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Microhabitat and morphological variation in fresh water *Blennothrix ganeshii* (Oscillatoriaceae, Cyanophyceae) populations in streams of central Mexico

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With 3 figures and 4 tables in the text

Abstract: Microhabitat was investigated in four populations of *B. ganeshii* in calcareous tropical streams in central Mexico to determine the distributional patterns and some of their controlling factors, as well as morphometric adaptations to varying conditions on scales of a few centimetres. Morphometric variations and their relation to physical variables (current velocity, depth, irradiance, and type of substratum) revealed some characteristics for each population and indicated particular adaptations: current velocity was negatively correlated with filament length, filament diameter and trichome width; irradiance was positively correlated with filament diameter and trichome width, number of false branches in a filament and percent cover; and predominant substratum was positively correlated with filament length and sheath thickness. The information here reported about the ecological distribution of *B. ganeshii* supplements the taxonomic knowledge with data about its environmental requirements, which are important for the taxonomy of the genus. Variations in microhabitat conditions and niche widths are the main contributors to the wide spatial and seasonal distribution of this Oscillatorian in central Mexican streams.

Key words: *Blennothrix,* central Mexico, Cyanobacteria, Cyanophyceae, ionic composition, current velocity, irradiance, microhabitat, morphometric variation, streams.

Introduction

Occurrence of representatives of the Cyanophyceae (Cyanobacteria, Cyanoprokaryota), family Oscillatoriaceae, has been sparsely documented as a component of the macroscopic communities of algae in lotic ecosystems throughout the world (GOLUBIĆ 1967, CANTORAL & ABOAL 2001, MONTEJANO et al. 2000, WHIT-

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TON & POTTS 2000, BRANCO et al. 2001, KOMÁREK et al. 2003). The most recent taxonomic proposal (ANAGNOSTIDIS & KOMÁREK 1988) is based mainly on morphological and cytological characters and emphasizes the importance of incorporating information from different sources (environmental, physiological, etc.) that explain the genetic and phenetic variation of Oscillatoriaceae (KOMÁREK 1994).

Ecological studies of Cyanophyceae have focused on phytoplanktonic communities or those with economic importance, with less emphasis on other groups (WHITTON & POTTS 2000). Studies on the major factors determining the spatial and temporal distribution of Oscillatoriaceae are still scarce. Information on algal ecophysiology, and particularly on freshwater Oscillatoriaceae, is found in BENNETT & BOGORAD 1973, WYMAN & FAY 1986, NECCHI 1992, PINEVICH et al. 1997, YOUNG LEE & YULL RHEE 1999, EHLING-SCHULTZ & SCHERER 1999, COLES & JONES 2000, BRANCO et al. 2001, and KAEBERNICK & ENHILAN 2001. This includes information on the following: the morphological, photosynthetic and physiological (pigment concentration) response to temperature and irradiance changes; growth rate; toxin production; and adaptation against ultraviolet light. Studies of *Blennothrix* have concerned supraspecific characteristics (ANAGNOSTIDIS & KOMÁREK 1988, WATANABE & KOMÁREK 1989, VALADEZ-CRUZ et al. 1996, KOMÁREK 1998, MONTEJANO et al. 2000, CANTORAL & ABOAL 2001), whereas ecological information is still lacking.

The genus *Blennothrix* belongs to the family Oscillatoriaceae, subfamily Oscillatorioidae, with the obligatory presence of sheaths, which contain one or several trichomes, and with "coleodesmioid" false branching. Freshwater members of *Blennothrix* have been recently divided into eight species by some morphological (sheath constriction, trichome color, number of trichomes in a filament, shape of sheath, thallus growth) and morphometric characters (trichome width, filament length, filament diameter, sheath thickness, cellular length) (WATANABE & KOMÁREK 1989, KOMÁREK 1998).

In Mexico, the only described species of genus *Blennothrix* has been *B. ganeshii* (MONTEJANO et al. 2000). It is often a major component of attached lotic communities in submerged (littoral and benthic) habitats. The purpose of this study is to evaluate the influence of physical (current velocity, depth, irradiance and substratum type) and chemical (major ions and nutrients) factors on microhabitat distribution, morphometric adaptations and niche width of *B. ganeshii* populations in four streams of the central region of Mexico.

Materials and methods

Fieldwork was carried out in four first-order calcareous streams in central Mexico (18–22° N, 98–99° W), at altitudes of 120–800 m, with a humid tropical climate (GARCÍA 1973, SPP 1981, 1985, HERNÁNDEZ-CERDA & CARRASCO-ANAYA 2004). Perennial and abundant growths of large mats of *Blennothrix ganeshii* have been frequently found in these habitats (VALADEZ-CRUZ et al. 1996, MONTEJANO et al. 2000). From September 2003 to May 2004, water samples were collected to determine physico-chemical parame-

ters. Water was sampled during the most contrasting periods of the year (dry winter, rainy season and during summer months). Water sample collection and analyses were based on APHA et al. (1995) and ASTM (1989).

Each sampling site consisted of a stream segment of 10 m in length. Observations were realized on natural substratum (clay, gravel, sand, bedrock, boulders and macrophytes). Microhabitat was analyzed by the quadrants technique (KREBS 1989, NECCHI et al. 1995) which evaluates the influence of microhabitat variables (current velocity, depth, subaquatic irradiance, and type of substratum) over the vegetative and reproductive characteristics of the growths. Each sampling unit was a circle of 10 cm radius (area = 314 cm^2). Type and size of sampling units were defined from preliminary tests and from previous research (NECCHI et al. 1995, CARMONA et al. 2005). Sampling size consisted of 10 quadrants, each separated from all others by one meter and its location was determined by a table of random numbers. In each sampling site, 10 quadrants without the algae (designated absence) were also sampled to evaluate differences in microhabitat characteristics in comparison with those with the algae.

The following environmental variables were measured for every transect: temperature, pH and specific conductance with a Conductronic PC-18 conductimeter. Microhabitat variables were measured *in situ* at the center of each sampling unit: current velocity and irradiance were measured as close as possible to the algal growth (2.5–18 cm) using respectively a Swoffer 2100 current velocity meter and a Li-Cor LI-1000 quantum meter with a flat subaquatic sensor of photosynthetically available radiation (PAR).

Algal cover (%) was recorded within each sampling unit by visual estimate (NECCHI 1997) with a 175 cm^2 viewfinder. Fragments of growths were collected and preserved in 3 % formaldehyde for subsequent evaluation in the laboratory. Characters previously considered to be of taxonomic importance at generic and specific levels in relevant studies were measured in each filament (FRÉMY 1930, GEITLER 1932, ANAGNOSTIDIS & KOMÁREK 1988, WATANABE & KOMÁREK 1989, KOMÁREK 1998). Quantitative (diameter and length of filaments, sheath thickness, trichome width, cellular length, number of false branches, number of hormogonia per filament and epiphytic species per filament) morphological measurements were made in 20 filament replicas. The number of replicas was determined by the following equation: $n = (s/E\bar{x})^2$, where s is standard deviation, E is standard error (0.05), and $\bar{x}$ is average (SOUTHWOOD 1978).

For each population, niche width was calculated in order to evaluate the degree of microhabitat specialization, applying Levin's standardized index (KREBS 1989): $B_A = (B-1)(n-1)$, where $B = 1 / \sum (p_{xi})^2$, p_{xi} is relative abundance (cover) of species x at sampling unit i (xi / X), $X = \sum xi$ and n is total sampling number. Values ranged along a scale of 0 to 1.

Differences in chemical composition of the microhabitats of quadrants showing presence or absence of the algae were evaluated within and among populations by Student's *t*-test and Analysis of Variance (ANOVA, one way). Associations of cover (%) and morphometric data with stream variables were tested by Pearson's *r* correlation coefficient. Tests were performed with the STATISTICA v. 3.0 statistical package.

Results

Environmental characteristics and chemical composition of the sampling sites are summarized in Tables 1 and 2.

The four sites with *B. ganeshii* were fresh water, total dissolved solids, TDS, 0.4–2.3 g l^{-1}, neutral to slightly alkaline pH (7.1–7.8), a relatively high water temperature (20.3–29.7 °C), high dissolved oxygen (7.8–8.8 mg l^{-1}), total alkalinity (Talk, 2.6–5.0 meq l^{-1}), and relatively high ionic content (22–48 meq l^{-1}); 674–3000 µS cm^{-1} of specific conductance, K_{25}; and a calcium/sulfate dominance.

Table 1. Climatic and chemical characteristics of the central Mexico sampling sites. Abbreviations: (TDS, Total Dissolved Solids; Sobindex conductivity standarized at 25 °C; DO, dissolved oxygen; DIN, Soluble Inorganic Nitrogen; SRP, Soluble Reactive Phosphorus).

Location and position	Altitude m a. s. l.	Climate	Precipitation [mm year^{-1}]	Temperature [°C]	Total ionic concentration [meq l^{-1}]	Ionic dominance	pH	TDS [g l^{-1}]	K_{25} [µS cm^{-1}]	DO [mg l^{-1}]	DIN [mM l^{-1}]	SRP [mM l^{-1}]
Site 1												
Manantiales	800	A w_0 (w)	800–1000	29.0–29.7	48	SO_4=>HCO_3->CO_3=>Cl^-	7.1–7.7	1.51–1.60	1703–1763	7.8	9968	0.76
18° 55' N		humid		29.3±0.03		Ca^{++}>Mg^{++}>Na^+>K^+	7.4±0.3	1.55±0.06	1727±31	78.±0		
96° 00' W												
Site 2												
Tambaque	150	(A) C (m) (w)	1500	22.5–24.4	30	SO_4=>HCO_3->CO_3=>Cl^-	7.3–7.7	0.46–1.64	674–2360	8.3–8.5	16943	0.34
21° 41' N		humid		23.5±0.9		Ca^{++}>Mg^{++}>Na^+>K^+	7.5±0.2	1.21±0.65	1568±847	8.4±0.1		
99° 02' W												
Site 3												
Micos	120	(A) C (m) (w)	1500	20.3–24.3	22	SO_4=>HCO_3->CO_3=>Cl^-	7.2–7.8	0.49–0.77	704–948	8.4–8.8	12381	0.33
22° 05' N		humid		22.5±2.0		Ca^{++}>Mg^{++}>Na^+>K^+	7.5–0.3	0.66±0.15	844±125	8.6±0.2		
99° 09' W												
Site 4												
Puente de Dios	450	(A) C (m) (w)	1500	23.2–26.5	40	SO_4=>HCO_3->CO_3=>Cl^-	7.6–7.7	0.64–2.32	908–3000	8.2–8.8	11499	0.38
21° 55' N		humid		25.0±1.6		Ca^{++}>Mg^{++}>Na^+>K^+	7.6±0.05	1.51±0.84	1885±1052	8.5±0.4		
99° 24' W												

Table 2. Chemical composition of sampling sites (first row, range; second row, average ± standard deviation).

	Site 1 Manantiales	**Site 2** Tambaque	**Site 3** Micos	**Site 4** Puente de Dios
Total alkalinity [meq l^{-1}]	4.7–5.0 4.8±0.1	3.7–4.4 4.0±0.4	2.6–3.5 3.1±0.5	3.6–4.1 3.8±0.2
Phenolphthalein alk. [meq l^{-1}]	0.5 0.5±0	0.2–3.3 1.2±1.8	0.1–2.9 1.0±1.6	0.2–3.4 1.3±1.8
HCO_3^- [mg l^{-1}]	224–305 274±44	197–245 227±26	150–213 181±31	183–248 209±34
$CO_3^=$ [mg l^{-1}]	31 31±0	11–196 73±106	4–174 63±96	11–203 78±108
Cl^- [mg l^{-1}]	11–13 12±1	1–5 3±2	4–6 5±1	17–46 31±20
$SO_4^=$ [mg l^{-1}]	879–907 892±14	223–806 454±309	261–360 322±53	327–828 654±283
Si-SiO_2 [mg l^{-1}]	23–52 37±14	3–9 5±3	5–9 6±2	7–10 8±1
Total Hardness [mg l^{-1}]	1040–1094 1067±27	380–1089 699±359	398–581 504±95	501–1076 880±328
Ca Hardness [mg l^{-1}]	772–799 788±14	300–836 545±270	310–464 391±77	385–780 625±211
Mg Hardness [mg l^{-1}]	268–299 278±17	87–252 156±85	115–134 122±10	115–351 253±123
Ca^{++} [mg l^{-1}]	309–320 315±5	120–335 218±108	124–186 156±31	154–312 250±84
Mg^{++} [mg l^{-1}]	65–72 67±4	19–61 37±21	21–32 27±5	28–85 61±29
Na^+ [mg l^{-1}]	35–48 43±7	4–14 9±7	9–12 10±2	21–53 37±22
K^+ [mg l^{-1}]	5–6 5±0.5	0–1 0.6±0.5	1–2 1±0.5	2–5 4±1
SRP [mg l^{-1}]	0.010–0.031 0.02±0.01	0.007–0.016 0.01±0.004	0.005–0.014 0.01±0.004	0.007–0.020 0.012±0.007
N-NO_3^- [mg l^{-1}]	0.02–203 135±117	152–344 237±98	139–196 173±30	131–195 161±32
N-NO_2^- [mg l^{-1}]	0.002–0.006 0.004±0.002	0.001–0.002 0.003±0.0005	0.001–0.004 0.002±0.001	0.001–0.002 0.001±0.0005
N-NH_4 [mg l^{-1}]	0.01–0.05 0.02±0.02	0.01–0.04 0.02±0.01	0.02–0.05 0.03±0.01	0.02–0.17 0.07±0.08

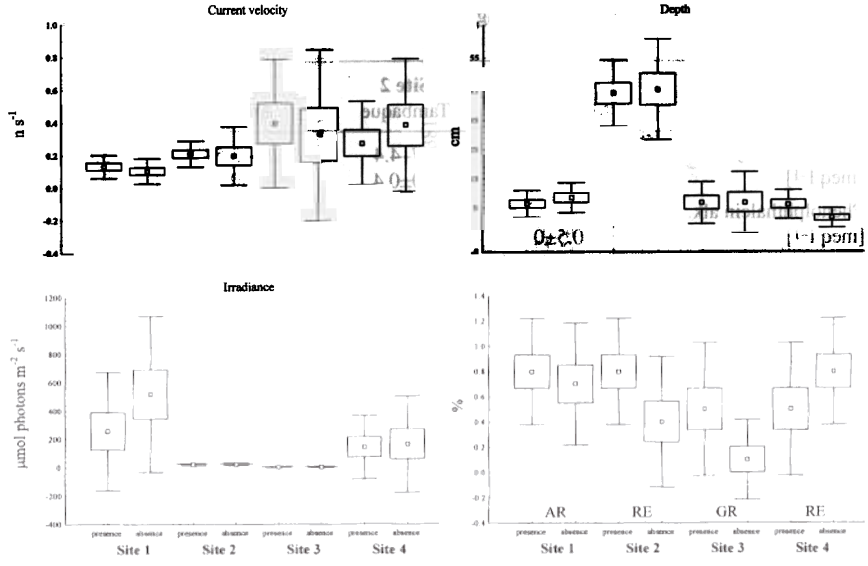

Fig. 1. Current velocity, depth, irradiance and dominant substratum (**CL** = clay, **BD** = bedrock and **GR** = gravel) (mean ± 1 SD) for *Blennothrix ganeshii* populations within quadrants (presence and absence) in the four studied sites. $n = 10$. Site numbers according to Table 1.

Dissolved inorganic nitrogen (DIN) and dissolved reactive phosphorus (SRP) showed a dissimilar behavior: whereas SRP was consistently low, DIN was quite variable, with high values of $N\text{-}NO_3^-$. Because of this, the DIN:SRP ratio always showed a phosphorus limitation (taking into account an equilibrium level, or Redfield ratio) (STEINMAN & MULHOLLAND 1996).

The main physico-chemical characteristics determined in the present study (Table 1) were similar to values of temperature, pH, specific conductance and dissolved oxygen recorded in microhabitat studies conducted earlier (Table 3).

Comparison of characteristics among *B. ganeshii* populations

Within a site, some significant differences were found between quadrants with *B. ganeshii* growth and those without: depth for quadrants of site 4 ($F = 2.2$, $p < 0.05$), irradiance for site 3 ($F = 6.7$, $p < 0.01$), and predominant substratum (clay) for site 1 ($F = 1.0$, $p < 0.01$).

Microhabitat characteristics for sampling quadrants (as explained in methods) with algal presence are summarized in Table 3 and Fig. 1. Current velocity varies significantly between quadrants of site 1 and sites 2 and 3 ($F = 1.2$–31.2, $p < 0.05$), with the lowest values in site 1 (0.03– 0.23 m s^{-1}) and the highest in site 3 (0.07– 1.24 m s^{-1}). Variation in depth was significantly different between quadrants in site 2 and those in sites 1, 3 and 4 ($F = 2.5$–6.0, $p < 0.001$), with the low-

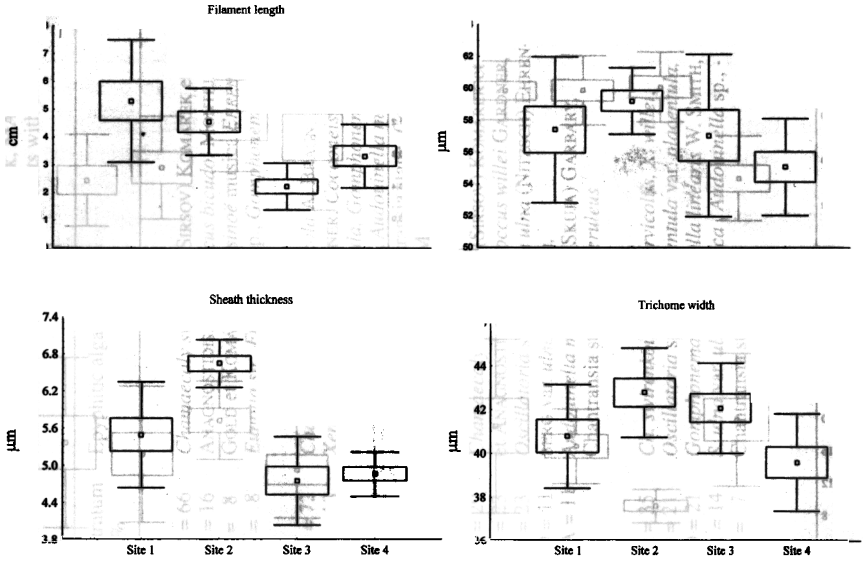

Fig. 2. Filament length and diameter, sheath thickness and trichome width (mean ± SD) for the populations of *Blennothrix ganeshii* in the four studied sites. $n = 20$.

est values in site 4 (1–15 cm) and the highest in site 2 (26–54 cm). Irradiance varied significantly between all sites ($F = 16.3$, $p < 0.001$), with the lowest values in site 3 (0.04–6 µmol photons m^{-2} s^{-1}) and the highest values in site 1 (25–1426 µmol photons m^{-2} s^{-1}). Variations in the predominant substratum were very wide between sampling sites: clay was dominant in quadrants from site 1, boulders those from sites 2 and 4, and gravel in the ones from site 3.

Algal cover (%), morphometric variables and niche width (calculated as proposed in methods) for the four populations are summarized in Table 4, and Figs 2 and 3. ANOVA did not reveal any significant difference in percentage cover between the four populations ($\bar{x} = 20.5$–28.5). Highly significant differences ($F = 1.1$–530.8, $p < 0.05$) were obtained for filament length between all sampling sites, with the lowest values in site 3 ($\bar{x} = 2.2$ cm) and the highest in site 1 ($\bar{x} = 4.7$ cm). There were significant differences between populations of sites 2 and 4 ($F = 2.1$, $p < 0.05$) in filament diameter, with the lowest values in site 4 ($\bar{x} =$ 55.0 µm) and the highest in site 2 ($\bar{x} = 59.2$ µm). Trichome width varied significantly between site 4 and sites 2 and 3 ($F = 1.1$, $p < 0.05$), with the lowest values in site 4 ($\bar{x} = 39.5$ µm) and the highest in site 2 ($\bar{x} = 42.7$ µm). Sheath thickness differed significantly among all sites ($F = 1.2$–5.7, $p < 0.05$), except between populations of sites 3 and 4, with the lowest values in site 3 ($\bar{x} = 4.7$ µm) and the highest values in site 2 ($\bar{x} = 6.6$ µm). Cellular length varied significantly between site 1 and sites 2, 3 and 4 ($F = 1.9$–2.7, $p < 0.05$), with the lowest values in site 1 ($\bar{x} = 3.5$ µm) and the highest in sites 2, 3 and 4 ($\bar{x} = 4.2$ µm). The number of false

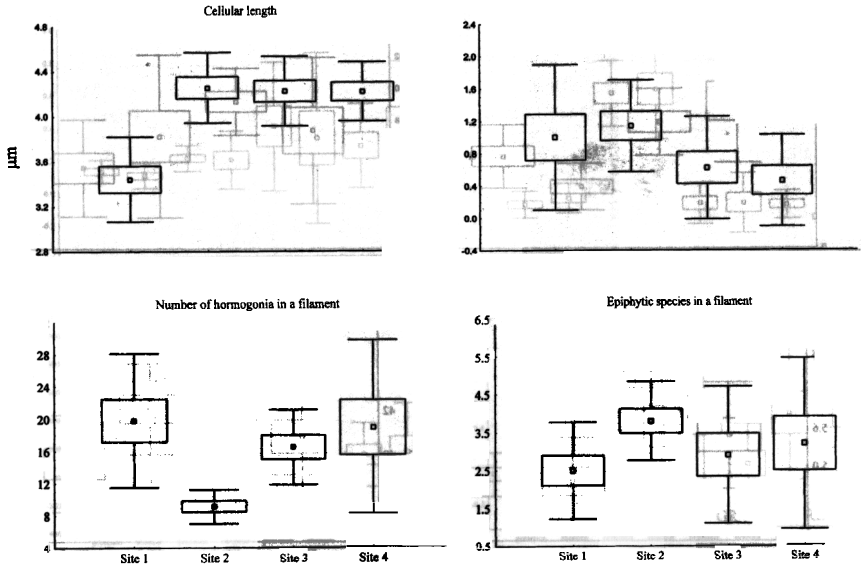

Fig. 3. Cellular length, number of false branches in a filament, number of epiphytic species in a filament and number of hormogonia in a filament for the populations of *Blennothrix ganeshii* in the four studied sites. $n = 20$.

branches per filament differed significantly between populations of sites 2 and 4 ($F = 1.0, p < 0.05$), with the lowest values in site 4 ($\bar{x} = 0.4$) and the highest in site 1 ($\bar{x} = 1.7$). Number of hormogonia in a filament differed significantly between populations from site 2 and sites 1, 3 and 4 ($F = 5.0\text{-}27.3, p < 0.05$), with the lowest values in site 2 ($\bar{x} = 5.1$) and the highest in sites 1, 3 and 4 ($\bar{x} = 15.4\text{–}19.8$). Significant differences were also shown in the number of epiphytic species in a filament between populations of sites 1 and 2 ($F = 1.1, p < 0.05$), with the lowest values in site 1 ($\bar{x} = 2.4$) and the highest values in site 2 ($\bar{x} = 3.9$). Niche width values were relatively high in populations of sites 1 and 2 ($B_A = 0.73\text{–}0.77$), but low in sites 3 and 4 ($B_A = 0.24\text{–}0.39$) (Table 4).

Characteristics of individual populations

Filament diameter and trichome width were positively correlated ($r = 0.83\text{–}0.84$, $p < 0.05$) with irradiance in population of site 1. Sheath thickness was positively correlated with predominant substratum ($r = 0.85, p < 0.05$). The number of false branches per filament was positively correlated ($r = 0.64, p < 0.05$) with irradiance in population of site 2. Filament length, filament diameter and trichome width, were negatively correlated ($r = -0.72\text{–}0.78, p < 0.05$) with current velocity in population of site 4. Irradiance was positively correlated ($r = 0.70\text{–}97, p < 0.05$) with percent cover, filament diameter and trichome width. Predominant substra-

Table 3. Characteristics of the sampling sites of *Blennothrix ganeshii* populations. Abbreviations: **CL** = clay, **GR** = gravel, **SD** = sand, **BD** = bedrock, **MA** = macrophytes, **BO** = boulder. *Values represent minimum, maximum, averages and standard deviation, calculated from measurements taken within quadrants with *B. ganeshii*. n = 10.

Location and sampling dates	T [°C]	K25 [µS cm^{-1}]	pH	Dissolved oxygen	Current velocity*	Depth* [cm]	Irradiance* [µmol m^{-2} s^{-1}]	Substratum %	Epyphitic algae
Site 1									
Manantiales	29.5	1900	7.0	8.1	3–23	5–17	25–1426	CL = 66	*Chamaecaly swirenkoi* (SIRSOV) KOMÁREK et
15.v.01					13±7	10±4	259±419	GR = 16	ANAGNOSTIDIS, *Xenococcus bicudoi* MONTEJANO,
								SD = 8	GOLD et KOMÁREK, *Terpsinoë* musica *EHRENBERG,*
								BD = 8	*Eunotia sp., Fragilaria* sp., *Gomphonema* sp.
Site 2									
Tambaque	22	410	7.2	8.2	3–31	26–54	16–42	BD = 72	*Chamaesiphon confervicola* A. BRAUN,
					21±8	44±10	22±8	GR = 18	*Xenococcus willei* GARDNER, *Cocconeis placentula,*
								SD = 9	EHRENBERG var. *placentula, Gomphonema gracile*
									EHRENBERG, *Eunotia* sp., *Audouinella meiospora*
									(SKUJA) GARBARY, Chantransia stage, *Compsopogon*
									coeruleus (C. AGARDH) MONTAGNE.
Site 3									
Micos	23	545	6.9	8.8	7–124	1–20	0.04–6	GR = 29	*Chamaecalyx swirenkoi* (SIRSOV) KOMÁREK et
					40±39	10±6	3±2	SD = 23	et ANAGNOSTIDIS, *Xenococcus willei* GARDNER,
								CL = 23	*Oscillatoria* sp., *Synedra ulna* (NITZSCH) EHREN-
								BD = 11	BERG var. *ulna, T. musica,*
								MA = 11	*Audouinella meiospora* (SKUJA) GARBARY,
									Chantransia stage, *C. coeruleus*
Site 4									
Puente de Dios	22.5	653	6.8	8.2	1–72	1–15	5–617	BD = 35	*Ch. swirenkoi, Ch. confervicolus, X. willei,*
09.xi.02					28±26	10±4	143±224	SD = 21	*Oscillatoria* sp., *C. placentula* var. *placentula,*
								BO = 21	*Gomphonema* sp., *Surirella linearis* W. SMITH,
								GR = 14	*S. ulna* var. *ulna, T. musica* , *Audouinella* sp., -
								CL = 7	Chantransia stage.

Table 4. Abundance, morphometric variables (range; mean ± SD) and niche width for four populations of *Blennothrix ganeshii* within quadrants in the study sites.

	Site 1 Manantiales	**Site 2** Tambaque	**Site 3** Micos	**Site 4** Puente de Dios
Abundance, cover [%]	5–40 20.5±12.1	5–85 28.5±23.9	1–90 26.2±29.9	1–100 20.7±31.6
Filament length [cm]	2.0–15.0 4.7±1.9	1.3–7.5 4.5±1.2	0.4–4.4 2.2±0.8	1.0–7.5 3.3±1.1
Filament diameter [µm]	41.9–76.0 58.2±3.9	40.7–75.4 59.2±2.0	29.2–83.0 57.0±5.0	44.0–85.7 55.0±3.0
Trichome with [µm]	31.6–51.8 41.1±2.1	34.5–50.0 42.7±2.0	36.0–54.0 42.0±2.0	32.0–48.1 39.5±2.2
Sheath thickness [µm]	2.4–10.0 5.7±0.8	3.7–13.1 6.6±0.3	0.05–14.5 4.7±0.7	1.5–8.0 4.8±0.2
Cellular length [µm]	2.5–6.0 3.5±0.1	2.5–6.2 4.2±0.2	2.0–6.7 4.2±0.3	1.7–6.7 4.2±0.2
Number of false branches in a filament	0–6 1.7±2.9	0–4 1.1±0.5	0–3 0.6±0.6	0–6 0.4±0.5
Number of hormogonia in a filament	4–49 19.8±8.2	2–27 5.1±4.3	0–54 15.4±6.6	0–52 18.9±10.7
Epiphytic species per filament	1–5 2.4±1.2	3–6 3.9±1.1	1–7 2.8±1.7	1–6 3.0±2.2
Niche width (B_A)	0.73	0.77	0.39	0.24

tum was positively correlated ($r = 0.74$, $p < 0.05$) with filament length. Among the morphometric variables, the following correlations were found: filament length was positively correlated ($r = 0.65$–0.72, $p < 0.05$) with number of false branches. Filament diameter was positively correlated ($r = 0.63$–0.95, $p < 0.05$) with percent cover and cellular length. Trichome width was positively correlated ($r = 0.67$–79, $p < 0.05$) with percent cover and cellular length. In all sites there was a positive correlation ($r = 0.63$–0.93, $p < 0.05$) between filament diameter and trichome width.

A high number of epiphytic species was registered in all sampling sites (6–11) with some common species: *Terpsinoë musica*, *Chamaecalyx swirenkoi*, *Xenococcus willei*, "*Chantransia*" stage (3 sites), *Chamaesiphon confervicola*, *Compsopogon coeruleus* (2 sites) (Table 3, Fig. 3).

Discussion

The four studied sites are hard-water, tropical streams with similar macrohabitat (general physical and chemical composition).

B. ganeshii from central Mexico occurred under a wide range of microhabitat conditions: depth (1–54 cm), irradiance (0.04–1426 µmol photons m^{-2} s^{-1}), current velocity (0.03–1.24 m s^{-1}) and type of substratum (clay, gravel, sand,

bedrock, macrophytes and boulders). However, our results suggest that the following combination of microhabitat characteristics were the most favorable for the development of this species in the sampled streams: fresh water with medium to high mineralization, hard water, moderate current velocity, low to medium depth, low irradiance and clay, gravel or bedrock substratum.

Some of the variations in the morphometric characteristics of length and diameter of filaments, trichome width, sheath thickness, number of false branches in a filament and percent cover reported here can probably be viewed as adaptations to distinct microhabitat conditions. The effect of current velocity on morphometric characters (length and diameter of filaments and trichome width) for this study can be summarized as follows: greater dimensions in low to medium current velocity ($\leq$0.31 m s^{-1}) and smaller dimensions in the higher current velocity ($\geq$0.72 cm s^{-1}). Similar trends have been observed in several stream populations of filamentous algae, such as *Phormidium tenue* (MENGHINI) GOMONT (Cyanophyceae), *P. retzii* GOMONT (Cyanophyceae), *Schizothrix fasciculata* (NÄGELI) GOMONT (Cyanophyceae), *Batrachospermum delicatum* (SKUJA) NECCHI et ENTWISLE (Rhodophyceae) (NECCHI 1997), *Stigeoclonium helveticum* VISCHER (Chlorophyceae) (BRANCO & NECCHI 1998), *Composopogon coeruleus* (Rhodophyceae) (NECCHI et al. 1999), *Nitella subglomerata* A. BRAUN (Chlorophyceae) (MCINTIRE 1966, ROTT & PFISTER 1988, BRANCO et al. 2001, VIEIRA & NECCHI 2002). On the other hand, a firm mucilaginous sheath could also reduce the direct flow and the breaking effect, similar to how mucilaginous filaments of Batrachospermaceae (Rhodophyceae) behave in central Mexico (CARMONA et al. 2004).

Blennothrix ganeshii could be regarded as an organism particularly adapted to low light intensity ($\bar{x}$ = 259 µmol photons m^{-2} s^{-1}). WHITTON & POTTS (2000) found that several Oscillatoriaceae were adapted to growth at low light intensities. Riparian vegetation accounts for the low variation in irradiance (0.04–42 µmol photons m^{-2} s^{-1}) registered in sites 2 and 3, and the highly variable irradiance (5–1426 µmol photons m^{-2} s^{-1}) of sites 1 and 4, where a positive correlation was found between higher irradiances and some morphometric characters (such as filament diameter and trichome width) and percent cover. Some endolithic Cyanophyceae mats are capable of avoiding high irradiance levels through the migration of trichomes in or out of the sheath. This mechanism could explain the presence of our populations in sites with a highly variable irradiance. The positive correlation found between predominant substratum (bedrock) and filament length could be explained by filaments capacity to grow on rougher surfaces (limestones) (DUDLEY & D'ANTONIO 1991), as well as the positive correlation between the predominant substratum (clay) and the sheath thickness. *B. ganeshii* populations in central Mexico occur in a variety of substrata, including an ability to grow entangled with other macrophytes.

B. ganeshii is an important component of microbial mats because it can function as substratum for other species of algae. Lack of significant differences between "presence" and "absence" quadrants and the ample niche width (0.24–

0.77) recorded in sampling sites may characterize *B. ganeshii* as a generalist species, similar to other algal species belonging to lotic ecosystems: *Batrachospermum macrosporum* (0.74), *Batrachospermum delicatulum* (0.44–0.64), the *Chantransia* stage of *Batrachospermum* spp. (0.19-0.62) (calculated from data presented by NECCHI 1997), *Stigeoclonium helveticum* (0.65–0.84) (BRANCO & NECCHI 1998), *Compsopogon coeruleus* (0.70–0.83) (NECCHI et al. 1999), *Chara guairensis* (0.60–0.99), *Nitella subglomerata* (0.74–0.89), *Nitella* sp. (0.76) (VIEIRA & NECCHI 2002). The relatively wide variations in microhabitat conditions reported here contribute to the wide distribution of *B. ganeshii* in central Mexican streams, whether spatially (it is a widespread species and is relatively well distributed in single drainage basin streams) as well as seasonally (it can occur throughout the year) (VALADEZ-CRUZ et al. 1996, MONTEJANO et al. 2000, CARMONA et al. 2004). The present information about the ecological distribution of *B. ganeshii* supplements the taxonomic knowledge with data about its environmental requirements, which are very important for the taxonomy of the genus. However we found a wide variation in physico-chemical characteristics of the sites and morphometric characters of the species that need to be further analyzed by means of cultures and physiological studies.

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