Summer periphyton community
in two streams of the Pampa Plain, Argentina

Comunidad perifítica estival
en dos arroyos de la Pampasia Argentina

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Karina Soledad Esquius [1]
Alicia Haydeé Escalante[2]
Lía Cristina Solari[3]

ABSTRACT

During summer 2001, periphytic algae associated to the giant bulrush *Schoenoplectus californicus* (Cyperaceae) were studied in Los Padres and La Tapera streams (Pampa Plain, Argentina). One hundred and seven taxa were determined, being 76 of them common to both sampling sites. Diversity, total number of taxa and abundance of periphytic algae were greater in stems from the effluent (La Tapera Stream). Diatoms were the most important group in both streams, according to their richness and abundance. Periphyton from the influent (Los Padres Stream) was characterized by the dominance of the diatom *Navicula cryptocephala* and the codominance of another three algae. In contrast in La Tapera Stream, not any species could be recognized as dominant. Periphyton community architecture was more complex in the effluent, with a high development of five physiognomic groups. In conclusion, algal community attached to *S. californicus* differs in terms of diversity, abundance and community complexity, possibly due to the differences registered in certain abiotic parameters, mainly in water transparency and velocity.

Key Words: Epiphytes, Summer season, Streams, Los Padres Basin, South America.

RESUMEN

En el verano de 2001, se estudió la comunidad perifítica asociada al junco Schoenoplectus californicus (Cyperaceae) de los arroyos de Los Padres y de La Tapera, en la región pampeana (Argentina). Se determinó un total de 107 taxa algales perifíticos, de los cuales 76 fueron comunes a ambos sitios de muestreo. Los valores de diversidad, número total de taxa y abundancia algal resultaron mayores en los juncos extraídos del efluente (Arroyo de La Tapera). Las diatomeas constituyeron el grupo taxonómico más diverso y abundante en ambos sistemas lóticos. El perifiton del afluente (Arroyo de Los Padres) estuvo caracterizado por la dominancia de Navicula cryptocephala y la codominancia de otras especies algales. En cambio en el efluente, seis taxa resultaron dominantes. La arquitectura comunitaria fue más compleja en los juncos del Arroyo de La Tapera, debido a que cinco de los grupos fisonómicos algales establecidos presentaron un gran desarrollo. En conclusión, el perifiton del junco S. californicus difiere en términos de diversidad, abundancia y complejidad comunitaria, esto posiblemente debido a las diferencias registradas en ciertos parámetros abióticos, tales como la trasparencia y la velocidad del agua.

Palabras Clave: Perifiton, Arroyos, Laguna de Los Padres, América del Sur.

1. Dra. en Ciencias Biológicas, Becaria postdoctoral del CONICET, Argentina
kesquius@mdp.edu.ar

2. Dra. en Ciencias Naturales, Investigador de CONICET, Profesor Asociado UNMdP, Argentina.
aescalan@mdp.edu.ar

Laboratorio de Limnología, Departamento de Biología, Facultad de Ciencias Exactas y Naturales, Universidad Nacional de Mar del Plata, Argentina, y Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET, Argentina).

3. Dra. en Ciencias Naturales, Jefe de Trabajos Prácticos, UNLP, Argentina. 3. Instituto de Limnología Dr. Raúl A. Ringuelet, Argentina.
solari@ilpla.edu.ar

1. INTRODUCTION

The periphyton community, with predominance of algal biomass, is of great concern in researches on productivity of aquatic systems (Neely and Wetzel, 1997; Moeller, Wetzel and Osenberg, 1998; Wetzel, 2000), trophic web interactions (Tessier *et al.*, 2004), herbivory (Wellnitz and Ward, 2000; Sommer, 2001), trophic status (Hillebrand and Kahlert, 2001), and because of its stationary nature, in monitoring sources of pollution (Niyogi, Mc Knight and Lewis Jr., 1999) or nutrients (Wetzel, Ward and Stock, 1997; Havens *et al.*, 1999; Mann and Wetzel, 2000).

The Pampa Plain streams and lakes from Buenos Aires province (Argentina) are characterized by their shallowness, in such a way that the whole bottom can play the role of littoral zone covered by macrophytes (Ringuelet, 1962). Submersed and free - floating macrophytes, as well as submersed structures of emergent macrophytes, are densely colonized by sessile microflora. Los Padres Basin here studied is a case where the most common species among macrophytes is the giant bulrush *Schoenoplectus californicus* (Meyer) Steud. (Cyperaceae) (González Sagrario and Balseiro, 2003). Despite of its importance, the structure of periphyton communities colonizing this macrophyte in Argentina is poorly known. There are only three researches referred to periphytic algae from Los Padres Lake: the first has been done on *Ricciocarpus natans* (L.) Corda, a free-floating Hepaticae that frequently appears on the water surface of the lake and streams (Pozzobon and Tell, 1995), the second is related to artificial substrates placed in the water in order to study the algal colonization process (Esquius, Escalante and Solari, 2005) and the third is referred to periphytic diatoms on *S. californicus* as an indicator of the trophic status of the aquatic environment (Esquius, Escalante and Solari, 2008).

Thus, the aim of the present study was to know the composition, the vertical distribution and the architecture of the epiphyton living associated to *S. californicus* during summer in two streams of the Pampa Plain. It was predicted that algal community attached to *S. californicus* in Los Padres Stream differs from that growing at La Tapera Stream.

2. STUDY AREA

Los Padres Basin (37º 55' – 38º 02´ S; 57º 43' – 57º 53´ W) is placed at the eastern border of Sierra de Los Padres, in Buenos Aires province, Argentina (del Río *et al.*, 1992). Because of its shallowness, Los Padres Lake is strongly influenced by wind and is therefore polymictic (Ringuelet, 1972). As many lakes from Pampa Plain, its catchment area has an intensive agricultural land use and its trophic status is eutrophic (Quirós and Drago, 1999), with some level differences between its influent and effluent areas (Esquius, Escalante and Solari, 2008). In the last few years, tourist and deportive activities have changed its ecosystem structure (Savigny, 2001; Cardoni, Favero and Isacch, 2008).

Los Padres Stream (influent stream) flows through horticultural land before entering the lake (Campana *et al*., 2001). A big breeding colony is located in this area. It is mainly made up of waterbirds like *Bubulcus ibis* Linneaus (Cattle Egret) and *Plegadis chihi* Vieillot (White- faced Ibis) with a mix diet, and *Larus maculipennis* Lichtenstein (Brown-hooded Gull), *Larus cirrocephalus* Vieillot (Grey- headed Gull) and *Phalacrocorax olivaceus* Humboldt (Neotropic Cormorant) with a carnivorous diet, among others (Savigny, 2001; Josens, Escalante and Favero, 2009). Opposite Los Padres Stream, the lake drains into the effluent and over a small dam to La Tapera Stream (Esquius, Escalante and Solari, 2005).

Both streams were selected for sampling in the present study (Figure 1). The giant bulrush *Schoenoplectus californicus* is greatly developed in the lake, particularly in the input and output areas, corresponding to the inflow discharge and the headwaters of the effluent, respectively. In addition to *S. californicus*, submersed (*Ceratophyllum demersum* L.) and free - floating macrophytes (e.g. *Ricciocarpus natans, Azolla* spp. and Lemnaceae) are frequently observed (González Sagrario *et al.*, 1998; González Sagrario and Balseiro, 2003).

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Figure 1. Map of Los Padres Basin. Study sites (•).

3. METHODS

3.1. Sampling and periphyton analysis

Each stream was visited once, at mid - summer 2001. For each sampling site the following physical and chemical parameters were recorded: air and water temperatures, transparency (Secchi disk), depth, water velocity, pH, dissolved oxygen concentration, biochemical oxygen demand (BOD_5), and total alkalinity (APHA, 1998).

Ten stems of bulrush were randomly removed up to 20 cm from the sediment. Each stem was cut into five segments indicated from top to bottom as A (0.20 – 0.16 m from sediment), B (0.16 – 0.12), C (0.12 – 0.08), D (0.08 – 0.04) and E (0.04 – sediment level), in both the text and figures. Periphytic biofilm of each segment was removed by brushing and preserved in a mixture of distilled water, alcohol and formol solution, in 6:3:1 proportion. Prior to counting, the samples were homogenized at low speed for 30 seconds using a magnetic stirrer HI 190M. Counts were performed in a 0.3 ml Sedgwick - Rafter chamber under an Olympus CH30 microscope. Algal abundances were expressed as the number of individuals per cm^2, considering the bulrush area as the lateral area of a cylinder (Claps, 1984).

Shannon- Weaver diversity index, species richness and algal abundance were used for community structure analyses. Statistical differences of periphyton density between the two streams sampled were analyzed by means of Student Test (t) or Mann - Whitney Rank Sum Test (T). Related to the abundance of periphytic algae in different segments of the stems, the statistical test performed was the non - parametric Kruskal - Wallis (H). The non - parametric multiple comparisons test Student - Newman - Keuls was used to locate significant differences among segments (Zar, 1984).

Periphytic algae were joined in five groups in order to determine the community architecture, according to their physiognomy, as follows: prostrates (as *Navicula cryptocephala*, Kützing or *Nitzschia palea* [Kützing] W. Smith); adnates (as *Achnanthes delicatula* Simonsen or *Amphora ovalis* [Kützing] Kützing); erects (taxa with stalk or mucilaginous peduncle as *Gomphonema parvulum* Kützing or with perpendicular growth to substrates, as *Fragilaria ulna* [Nitzsch] Lange - Bertalot); filaments or chains (taxa forming filaments, as *Anabaena spiroides* Klebahn or *Oedogonium sp.* or chains of cells, as *Pleurosira laevis* [Ehrenberg] Compère); and planktonics (as *Euglena* sp., *Trachelomonas oblonga* Lemmermann).

4. RESULTS

The two sampling stations showed differences in the physical and chemical parameters measured (Table 1). La Tapera Stream was scarcely shallower and more transparent than Los Padres Stream. Water velocity was higher in the influent and BOD_5 value at here was twice that of the effluent. Dissolved oxygen concentration estimated at both sampling sites had a contrary trend that BOD_5.

Table 1. Physical and chemical parameters of two streams from Los Padres Basin.

Parameters	Los Padres Stream	La Tapera Stream
Temperature (°C)	21	22
Depth (m)	0.47	0.36
Transparency (m)	0.10	0.36
Water velocity ($m\ seg^{-1}$)	0.11	0.06
pH	8.95	8.35
Alkalinity ($mg\ CaCO_3\ L^{-1}$)	309	325
Dissolved oxygen concentration ($mg\ L^{-1}$)	8.15	9.6
BOD_5 ($mg\ O_2\ L^{-1}$)	7.23	3.40

La Tapera Stream showed an alkaline pH, slightly lower than the value measured in Los Padres Stream. The value of total alkalinity was hardly higher at the former. At both sampling stations, total alkalinity values were mostly due to bicarbonate concentrations, as carbonate concentrations were very low (La Tapera Stream) or were lacking (Los Padres Stream).

One hundred and seven taxa of algae were found: 14 corresponding to cyanophytes, three to euglenophytes, 33 to chlorophytes and 57 to diatoms (Figure 2). Seventy - six of the 107 taxa were common to both sampling sites, whereas 24 were only present in bulrushes from the outflow, and only seven were typical of the inflow.

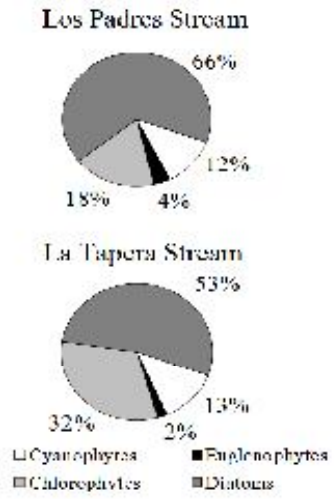

Figure 2. Specific composition (%) of periphytic algae associated to Schoenoplectus californicus in Los Padres and La Tapera streams.

Diatoms constituted the group with the greatest number of taxa in the periphyton from both lotic systems. Conversely, cyanophytes and euglenophytes presented similarly low values of number of taxa at both sites, whereas chlorophyte richness was greater in bulrushes from La Tapera Stream (Figure 2).

Diversity (Shannon - Weaver Index) and total number of taxa were greater in stems from the effluent. According to the analysis of the five segments of each stem, diversity index values increased towards those segments close to the sediment at both streams (Figure 3).

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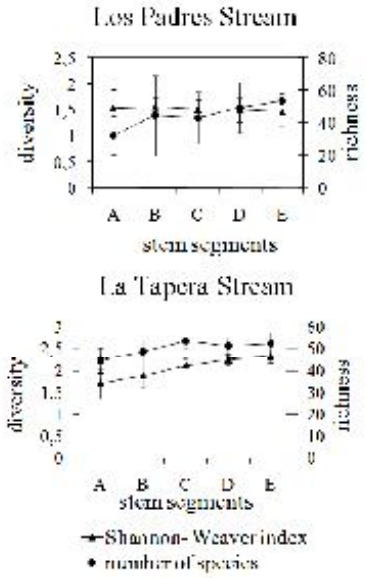

Figure 3. Diversity (Shannon – Weaver Index) and total number of taxa of periphyton algae associated to Schoenoplectus californicus in Los Padres and La Tapera streams.

The periphyton community of Los Padres Stream was characterized by the dominance of *Navicula cryptocephala* and the codominance of *Planktonema lauterbornii* Schmidle*, Cocconeis placentula* Ehrenberg and *Rhoicosphenia abbreviata* (Agardh) Lange - Bertalot. In contrast, in La Tapera Stream not any species could be recognized as dominant, but six taxa were codominant: *Calothrix* sp., *Trachelomonas oblonga*, *Aulacoseira granulata* (Ehrenberg) Simonsen, *Eolimmna sorex* Kützing*, N. cryptocephala* and *R. abbreviata.*

In bulrushes from La Tapera Stream the average abundance of periphytic taxa was significantly higher than that for bulrushes from Los Padres Stream, being the former more than twice that found in the latter (t = 3.05, p = 0.0069). The depth of maximum abundance of periphytic algae was also different at both sampling stations. In bulrushes from La Tapera Stream, the maximum abundance value occurred in B, whereas in those from Los Padres Stream, it was observed in A. The minimum abundance value of periphytic algae was registered in E at both streams (Figure 4).

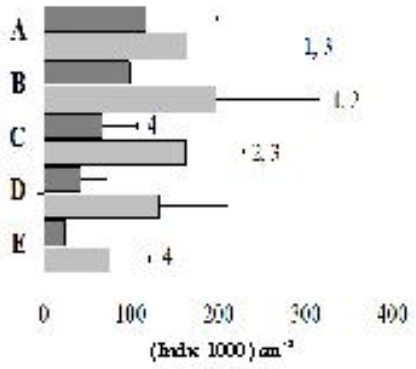

Figure 4. Total abundance of periphyton algae associated to Schoenoplectus californicus in Los Padres (dark gray) and La Tapera (light gray) streams. Bars show mean values and lines show positive standard deviation. Distributions with the same number are not significantly different (Student – Newman - Keuls test, p level < 0.05).

There were significant differences in the mean values of algal abundance among the stems analyzed in both sampling sites (H = 43.4, p = 0.0001). The Student - Newman - Keuls multiple comparisons test showed significant differences in periphytic densities of stems between the inflow and outflow streams, except in four cases (Figure 4).

Diatoms were the most abundant algae in bulrushes from Los Padres and La Tapera streams. No significant differences were found in their abundance between streams (t = 1.52, p = 0.1463). Pennate

diatoms were the most important group, according to their richness and density. Central diatoms were not numerically important, except *Aulacoseira granulata* in bulrushes from La Tapera Stream.

Euglenophytes reached great and statistically significant amounts in the periphyton community from La Tapera Stream, brought about by *Trachelomonas oblonga* (T = 155, p = 0.0001). Cyanophytes density was significantly greater in bulrushes of the effluent, particularly due to the high values of *Calothrix* sp. and *Leibleinia epiphytica* (Hieronymus) Compère (T = 154, p = 0.0001). Chlorophytes taxa were found at low and no significantly different densities were registered in bulrushes from both streams (T = 109, p = 0.791).

The community architecture in both streams was different too (Figure 5). In Los Padres Stream dominated the prostrate and adnate forms, corresponding to more than 70 % of the relative abundance, while planktonic forms had an insignificant contribution.

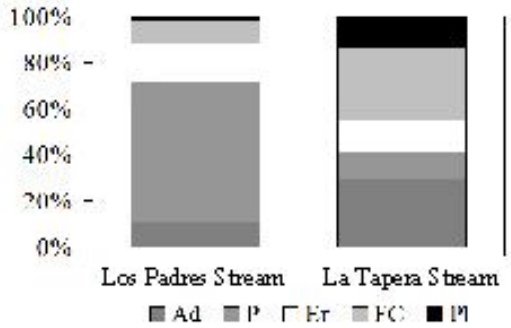

Figure 5. Relative contribution (%) of the physiognomic groups in bulrushes of Los Padres and La Tapera streams. Ad: adnate, P: prostrate, Er: erect, FC: filamentous and chains and Pl: planktonic.

Instead, periphyton from La Tapera Stream was more complex because the five physiognomic groups had a high representation (Figure 5). Erect, filamentous and chain - forming taxa were dominant, representing 50 % of the biofilm. The adnate and prostrate forms constituted 40 % of the relative abundance, and planktonic forms were more abundant here than in the influent, particularly due to the high values of Trachelomonas oblonga.

In Los Padres Stream, the relative abundance of adnate and prostrate forms remained constant independently of depth. Filamentous and chain - forming algae had higher values in deeper bulrush segments, while algae with mucilaginous stalks or with perpendicular growth to the substrate decreased to the sediment (Figure 6).

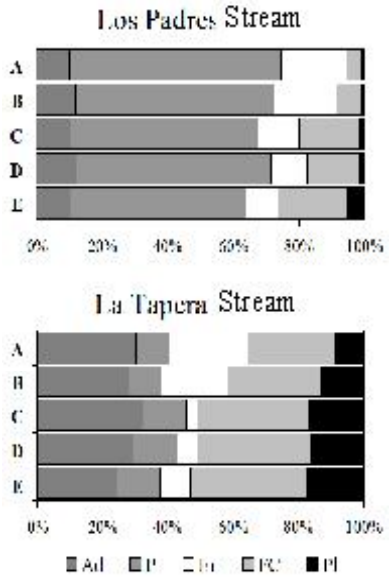

Figure 6. Relative contribution (%) of the physiognomic groups in bulrushes of Los Padres and La Tapera creeks in relation to depth. Ad: adnate, P: postrate, Er: erect, FC: filamentous and chains and Pl: planktonic.

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The adnate and prostrate periphyton showed similar situation in La Tapera Stream. Among algae developing strategies for light capture, filamentous forms increased in number with depth while erect algae reached the minimum abundance value in the C stem segment. Planktonic forms did not show significant changes with depth (Figure 6).

5. DISCUSSION

The periphyton community growing on the giant bulrush Schoenoplectus californicus from the streams of Los Padres Basin was composed of 107 taxa during mid - summer 2001. Seven of these taxa were only present in Los Padres Stream and 24 in La Tapera Stream. This total number of periphytic taxa was somewhat higher than that found by Claps (1984) and Gómez, Licursi and Hualde (2003) on the same macrophyte in the littoral zone of Samborombón Bay and Rio de la Plata estuary, respectively.

Diatoms constituted the dominant group according to their richness and abundance in the lotic systems here studied. This agrees with the results obtained by several authors (Luchini, 1974; Claps, 1984, 1987; Gómez, Licursi and Hualde, 2003; Esquius, Escalante and Solari, 2008) for the periphyton attached to S. californicus in different lentic and lotic environments from Argentina.

As confirmed by Luttenton and Rada (1986) and Rodrigues and Bicudo (2001) for other waterbodies, in the present study it might be proved that the speed of stream flow affects periphyton community. Los Padres Stream is the place where the inflow is entering to the lake, and produces some disturbances due to water movement. So, it showed a lower periphytic species diversity and richness than those of the effluent, whose headwaters have hardly movement.

Periphyton abundance in La Tapera Stream was significantly higher than that found in Los Padres Stream. This result confirms those obtained from artificial substrata placed in the same two environments when studying the algal colonization process (Esquius, Escalante and Solari, 2005). Differences in algal density between the two studied areas could be correlated with certain abiotic factors, mainly transparency and water velocity. A greater value of Secchi disk, as recorded in La Tapera Stream, would indicate a deeper light penetration, and the possibility of a larger development of periphyton community (Goldsborough and Robinson, 1996).

The abundance of epiphyton algae can also be related to the kind of waterbody studied and to the shape and structure of macrophytes acting as substrates (Claps, 1991). Values of epiphyton density on Schoenoplectus californicus reported by Claps (1984) in a riverine environment during summer (approx. 700 ind. cm-2) were much lower than those found in the present work.

On the other hand, the mean value of epiphyton abundance reported by Pozzobon and Tell (1995) for the free - floating Ricciocarpus natans from Los Padres Lake during summer was nearly 3 x 104 ind. cm-2, a much lower density than that found on S. californicus from the streams of the same basin. The greater development of the periphyton attached to S. californicus could be related to the perennial character of the giant bulrush. Moreover, the composition of the periphyton community developed on R. natans was completely different from that here described for the bulrush.

The depth of maximum density of epiphytic algae differed from one stream to another, but minimum density values occurred at the same depth in both sampling sites. The maximum density registered only at the upper segment of bulrushes in Los Padres Stream might be possibly due to the great load of suspended particulate matter transported by this stream from nearby agricultural soils (Miglioranza et al., 2002) or to the shadow effect of phytoplankton upon the periphyton (Lalonde and Downing, 1991).

In this work, all the periphytic taxa found on S. californicus were joined in five physiognomic groups named adnates, prostrates, erects, filaments or chains and planktonics. Agreeing with Gómez, Licursi and Hualde (2003), these groups were selected because they represent the predominant physiognomies in the periphyton community of Los Padres Lake. Gelatinous and rod clusters taxa, as reported by Wellnitz and Ward (2000), were present neither Los Padres nor La Tapera streams and, therefore, they were not considered.

Besides, the architecture of the community developed upon bulrushes of the influent stream was different from that of the effluent. Adnate and prostrate forms were dominant in Los Padres Stream biofilm, while in La Tapera Stream the architecture was more complex. This agrees with Luttenton and Rada (1986) and Peterson (1996), who had already demonstrated that water movement affects periphyton development, resulting in a reduction of community diversity, biomass accumulation and architectural complexity.

In the influent, algae developing strategies for light capture (as filamentous or chain-forming taxa) increased their relative abundance with depth, possibly due to light and current velocity as major regulator community factors (Hill, 1996; Gómez, Licursi and Hualde, 2003). On the other hand in the effluent, without light limitation in the water column, the erect algae decreased their relative density with depth, possibly because of grazing pressure as the more important factor enable to modify periphyton architecture and structure (Wellnitz and Ward, 2000).

6. CONCLUSIONS

The results of this work show that the periphyton community growing on *S. californicus* from Los Padres Stream differs from that growing in La Tapera Stream, in terms of species diversity, abundance and architectural complexity, possibly due to the differences registered in certain abiotic parameters, mainly in transparency and water velocity.

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REFERENCES

American Public Health Association APHA, 1998. Standard methods for the examination of water and waste water. Washington D.C.

Campana, M. A., Panzeri, M. A., Escalante, A. H., Moreno, V. J. and Dulout, F. N., 2001. Micronucleus test in fish from a pampasic pond (Argentina): an estimation of the presence of genotoxic compounds. J. Env. Pathology, Toxicology and Oncology, 20, pp. 325- 331.

Cardoni, D. A., Favero, M. and Isacch, J. P., 2008. Recreational activities affecting the habitat use by birds in Pampa's wetlands, Argentina: Implications for waterbird conservation. Biological conservation, 141, pp. 797- 806.

Claps, M. C., 1984. Perifiton en Scirpus californicus (Meyer) Steud. (Marjal de Ajó – Bahía Samborombón). Rev. Mus. La Plata (NS) Zool., 13, pp. 139- 149.

Claps, M. C., 1987. Valores de pigmentos hallados en el perifiton de Schoenoplectus californicus (Punta Atalaya - Río de la Plata). Limnobios, 2, pp. 653- 656.

Claps, M. C., 1991. Diatom communities on aquatic macrophytes of pampasic lotic environments (Argentina). Acta Hydrobiol., 33, pp. 195- 208.

Del Río, J. L., Massone, H. E., Martínez Arca, J., Bó, J., Bernasconi, V., Bocanegra, E., Farenga, M., Ferraro, R., López de Armentia, A., Osterrieth, M. y Tomás, M., 1992. Carta ambiental de la Cuenca del Arroyo y Laguna de Los Padres, Municipalidad General Pueyrredón, 58 P.

Esquius, K. S., Escalante, A. H. y Solari, L. C., 2005. Algas no planctónicas: un experimento de

colonización. Biología Acuática, 22, pp. 103- 110.

Esquius, K. S., Escalante, A. H. y Solari, L. C., 2008. Algas epífitas indicadoras de calidad del agua en arroyos vinculados a la Laguna de Los Padres. Biología Acuática, 24, pp. 95- 102.

Goldsborough, L.G. and Robinson, G. G. C., 1996. Pattern in wetlands. In: Stevenson, R. J., Bothwell, M. L. and Lowe, R. L. (eds.). Algal Ecology. Freshwater Benthic Ecosystems, 77- 177. Academic Press, San Diego.

Gómez, N., Licursi, M. and Hualde, R. R., 2003. Epiphytic algae on the bulrush (Scirpus californicus (Mey) Steud) in the Rio de la Plata (Argentina): structure and architecture. Arch. Hydrobiol. Suppl., 14, pp. 231- 247.

González Sagrario, M. A., Aizpún de Moreno, J. E., Moreno, V. J. and Escalante, A. H., 1998. Dynamics of organochlorine compounds in different trophic levels of Los Padres pond in Argentina. I. Pesticides. Env. Sciences, 6, pp. 153- 169.

González Sagrario, M. A. and Balseiro, E., 2003. Indirect enhancement of large zooplankton by consumption of predacious macroinvertebrates by littoral fish. Arch. Hydrobiol., 158, pp. 551- 574.

Havens, K. E., East, T. L., Rodusky, A. J. and Sharfstein, B., 1999. Littoral periphyton responses to nitrogen and phosphorus: an experimental study in a subtropical lake. Aquat. Bot., 63, pp. 267- 290.

Hill, W. R., 1996. Effects of light. In: Stevenson, R. J., Bothwell, M. L. and Lowe, R. L. (eds.). Algal Ecology. Freshwater Benthic Ecosystems, Academic Press, San Diego, pp. 121- 148.

Hillebrand, H. and Kahlert, M., 2001. Effect of grazing and nutrient supply on periphyton biomass and nutrient stoichiometry in habitats of different productivity. Limnol. Oceanogr., 46, pp. 1881- 1898.

Josens, M. L., Escalante, A. H. and Favero, M., 2009. Seasonal variability of waterbird assemblages and its relationship to habitat characteristics in a pampas wetland. Waterbirds, 32 (4), pp. 523- 530.

Lalonde, S. and Downing, J. A., 1991. Epiphyton biomass is related to lake trophic status, depth, and macrophyte architecture. Can. J. Fish. Aq. Sc., 48, pp. 2285- 2291.

Luchini, L., 1974. Diatomeas epífitas de algunas macrófitas del Lago Situación (Prov. Chubut). Physis, 33, pp. 127- 139.

Luttenton, M. R. and Rada, R. G., 1986. Effects of disturbance on epiphytic community architecture. J. Phycol., 22, pp. 320- 326.

Mann, C.J. and Wetzel, R. G., 2000. Effects of the emergent macrophyte Juncus effusus L. on the chemical composition of interstitial water and bacterial productivity. Biogeochemistry, 48, pp. 307- 322.

Miglioranza, K. S. B., González Sagrario, M. A., Aizpún de Moreno, J. E., Moreno, V. J., Escalante, A. H. and Osterrieth, M. L., 2002. Agricultural soil as a potential source of input of organochlorine pesticides into a nearby pond. Environ. Sc. Pollut. R., 9, pp. 250- 256.

Moeller, R. E., Wetzel, R. G. and Osenberg, C. W., 1998. Concordance of phosphorus limitation in lakes: bacterioplankton, phytoplankton, epiphyte – snail consumers, and rooted macrophytes. - In: Jeppesen, E., Sondergaard, M. A., Sondergaard, M. O. and Christoffersen, L. (eds.). The structuring role of submerged macrophytes in lakes. Springer- Verlag, New York, pp. 318- 325..

Neely, R. K. and Wetzel, R. G., 1997. Autumnal production by bacteria and autotrophs attached to Typha latifolia L. detritus. J. Freshwater Ecol., 12, pp. 253- 267.

Niyogi, D. K., Mc Knight, D. M. and Lewis Jr., W. M., 1999. Influences of water and substrate quality for periphyton in a montane stream affected by acid mine drainage. Limnol. Oceanogr., 44, pp. 804- 809.

Peterson, C. G., 1996. Responses of benthic algal communities to natural physical disturbances. In: Stevenson, R. J., Bothwell, M. L. and Lowe, R. L. (eds.). Algal Ecology. Freshwater Benthic

Ecosystems, Academic Press, San Diego, pp. 335- 402.

Pozzobon, M. V. y Tell, G., 1995. Estructura y dinámica de la comunidad perifítica sobre Ricciocarpus natans (Hepaticae) de la Laguna de Los Padres (Buenos Aires, Argentina). Bol. Soc. Argent. Bot., 30, pp. 199- 208.

Quirós, R. and Drago, E., 1999. The environmental state of Argentinean lakes: An overview. Lakes & Reservoirs: Research and Management, 4, pp. 55- 64.

Ringuelet, R. A., 1962. Ecología acuática continental. Eudeba, Buenos Aires.

Ringuelet, R. A., 1972. Ecología y biocenología del hábitat lagunar o lago de tercer orden de la Región Neotrópica Templada (Pampasia Sudoriental de la Argentina). Physis, 31, pp. 55- 76.

Rodrigues, L. and Bicudo, D., 2001. Similarity among periphyton algal communities in lentic-lotic gradient of the upper Paraná river floodplain, Brazil. Revta brasil. Bot., 24, pp. 235- 248.

Savigny, C., 2001. Aves de Mar del Plata. Laguna de Los Padres, Puerto y Costas Marinas. - Nuestras Aves. Revista de aves argentinas de la Asociación Ornitológica del Plata, 42, pp. 11- 18.

Sommer, U., 2001. Reversal of density dependence of juvenile Littoridina littorea (Gastropoda) growth in response to periphyton nutrient status. J. Sea Res., 45, pp. 95- 103.

Tessier, C., Cattaneo, A., Pinel – Alloul, B., Galanti, G. and Morabito, G., 2004. Biomass, composition and size structure of invertebrate communities associated to different types of aquatic vegetation during summer in Lago di Candia (Italy). J. Limnol., 63, pp. 190- 198.

Wellnitz, T. A. and Ward, J. V., 2000. Herbivory and irradiance shape periphytic architecture in a Swiss alpine stream. Limnol. Oceanogr. 45, pp. 64- 75.

Wetzel, R. G., 2000. Freshwater ecology: changes, requirements, and future demands. Limnology, 1, pp. 3- 9.

Wetzel, R .G, Ward, A. and Stock, M., 1997. Effects of natural dissolved organic matter on mucilaginous matrices of biofilm communities. Arch. Hydrobiol., 139, pp. 289- 299.

Zar, J. H., 1984. Biostatistical analysis. Prentice- Hall, Englewood Cliffs.