

NEW RECORDS OF FRESHWATER ALGAE AND CYANOBACTERIA FROM MOUNTAIN STREAMS OF CÓRDOBA (ARGENTINA)

CLAUDIA DAGA^{1,*}, FLORENCIA SOTERAS², GRACIELA M. DANIELE^{1,2} and LAURA S. DOMINGUEZ^{1,2}

Summary: Constant collection surveys of freshwater Algae and Cyanobacteria in central Argentina streams have revealed new identities. This study reports for the first time six species for Córdoba Province and five for Argentina. Biodiversity description of the streams of central Argentina is crucial for the development of conservation activities. In this study the record of new species for this region and for Argentina highlights the relevance of further research to help improving knowledge of the diversity and ecology in this hydrographic system.

Key words: Biodiversity, rivers, South America.

Resumen: Nuevos registros de algas de agua dulce y de Cyanobacteria de los arroyos de montaña de Córdoba (Argentina). Diferentes muestreos en arroyos de agua dulce del centro de la Argentina han revelado nuevas identidades de algas y cianobacterias. Este estudio reporta nuevas citas, seis especies para la provincia de Córdoba y cinco para Argentina. La descripción de la biodiversidad de los arroyos de la región central de Argentina, es crucial para el desarrollo de las actividades de conservación. En este estudio el registro de nuevas especies para la región y para el país pone de relieve la necesidad de promover la investigación para mejorar el conocimiento de la diversidad y ecología de este sistema hidrográfico.

Palabras clave: Biodiversidad, ríos, Sudamérica.

INTRODUCTION

Freshwater algae and Cyanobacteria comprise ancient worldwide and highly diverse organisms including endemisms and taxa adapted to extreme conditions (Bellinger & Sigeo, 2010; Whitton & Potts, 2012). Recently, freshwater algae have received special attention due to their potential use as biodiesel (Demirbas, 2011; Zhu *et al.*, 2013) or as bioindicators (Wehr, 2011). Towards the sustainable use of natural resources and the development of conservation activities, the identification of native communities is of great importance.

Biogeography and distributional studies have improved the taxonomic knowledge of worldwide freshwater Cyanobacteria and algal flora (Sheath *et al.*, 1993; Kristiansen, 1996; Tyler, 1996). In particular, the composition of Argentinean freshwater communities has been partially described (Nordstedt, 1882; Kühnemann, 1963; Parodi & Pujals, 1968; Cáceres, 1973; Lazo, 1978).

Freshwater rivers, permanent and temporal streams of the high mountain of central Argentina are key constituents of the natural river basins that supply water for human consumption (Fjeldså & Kessler, 1996; Aronson *et al.*, 2007). In general, studies have described the land plant communities (Cingolani *et al.*, 2004) and even macromycetes (Robledo & Renison, 2010; Hernández Caffot *et al.*, 2011) and belowground fungi (Soteras *et al.*, 2015) of these ecosystems. However, algae and Cyanobacteria have rarely been the focus of research. Therefore there still appears to be a high

¹ Cátedra Diversidad Vegetal I, Universidad Nacional de Córdoba (UNC). *Corresponding author: inesclaudiadaga@gmail.com

² Instituto Multidisciplinario de Biología Vegetal (IMBIV), CONICET, Universidad Nacional de Córdoba (UNC), CC 495, 5000 Córdoba, Argentina. TE 54-0351-433-4459 int 34.

number of poorly known but common taxa. The aim of this study was to identify freshwater algae and Cyanobacteria of central Argentina streams.

MATERIALS AND METHODS

Material was collected over the last ten years from streams of Córdoba Province, Central Argentina within Punilla (31° 14' S, 64° 27' W), San Alberto (31° 27' S, 64° 14' W) and Santa María (31° 39' S, 64° 25' W) Departments (Fig. 1). The permanent streams sampled (850-1200 m a.s.l) are abundant only due to intense rains, present clear water and temperatures varying from 2 to 28 °C (Vázquez *et al.*, 1979).

Samples were carefully collected by hand, placed in plastic flasks and preserved with 4 % formaldehyde until examination. Collections were first examined under a compound microscope and structures were evaluated under Leica 4-100X microscope. Specimens color was determined from fresh material when possible. Species identification was based on current species descriptions (Guarrera & Kühnemann, 1962; Guarrera *et al.*, 1970; Joshi & Krishnamurthy, 1972; Ettl, 1978; Bourrelly, 1981; Tell, 1985; Necchi, 1989; Compère, 1991; Sheath *et al.*, 1993; Necchi & Zucchi, 1997; Necchi

et al., 1999; Boraso de Zaixso, 2004; Komárek & Anagnostidis, 2005) and following the Algae Base web page classification system (Guiry & Guiry, 2013).

The specimens were deposited at the Facultad de Ciencias Exactas, Físicas y Naturales (Universidad Nacional de Córdoba), herbarium of the Laboratorio de Hidrobiología (LH).

RESULTS AND DISCUSSION

Phylum Cyanobacteria
Class Cyanophyceae
Subclass Oscillatoriophyceae
Order Oscillatoriales
Family Oscillatoriaceae

Plectonema tomasinianum var. *cincinnatum* Hansgirg (Fig. 2 A-B).

Description: Straight to curved filaments with false branching single or double, blue greenish. Sheath colorless to yellowish brown. Discoid shaped terminal cells.

Size: Filaments 16-32 µm width; trichome 12-28 µm width; cells 4-10 µm length. Sheaths 2-4 µm thick.

Habitat: In rapid streams with clear water and low depth, benthic.

Material examined: Córdoba Province, San Alberto Department, “Chico de Nono” stream, 3-III-2012, LH 127 (UNC).

Geographic distribution: Europe (Álvarez-Cobelas & Gallardo, 1988), North America (Smith, 2010), Oceania (Day *et al.*, 1995), Asia (Hu & Wei, 2006). This is the first record of this species for Argentina.

Observations: Filaments width of the material studied (up to 35 µm) was higher than the reported in the bibliography (up to 30 µm) (Komárek & Anagnostidis, 2005).

Subclass Nostochophycideae
Order Nostocales
Family Hapalosiphonaceae
Nostochopsis lobatus Wood ex Bornet & Flahault (Fig. 2 C-D).

Description: Gelatinous and hollow colonies, macroscopic, spherical or lobed, yellowish green to dark green. When young generally attached to the rocks by a wide surface, when adults attached by

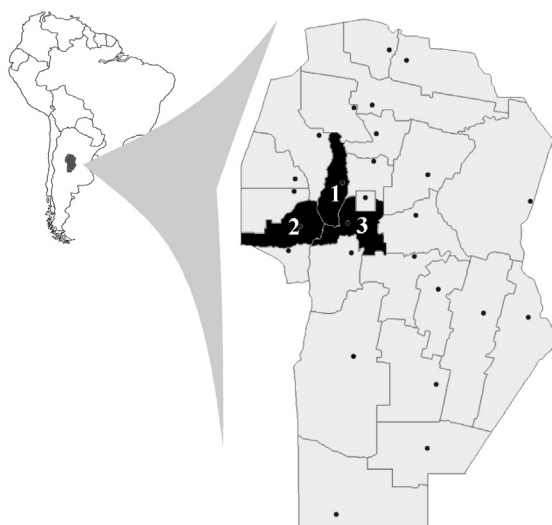


Fig. 1. Sampling sites at Córdoba Province: (1) Punilla, (2) San Alberto and (3) Santa María Departments.

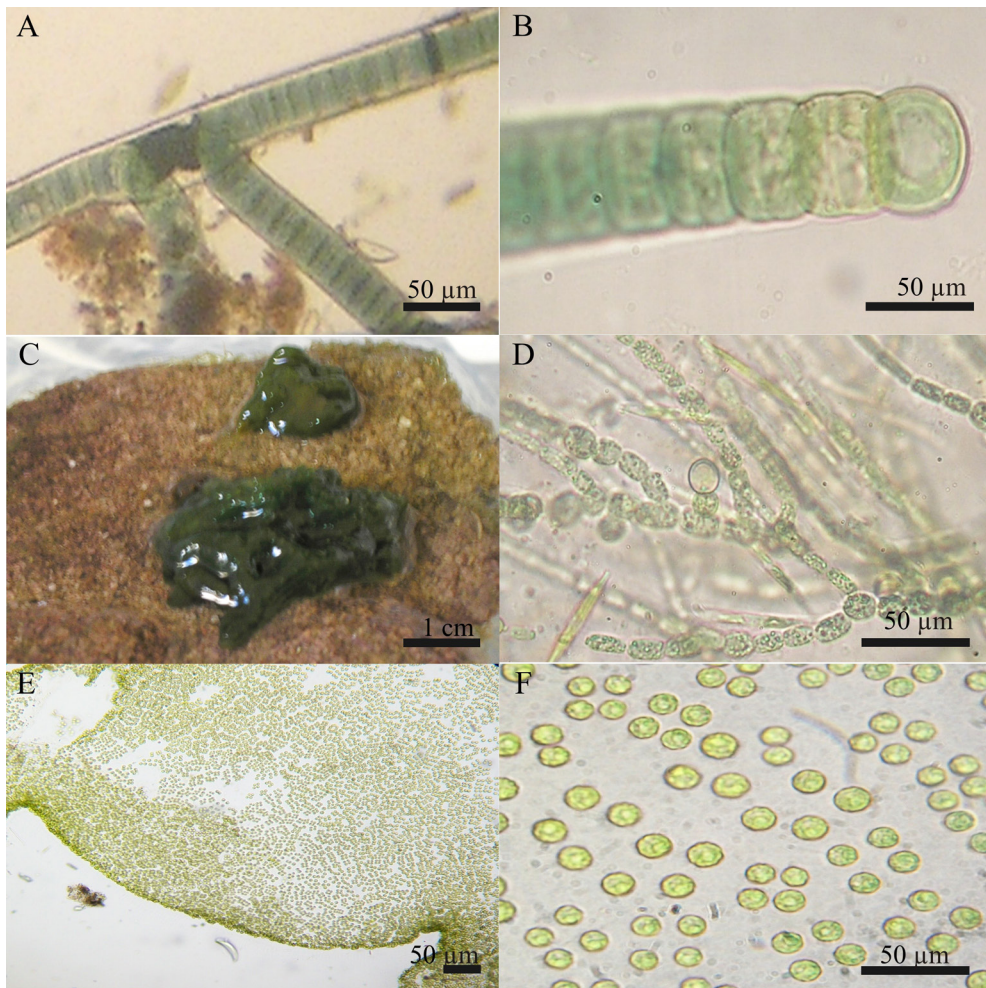


Fig. 2. *Plectonema tomasinianum* var. *cincinnatum*. **A:** Filament with double branches. **B:** Detail of terminal cell. *Nostochopsis lobatus*. **C:** Colonies. **D:** Thallus detail of *Tetraspora gelatinosa*. **E:** General view of part of the colony. **F:** Cells within the colony.

an annular surface. Branched, uniseriate trichomes, radially oriented in the thallus. Terminal or lateral heterocysts, always present in short branches.

Size: Colonies ranged in diameter from 0.5 cm to 4 cm. Terminal heterocysts from 4 to 6 µm in diameter. Lateral heterocysts from 6 µm to 8 µm in diameter. Cells from 4 to 12 µm length, 2-4 µm in diameter.

Habitat: In rapid streams with clear water and low depth (up to 50 cm).

Material examined: Córdoba Province, Punilla Department, “San Pablo” stream, 24-XII-2012, LH 132 (UNC).

Geographic distribution: Europe (Caraus, 2012), Oceania (Day *et al.*, 1995), South America: Argentina, Córdoba Province, Punilla Department, “Las Cascadas” stream, (Cáceres, 1973; Rodríguez *et al.*, 2006). We confirm the presence of this species for Córdoba Province.

Phylum Chlorophyta
Class Chlorophyceae
Order Chlamydomonadales
Family Tetrasporaceae

Tetraspora gelatinosa (Vaucher) Desvaux (Fig. 2 E-F).

Description: Macroscopic gelatinous colonies, cylindrical to irregular, often with holes. Spherical cells in groups of two or four, with pseudoflagellums extending up to the mucilage.

Size: Colonies up to 5 cm length. Cells 2-12 µm in diameter.

Habitat: In rapid streams with clear water and low depth (up to 50 cm).

Material examined: Córdoba Province, Santa María Department, "Anisacate" stream, 16-XI-2009, LH 104 (UNC).

Geographic distribution: Europe (Caraus, 2002; 2012), North America (Smith, 2010), Asia (Hu & Wei, 2006), Oceania (Day *et al.*, 1995), South America: Argentina, Córdoba (Guarrera & Kühnemann, 1949). We confirm the presence of this species for Córdoba Province.

Subphylum Tetrphytina
Class Ulvophyceae
Order Cladophorales
Family Pithophoraceae

Pithophora roettleri (Roth) Wittrock (Fig. 3 A-B).

Description: Branched macroscopic thallus, filaments of cylindrical cells, with rounded extremity. From one to four intercalary akinetes, cylindrical or tonel shaped, terminal ovoid akinetes with mucronate extremity. Attached by rhizoids.

Size: Branched thallus 6-10 cm in height. Intercalary akinetes 160-240 µm length and 80-96 µm width, terminal akinetes larger (160-270 µm length and 80-120 µm width). Vegetive cells 150-400 µm length and 70-906 µm width.

Habitat: On rocks in rapid streams with clear water and low depth (up to 50 cm).

Material examined: Córdoba Province: Punilla Department, San Pablo stream, 15-VI-2007 LH 111 (UNC).

Geographic distribution: Europe (Boedeker *et al.*, 2012), North America (Smith, 2010), South America: Argentina, Jujuy (Tracanna, 1985). This is the first record of this species for Córdoba Province.

Class Trebouxiophyceae
Order Chaetophorales
Family Chaetophoraceae

Chaetophora elegans (Roth) C. Agardh (Fig. 3 C-D).

Description: Gelatinous macroscopic thallus. Uniseriate branched filaments, parietal and laminar

chloroplast, with several pyrenoids. Filament cells decreasing in size towards the extremity and ending in hyaline hair. Attached to rocks or to submerged aquatic vegetation by a rhizoid.

Size: Thallus up to 5 cm in diameter. Filament cells of 8-12 µm length and 4 µm width; terminal cells of 10-20 µm height; intercalary spherical akinetes of 20-24 µm in diameter.

Habitat: In rapid streams with clear water and low depth (up to 50 cm).

Material examined: Córdoba Province, Punilla Department, "San Pablo" stream, 25-IV-2010, LH 111 (UNC).

Geographic distribution: Europe (Caraus, 2002, 2012; Sarma, 1986), North America (Smith, 2010), Central America (Sarma, 1986), Asia (Sarma, 1986; Hu & Wei, 2006), Oceania (Sarma, 1986; Day *et al.*, 1995), South America: Argentina (Sarma, 1986). This is the first record of this species for Córdoba Province.

Order Prasiolales
Family Prasiolaceae

Prasiola crispa (Lightfoot) Kützing (Fig. 3 E-F).

Description: Thallus laminar to band like, attached by a rhizoid, cubic to rounded cells usually gathered in fours, axial and stellate chloroplasts.

Size: Thallus up to 10 cm wide; cells 4-10 µm in diameter.

Habitat: On rocks, in rapid streams with clear water and low depth.

Material examined: Córdoba Province: Punilla Department, "Yuspe" stream at Los Gigantes locality, 24-II-2012, LH 126 (UNC).

Geographic distribution: Europe (Caraus, 2002), Atlantic Islands (Caram & Jónsson, 1972), Asia (Hu *et al.*, 1979), Oceania (Adams, 1994), South America: Argentina, Antarctic and subantarctic islands (Guarrera & Kühnemann, 1949), Falklands Islands (Guarrera & Kühnemann, 1949). This is the first record of this species for Córdoba Province.

Class Ulvophyceae
Order Ulvales
Family Ulvaceae

Enteromorpha intestinalis (Linnaeus) Nees (Fig. 4 A-B).

Description: Thallus formed by hollow tubes thinning to the base, or with a strong contraction and a small solid stipe.

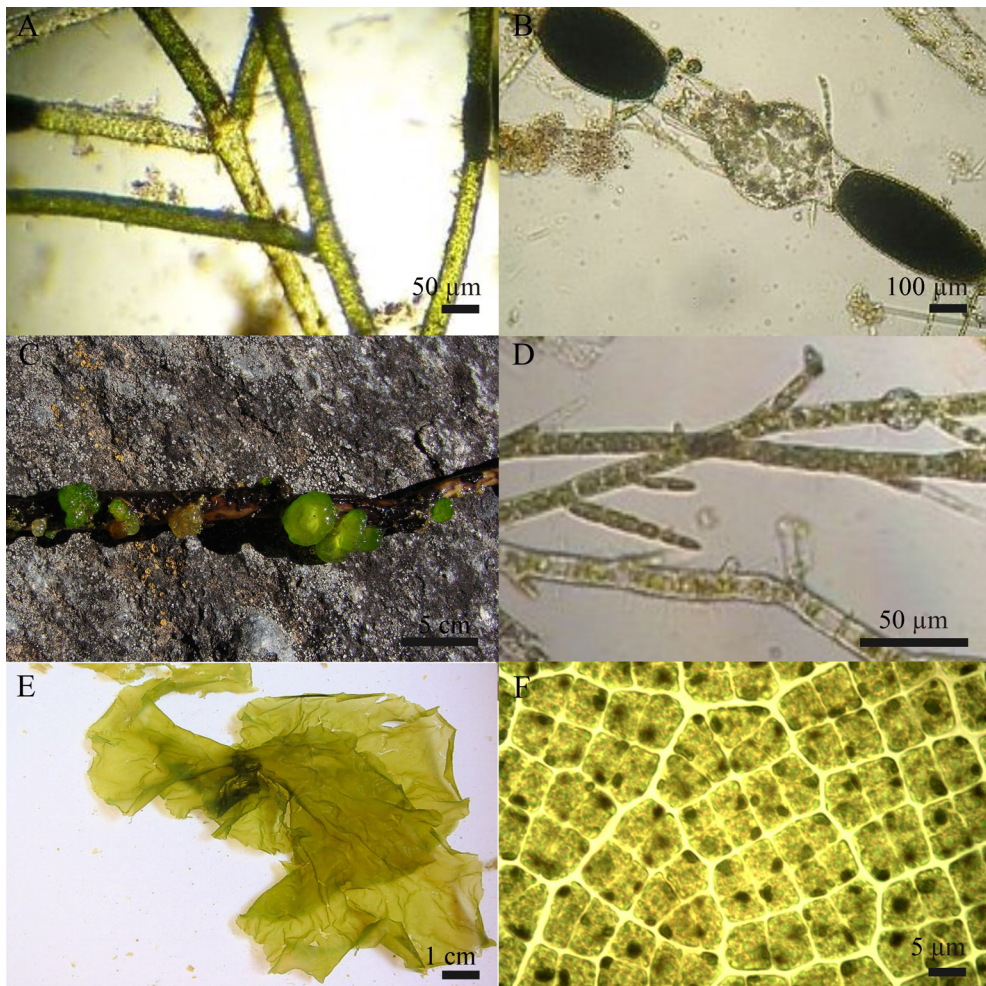


Fig. 3. *Pithophora roettleri*. **A:** Thallus filaments. **B:** Detail of filament of *Chaetophora elegans*. **C:** Gelatinous macroscopic thallus. **D:** Detail of filament of *Prasiola crispa*. **E:** Macroscopic thallus. **F:** Cells with axial and stellate chloroplasts.

Size: Thallus 10-30 cm length and 1-10 mm width; cells 4-12 µm in diameter.

Habitat: On rocks or sand in streams with runoff, clear water and shallow (up to 50 cm) or floating freely in calm places.

Material examined: Córdoba Province, Punilla Department, “Yuspe” stream, 27-XII-2006, LH 80 (UNC).

Geographic distribution: Europe (Álvarez-Cobelas & Gallardo, 1988; Caraus, 2002, 2012), North America (Cohen & Fong, 2005), South America: Argentina, Córdoba (Guarrera & Kühnemann, 1949). This confirms the presence of this species for

Córdoba Province.

Phylum Rhodophyta
Subphylum Eurhodophytina
Class Florideophyceae
Subclass Nemaliophycidae
Order Batrachospermales
Family Batrachospermaceae

Batrachospermum atrum (Hudson) Harvey (Fig. 4 E).

Description: Macroscopic and monoecious thallus, with scarce mucilage, highly branched, irregular, corticated. Conical and pyriform verticils.

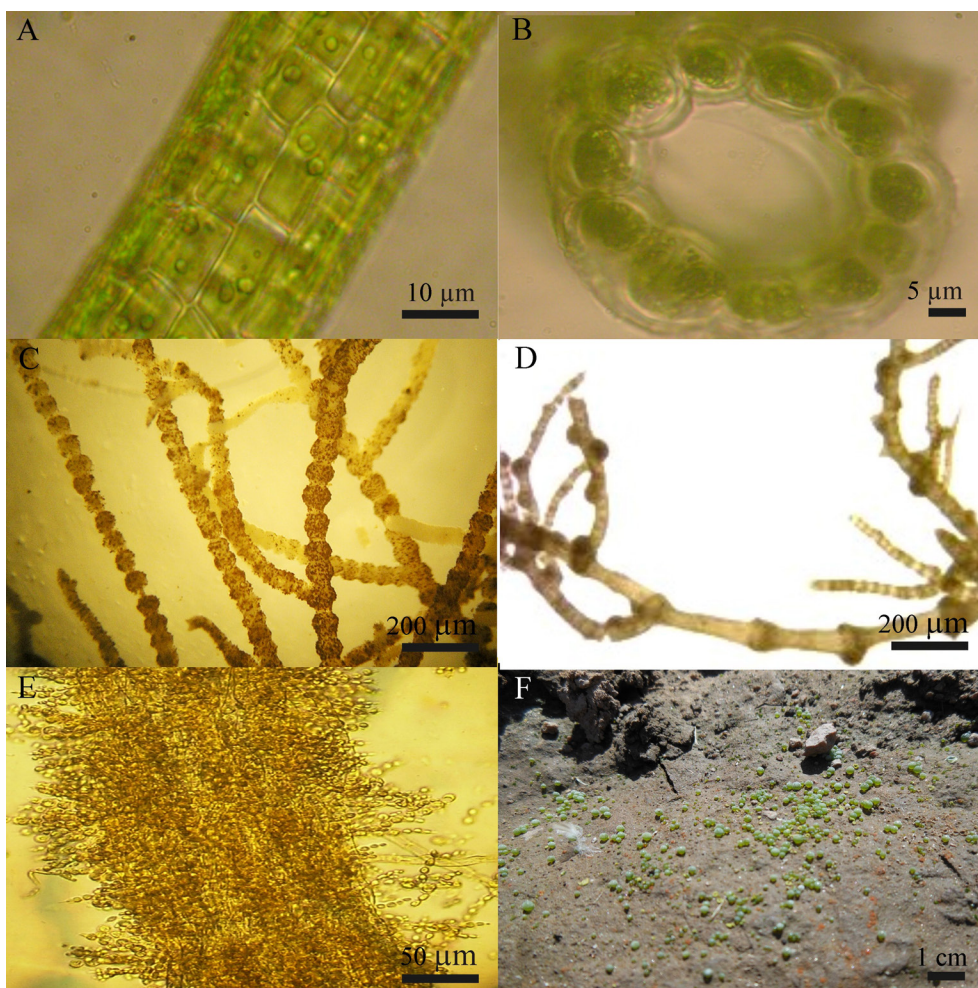


Fig. 4. *Enteromorpha intestinalis*. **A:** Longitudinal view of thallus. **B:** Transversal section of thallus. **C:** *Batrachospermum moniliforme*. **D:** *Batrachospermum atrum* var. *puiggarianum*. **E:** *Batrachospermum atrum*. **F:** *Botrydium granulatum*.

Size: Verticils 120-200 µm in diameter.

Habitat: On rocks in rapid streams with clear and cold water, low depth.

Material examined: Córdoba Province, Punilla Department, “Copina” stream, 14-IV-1999, LH 1 (UNC).

Geographic distribution: Europe (Caraus, 2012), North America (Sheath *et al.*, 1993), Oceanía (Day *et al.*, 1995). This is the first record of this species for Argentina.

Batrachospermum atrum var. *puiggarianum* (Grunow) Necchi (Fig. 4 D).

Description: Macroscopic and monoecious thallus, with scarce mucilage, highly branched, corticated. Inconspicuous rounded verticils, knots compacted. Thallus olivaceous green to black. Terminal spermatangia. Carpogonium not observed.

Size: Thallus 4-8 cm height; verticils 80-110 µm in diameter. Spermatangia 4-6 µm in diameter.

Habitat: On rocks in rapid streams with clear and cold water, low depth (up to 50 cm).

Material examined: Córdoba Province, Punilla Department, “Copina” stream, 14-IV-1999, LH 1 (UNC). Córdoba Province, Punilla Department, “San Pablo” stream, 24-XII-2012, LH 137 (UNC).

Geographic distribution: South America: Argentina, Córdoba, Sierras Chicas (Lazo, 1978; Nordstedt, 1882, as *Batrachospermum puiggarianum*). This confirms the presence of this species for Córdoba Province.

***Batrachospermum macrosporum* Montagne**

Description: Macroscopic and monoecious thallus, with plentiful mucilage, irregularly branched, corticated, conical verticils contiguous or distant, cortical cells poorly developed. Terminal or subterminal spermatangia. Spherical spermatia. Carpogonium branch long with doliform cells at the base. Trichogyne club-shaped. Fixed by an adhesive disc.

Size: Thallus 10-15 cm height; verticils 380-400 μm in diameter. Spermatangia of 6-7 μm in diameter; spermatid of 4.8-5 μm in diameter. Carpogonium of 25.5- 47 μm length and 3.2-6.4 μm width.

Habitat: On rocks or vegetation, in shadow zones of rapid streams with cold and clear water, low depth (up to 50 cm).

Material examined: Córdoba Province, Punilla Department, “Copina” stream, 14-IV-1999, LH 3 (UNC).

Geographic distribution: North America, South America: Brazil (Vis *et al.*, 2008). This is the first record of this species for Argentina.

***Batrachospermum moniliforme* Sirodot (Fig. 4 C).**

Description: Macroscopic monoecious thallus, with scarce mucilage, irregular and highly branched, corticated. Globose verticils separated from each other. Cortex properly developed. Terminal spermatangia. Hyaline and spherical spermatia. Carpogonium not observed.

Size: Thallus 3-7cm height; verticils 200-220 μm in diameter. Spermatangia 3-4 μm in diameter.

Habitat: On rocks, in shadow zones of rapid streams with cold and clear water, low depth.

Material examined: Córdoba Province, Punilla Department, “Copina” stream, 14-IV-1999, LH 2 (UNC).

Geographic distribution: Europe (Caraus, 2002, 2012), Oceania (Day *et al.*, 1995). This is the first record of this species for Argentina.

Orden Thorealess
Familia Thoreaceae

***Thorea bachmannii* Pujals**

Description: Branched thallus, a bit gelatinous, with cylindrical and erects filaments, fixed by an adhesion disc. Dark brown-greenish. Multiaxial medula with several crossed filaments, filaments or assimilation uniseriate hairs with cylindrical or tonel shaped cells and rounded apical cells; lobed parietal chloroplasts. Monosporangia (asexual) isolated or in pair, generally ovoid, in the apex of short branches (2 to 3 cells) among assimilation filaments.

Size: Thallus 10-30 cm height; 600-1200 μm in diameter; adhesion disc of 1 mm in diameter. Medula zone 180-420 μm in diameter. Assimilation filaments 345-960 μm length. Assimilation filament cells 20-30 μm length and 5.5-12 μm in diameter. Monosporangia 1-28 μm length and 3.5 μm width.

Habitat: On rocks, rapid streams with clear water and low depth.

Material examined: Córdoba Province, Punilla Department, “San Pablo” stream, 2-V-1999, LH 4 (UNC).

Geographic distribution: South America: Argentina, Buenos Aires Province, “Del Gato” stream, (Pujals, 1968). This is the first record of this species for Córdoba Province.

Phylum Ochrophyta
Subphylum Phaeista
Infraphylum Marista
Superclass Fucistia
Class Xanthophyceae
Order Tribonematales
Family Tribonemataceae

***Bumilleria klebsiana* Pascher**

Description: Unbranched filamentous thallus, yellowish green. Short cells generally cylindrical to squared-shaped, up to two times wider than long. Cellular wall formed by a single piece, every two or four cells contain a transverse septum H-shaped, which cover the apex or extremes of two contiguous cells. Parietal chloroplasts.

Size: Cells 6-15 μm length and 8-10 μm width.

Habitat: On rocks in rapid streams.

Material examined: Córdoba Province, Punilla Department, “El Cajón” stream, 18-V-1999, LH 5 (UNC).

Geographic distribution: Europe (Caraus, 2002, 2012), Asia (Ettl & Gärtner, 1995). This is the first record of this species for Argentina.

Phylum Ochrophyta
Subphylum Phaeista
Infraphylum Marista
Superclase Fucistia
Clase Xanthophyceae
Orden Tribonematales
Familia Tribonemataceae
Tribonema viride Pascher

Description: Very long filaments, yellowish green. Cells cylindrical or tonel-shaped two to eight times longer than wide. Several disc-shaped and parietal chloroplasts.

Size: Cells from 20-25 μm to 8-10 μm in diameter.

Habitat: In rapid streams with clear water and low depth (up to 50 cm).

Material examined: Córdoba Province: San Alberto Department, "El Cajón" stream at Los Gigantes locality, 18-V-1999, LH 5 (UNC).

Geographic distribution: Europe (Álvarez-Cobelas, 1984; Caraus, 2002; Zuccarello & Lokhorst, 2005), Atlantic Islands (Ettl & Gärtner, 1995), North America (Smith, 2010), Asia (Hu *et al.*, 1979), Oceania (Day *et al.*, 1995), South America: Argentina, Buenos Aires (Kühnemann, 1963). This is the first record of this species for Córdoba Province.

Phylum Ochrophyta
Subphylum Phaeista
Infraphylum Marista
Superclass Fucistia
Class Xanthophyceae
Order Botrydiales
Family Botrydiaceae

Botrydium granulatum (Linnaeus) Greville (Fig. 4 F).

Description: Thallus formed by air globose vesicles joined to a colorless branched rhizoid inside the soil. Vesicle with several disc-shaped chloroplasts.

Size: Areal vesicles up to 30 mm of diameter.

Material examined: Córdoba Province: Punilla Department, River "Yuspe" at Los Gigantes locality, III-2012, LH 129 (UNC).

Geographic distribution: Europe (Caraus, 2002), Asia (Hu *et al.*, 1979), Oceania (Day *et al.*, 1995), South America: Argentina, Buenos Aires (Tell, 1985). This is the first record of this species for Córdoba province.

CONCLUSIONS

This study reports for the first time six species for Córdoba Province and five for Argentina. The description of the biodiversity of the streams of central Argentina is crucial for the development of conservation activities. In this study the record of new four species for this region highlights the relevance of further research to help improving knowledge in this hydrographic system.

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