary, 1959: 308)

**General characters:** Trichomes 12-14 \( \mu m \) broad, not constricted at the cross walls, slightly thickened at the apex; cells 1.5-2.0 \( \mu m \) long, contents granulated (Fig. 5).

**Geographical distribution:** India: Calcutta, Lucknow (Brühl and Biswas, 1923); Pakistan.

**Locality:** Sialkot District: Head Marala.

**Remarks:** The specimens were collected from stagnant water channel during June 1996, where it occurred in large quantity and free floating state. The high rate of its growth was probably due to high temperature and alkaline pH of stagnant water, which constituted a favourable environment.

6. *L. dendrobia* Bruhl et Biswas
( Brühl and Biswas, 1923: 8; Geitler, 1932: 1051; Desikachary, 1959: 302)

**General characters:** Thallus more or less expanded, compact, thin, minutely and densely tomentose; filaments long and flexible, closely interwoven, 13-14 \( \mu m \) thick, 8-10 \( \mu m \) broad; sheath usually thin, 1.0-1.4 \( \mu m \) thick, smooth,
hyaline; scarcely or not at all constricted at cross walls; cells 1.7-2.5 \(\mu\)m broad, 4-7 \(\mu\)m long, brownish in colour, uniformly and densely granular (Fig. 6).

**Geographical distribution:** India: Calcutta, Lucknow and Burdwan (Bruhl and Biswas, 1923); Pakistan.

**Localities:** Lahore: Minar-i-Pakistan; Gujranwala District: Nandipur.

**Remarks:** The collection work was carried out at two different places during June and December 1996. The specimens collected in summer were found in fountain water growing abundantly as compared to those obtained in winter. Slight morphological changes were found within the two collections, because fountain water is more oxygenated than stagnant water.

7. *L. hieronymusii* Lemmermann


**General characters:** Filaments occur singly, free floating, almost straight or slightly bent, 11.5-18.0 \(\mu\)m broad, 4-5 \(\mu\)m long; sheath firm, homogenous, colourless; cells 9-13 \(\mu\)m broad, 2-5 \(\mu\)m long; not constricted at cross walls; septa very thin, granulated with gas vacuoles; end cell semicircular or broadly rounded; sheath much projected (Fig. 7).

**Geographical distribution:** India: Allahabad (Mitra, 1951; Gupta, 1965); Pakistan.

**Localities:** Lahore: Dinanath, Lakhoder; Jauharabad: Saim Nala; Pasrur: Jajupur Village; Jhang: Chund; Sialkot: Head Marala; Gujranwala District: Village Shameer, Nandipur; Sargodha: Near Saim Nala; NWFP: between Bahrain and Kalam.

**Remarks:** The collections have been made from different habitats in different seasons of 1996. The specimens were collected from riverside ponds, stagnant pools, rice fields and slow running water. Its most prominant growth was observed in summer season in free floating state. It appears that this species survives in winter, spring and autumn seasons.

8. *L. lachneri* (Zimmermann) Geitler

(Geitler, 1932: 1037; Desikachary, 1959: 281)

**General characters:** Filaments attached by one end, single, straight, apparently without a sheath but visible under high magnification; trichomes 3.5-4.5 \(\mu\)m broad, constricted at cross walls; cells 4-5 \(\mu\)m long; end cell hemispherical, hormogonia present (Fig. 8).

**Geographical distribution:** India: Travancore (Parukutty, 1940); Pakistan.

**Locality:** Lahore: Government College University Campus.

**Remarks:** The collection was made during July 1997. The specimens were obtained in soil binding habitat in massive quantity. It occurred at the surface as well as at varying depths of the soil, together with other organisms.

9. *L. martensiana* Meneghini ex Gomont


**General characters:** Thallus coespitose, blue-green, filaments long; sheath colourless; trichomes 6-9 \(\mu\)m broad, not constricted at the cross walls; cross walls granulated or not; apices not attenuated; cells 1.5-3.5 \(\mu\)m long, 4.5-5 \(\mu\)m broad; end cell round; without calyptra (Fig. 9).

**Geographical distribution:** Myanmar: Rangoon (Skuja, 1949); India: Assam (Biswas, 1930), Travancore (Parukutty, 1940); Pakistan.
**Locality:** Lahore: Dinanath; Sialkot: Head Marala.

**Remarks:** The specimens were collected from two different rice cultivated areas during July and September 1997. Rice field appears to provide suitable environment for the growth of blue-green algae where large quantity of water is supplied in the field and pH of water remains nearly 8.0 *i.e.* slightly alkaline. That is why this species occurred in massive quantity in free floating state.

10. *L. majuscula* (Dillwyn) Harvey *ex* Gomont


**General characters:** Thallus expanded up to 3 cm long, dull blue-green to brown; filaments straight, 8-11 µm broad; sheath hyaline and delicate, later become firm, yellowish or colourless, lamellated, up to 11 µm thick, outside often rough, not coloured violet by chlor-zinc-iodide; trichomes blue-green, not constricted at the cross walls, not attenuated at the ends, 16-17 µm broad, mostly 20-22 µm broad; cross walls not granulated; end cell round, calyptra absent; cells short, 3-4 µm long (Fig. 10).

**Geographical distribution:** Myanmar; India: Madras; Sri Lanka; Pakistan.

**Localities:** Lahore: Badshahi Mosque; Sheikhupura District: Waghray Village.

**Remarks:** It has been reported for the first time from Pakistan during May 1996. It was collected from fountain of mosque and discharge box of tube-well. Fountain of mosque mostly remains closed and opens occasionally but during rainy season the pool of fountain becomes full of water, so massive growth of cyanophytes usually occurred in fountain pool as compared to discharge box of tube-well. It appears that stagnant pond locality is favourable for its growth.

11. *L. polysiphoniae* Frémy

(Frémy, 1929: 194; Geitler, 1932: 1040; Desikachary, 1959: 287)

**General characters:** Filaments straight, sheath very thin and colourless; trichomes pale blue-green, constricted at the cross walls, about 1.5 µm broad, 1.2 µm long; cross walls visible, not granulated (Fig. 11).

**Geographical distribution:** India, Pakistan.

**Locality:** Sheikhupura District: Aliwala Village.

**Remarks:** The collection was made from rice fields during September 1997. It occurred in massive quantity due to favourable temperature, water pH and locality conditions. It appears that rice field locality is favourable for its growth, where it occurred in vegetative as well as reproductive stages.

12. *L. rubida* Frémy

(Frémy, 1929: 187; Geitler, 1932: 1054; Desikachary, 1959: 298)

**General characters:** Thallus floccose or caespitose; filaments straight, 6-7 µm broad, loosely intricate, brownish purple in colour; sheath about 1 µm broad, firm, unlamellated, colourless; trichomes not constricted at cross walls, 4.0-4.5 µm broad, at the end not attenuate, not capitate; cells 10-21 µm long, 6-8 µm broad; calyptra absent; cell contents non-granulated (Fig. 12).

**Geographical distribution:** India: Allahabad (Mitra, 1951); Pakistan.

**Localities:** Gujranwala: Nandipur; Lahore.

**Remarks:** The collection was made in May and December 1997 from a variety of habitats such as rice fields, canal side ponds, freshwater pools at the right bank of the upper Chenab Canal from Nandipur. The ponds were of somewhat perennial nature and quite large number of hydrophytes and green algae were present in a huge quantity,
and this species occurred among others. When collected from rice fields during summer it was found in large quantity due to favourable temperature, locality and pH of water.

13. *L. scotti* Fritsch
(Fritsch, 1912: 29; Geitler, 1932: 1058; Desikachary, 1959: 310; Starmach, 1966: 242; Anagnostidis and Komárek, 1988: 392)

**General characters:** Trichomes mass forming, straight, slightly tapering towards ends, septa constricted, 1-3 µm broad; sheath thin, hyaline; cells shorter or longer than broad, 1.5-5.5 µm long; end cell conical, not capitate, without calyptra; cell contents greenish, minutely granulated (Fig. 13).

**Geographical distribution:** India: Mumbai (Gonzalves and Gangla, 1949); Pakistan.

**Locality:** Lahore: Punjab University’s old campus.

**Remarks:** The collection work was done during June 1998. It occurred in soil binding habitat in massive quantity, being spread over the soil surface just like sheath. It showed the ability to fix atmospheric nitrogen and, therefore, tends to increase the fertility of soil.

14. *L. stagnina* Kützing
(Geitler, 1932: 1066; Desikachary, 1959: 317; Starmach, 1966: 260)

**General characters:** Filaments dull green, 12-13 µm broad; sheath colourless; trichomes 10-11 µm broad, not constricted at cross walls; contents not granulated; cells 3-4 µm long; end cell broadly rounded, not attenuated (Fig. 14).

**Geographical distribution:** India: Benaras; Pakistan.

**Localities:** Gujranwala District: Nandipur; Azad Kashmir: Neelum Valley.

**Remarks:** The collection was made during February 1997 from Punjab and November 1998 from Azad Kashmir areas. Azad Kashmir consists of mountains and valleys, and in this area winter season is long as compared to the plain areas of the Punjab. So ecological conditions of both the localities are totally different from one other. This species was found in low quantity during winter season as compared to that of spring season. Although blue-green algae occur in summer but can also survive in winter season.

15. *L. taylorii* Drouet et Strickland

**General characters:** Thallus free floating; trichomes unconstricted or slightly constricted at the cross-walls, not attenuated towards the apices, 4.5-5.5 µm broad; sheath thin, colourless, coloured blue by chlor-zinc-iodide; cells as long as broad or shorter, 3.0-4.0 µm long; cell contents granular; end cell broadly convex (Fig. 15).

**Geographical distribution:** North America, Pakistan.

**Locality:** Lahore: Punjab University’s old campus.

**Remarks:** The collection was made during May 1999. It is a soil binding alga and occurs at soil surface. It requires little moisture, nutrients and light for its growth. Such algae have a profound influence on the biology of soil.

16. *L. truncicola* Ghose
(Ghose, 1924: 339; Geitler, 1932: 1054; Desikachary, 1959: 308; Starmach, 1966: 257)

**General characters:** Thallus thin, expanded, blue-green; filaments straight, more or less parallel, 9-16 µm broad, not constricted at the cross walls; sheath hyaline, delicate or firm, yellowish; cell walls not granulated; cells short, 3-6 µm long, cell contents granulated; apical cell rounded, not attenuated, calyptra absent (Fig. 16).
Geographical distribution: India: Benaras (Rao, 1937); Pakistan: Lahore (Ghose, 1924).

Localities: Gujranwala District: Qadyan, Nandipur; Sheikhupura District: Kot Noor Shah Village; Lahore: Mureedke and Narang Mundi.

Remarks: It has been collected from a variety of habitats such as rice fields, stagnant ponds and canal side pools during December 1998 and July 1999. Usually the form, kind and distribution of algae are affected by locality, climate and other ecological factors. This species occurred in stagnant water as well as in free floating state. Due to high temperature and rainfall it was present in massive quantity during summer. But in winter it appeared in low quantity and only in vegetative state, because low temperature is not suitable for its reproduction. It may be concluded that it can survive in winter but occurs in limited quantity as compared to the summer season.

REFERENCES


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