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Original Paper

Epilithic diatoms (Bacillariophyceae) in a tropical Andean River of Southwest Colombia

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Abstract

In tropical regions there are a large number of species of diatoms that have not been identified yet. This research aimed to study the composition of epilithic diatom flora found in samples collected in Dagua River a tropical Andean hydrographical basin located to the southwest of Colombia. Samplings were performed in three stations with their respective three replicas between January and April 2018 to collect samples for identification of diatom (Class Bacillariophyceae). These samples were analyzed with light microscopy and interferential contrast microscopy. The results indicated the occurrence of 18 taxa distributed in 9 families and 11 genera. Two of these are new records for Colombia: *Navicula incarum* and *Fragilaria* aff. *socia*. The most species-rich genera was *Navicula.* A comparison with the diatom flora of the region shows that 9 species were recorded in common with the Cali River.

Key words: *Fragilaria* aff. *socia*, *Navicula incarum*, new record, Southwest Colombia, tropical Andean River.

Resumen

En regiones tropicales hay una gran cantidad de especies de diatomeas que todavía no han sido identificadas. Esta investigación tuvo como objetivo estudiar la composición de la flora de diatomeas epilíticas encontradas en muestras recolectadas en el río Dagua, una cuenca hidrográfica andina tropical, ubicada suroeste de Colombia. Los muestreos se realizaron en tres estaciones con sus respectivas tres réplicas entre enero y abril de 2018 para recolectar muestras para la identificación de diatomeas (Clase Bacillariophyceae). Estas muestras se analizaron con microscopía óptica y microscopía de contraste interferencial. Los resultados indicaron la presencia de 18 taxa distribuidos en 9 familias y 11 géneros. Dos de estas, son nuevos registros para Colombia: *Navicula incarum* y *Fragilaria* aff. *socia*. El género con mayor riqueza específica fue *Navicula*. Una comparación con la flora de diatomeas de la región muestra que se registraron nueve especies en común con el Río Cali.

Palabras clave: *Fragilaria* aff. *socia*, *Navicula incarum*, nuevo registro, Sureste Colombia, río andino tropical.

Introduction

Diatoms are microscopic unicellular or colonial eukaryotic algae (Seckbach & Kociolek 2011), and they constitute one of the most diverse lineages of eukaryotes with possibly over 100,000 extant species (Not *et al.* 2012). The estimated number of Diatoms species is at least 30,000 (Mann & Vanormelingen 2013), which are grouped into about 1,250 genera (Seckbach & Kociolek 2011) and are ubiquitous in plankton and benthos in marine and freshwater environments (Not *et al.* 2012). Their biological and ecological characteristics have become good indicators of water quality and are one of the main dominant groups of periphytic algae in lotic systems. They respond quickly to environmental changes and anthropogenic tensions (Lobo *et al.* 2002, 2014, 2016), so they are often also used in paleolimnological studies for

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ecological reconstructions (Denys 2003; Bennion *et al.* 2004; Bradshaw *et al.* 2000; Della Bella *et al.* 2007; Gomes *et al.* 2017).

The taxonomy and ecology of diatoms has been widely studied in Europe and North America, however in South America, the information is less extensive, which has made it necessary to use information from other regions of the world (Vélez-Agudelo *et al.* 2017). Metzeltin & Lange-Bertalot (1998) highlighted that in the warm or cold regions of South America there is a high number of cosmopolitan or typical species of temperate climatic zones, but in tropical regions the diatomoflora is totally different, excluding areas with strong anthropogenic influence (Sala *et al.* 2008). This suggests the need to increase Diatoms studies in South America, especially in taxonomy and at regional scales.

In Colombia, most of the Diatom research have focused on ecological studies specially, the use of species for monitoring water quality. Studies about the morphology and taxonomy of diatoms is scarce, and they are concentrated at local scale in certain Colombian regions (Rivera-Rondón & Díaz-Quirós 2004; Hernández-Atilano *et al*. 2005; Zapata & Donato 2005; Sala *et al.* 2008, 2015; López-Martínez 2008; Bustamante-Toro *et al*. 2009; Marín Villegas *et al.* 2011). Studies on diatoms in tropical areas are less frequent than in temperate zones. Therefore, available data on diatoms from Andean tropical rivers are scarce (Metzeltin & Lange-Bertalot 2007). For the study area, little information has been registered related with taxonomic and ecological literature of diatoms. Heinrich *et al.* (2019) reported the first diatom list for an Andean river in the Southwestern region of Colombia. In this sense, this research aimed to study the taxonomic composition of ephilitic diatoms in Dagua River hydrographic basin, and thereby consolidate a taxonomic baseline of these organisms in the Southwestern (Colombia).

Materials and Methods

Study site

The Dagua River Hydrographical Basin is located in the southwestern region of Colombia in the Western slope of the Western mountain range, Department of Valle del Cauca. The river is born on the western side of the Parque Nacional Natural Farallones de Cali and has an approximate area of 142,500 ha. The Hydrographic basin is divided into two parts: Basin upper and Basin lower (Fig. 1). This investigation was carried out along three zones of the upper basin: High Zone (El Carmen: EC), Middle Zone (La Harinera: HA) and Low Zone (Union Bitaco-Dagua: BD) (Fig. 1; Tab. S1, available on supplementary material <https://doi.org/10.6084/m9.figshare.20771038.v1>).

Diatom sampling

Sampling campaigns were conducted between January and April 2018 in the established zones of the basin. In each area of the river, three sampling stations were established, with their respective three replicas. The diatoms were collected in five rocks approximately 10 cm in diameter, which were completely submerged in the river. From each rock 25 cm^2 was scraped with a brush with hard bristles. The material collected was washed with distilled water, fixed with 4% formalin (v/v) and deposited in bottles for transport to the laboratory.

Processing and taxonomic identification

The Diatoms samples were digested with 33% hydrogen peroxide (H_2O_2) and hydrochloric acid (HCl 1N), to eliminate the organic matter. After the oxidative process, excess reagents were removed by adding distilled water, centrifuging and removing the supernatant. Later, permanent slide of the diatoms samples were made on slides using the Naphrax® resin (Robert Charles laboratories ltd., Bedfordshire, UK). The diatoms were quantified and identified, in a Carl Zeiss Axio Imager A2 microscope with interferential contrast (DIC), from the count of 400 valves per sample, at least. Additionally, mounts were made to be observed under Scanning Electron Microscopy (SEM). Taxa classification followed the system proposed by Round *et al*. (1990) modified by Medlin & Kaczmarska (2004). The taxonomic identification was based on the consultation of regional specialized bibliography, such as Metzeltin & Lange-Bertalot (1998, 2007), Metzeltin *et al.* (2005) and comparison with general and local works (Heinrich *et al.* 2019). The material was deposited in the Limnological Collection of the Museo Javeriano de Historia Natural "Lorezo Uribe, S.J."

Results

The epilithic diatom in Dagua River Basin was represented by 18 species (Tab. S2, available on supplementary material <https://doi.org/10.6084/

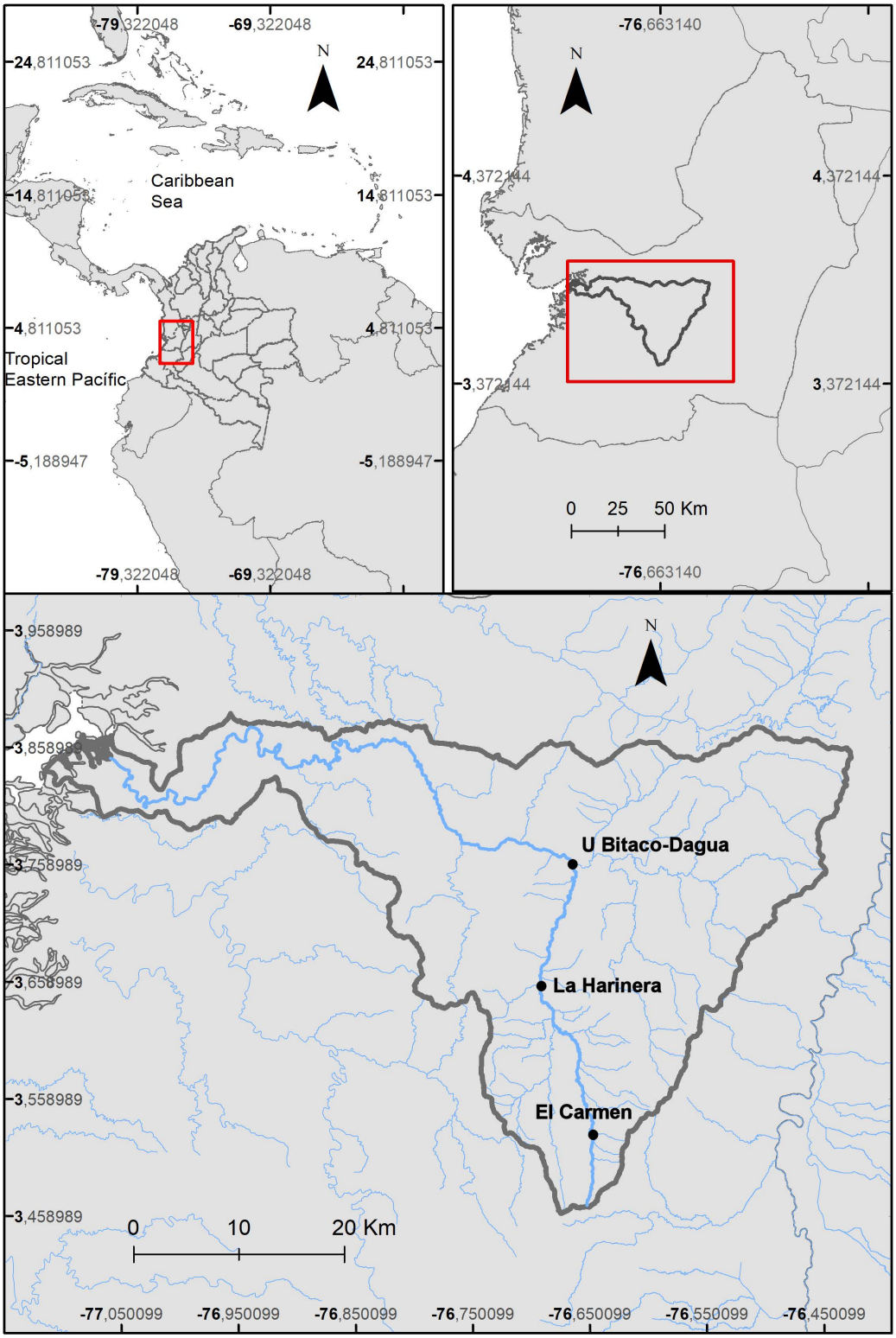

Figure 1 – Map of the study site showing the sampling station along Dagua river basin in the Valle del Cauca. Zones: 1. High Zone (EC = El Carmen), 2. Middle Zone (HA = La Harinera) and 3. Low Zone (BD = Union Bitaco-Dagua).

m9.figshare.20771038.v1>; Figs. 2-5) distributed in 9 families and 11 genera. The family and genera with the largest number of species corresponds to Naviculaceae, with 6 species. Table S2 (available on supplementary material <https://doi.org/10.6084/m9.figshare.20771038.v1>) shows the geographic distribution (Latin America and Colombia) of each of the identified species.

Melosira varians C.Agardh. Fig. 2a

Valves cylindrical, forming rectilinear chains. The valve is slightly convex. The surface of the valve is covered by small spines and the mantle by small granules. Rimoportulae are scattered over valve face and mantle and one row of rimoportulae occurs on the mantle edge. Valve dimensions: Diameter: 20–21 µm.

Examined material: Valle del Cauca, Río Dagua, EC1-A (slide B1438, Limnological Collection of the Museo Javeriano de Historia Natural "Lorezo Uribe, S.J.").

Illustrations: Metzeltin, Lange-Bertalot & García-Rodríguez, Iconogr. Diatomol., v.15. 2005. p. 246, pl. 2, figs. 7-12.

Fragilaria aff. ***socia*** (J.H. Wallace) Lange -Bertalot. Basionym: *Synedra socia* J.H. Wallace. Fig. 2b

Linear-lanceolate valves; rostrate ends, attenuate to subcapitulate; striae almost parallel, intercalated with those of the opposite margin. Central area that occasionally extends to the margins, with a slight constriction causing bilateral swelling in the median region. The identification of Dagua River specimens was based on the swelling of the valve in the central area, and in the valve dimensions. However, the stries number is lower than description of *F. socia* (17 in 10 µm). Valve dimensions: Length: 17.9–39.5 µm; width: 4.1–5.5 µm; striae: 8–12 in 10 µm. Specimens with similar number of stries has been reported at the Iguacu River by Nardelli *et al.* (2014).

Examined material: Valle del Cauca, Río Dagua, BD3-J, EC1-A, HA3-A, BD3-A. (slides B1437, B1438, B1443, and B1446, Limnological Collection of the Museo Javeriano de Historia Natural "Lorezo Uribe, S.J.").

Illustrations: Wallace. 1960. Notulae Naturae 331: 1-8, p. 1, pl. 1, figs. 1 A-E.

Pseudostaurosira brevistriata (Grunow) D.M.Williams & Round. Basionym: *Fragilaria brevistriata* Grunow. Fig. 2c

Valves lanceolate to elliptical. Valves have rostrate ends in larger specimens to rounded ends in smaller specimens. The axial area is lanceolate. Striae short with wide areolae, rounded or oval shaped, parallel striae that radiate in the center of the valve and gently at the ends. Spines are present along the valve face edge. In girdle view, frustules are rectangular, joined by linking spines. Apical pore fields with round poroids are present on the valve mantle close to valve face. Valve dimensions: Length: 21–27.6 µm; width: 4.1–4.2 µm; striae: 14–15 in 10 µm.

Examined material: Valle del Cauca, Río Dagua, BD3-J, HA1-A (slides B1437 and B1441, Limnological Collection of the Museo Javeriano de Historia Natural "Lorezo Uribe, S.J.").

Illustrations: Rumrich, Lange-Bertalot & Rumrich. Iconogr. Diatomol. V9, 2000. p.266, pl. 13, figs. 1-9.

Synedra goulardii Brébisson *ex* Cleve & Grunow. Fig. 2d

Valves linear-lanceolate to lanceolate, with a slight to pronounced constriction in the median region; extremities rostrate, rostratecapitate or subcapitate; axial area linear, narrow and straight; central area rectangular to circular, reaching the margins, delimitated by smaller striae, biseriate, parallel to the opposite margin. Ghost striae are present in the central area. Each valve has two rimoportula. Apical rimoportula are visible in light microscopy. The population studied showed polymorphism in relation to the contour of the extremities and the shape of the median region of the valve, observing individuals with slight to pronounced constrictions in the central area of the valve. Valve dimensions: Length: 47.8–62.2 µm; width: 6.8–8.7 µm; striae: 9–11 in 10 µm.

Examined material: Valle del Cauca, Río Dagua, BD3-J, BD1-A. (Slides B1437 and B1444, Limnological Collection of the Museo Javeriano de Historia Natural "Lorezo Uribe, S.J.").

Illustrations: Rumrich, Lange-Bertalot & Rumrich. Iconogr. Diatomol. V9, 2000. p.250, pl. 5, figs. 1-2.

Achnanthidium minutissimum (Kützing) Czarnecki. Basionym: *Achnanthes minutissima* Kützing. Fig. 2e

Valves elliptical-lanceolate; rounded extremities, sometimes slightly capitated. In the raphe valve, raphe filiform, with external proximal extremities slightly dilated and internal gently curved to opposite sides; central area asymmetric reaching one margin; axial area narrow, slightly widen to the valve center. Raphe-less valve: striae uniseriate, gently radiate and interrupted; central area symmetric reaching both valve margins and axial area linear-lanceolate. Valve dimensions: Length: 10.6–14.5 µm; width: 2.7–3.8 µm; striae

raphe valve: 26–28 in 10 µm; stries raphe-less valve: 24–28 n 10 µm.

Examined material: Valle del Cauca, Río Dagua, HA1-J, HA2-J, HA3-J, EC1-A, EC3-A. (Slides B1432, B1433, B1434, B1438, and B1440, Limnological Collection of the Museo Javeriano de Historia Natural "Lorezo Uribe, S.J.").

Illustrations: Blanco *et al.* 2010. p. 196, pl. 43, figs. 22-24, 29, 30.

Achnanthidium saprophilum (H.Kobayashi & Mayama) Round & Bukhtiyarova. Basionym: *Achnanthes minutissima* var. *saprophila* H.Kobayasi & Mayama. Fig. 2f

Lineal-lanceolate valves to lineal-elliptic, with central raphe ends curved to the same side. The raphe valve is almost flat, relatively concave along the axis, while the rapheless valve is convex along

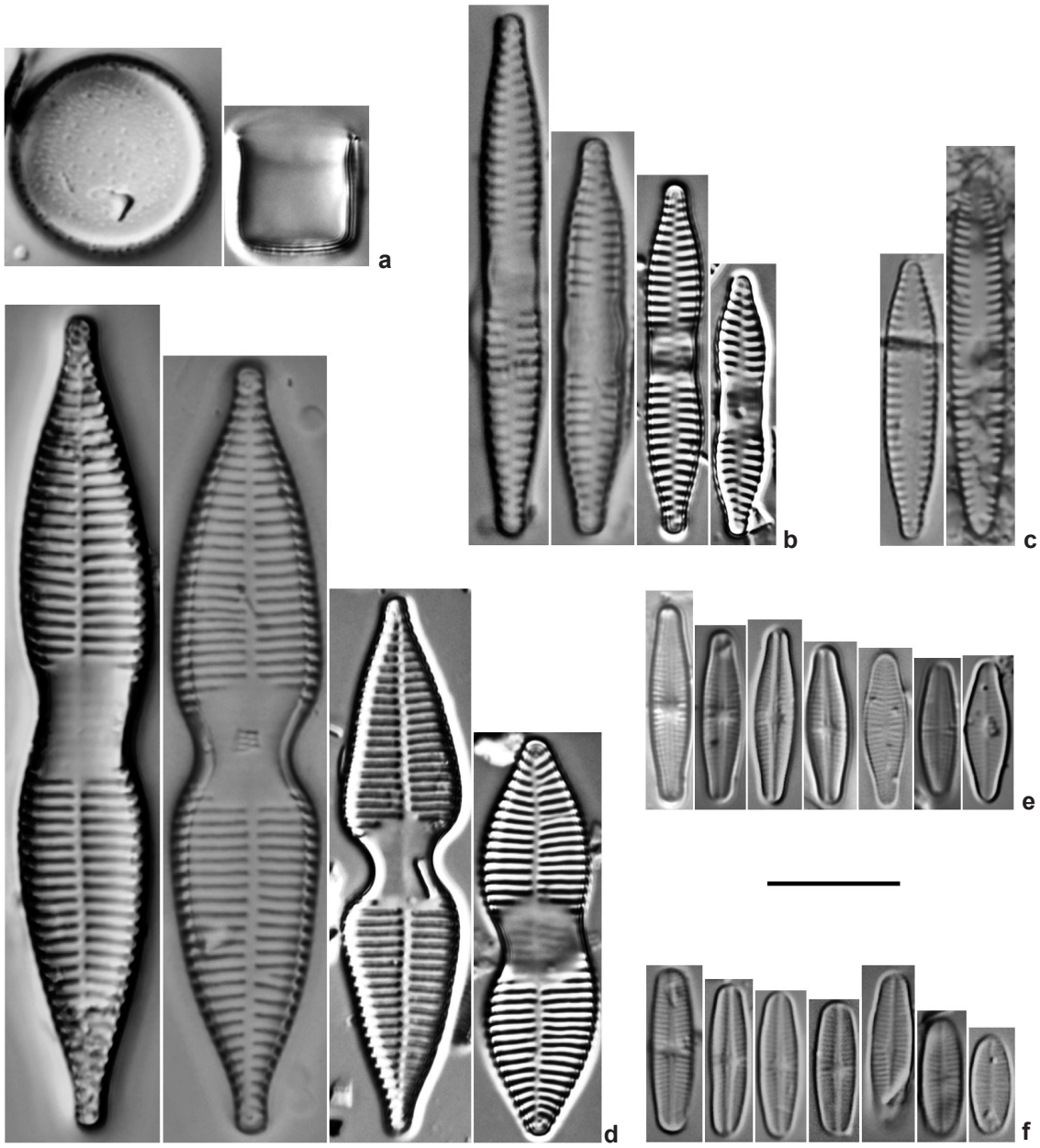

Figure 2 – a-f. Micrographs of the species of epilithic diatoms from Dagua River Basin, Colombia – a. *Melosira varians*; b. *Fragilaria* aff. *socia*; c. *Pseudostaurosira brevistriata*; d. *Synedra goulardii*; e. *Achnanthidium minutissimum*; f. *Achnanthidium saprophilum.* Scale bar: 10 µm.

the axis, where the axial area is wider and slightly lanceolate. The striae are composed of elongated rectangular areolas. Valve dimensions: Length: 6.06–12.36 µm; width: 2.09–3.34 µm; striae raphe valve: 21–27 in 10 µm; stries raphe-less valve: 25–28 in 10 µm.

Examined material: Valle del Cauca, Río Dagua, HA1-J, HA2-J, HA3-J, HA3-A. (Slides B1432, B1433, B1434 and B1443, Limnological Collection of the Museo Javeriano de Historia Natural "Lorezo Uribe, S.J.").

Illustrations: Krammer & Lange-Bertalot. Süsswasserflora von Mitteleuropa. Vol. 2/4. 1991. p316, pl. 33, figs. 13-19.

Cocconeis placentula *sensu lato* Ehrenberg. Fig. 3a

Elliptic to linear-ellipitic valves, slightly flattened. Filiform and straight raphe.

Radiate striae that are interrupted by a hyaline ring that is located near the margin of the raphe valve. The axial area of the raphe valve is narrow, with a central circular area, while the axial area of the raphe-less valveis linear to linear-lanceolate with radiating striae. The concept of *C. placentula* presented here is in the broad sense (sensu lato) due to the difficulty of distinguishing raphe valve of varieties and species. Valve dimensions: Length: 16.3–34 µm; width: 8.8–18.1 µm; striae raphe valve: 24–32 in 10 µm; striae raphe-less valve: 20–28 in 10 µm.

Examined material: Valle del Cauca, Río Dagua, EC1-J, EC2-J, EC3-J, HA1-J, HA2-J, HA3-J, BD1-J, BD2-J, BD3-J, EC1-A, EC2-A, EC3-A, HA1-A, HA2-A, HA3-A, BD1-A, BD2-A, BD3-A (Slides B1429 to B1446, Limnological Collection of the Museo Javeriano de Historia Natural "Lorezo Uribe, S.J.").

Illustrations: Krammer & Lange-Bertalot. Süsswasserflora von Mitteleuropa. Vol. 2/4. 1991. P352-356, pls. 52-54.

Planothidium frequentissimum (Lange-Bertalot in Krammer and Lange-Bertalot) Lange-Bertalot. Basionym: *Achnanthes lanceolata* subsp. *frequentissima* Lange-Bertalot. Fig. 3b

Valves lanceolate to elliptic with rounded or slightly protracted. In the raphe valve there is a linear axial area and a central area with variable shape, which can be transversely rectangular to elliptical. In the rapheless valve has a linear lanceolate axial area that can be slightly enlarged in the center and central cavum or septum (hood) presence. The raphe is straight, with the presence of expanded external proximal ends. The terminal raphe is curved to same side. Presence of multiseriate striae, which radiate along the valves. Valve dimensions: Length: 11.9–16.4 µm; width: 4.16–5.1 µm; striae raphe valve: 13–14 in 10 µm; striae raphe-less valve: 13–16 in 10 µm.

Examined material: Valle del Cauca, Río Dagua, EC2-J, HA1-J, HA2-J, HA3-J, BD3-J, EC2-A, EC3-A, HA1-A. (Slides B1430, B1432, B1433, B1434, B1437, B1439, B1440, and B1441, Limnological Collection of the Museo Javeriano de Historia Natural "Lorezo Uribe, S.J.").

Illustrations: Blanco *et al.* 2010. p. 196, pl. 43, figs. 22-24, 29, 30.

Navicula gregaria Donkin. Fig. 3c

Valves symmetrical, isopolar and lanceolate with protracted ends usually rostrate and sometime subcapitate. Presence of a filiform raphe in both valves, the raphe is straight with the proximal raphe ends abruptly bent towards the side of the valve. Axial area narrow-linear, central area variable in size and noticeable asymmetric. Striae that radiate slightly in the central nodule, become parallel and then converge at the extremes. Valve dimensions: Length: 27–28.4 µm; width: 5.5–6.7 µm; striae: 19–20 in 10 µm.

Examined material: Valle del Cauca, Río Dagua, BD1-A. (Slide B1435, Limnological Collection of the Museo Javeriano de Historia Natural "Lorezo Uribe, S.J.").

Illustrations: Lange-Bertalot. Diatoms of Europe. Vol 4. 2001. p. 85, pl. 38, figs. 8-18.

Navicula incarum Rumrich & Lange-Bertalot. Figs. 3d; 5a-b

Valves lanceolate with rounded ends. Raphe filiform scarcely visible in the middle part of the valve and only evident in distal and proximal area. Narrow axial area. Central area from small to moderately wide and variable from rounded to rhombic form. Striae subparallel in the central part of the valve and moderate radiated close to the ends. The striae are well differentiable in a light microscope and the lineola are distinguishable. The specimens reported for the Dagua River (Colombia) are in the smallest size range of that reported for the population of the diagnosis in the Puyango River (Ecuador). No other reports are known for Colombia and this material expands the knowledge of the distribution of *N. incarum*. Valve dimensions: Length: 19.9–21.1 µm; width: 4.5–5.5 µm; striae: 13–19 in 10 µm.

Examined material: Valle del Cauca, Río Dagua, EC1-A, EC3-A. (Slides B1438 and B1440 Limnological Collection of the Museo Javeriano de Historia Natural "Lorezo Uribe, S.J.").

Illustrations: Rumrich, Lange-Bertalot & Rumrich Iconogr. Diatomol. V9. 2000. p. 158, pl. 49, figs. 7-16.

Navicula lohmannii Lange-Bertalot & Rumrich. Fig. 4a

Valves lanceolate with rounded and attenuated ends. Presence of filiform raphe. Proximal raphe pores well separated. Wide axial area that progressively expands in the central area. Central area from small to moderately wide and variable from rounded to rhombic form. Striae radiate in the center and almost parallel to converge towards the ends. Valve dimensions: Length: 70.5 µm; width: 9.4 µm; striae: 12 in 10 µm.

Examined material: Valle del Cauca, Río Dagua, HA3-A. (Slide B1443 Limnological Collection of the Museo Javeriano de Historia Natural "Lorezo Uribe, S.J.").

Illustrations: Rumrich, Lange-Bertalot & Rumrich Iconogr. Diatomol., v.9. 2000. p. 312, pl. 36, figs. 6-7.

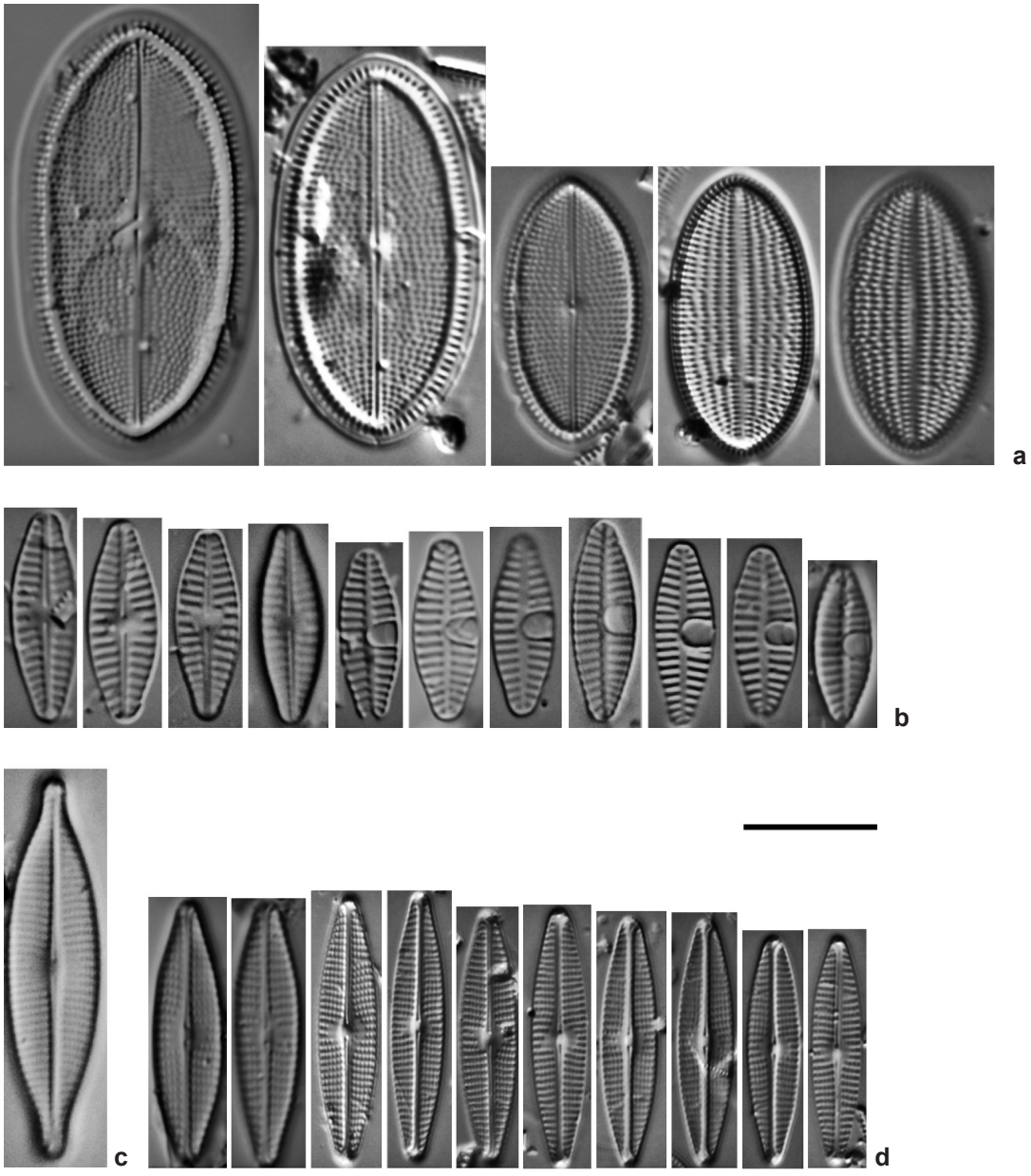

Figure 3 – a-d. Micrographs of the species of epilithic diatoms from Dagua River Basin, Colombia – a. *Cocconeis placentula*; b. *Planothidium frequentissimum*; c. *Navicula gregaria*; d. *Navicula incarum.* Scale bar: 10 µm.

Navicula longicephala Hustedt. Fig. 4b

Linear valves, ends abruptly rostrate, subcapitate to capitate. A filiform raphe distinguishable in light microscopy only in distal and proximal area. Central pores distinct and very close together. Central area variable due to the presence of irregularly shortened, striae. Central area lanceolate to transversely rectangular. Striae pronounced radiate in the center, and convergent at the extremes. Valve dimensions: Length: 18.5 µm; width: 3.7 µm; striae: 15 in 10 µm.

Examined material: Valle del Cauca, Río Dagua, EC3-A. (Slide B1440 Limnological Collection of the Museo Javeriano de Historia Natural "Lorezo Uribe, S.J.").

Illustrations: Lange-Bertalot. Diatoms of Europe. Vol 4. 2001. p. 45, pl. 32, figs. 41-47.

Navicula rostellata Kützing. Figs. 4c; 5c

Valves symmetrical, isopolar and elliptical-lanceolate with slightly convex to subrostrate ends. Presence of raphe in both valves, with proximal ends curved toward the primary side of the valve, and curved terminal ends toward the secondary side of the valve. Central asymmetric nodule, expanded on the internal surface of the valve towards the primary side. Striae that bend and radiate around the center, become parallel and then converge at the ends. Valve dimensions: Length: 35–38.8 µm; width: 9–9.8 µm; striae: 13–16 in 10 µm.

Examined material: Valle del Cauca, Río Dagua, HA2-J, HA3-J, EC1-A, HA3-A. (Slides B1443, B1434, B1438, and B1444, Limnological Collection of the Museo Javeriano de Historia Natural "Lorezo Uribe, S.J.").

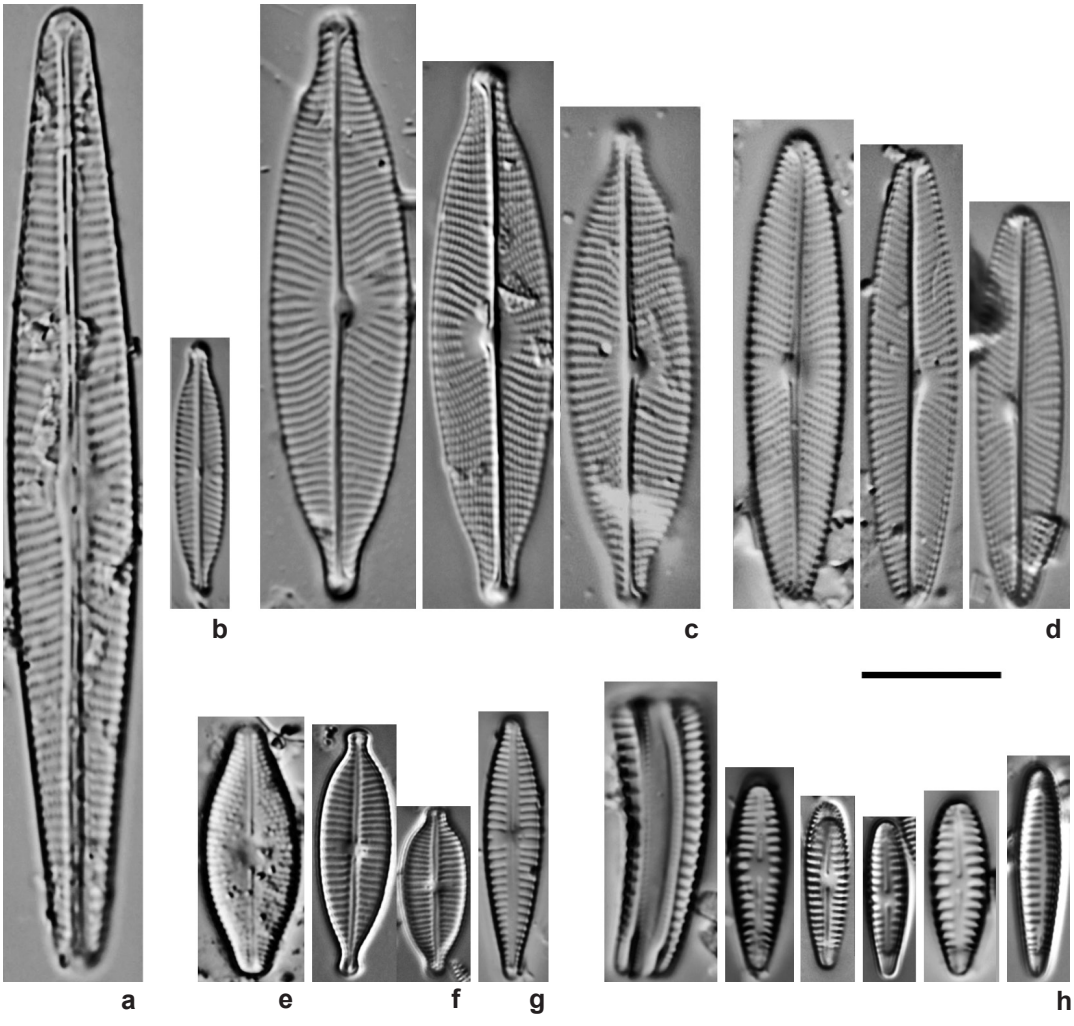

Figure 4 – a-h. Micrographs of the species of epilithic diatoms from Dagua River Basin, Colombia – a. *Navicula lohmannii*; b. *Navicula longicephala*; c. *Navicula rostellata*; d. *Navicula symmetrica*; e. *Diadesmis confervacea*; f. *Gomphonema lagenula*; g. *Gomphonema parvulum*; h. *Rhoicosphenia abbreviata.* Scale bar: 10 µm.

Illustrations: Lange-Bertalot. Diatoms of Europe. Vol 4. 2001. p. 91, pl. 35, figs. 1-6.

Navicula symmetrica Patrick. Figs. 4d; 5d

Valves linear-elliptical to linear-lanceolate with rounded extremes. Presence of straight raphe in both valves, with enlarged proximal ends that deviate slightly to one side of the valve. Axial area narrow, central area varying from rounded to elliptic to rectangular, lanceolate expanded on one side, and therefore, asymmetric. Striae radiate on the entire surface of the valve. Presence of a thickened central nodule on the primary side of the valve. Valve dimensions: Length: 24.2–34.6 µm; width: 5.8–7.0 µm; striae: 14–16 in 10 µm.

Examined material: Valle del Cauca, Río Dagua, EC1-J, BD3-J, HA1-J. (Slides B1429, B1437, and B1432, Limnological Collection of the Museo Javeriano de Historia Natural "Lorezo Uribe, S.J.").

Illustrations: Lange-Bertalot. Diatoms of Europe. Vol 4. 2001. p. 93, pl. 39, figs. 8-14.

Diadesmis confervacea Kützing. Fig. 4e

Elliptical valves, with apiculate ends. The central area is wide and rounded, while the axial area narrows in the central area to the extremes.

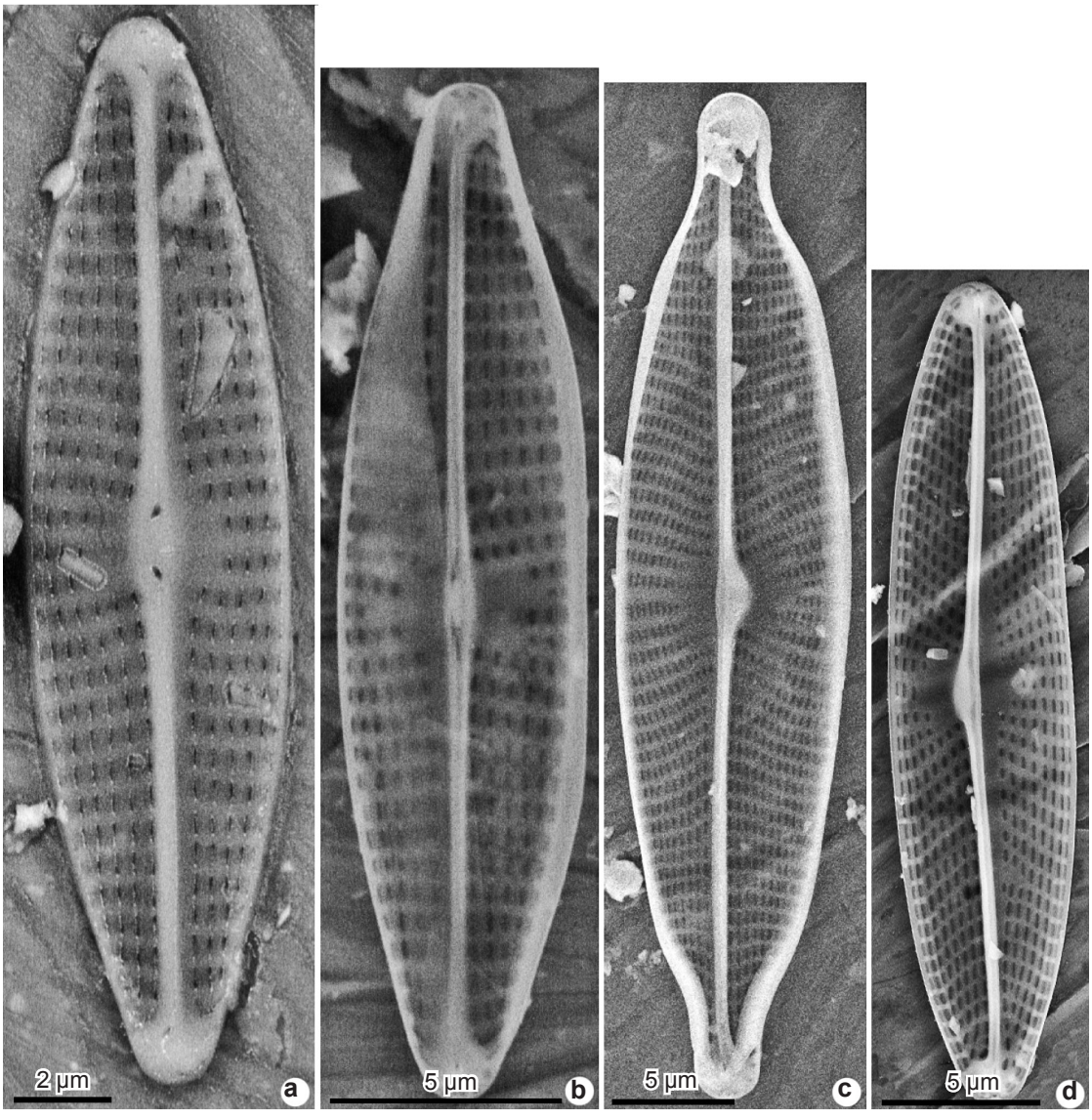

Figure 5 – a-d. SEM Micrographs of the species of epilithic diatoms from Dagua River Basin, Colombia – a, b. *Navicula incarum*; c. *Navicula rostellata*; d. *Navicula symmetrica.*

The valve has a rounded, thickened central nodule. Filiform and straight raphe, external distal ends slightly dilated and proximal ends expanded. Radiated and punctate striae. Striae length is highly variable. Valve dimensions: Length: 18 µm; width: 7 µm; striae: 21 in 10 µm.
Examined material: Valle del Cauca, Río Dagua, EC1-A. (Slide B1438, Limnological Collection of the Museo Javeriano de Historia Natural "Lorezo Uribe, S.J.").
Illustrations: Krammer & Lange-Bertalot. Süsswasserflora von Mitteleuropa, Band 2/1.1986. p 221, pl. 75, figs. 29-31.

Gomphonema lagenula Kützing. Fig. 4f

Valves heteropolar and asymmetric, lanceolate to elliptic-lanceolated, with apical ends subcapitate to subrostrate and basal ends subcapitate. Presence of raphe in both valves, which extends generally along the entire valve. Central area limited by the shortening of a median stria. Presence of stigma, at the end of a median stria. Striae are uniseriate, slightly radiate at the center and radiate at the apices. *Gomphonema lagenula* is morphologically similar to *Gomphonema parvulum*. In this work, these two species were differentiated by the apical ends subcapitate to capitate observed in *G. lagenula*, which is different from the apical rostrate end of *G. parvulum.* Valve dimensions: Length: 19.4–32.5 µm; width: 5.4–6.4 µm; striae: 15–16 in 10 µm.
Examined material: Valle del Cauca, Río Dagua, BD3-J, EC1-A, HA3-A, BD1-A. (Slides B1437, B1438, B1443, and B1444, Limnological Collection of the Museo Javeriano de Historia Natural "Lorezo Uribe, S.J.").
Illustrations: Rumrich, Lange-Bertalot & Rumrich Iconogr. Diatomol. V9. 2000. p. 506, pl. 133, figs. 6-7.

Gomphonema parvulum (Kützing) Kützing. Basionym: *Sphenella parvula* Kützing. Fig. 4g

Valves heteropolar and asymmetric, lanceolate to elliptic-lanceolate, with apical extreme subrostrate and basal extreme attenuated rounded. Presence of raphe in both valves, which extends generally along the entire valve. Central area limited by the irregular shortening of a median stria. Presence of stigma, at the end of a median stria. Striae are parallel to slightly radiate at the apices. Valve dimensions: Length: 20–26.1 µm; width: 5.19–5.48 µm; striae: 15–16 in 10 µm.

This species has a great morphological variation.
Examined material: Valle del Cauca, Río Dagua, HA2-A. (Slide B1442, Limnological Collection of the Museo Javeriano de Historia Natural "Lorezo Uribe, S.J.").
Illustrations: Metzeltin, Lange-Bertalot & García-Rodríguez, Iconogr. Diatomol., v.15. 2005. p. 534, pl. 145, figs. 37- 44.

Rhoicosphenia abbreviata (C.Agardh) Lange-Bertalot. Basionym: *Gomphonema abbreviatum* C.Agardh. Fig. 4h

Claviform valves with presence of raphe, reduced to the apices. Asymmetric and heteropolar valves with rounded ends. Curved valve in girdleview. A pseudoseptum is present at both poles on valve margins which is distinguished in light microscopy. The dorsal valve has a short raphe situated close to the poles. Striae are uniseriate and areolae are apically elongated. Valve dimensions: Length: 9.8–20.55 µm; width: 3.16–5.84 µm; striae: 10–18 in 10 µm.
Examined material: Valle del Cauca, Río Dagua, EC3-J, HA1-J, HA2-J, BD3-J, EC1-A, HA1-A, HA2-A, HA3-A, BD1-A. (Slides B1431, B1432, B1433, B1437, B1438, B1441, B1442, B1443, and B1444, Limnological Collection of the Museo Javeriano de Historia Natural "Lorezo Uribe, S.J.").
Illustrations: Blanco *et al.* Diatom atlas of the Duero basin. 2010. p. 278, pl. 84, figs. 1-21.

Discussion

Although the great biodiversity of Colombia has been widely recognized, being part of the group of megadiverse countries, which exhibit the highest biodiversity index on the planet, some groups of organisms such as diatoms have been poorly studied, generating the need to consolidate a biodiversity monitoring system (Andrade-Correa 2011). In Colombia, most studies on algal diversity have been conducted in lakes, and approximately 1,500 species of diatoms have been cited for the country, most of them from high-Andean lakes (Zapata & Donato 2005; Ramirez & Plata 2008; Sala *et al*. 2008; Donato 2010). However, a variety of studies from the Colombian Andean-Amazonian rivers suggest that diatom diversity could be greater than in the Andean ecosystem streams (Duque & Núñez-Avellaneda 2000; Montoya-Moreno *et al.* 2012). Studies of diatom diversity in the region have been scarce, in this way, lower diversity in the aquatic diversity patterns in the Southwestern region of Colombia is could be related to reduced number of studies which have been conducted in those watersheds (Mosquera-Restrepo & Peña-Salamanca 2019).

Especially, for the tropical Andes, few regional-scale efforts for interpreting epilithic

diatoms diversity patterns exist (Rumrich *et al.* 2000; Donato 2019). In the Andean Colombian region, more species of the algal flora occur in generally oligotrophic (*i.e.*, with low primary productivity) high-altitude lakes than at lower mesotrophic lotic ecosystems such as rivers, streams, springs (Blanco *et al*. 2020; Díaz-Quirós & Rivera-Rondón 2004; Pinilla 2010).

At the study area, different taxa analyzed are new records for the Southwestern region of Colombia. Seven species are new records for Valle del Cauca*, Fragilaria* cf. *socia* and *Navicula incarum* are new records for Colombia. The specimens studied of *Fragilaria socia* coincide with the original description of *Synedra socia* (basionym), with the exception of the number of striae, which in this case was lower (8–12 in 10 μm) compared to that reported by Wallace (1960), who described the species with 17 striae in 10 μm. In addition, Wallace describes the species with a valve width of 3.5–4 μm. In this work, specimens with a valve width between 4.09 and 5.46 μm were found. *Fragilaria socia* is freshwater species, which has been reported in Brazil (Nardelli *et al.* 2014) in South America.

It is important to highlight that different species have a very wide morphological variability, in terms of shape and size of valve, as *Fragilaria* aff. *socia*, *Gomphonema parvulum*, *Gomphonema lagenula*, *Cocconeis placentula*, *Achnanthidium minutissimum*, *Navicula symmetrica*. *Gomphonema lagenula* presents a morphology similar to *Gomphonema parvulum*. This aspect deserves special attention, since it is possible that changes in some morphological features may be associated with small changes in water quality.

The species of the genus *Navicula* were the most representative in this study, as according to Round *et al.* (1990), *Navicula* is an extremely common genus, cosmopolitan and with a wide geographical distribution. Traditionally, species of *Navicula* genus have been used as bioindicators of pollution (Lobo *et al.* 2010). Particularly, *N. lanceolata* and *N. symmetrica* have been reported as indicative species of moderate levels of organic pollution. Aditionally, it has been used as inocolum in high rate algal ponds used for treatment of landfill leachate (Sardi-Saavedra *et al.* 2016). The presence of organic pollutants in these systems resulted in decreased diatom biodiversity because of losses of species that were nonresistant to pollution. However, *Navicula* species dominated the diatom assemblages of those aquatic environments.

This study of the assessment of algal species richness at a regional scale is a first step to know the diatomoflora of the department of Valle del Cauca, which has been little studied and to suggest future studies on a broader spatial-temporal scale.

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