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Anabaenopsis morphospecies (Cyanobacteria, Nostocales) from Los Patos shallow lake (Province of Buenos Aires, Argentina)

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Abstract

The genus *Anabaenopsis* comprises about 20 morphospecies distributed in plankton of tropical, subtropical and temperate regions during warm periods. The morphological diversity and population dynamics of *Anabaenopsis* species from one artificial shallow lake from the Province of Buenos Aires, Argentina, was studied during summer 2005 and 2006; and from April 2012 to May 2014. The most common and abundant species were identified as *A. elenkinii* and *A.* cf. *cunningtonii* (first report in Argentina). *Anabaenopsis circularis* and *A. milleri* (first report in the American continent and Argentina) were less common, whereas *A. nadsonii* was rarely observed. Almost all species contributed to algal blooms during warm periods. However, some species were registered even under the lowest temperatures recorded (7.5 °C) and sustained biovolume also during winter (*A. milleri, A. elenkinii* and *A.* cf. *cunningtonii*). These results indicate that some species of the genus are capable of growing at temperatures much lower than 20°C. The species richness noted in this study suggests that there is likely much more diversity remaining on this genus to be reported in Argentina.

Key words: *Anabaenopsis*, Argentine, biodiversity, cyanobacterial blooms, shallow lakes

Introduction

The genus *Anabaenopsis* Miller (1923:125) comprises about 20 planktic filamentous and heterocytous morphospecies, mainly described by Jeeji-Bai *et al.* (1977, 1980); and revised by Komárek (2005). The genus is characterized by the formation of paired intercalar heterocytes, which develop metamerically after the asymmetrical division of neighboring intercalary vegetative cells (Miller, 1923; Hindák, 1988; Komárek, 2010). Trichomes between heterocytes disintegrate later and short trichomes with apical heterocytes arise from this process. Free-floating trichomes grow in irregular or regular spirals or screw-like coils. Akinetes, spherical to elliptical (rarely cylindrical), develop intercalarly (Komárek, 2013).

The genus is mainly distributed in lakes and ponds of tropical, subtropical and temperate regions in warm periods, therefore it has been proposed as more or less thermophilic, inhabiting waters with average temperature over 20–25ºC (Komárek, 2005). The species are frequently found in mesotrophic to eutrophic reservoirs, the majority preferring alkaline saline waters (Ballot *et al.*, 2008; Santos *et al.*, 2011) and some of them develop water blooms (Lanaras & Cook, 1994; Santos *et al.*, 2011). Although *Anabaenopsis* is a phenotypically distinct and clearly definable genus, also supported by phylogenetic analyses (Iteman *et al.*, 2002; Ballot *et al.*, 2008), some species are often difficult to identify given the morphological intraspecific variation and the existence of transitional forms (Komárek & Mareš, 2012). The determination of stable morphotypes is essential for progress in the study of natural cyanobacterial diversity. Thus, the aim of our study was to analyze natural populations of *Anabaenopsis* from temperate water bodies to contribute to the taxonomic knowledge, ecology, and geographic distribution of the genus.

In Argentina, only few species of *Anabaenopsis* have been reported in rivers and shallow lakes located in subtropical and temperate zones, sometimes forming blooms (Izaguirre & Vinocur, 1994; Gabellone *et al.*, 2001; O'Farrell *et al.*, 2015). During our studies of planktic cyanobacteria in artificial shallow lakes from the Buenos Aires province, numerous populations of *Anabaenopsis* were collected, clearly belonging to different taxonomic types. Five taxa were identified. Among them, *A. milleri* is first reported for America, and. *A.* cf. *cunningtonii* for Argentina.

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Material and methods

The studied populations were obtained from Los Patos shallow lake, located in Ensenada city, Province of Buenos Aires, Argentina (34°50'44'' S, 57°57'26'' W) (Fig. 1). The region is under temperate humid climate, with an annual average temperature of 16°C and mean annual rainfall of 1000 mm (Martínez *et al.*, 2006). Los Patos shallow lake is a small (surface area 2.5 ha, maximum depth 1 m), alkaline and hypertrophic freshwater body, with dense phytoplankton dominated by filamentous cyanobacteria. The water body is used for recreational activities and fishing (Werner *et al.*, 2012; Bauzá *et al.*, 2014).

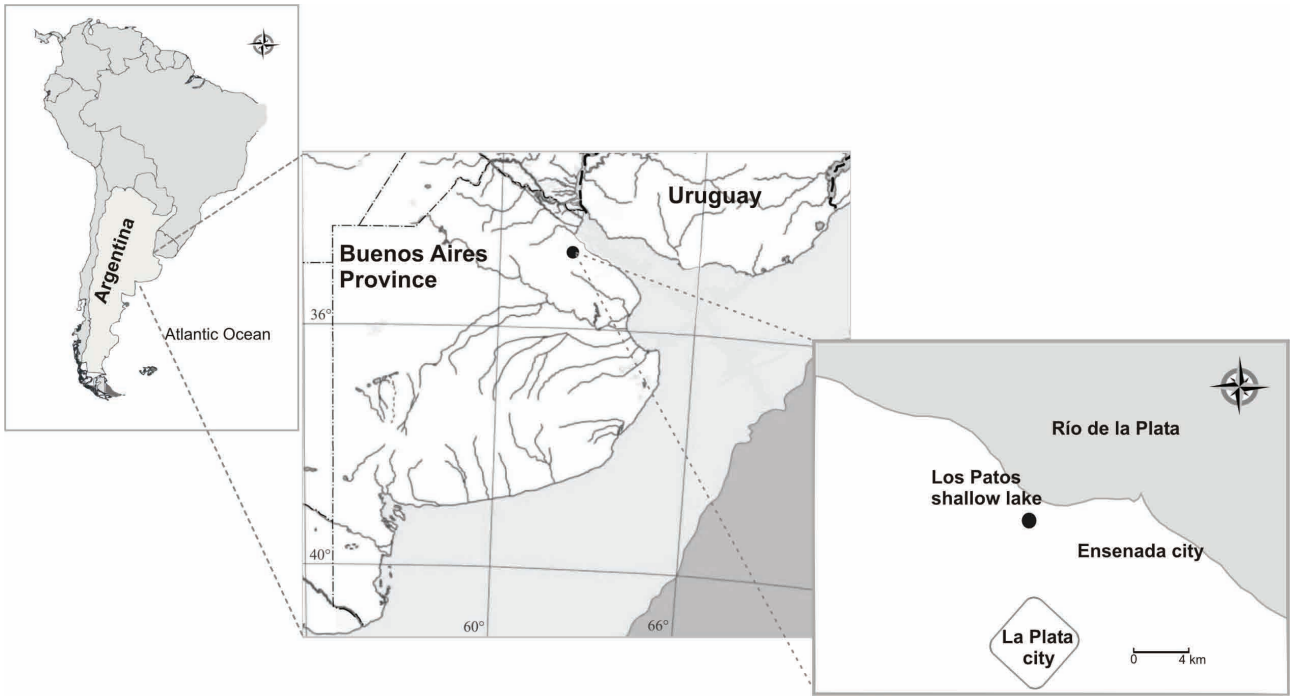

FIGURE 1: Map of the Province of Buenos Aires (Argentina) and location of Los Patos shallow lake.

Qualitative samples were collected fortnightly in summer of 2005 and 2006, and through the whole year for two years (2012 to 2014), using plankton nets (mesh 30 µm) and preserved with Transeau solution (1:1). Samples were deposited in Herbarium of the División Ficología "Dr. Sebastián A. Guarrera", Facultad de Ciencias Naturales y Museo de La Plata (UNLP, Argentina), with the acronym LPC.

Quantitative sampling was performed fortnightly for two years (April 2012–May2014). Samples were taken 40 cm below the water surface using a van Dorn bottle and preserved in Lugol's iodine solution (1%). Surface water temperature, pH and conductivity were measured "in situ" using portable pH and conductivity meters (Parsec). The morphological and metric (n = 60 when possible) characterization of the material from field were done under light microscope (WILD M20 and NIKON eclipse E600). The specimens were drawn with the aid of a camera Lucida and photos were taken using a digital camera (NIKON E995). Olympus CellSence 1.6 software was used for image analysis. The Hoffmann *et al.*, (2005) classification system and taxonomic reviews of Komárek (2005, 2013) were adopted.

Phytoplankton quantifications were done with an inverted microscope (Carl Zeiss AXIOVERT 40C) following the Utermöhl method (1958). Individual biovolume was calculated by measuring 30 individuals of each species, following volumetric formulae (Hillebrand *et al.*, 1999). Biovolume was calculated by multiplying abundance per individual biovolume and expressed as mm^3L^{-1}.

Measured morphological parameters were compared with Kruskal-Wallis H test (one-way ANOVA on ranks) in SigmaPlot version 11.0. Box plots were plotted to visualize the distribution of morphological variables. The relationship between the physical-chemical parameters and the biovolume of *Anabaenopsis* species was analyzed using Spearman's correlation.

Results

Table 1 presents the mean and range of limnological variables recorded during this study.
On the basis of morphological features, five species of the genus *Anabaenopsis* were found in Los Patos shallow lake. The statistical data of the measurements are shown in Table 2.

TABLE 1. Mean, range, standard deviation and coefficient of variation (%) of water temperature (T), conductivity (C) and pH in Los Patos shallow lake (Ensenada, Argentina) during the period of study (Summer 2005–2006; April 2012–March 2014)

Variable	Mean	Min	Max	SD	CV (%)	n
T (°C)	20.58	7.50	31.85	6.37	30.94	49
C (µS/cm)	514.74	328.50	800.00	133.84	26.00	49
pH	9.84	6.55	10.80	1.12	11.39	48

Determination key of species:

1a- Trichomes mainly straight or slightly curved ..... *A.* cf. *cunningtonii*
1b- Trichomes mainly coiled 2
2a- Doliiform or barrel-shaped cells 3
3a- Trichomes rarely up to 6 cells ..... *A. nadsonii*
3b- Trichomes usually with more than 4 cells ..... *A. milleri*
2b- Cells cylindrical 4
4a- Cells slightly arcuated ..... *A. circularis*
4b- Cells long ellipsoid ..... *A. elenkinii*

Anabaenopsis cf. *cunningtonii* Taylor (1932:457,461) (Fig.2)

Trichomes solitary, straight or slightly curved, 48–171 µm long, without mucilaginous sheaths. Cells cylindrical, 4.1–12.3 × 3.1–6 µm, slightly granulated, usually without visible aerotopes. Heterocytes mainly spherical, rarely oval, 4.6 µm in average diameter. Trichomes with one heterocyte at both ends predominated. Trichomes with only one terminal heterocyte also observed. Akinetes mainly long cylindrical to oval, 6–12.7 × 5.7–10 µm, solitary and distant from the heterocytes.

Samples examined:—Argentina. Buenos Aires: Los Patos shallow lake, 20 December 2005, *R.O. Echenique* (LPC 7304); Los Patos shallow lake, 27 December 2012, 30 April 2013, 14 May 2013, 30 July 2013, *R.O. Echenique* and *A. Aguilera* (LPC 7310, LPC 7314, LPC 7315, LPC 7317).

Ecology:—*Anabaenopsis* cf. *cunningtonii* was found in almost all the samples, being a component of mixed cyanobacterial blooms. The populations were present with high biovolume in summer–autumn and continued till early winter 2013 (water temperature, 11 °C). During late winter 2012 and 2013 the population was still noticeable, albeit in low concentration (Fig. 3). Four peaks were observed in January– May 2014, in alkaline conditions, with a pH between 8 and 9. Conductivity fluctuations (328.5–800 µS/cm) were negatively correlated with the species biovolume ($r = -0.588$, $n = 34$, $p < 0.01$). Heterocytes were always present and akinetes appeared in summers of the years 2005, 2012 and 2013 (water temperature 25–31°C and pH 8.3–10.45).

Notes:—*Anabaenopsis* cf. *cunningtonii* populations from Los Patos shallow lake present several distinct differences from other described populations. The cells are shorter, wider and more barrel-shaped than those described originally for the species by Taylor (1932), and much longer and wider than the cells of *A. cunningtonii* from Brazil (Santos & Sant'Anna, 2010). The width of trichomes (up to 6 µm) is distinctly wider than in previously described populations (Table 2). However, the main difference resides in the akinetes. According to previous descriptions of *A. cunningtonii* populations (Komárek, 2013; 2005), akinetes are cylindrical and, only rarely, slightly oval. Populations from Los Patos shallow lake present oval to widely oval akinetes. Furthermore, spherical akinetes in pairs (5.7–8 µm diameter), which have not been reported before, were also observed, though not often (Fig 2 D). Taken together, all these differences could indicate that Argentinean populations represent a different genotype. Further molecular studies should be carried out to certainly determine if the morphological separation found in our study is also supported by molecular data.

TABLE 2. Morphometric characteristics of natural populations of *Anabaenopsis* species from Los Patos shallow lake (Ensenada, Argentina), in comparison with those given in the literature. Numbers are minimum-maximum values (means ± sd). L, cell length; W, cell width.

	Cell (µm)			Heterocyte (µm)		Akinete (µm)	
	Width	Length	Ratio L/W	Width	Length	Width	Length
1.- *A. cunningtonii*							
Taylor, 1932	2.2–3.8	11.1–16.4		4.7–6.6	6.6–10.3		
Komárek, 2005; 2013	2–3.8(4.5)	6.6–16.4		(3.3) 4.7–6.6	(3.3)6.6–10.3(15)	3–4	6–10
Santos & Sant'Anna, 2010	2.3–3.2	1.9–4.2		2.1–2.5			
This study	**3.1–6 (4.3± 0.5)**	**4.1–12.3 (7.3± 1.6)**	**0.79–4.35 (1.69±0.5)**	**2.5–6 (4.56±0.6)**		**5.7–10 (7.7± 1.3)**	**6–12.7 (9± 2)**
2.- *A. elenkinii*							
Guarrera *et al.*, 1972	3.2–4.7	6–11.5		3.2–5		5.7–6.7	9–10
Jeeji–Bai *et al.,* 1980		4.6–5.7		4.6–6.7		8.3–10.7	9.3–12
Santos & Sant'Anna, 2010	3–6	4.7–9		3–5		6.4–8	8–9
Komárek, 2005; 2013	(2.8)4–6(8)	(3)4–9 (12.9)		(2.8)3–7(10)		(5.5)8–10.7(13.7)	(8.1)9.3–15(16.8)
This study	**3.6–6.7 (4.6±0.8)**	**5.0–11 (7.3±1.8)**	**1–2.7 (1.6±0.4)**	**2.9–6.4 (4.1±0.8)**		**4.6–8.1 (6.6±1.7)**	**5.7–11.8 (9.3±2.8)**
3.- *A. circularis*							
Hindák, 1988	(2)–2.5–3.5	4–10(15)		3–4(5)		4–7	7–12
Komárek, 2005; 2013	(2)4–6.5(8?)	4–10.6(15?)		(3?)3.5–7.5(8)	5–8.4	4–7	7–12
This study	**2.5– 6.4 (3.9± 0.64)**	**5.0–13 (7.5± 1.5)**	**1.1–4 (1.9±0.5)**	**2.8– 5.8 (4± 0.6)**		**5.3–8 (6.6± 0.7)**	**9.1–15.5 (11.1± 1.5)**
4.- *A. milleri*							
Komárek, 2005; 2013	(3) 4– 8 (11)	4.6–8.8 (9.9)		(3)4–8 (11)	(3)4.8–8	(5?)8–12(15)	(5?)6–9.6(12)
This study	**3.6– 8 (5.7± 1.1)**	**3.7–10.9 (7.1± 1.7)**	**0.8–2.3 (0.3±1.26)**	**2.4–5.7 (4.2± 0.8)**		**5–9.8 (7.1± 1.5)**	**8.2–12.7 (10.1± 1.1)**
5.-*A. nadsonii*							
Guarrera *et al.*, 1972	5.2	4–5.2		5.2	3.9–4.5		
Jeeji–Bai *et al.*, 1980	4.8	4.8–6.4		3.2–4.7		6.4	8
Komárek, 2005; 2013	3–4.8(5.2)	(3)4.8–6.4(13.2?)		(3)3.2–4.7(5.2)		4.5–8.3(9)	5.4–11(14)
This study	**3.2–5.2 (4.3± 0.6)**	**4.1–6.2 (5.4±0.6)**	**0.89–1.6 (1.3±0.2)**	**3.5–4 (3.7± 0.2)**		**5.2–8.8 (7.1± 1.8)**	**7.9–12 (10.1±2.1)**

Anabaenopsis cunningtonii has been reported in large lakes and reservoirs from the Caspian Sea, Chad, Cuba, Greece, India, Kenya, Sudan, Tanzania, Uganda, Zaire (Komárek, 2013) and Brazil (Santos & Sant' Anna, 2010). This is the first report of *Anabaenopsis* cf. *cunningtonii* in Argentina.

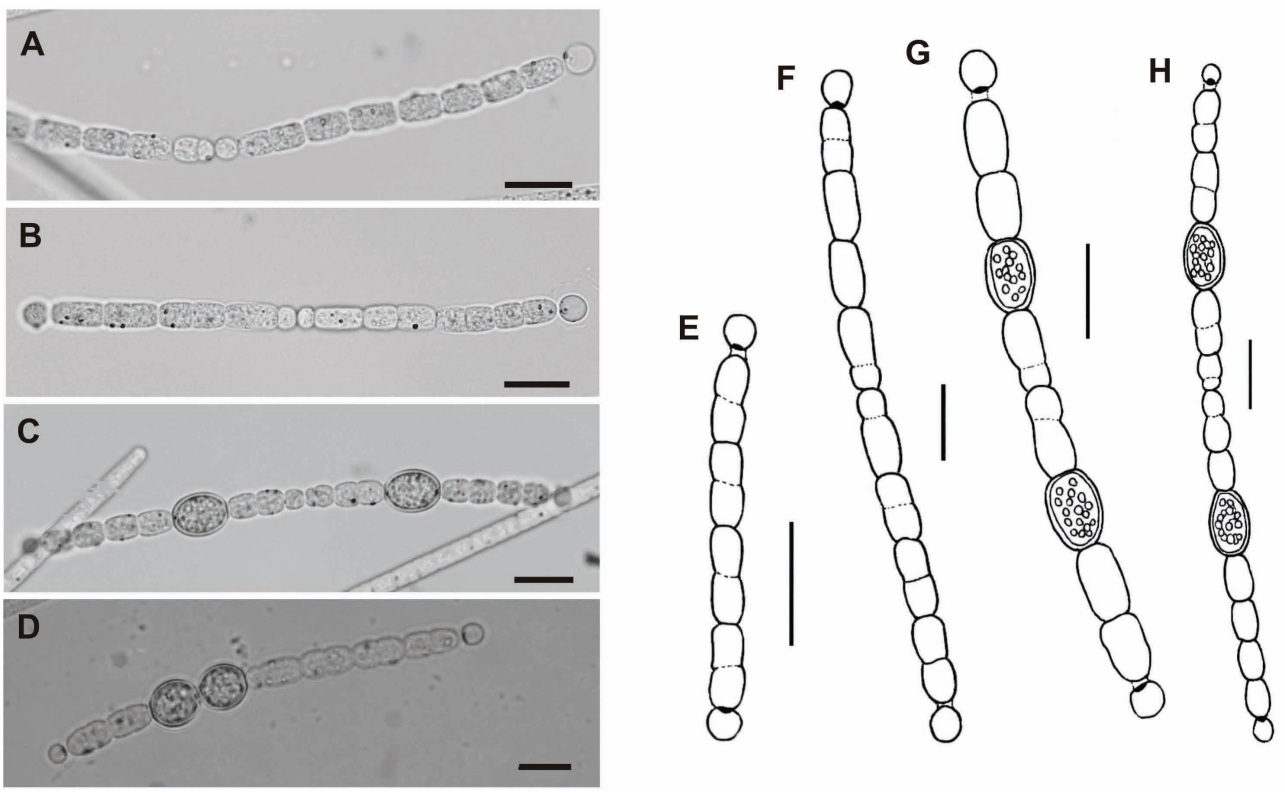

FIGURE 2 A–H: Morphology of *Anabaenopsis* cf. *cunningtonii*. A–B: Details of heterocyte differentiation. C: Cylindrical to oval akinetes. D: Spherical akinetes. E–H: Main trichome with heterocytes and akinetes. Scale: 10 µm.

Anabaenopsis elenkinii Miller (1923: 125) (Fig. 4 A–E)

Trichomes free floating, loosely spirally coiled, short, with no more than 2 coils. Cells cylindrical to long ellipsoid, 5–11 × 3.6–6.7 µm, with rounded ends and compressed at plane of contact with the contiguous cell, with aerotopes. Heterocytes spherical, 2.9–6.4 µm in diameter. Akinetes oval to ellipsoid, 5.7–11.8 × 4.6–8 µm, solitary and distant from the heterocytes.

Samples examined:—Argentina. Buenos Aires: Los Patos shallow lake, 20 December 2005, *R.O. Echenique* (LPC 7304); Los Patos shallow lake, 27 December 2012, 27 February 2013, 13 March 2013, 30 April 2013, 14 May 2013, 30 July 2013, 7 May 2014, *R.O. Echenique* and *A. Aguilera* (LPC 7310, LPC 7312, LPC 7313, LPC 7314, LPC 7315, LPC 7317, LPC 7322).

Ecology:—*Anabaenopsis elenkinii* formed blooms with other filamentous cyanobacteria in summer–autumn 2012–2013, decreasing progressively the biovolume over time, till reaching the lowest densities in winter. The morphospecies was observed even in July 2012 when the lowest water temperature of the whole sample period was recorded (7.5 °C) (Fig. 3). Biovolume was positively and significantly correlated with water temperature ($r = 0.448$, $n= 34$, $p < 0.005$); the highest values (4.6–10.2 mm^3L^{-1}) were observed in summer 2013 under pH 9.15–9.96. Akinetes appeared in summer and winter of 2012 (water temperature 13–31 °C, pH 7.6– 9.15).

Notes:—Populations from Los Patos shallow lake correspond to previous descriptions of *A. elenkinii* (Table 1). The variability found was considered as part of the natural variability of this species (Santos & Sant Anna, 2010; Komárek, 2013). *Anabaenopsis elenkinii* inhabits mainly tropical an subtropical regions, although the species has been also found in warmer areas of temperate zones. In the American continent, the species is frequently found in the phytoplankton communities of Mexican and Brazilian saline alkaline lakes (Ballot *et al.*, 2008; Santos *et al.*, 2011), and artificial eutrophic lakes of Uruguay and Colombia (Ramírez, 1994; UNESCO, 2009). In Argentina, *A. elenkinii* has been found in temperate and alkaline (pH ≥ 8) water bodies from Buenos Aires province, in many cases forming blooms in mid-spring and summer (Guarrera *et al.*, 1972; Izaguirre *et al.*, 2015; O'Farrell *et al.*, 2015). Coincidentally, this species formed blooms in Los Patos shallow lake during warm periods and alkaline conditions (Fig. 3).

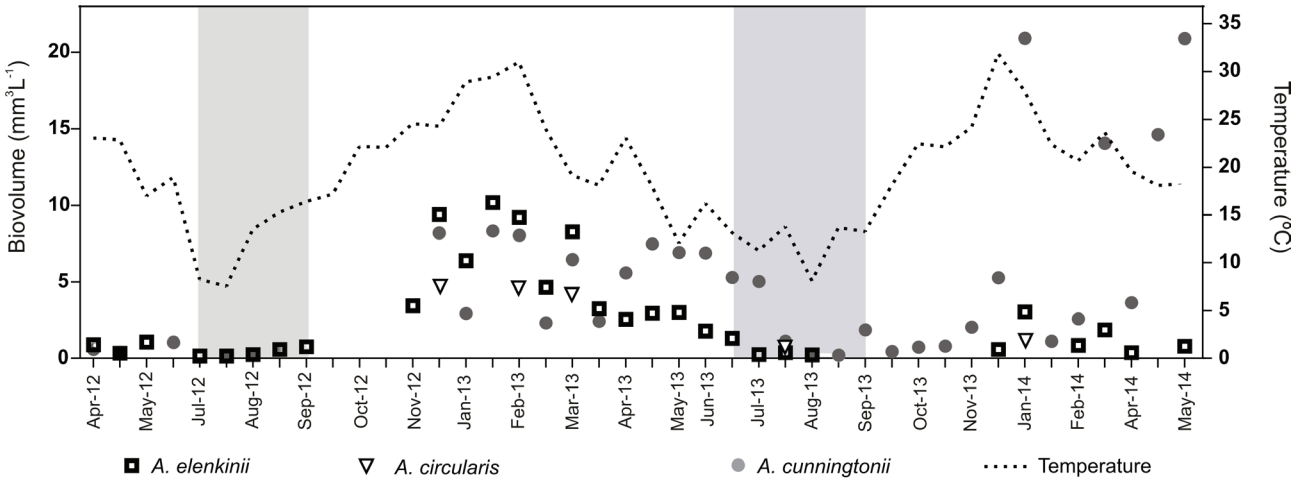

FIGURE 3: Water temperature, biovolume of *A. elenkinii*, *A.* cf. *cunningtonii* and *A. circularis* in Los Patos shallow lake from April 2012 to May 2014. Grey boxes indicate winter seasons.

Anabaenopsis circularis (G.S.West) Woloszynska & V. Miller in V. Miller (1923: 125) (Fig. 4 F–G)

Free floating trichomes, spirally coiled with 1 to 3 coils, without mucilaginous envelops and constricted at cross-walls. Cells cylindrical, usually slightly arcuated, 5–13 µm × 2.5–6.4 µm, with aerotopes. Heterocytes spherical, 2.8–5.8 µm in diameter. Akinetes widely oval to elliptical, solitary, 9.1–15.5 × 5.3–8 µm.

Samples examined:—Los Patos shallow lake (Ensenada, Argentina), 18 April 2012, 5 May 2012, 6 August 2012, 29 November 2012, 27 December 2012, 16 January 2013, 27 February 2013, 13 March 2013, 30 July 2013, *R.O. Echenique* and *A. Aguilera* (LPC, 7306, LPC 7307, LPC 7308, LPC 7309, LPC 7310, LPC 7311, LPC 7312, LPC 7313, LPC 7317)

Ecology:—*Anabaena circularis* was found only in warm periods (summer–early autumn), contributing to water blooms in small abundances. Although the biovolume was correlated with water temperature (r = 0.4, n= 6), the relationship was not significant ($p > 0.005$). The highest value (4.71 mm^3L^{-1}) was recorded in January 2013, when water temperature was 24.5 °C and pH 9.15. Akinetes were observed only in summer (water temperature 22.85–31 °C, pH 9.54–10.45).

Notes:—Our observations are in good agreement with the literary data on the species given by Hindák (1988) and Komárek (2013). However, larger dimensions of the akinetes were registered in the Argentinean populations (Table 1). In some cases, trichomes of *A. circularis* resemble *A. elenkinii*, but they differ in the shape of the cells, the pattern of coiling, and cell width, being *A. circularis* thinner than *A. elenkinii* (Hindák, 1988; Taylor, 1932). Our results agree with these observations, since the cell and heterocyte width of *A. circularis* as well as the cell length/width ratio are significantly different from those of *A. elenkinii* populations (one-way ANOVA on ranks, $p < 0.05$). Furthermore, the shape of the cells of these two morphospecies is different (Fig 4).

Anabaenopsis circularis is frequently found in tropical and subtropical freshwater bodies, but also in summer seasons of warm areas from Europe and temperate South America (Werner *et al.*, 2012; Komárek, 2013). In Argentina, the species has been cited in the Salado River Basin (Buenos Aires province) located in a dry temperate floodplain (Guarrera *et al.*, 1972; Izaguirre & Vinocur, 1994; Gabellone *et al.*, 2001). In our study, *A. circularis* was found together with *A. elenkinii*, contributing to water blooms in small abundance, as seen by Hindák (1988).

Anabaenopsis milleri Woronichin (1929:34) (Fig. 5 A–D)

Trichomes solitary, circular to irregularly coiled, with up to 3 coils. Cells widely barrel shaped, 3.7–10.9 × 3.6–8 µm, with aerotopes. Heterocytes spherical, 2.4–5.7 µm in diameter, narrower than vegetative cells. Akinetes spherical or slightly widely oval, solitary, 8.2–12.7 × 5–9.8 µm.

Samples examined:—Argentina. Buenos Aires: Los Patos shallow lake, 18 April 2012, 29 November 2012, 14 May 2013, 7 May 2014, *R.O. Echenique* and *A. Aguilera* (LPC 7306, LPC 7309, LPC 7315, LPC 7322).

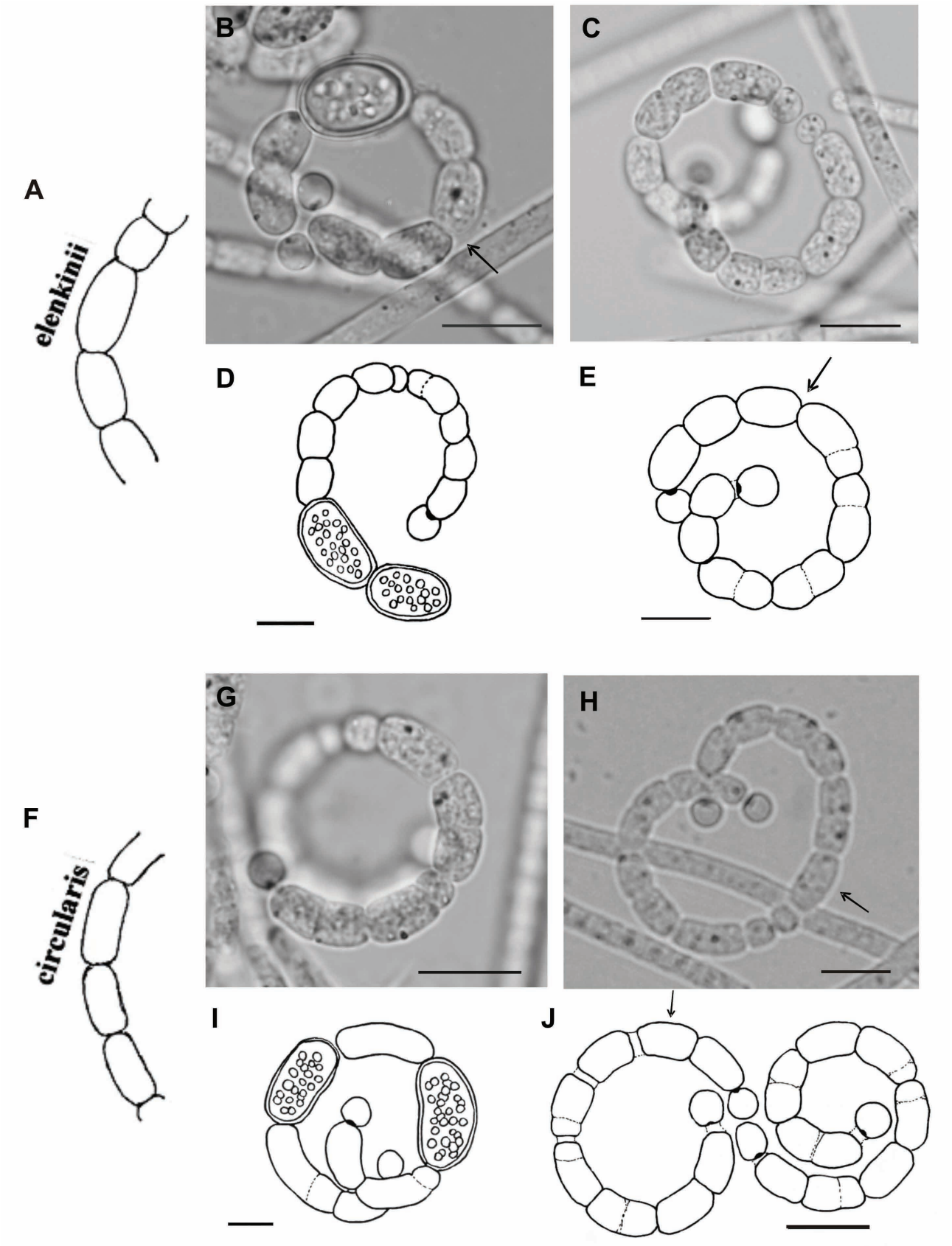

FIGURE 4: Morphology and typical shape of cells of *Anabaenopsis elenkinii* (A–E) and *A. circularis* (F–G). A and F: shape of cells of *A. elenkinii* and *A. circularis*, respectively, taken from Komárek (2005). B and E: Arrows point at the rounded extremes of the cells, flattened at the contact with the contiguous cells. H and J: Arrows point at the cylindrical, slightly arcuated cells. Scale: 10 µm.

Ecology:—*Anabaena milleri* was observed more frequently during summer and autumn but only in qualitative samples. The species was also present in winter, when temperature reached 16 °C. Akinetes were registered in summer 2005, 2012 and 2013.

Notes:—In general, the analyzed populations agree with those originally described by Woronichin (1929) and reviewed by Komárek (2013). Nevertheless, oval heterocytes, also described for the species, were never observed in our study.

The species has been reported in ponds and lakes of central Asia, the Czech Republic, Hungary, Romania, Slovakia and Greek lakes, where toxic blooms dominated by *A. milleri* were reported (Lanaras & Cook, 1994; Komárek, 2013). Accordingly, this is first report of *A. milleri* on the American continent and Argentina.

Anabaenopsis nadsonii Woronichin (1929:35) (Fig. 5 E–I)

Free floating and solitary trichomes, circular or coiled, with 1–2.5 tight coils. Cells barrel-shaped, 4.1–6.2 × 3.2–5.2 μm, only rarely with visible aerotopes. Heterocytes spherical, 3.5–4 μm in diameter, narrower than vegetative cells. Akinetes nearly spherical to widely oval, 7.9–12 ×5.2–8.8 μm, solitary.

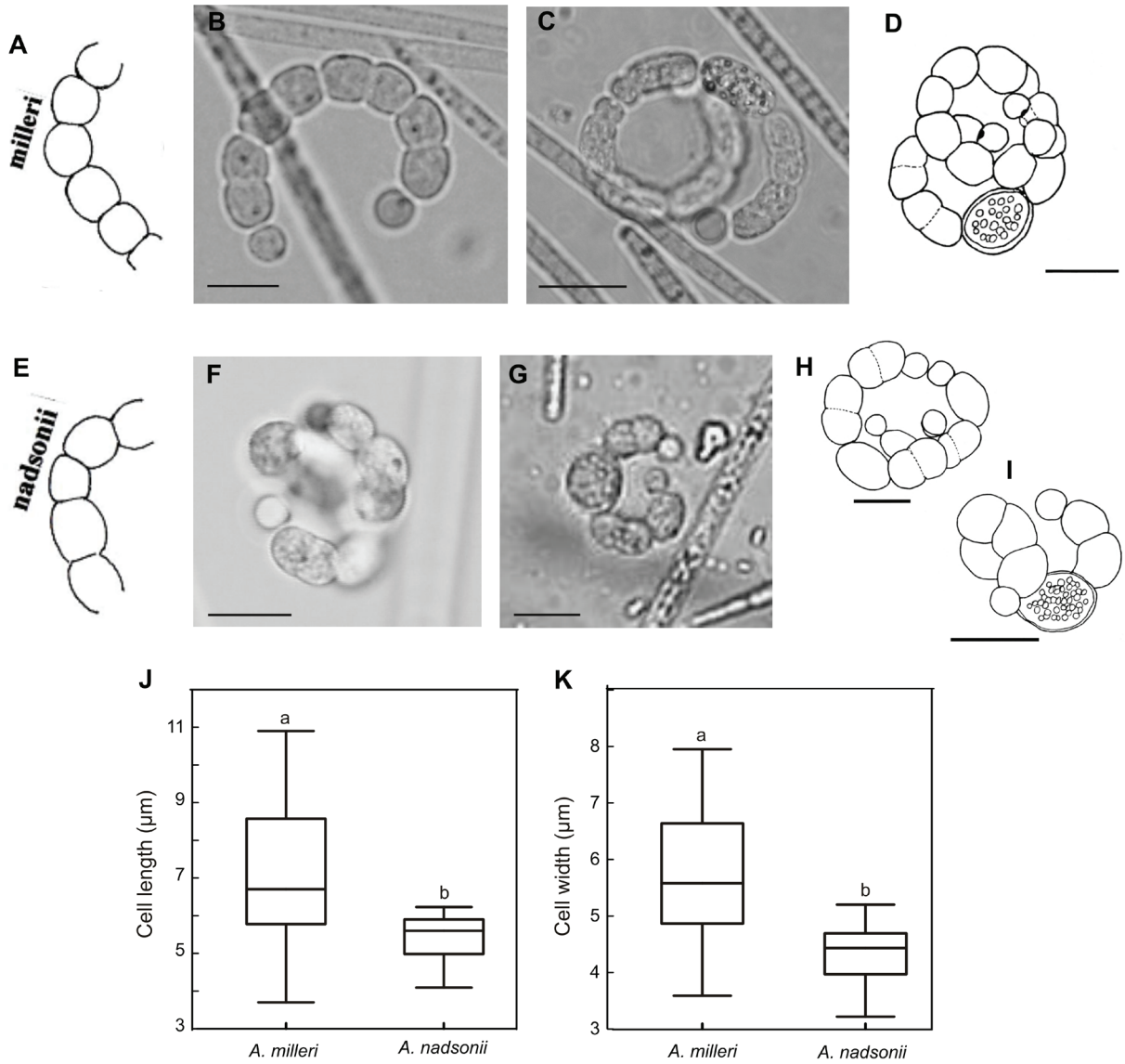

FIGURE 5 A–H: Morphometric characteristics of *A. milleri* and *A. nadsonii.* A and E: typical shape of cells of *A. milleri* and *A. nadsonii*, respectively, taken from Komárek (2005). B–D: Morphology of *A. milleri*. E–I: Morphology of *A. nadsonii*. Scale: 10 μm. J–H: Box and whisker plots of vegetative cell length (J) and width (H) of both morphospecies. The box represents the 25th–75th percentiles and the median value, the bars the 10th and 90th percentiles. Values significantly different are denoted with a and b (one-way ANOVA on ranks, $p < 0.05$).

Samples examined:—Argentina. Buenos Aires: Los Patos shallow lake, 18 April 2012, 6 June 2012, 27 December 2012, *R.O. Echenique* and *A. Aguilera* (LPC 7306, LPC 7308, 7310).

Ecology:—*Anabaenopsis nadsonii* was rarely observed during the whole sampling period, only in qualitative samples, being present in summer, when temperature was higher 24°C. Akinetes were observed in summer 2005 and 2012 (water temperature 24.25–31 °C, pH 9.15–10.45).

Notes:—The morphometric characteristics analyzed agree with those mentioned by Jeeji-Bai *et al.* (1980), Guarrera *et al.*, (1972), and those reviewed by Komárek (2013). *Anabaenopsis nadsonii* can be easily confused with *A. milleri* due to its morphological similarity. However, a morphometric comparison of vegetative cell sizes (fig 5 J–H, Table 2) of both populations reveals that *Anabaenopsis milleri* and *A. nadsonii* from Los Patos shallow lake significantly differ by the mean length and width of vegetative cells (one-way ANOVA on ranks, $p < 0.05$). These results are in concordance with previous reports indicating that *A. milleri* has larger dimensions than *A. nadsonii* (Komárek, 2005).

The species commonly inhabits temperate salty lakes and has been recorded in central Asia, Denmark, Hungary, Romania and India (Komárek, 2005). In Argentina, it was reported by Guarrera *et al.* (1972) in temperate salty shallow lakes of Buenos Aires province and by Zalocar de Domitrovic *et al.* (2014) in the Lower Salado River (Northeast Argentina). There are not other citations of *A. nadsonii* on the American continent.

Discussion

The genus *Anabaenopsis* is satisfactorily defined based on morphology and molecular characters (Jeeji-Bai *et al.*, 1980; Ballot *et al.*, 2008; Hindák, 1988; Komárek, 2013). However, the infrageneric diversity is unclear given the little variation between populations and the existence of transitional forms between described species (Komárek & Mareš, 2012). Since the cultivation of *Anabaenopsis* strains is commonly very complicated, the description of natural populations is vitally important for the taxonomical evaluation of the species of the genus. Furthermore, detailed morphologic studies on populations from environmental samples can be useful to better understand the phylogenetic relationships between taxa (Hentschke & Sant'Anna, 2015). In this study, five morphospecies of the genus *Anabaenopsis* are described from a temperate shallow lake located in Central-Eastern Argentina. In cases where the populations were morphologically very similar, the features used to differentiate between morphospecies were mainly the shape of the cells, and the length, width and the length/width ratio. It has been shown that the latter gives a good idea of the shape of the cells, which is useful to differentiate between taxa (Jeeji-Bai *et al.*, 1980). In the case of *A. elenkinii* and *A. circularis*, the feature more used to distinguish between populations was the shape of the cells and the cell length/width ratio (Fig 4 A–F). The intraspecific variation found in *A. elenkinii* was considered as part of the natural variability of the species, as has been previously considered by other authors (Hindák, 1988; Santos & Sant'Anna, 2010; Komárek, 2013). On the other hand, *A. milleri* was differentiated from *A. nadsonii* mainly by the cellular dimensions (Fig 5). *Anabaenopsis* cf. *cunningtonii* from Los Patos shallow lake present several differences from other described populations. The shape of the akinetes and also the metric parameters are very distinct. Further studies applying molecular methods could provide more information to define the species status of *Anabaenopsis* cf. *cunningtonii.*

The genus *Anabaenopsis* has been designated as more or less thermophilic, with the species occurring mainly in tropical and subtropical regions, and a few types occurring in temperate zones (Komárek, 2005). In our study, almost all species contributed to algal blooms during warm periods (spring–summer–autumn). Contrary to predictions, some species were also present in low temperatures (*A. milleri* and *A. elenkinii*) and contributed to form blooms even during winter (*A.* cf. *cunningtonii*), when temperature was as low as 13°C. These results allow us to conclude that some *Anabaenopsis* species are capable of sustaining growing at temperatures much lower than 20°C, and also suggest that the genus probably presents broad ecological plasticity. The sample period comprising two entire years allowed us to study the behavior of *Anabaenopsis* populations in all seasons and also find the akinetes of each morphospecies, which sometimes are not seen since they develop sporadically, induced by certain environmental conditions (Jeeji-Bai *et al.*, 1980; Hindák, 1988; Santos *et al.*, 2011).

The presence of more than one *Anabaenopsis* species in the same water body has been previously reported, not only in our country (Hindák, 1988; Krienitz *et al.*, 2012; Zalocar de Domitrovic *et al.*, 2014). Finally, given the species richness noted in this study, we conclude that there is likely much more diversity remaining on this genus to be reported in Argentina.

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