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Diatom communities on aquatic macrophytes of pampasic lotic environments (Argentina) *

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Abstract — In the period 1985—1986 diatom periphyton communities growing on 15 aquatic macrophytes were harvested from 12 rivers and streams belonging to the Delta Sub-basin. 75 species were determined, most of them alkaliphilous and corresponding to eutrophic environments with high conductivity. The maximum density and species richness peaks, generally took place during spring and fall. Different species were greater in number according to the season. The configuration of the cluster diagrams is due to the dominance of 9 species.

Key words: diatoms, periphyton, cluster analysis, lotic enviroments

1. Introduction

In Argentina, the study of diatoms associated with aquatic macrophytes has received little attention (Luchini 1973, 1974a). Only a few taxonomic papers can be mentioned (Tell 1973, Luchini 1974b). Other papers deal with diatoms as forming part of the periphyton community (Claps 1984, Zalocar de Domitrovic et al. 1986).

In the present work, several lotic environments from the north-eastern part of Buenos Aires province were sampled. Rivers and streams from this area had not previously been studied from a biological

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point of view. The present work is part of an extensive study on periphyton and plankton communities carried out in the area (M o d e n u t t i, C l a p s 1988, C l a p s 1991).

The aim was to analyse seasonal changes in species composition and density of diatoms growing on macrophytes from the lotic environments.

2. Study area

The study area lies in the north-east of the Buenos Aires province. The group of lotic bodies is defined as the Delta Sub-basin, belonging to the Rio de la Plata estuary Basin (CFI 1962).

Fourteen places were selected for the study: the rivers Luján (two stations), Arroyo del Medio, and Baradero; Pescado, Cañada Honda, Del Tala (two stations), Las Hermanas, Ramallo, Burgos, Luna, Giles, and De la Cruz streams (fig. 1).

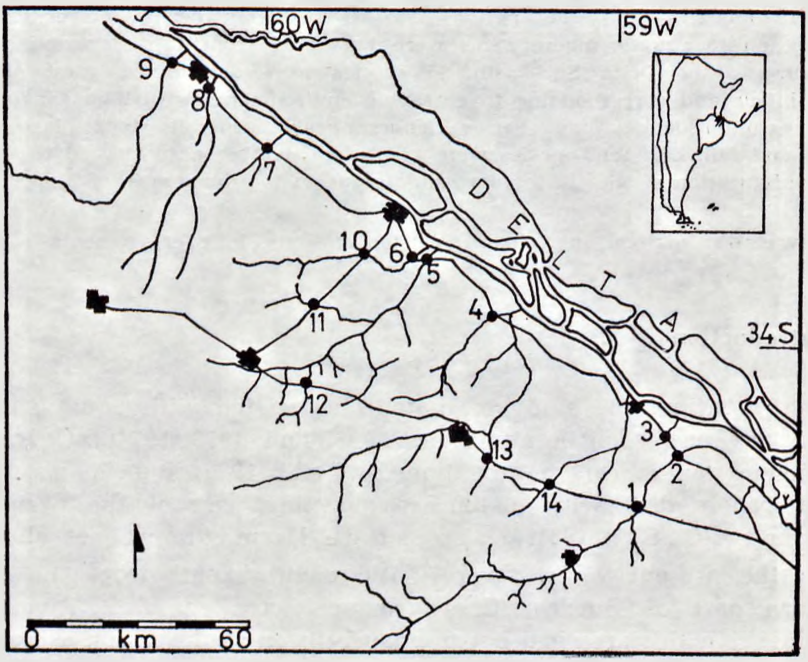

Fig. 1. Map of the studied area. Stations: 1, 2 — River Luján; 3 — Pescado stream; 4 — Cañada Honda stream; 5 — River Baradero; 6, 10 — Del Tala stream; 7 — Las Hermanas stream; 8 — Ramallo stream; 9 — River Arroyo del Medio; 11 — Burgos stream; 12 — Luna stream; 13 — Giles stream; 14 — De la Cruz stream

Most of them have beds composed of "caliche" (CaCO concretions), but others, such as the River Luján present sapropelic mud as a product of human activity. The margins of all the lotic bodies are covered by vegetation.

The area has a humid temperate climate, and is dominated by agricultural and cattle rearing activities. Human settlements are located on the banks of the principal rivers.

3. Material and methods

Samples were taken during the four seasons: spring (September 23—25, 1985), summer (December 16—18, 1985), fall (April 9—11, 1986), and winter (July 1—3, 1986).

For each sampling station the following parameters were registered: water temperature, transparency by means of a Secchi disc, pH, and conductivity (Table I).

Duplicated samples of aquatic plants were placed in individual jars and fixed with 5% formaline. Methods of removal by shaking and scraping was employed (Sladečková, Pieczyńska 1971).

Table I. Mean values for physico-chemical characteristics of rivers and streams analysed

Stations	pH	Conductivity μS cm at 20°C	Temperature (°C)	Transparency (cm)
1	7.76	1693	19	42
2	7.57	1667	20	28
3	7.75	823	22	24
4	7.84	1457	21	15
5	7.71	467	21	13
6	7.90	1090	20	15
7	7.88	627	21	26
8	8.14	840	19.5	25
9	7.85	440	21	15
10	7.76	733	21.4	24
11	7.98	643	21	45
12	8.11	773	18	28
13	8.05	763	18	32
14	8.03	637	19	25

Table II. Alphabetical list of diatoms present in the periphyton and their ocurrence the stations

Taxa	Stations													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
a	b	c	d	e	f	g	h	i	k	l	m	n	o	p
Achnanthes brevipes Ag.				+		+								
— deflexa Reim.		+		+		+		+		+	+		+	+
— exigua Grun.			+											
— flexella (Kutz.) Brun					+									
— inflata (Kutz.) Grun.		+								+		+		
— lanceolata Breb.	+	+	+	+	+		+	+	+	+	+	+	+	+
— minutissima Kutz.			+	+										
— sp.	+	+	+	+	+		+	+	+	+	+	+	+	+
Amphipleura pellucida (Kutz.) Kutz.		+		+	+		+					+		
Amphora coffeiformis (Ag.) Kutz.		+	+	+				+		+	+	+	+	+
— ovalis (Kutz.) Kutz.			+	+	+		+	+	+	+	+	+	+	+
— ovalis var. pediculus (Kutz.) V.H.	+	+	+	+	+	+	+	+	+	+	+	+	+	+
— perpusilla Grun.		+	+	+	+		+	+	+	+	+	+	+	+
Anomoneis sphaerophora (Ehr.) Pfitz.			+	+	+			+		+	+			+
Aulacosira granulata (Ehr.) Simonsen					+									
Bacillaria paradoxa (Mull.) Hendey		+	+	+	+		+	+		+	+	+	+	+
Caloneis ventricosa (Ehr.) Meister					+									
Capartograma crucicola (Grun. ex Cl.) Ross			+					+					+	
Cocconeis placentula var. euglypha (Ehr.) Cl.			+	+	+	+	+	+		+	+	+	+	+
Cyclotella meneghiniana Kutz.		+		+	+	+	+	+		+	+	+	+	
Cymbella affinis Kutz.	+	+	+	+	+	+	+	+	+	+	+	+	+	+
— amphicephala Nag.	+	+	+	+	+									+
— cistula (Ehr.)					+						+			
— tumida (Breb. ex Kutz.) V.H.				+	+	+		+		+	+	+		+
Denticula elegans Kutz.	+	+	+	+	+		+	+	+	+	+	+	+	+
Diploneis puella (Schumann) Cl.			+											
— smithii (Breb.) Cl.			+	+							+	+		
Entomoneis sp				+										
Epithemia turgida (Ehr.) Kutz.				+	+							+		
Eunotia curvata var. curvata (Kutz.) Lagerst.			+	+	+						+			
— pectinalis (Dill.) Rabh.			+	+	+				+	+			+	+
Frustulia rhomboides (Ehr.) De Toni								+						
Gomphonema olivaceum (Lyngbye) Kutz.			+	+		+	+	+		+	+	+	+	+
— parvulum (Kutz.) Grun.	+	+	+	+	+	+	+	+	+	+	+	+	+	+
— subclavatum (Grun.) Grun.	+	+	+	+	+	+	+	+		+	+		+	+
— truncatum Ehr.	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Gyrosigma terryanum (Perag.) Cl.								+		+				
— sp.											+			
Hantzschia amphioxys (Ehr.) Grun.	+			+			+				+	+	+	
Melosira varians Ag.	+	+	+	+	+		+			+	+	+	+	+
Meridion circulare (Grev.) Ag.			+											

Cont. Tab. II

a	b	c	d	e	f	g	h	i	k	l	m	n	o	p
Navicula cryptocephala Kutz.	+		+	+										
— cryptocephala var. veneta (Kutz.) Rabh.													+	
— cuspidata Kutz.					+	+		+				+		+
— muralis Grun.	+	+	+	+	+		+	+		+	+	+	+	+
— radiosa Kutz.		+	+	+	+	+		+			+	+	+	+
Nitzschia acicularis (Kutz.) W. Sm.			+	+	+	+	+	+		+	+			+
— amphibia Grun.	+	+	+	+	+	+	+	+		+	+	+	+	+
— apiculata (Greg.) Grun.	+												+	
— dissipata (Kutz.) Grun.	+	+		+	+		+	+	+	+	+	+	+	+
— filiformis (W. Sm.) Hust.	+	+	+	+	+	+		+		+	+	+	+	+
— hungarica Grun.	+											+	+	
— lacunarum Hust.	+			+	+			+		+	+			+
— linearis W. Sm.	+	+	+	+	+	+	+			+	+	+	+	
— palea (Kutz.) W. Sm.	+	+	+	+	+	+	+	+	+	+	+	+	+	+
— parvula Lewis				+	+		+	+		+		+		
— sigma (Kutz.) W. Sm.	+	+	+	+	+	+	+	+	+	+	+	+	+	+
— tryblionella Hantzsch.	+			+										+
— sp. 1			+	+	+									+
— sp. 2											+			
Pinnularia abaujensis (Pant.) Ross		+	+	+	+	+	+			+	+	+	+	+
— viridis (Nitzsch) Ehr.	+	+	+		+		+	+	+	+	+	+	+	+
Pleurosira laevis (Ehr.) Simonsen	+	+		+	+			+		+	+	+	+	
Rhoicosphenia curvata (Kutz.) Ehr.	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Rhopalodia gibba (Ehr.) Mull.			+	+							+	+	+	
— operculata (Ag.) Hakansson			+	+				+			+			
Stauroneis acuta Sm.		+												
— anceps Ehr.	+	+	+	+	+	+		+		+		+		+
Surirella angustata Kutz.						+								
— ovalis Breb.		+		+	+		+	+		+	+	+	+	+
— ovata Kutz.			+	+	+		+	+				+	+	
Synedra amphicephala Kutz.	+	+	+	+	+	+	+	+	+	+	+	+	+	+
— delicatissima W. Sm.	+	+	+	+				+				+	+	
— fasciculata (Ag.) Kutz.	+	+	+	+	+		+			+	+			+
— ulna (Nitzsch) Ehr.	+	+	+	+	+	+	+	+		+	+	+	+	+
Terpsinoe musica Ehr.		+	+	+				+				+	+	

Prior to counting, the samples were blended at low speed for a few seconds. Enumeration was performed in a 0.3 ml Sedgwick-Rafter chamber under a Wild M20 microscope. Quantification, according to Kadłubowska's method (1978), was based on the number of microscopic fields of known area, counted. At least 20 random microscopic fields were examined per sample.

The macrophyte material was oven dried at 100°C to constant weight and values were expressed as cell per dry weight (in g) of plant metarial.

Qualitative samples were treated to make permanent hyrax mounts of diatoms for taxonomic identification.

Table III. Average population density (cells × 10^4 g^{-1} dry weight of host plant) of diatoms associated to with macrophytes in spring (Sp), summer (Su), fall (F) and winter (W)

Macrophytes	Season	Stations													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Althernathera philoxeroides	Sp	115.6	13.0			74.5							273.7	74.4	
(Martius)	Su	107.1	61.1				14.4					214.4	54.7	49.5	103.8
Grisebach	F		32.4									236.2	63.2	48.0	160.7
	W		12.0			90.0					28.1		208.1	15.1	59.4
2. Ceratophyllum demersum L.	Sp				332.8							286.0	109.7		
	Su				95.7				365.6						
	F				287.8				159.4			585.3	28.9	34.7	265.0
	W				54.9	61.7						60.9			59.9
3. Cyperus giganteus Vahl.	Sp					18.0									
4. Echinochloa polystachya H.B.K.) Hitchc.	W					36.0									
5. Egeria sp.	Su								76.2						
6. Hydrocotyle ranunculoides L.	Sp				171.5		306.1					421.9	294.7	44.4	
	F				96.4								255.1	644.4	
	F				8.3										
7. Lilaeopsis carolinensis Coult et Ros	F													106.8	
8. Ludwigia sp.	Sp			15.2	297.3				289.5		96.7	141.2			
	Su			40.3	9.3				19.4						
	F			125.2	72.4							153.2			
	W			345.3	7.2							207.4			61.1

9.	Myriophyllum aquaticum (Velloz) Verdcourt	Sp			7.5					194.4						
		Su			23.6											
10.	Pistia stratiotes L.	F			206.1	106.1										
		W			371.2						105.0					
11.	Polygonum punctatum Elliot	Sp					69.3									
		Su				7.2										
		F		20.6								97.2				
		W	101.5	24.2	322.9							17.2			10.8	9.7
12.	Potamogeton berteroanus Phil.	F														135.3
13.	Potamogeton striatus Ruiz et Pavon	Sp	209.9	246.3						70.0		189.4				663.7
		Su							12.1	101.1						
		F	45.1						173.7	258.2			226.1			
		W							15.4							
14.	Sagittaria sp.	Su							6.4							
		F							80.4							
15.	Schoenoplectus californicus (Meyer) Sojak	Sp		1253.2		134.1										
		Su							11.3							
		F				165.8										
		W							1.8							

Basic data matrices were computed in a Q-mode matrix, using the Pearson coefficient. Cluster analysis was computed from the latter, using the unweighed pair group method with arithmetic averages (UPGMA) (Legendre L., P. Legendre 1983).

4. Results

Seventy-five species of Bacillariophyta were identified. From the total number of diatoms 48% were recorded on all 4 sampling occasions. Among these, only 8 were present at all stations (Table II).

In general, the maximum density and species richness peaks occurred during the spring and fall, and the minimum ones in summer and winter.

In spring most of the macrophytes showed a high density of epiphytic diatoms, the majority of which were on *Schoenoplectus californicus* at Station 2 (Table III). In summer and fall *Ceratophyllum demersum* showed maximum concentration at Stations 8 and 11 respectively. In winter *Hydrocotyle ranunculoides* showed maximum density at Station 13.

The minimum values were noted on emergent plants from different lotic environments (*Sagittaria* sp. at Station 7 in summer; *Polygonum punctatum* at Station 2 in the fall; *S. californicus* at Station 7 in winter), except in spring when the minimum value was observed on *Myriophyllum aquaticum* at Station 3 (Table III).

The greatest species richness was observed in spring (63 spp.) and the smallest in summer (50 spp.), different macrophytes showing the maximum and minimum values. *Potamogeton striatus* showed the largest number of species in the spring and fall at Stations 14 and 7, respectively (30 and 31 spp.); *Althernanthera philoxeroides* at Station 11 in summer (23 spp.); *P. punctatum* at Station 3 in winter (28 spp.). The minimum species richness was found on the following host plants: *Althernanthera philoxeroides* at Station 2 in the spring and fall (4 and 11 spp., respectively); *Ludwigia* sp. at Station 4 in summer (3 spp.) and *H. ranunculoides* at the same station in winter (3 spp.).

Different species of diatom were greater in number according to the season. *Cymbella affinis* and *Gomphonema parvulum* were abundant on the four sampling occasions. *Rhoicosphenia curvata* and *Nitzschia palea* only diminished in number in summer. *Synedra* ulna showed a decrease in its fall density and *Pleurosira laevis* in winter. *Melosira varians* presented its maximum density in spring and winter but *Synedra amphicephala* in spring and summer. *Achnanthes lanceolata*, *Cocconeis placentula*, and *Gomphonema truncatum* became more important in number in summer and the fall, but *Achnanthes minutissima* only at

Station 3 in the fall and winter. It is worth mentioning that *Denticula elegans* always one of the most abundant species on all the aquatic macrophytes at Stations 8 and 11.

Cyclotella meneghiniana was found in all the sampling periods in very reduced numbers. Another planktonic species, *Aulacosira granulata*, was only recorded in spring at Station 5.

In the spring cluster diagram (fig. 2a) four groups were distinguished. The first with 3 subgroups, includes the majority of the lotic environments of the sub-basin, the subgroups being defined by the dominance of 3 species (*S. ulna*, *G. parvulum*, and *D. elegans*). The second group, with *M. varians* as dominant species, is formed by all the macrophytes found at Station 5 and others from different environments. The third group is formed by two macrophytes from different lotic water bodies that have *R. curvata* as their most abundant species. The fourth group is defined by the dominance in number of *P. laevis* on two macrophytes of Station 12.

The summer cluster diagram (fig. 2b) is constituted by 4 assemblages: the first one formed by those host plants in which *S. amphicephala* dominates; the second with 2 subgroups, has *S. ulna* and *D. elegans* as the most numerous diatoms; in the third assemblage *G. parvulum* is the numerically dominant species and in the fourth one *C. affinis*.

In the fall 3 groups can be distinguished in the cluster diagram (fig. 2c). The first one, formed by host plants from Stations 1, 2, 3, and 13 shows *G. truncatum* as the dominant species. The second group, formed by the majority of the analysed environments, can be divided into 3 subgroups (one formed by all the macrophytes present at Station 4 together with others from different streams with *R. curvata* as the most abundant diatom: second subgroup which includes the macrophytes from Station 7 with *G. parvulum* as the dominant; and a third one formed by those aquatic plants with *P. laevis* as the most numerous species. The third group is formed by all the macrophytes of Stations 8 and 11 which have *D. elegans* as the most abundant species.

The winter cluster diagram (fig. 2d) shows 4 well-defined assemblages. The first one, which includes most of the environments, has *M. varians* as the most numerous species. The second is defined by the dominance of *D. elegans* and the third by that of *C. affinis*. The fourth group, with *R. curvata* as dominant, is formed by all the aquatic plants which were found at Station 14.

5. Discussion

Most of the diatoms found were alkaliphilous and corresponded to eutrophic environments with high conductivity (Patrick, Reimer

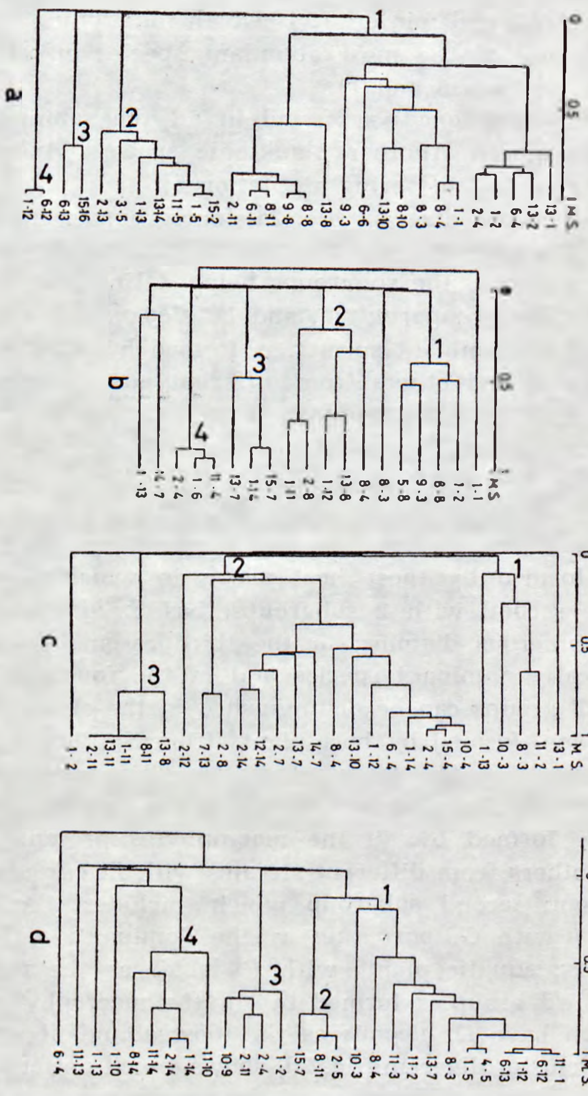

Fig. 2. Cluster analysis of diatom assemblages: a — from 8 aquatic macrophytes at 12 stations in spring (cophenetic correlation coefficient, c.c.c. = 0.87); b — from 9 aquatic macrophytes at 11 stations in summer (c.c.c. = 0.74); c — from 11 aquatic macrophytes at 11 stations in fall (c.c.c. = 0.87); d — from 10 aquatic macrophytes at 12 stations in winter (c.c.c. = 0.87). M — macrophytes as in Table III; S — stations

1966, 1975, L o w e 1974), according to the characteristics of the analysed bodies (Table I).

The seasonal fluctuations in density coincided with the ones indicated by S i v e r (1978). Minimum concentrations of epiphytic diatoms occurred coinciding with 2 hydrological phenomena unfavourable for their development. In summer, owing to the great evaporation and lack of rainfall, the water level was at a minimum. Under these conditions a reduction in the periphitic community took place (Douglas 1958). In winter, on the contrary, the lotic enivronments had high water levels. Some of them, as the Del Tala straem and River Baradero, even spread over their flood-plain. The wash action by floods has already been mentioned, among others, by Backhaus (1968), Ertl et al. (1972), and Siver (1978). Likewise, a reduction in the complexity and a decrease in the number of species was observed, as Luttenton and Rada (1986) pointed out for communities disturbed by strong currents.

The highly abundanc presence of *Melosira varians* in winter, with low temperatures and a flood period, did not coincide with Antoine and Benson-Evans's (1986) observations. This species, considered typical of epipelon (Hynes 1970, Britton 1977) or epilithon (Antoine, Benson-Evans 1986), may come from these communities by means of the combined action of currents and waves.

Besides, the summer decrease in density may be caused by predatory action (Steinman et al. 1989). During this period, periphytic rotifers and benthonic fauna reach their maximum concentrations (Modenutti, Claps 1988, Sampóns 1988). It must be stressed that *A. lanceolata* and *C. placentula* were present in great numbers. These species proliferate under moderate to high grazing pressure conditions, whereas others, such *M. varians* almost disappear (Swamikannu, Hoagland 1989, Stock, Ward 1989). In the other seasons, no great simplification in the periphytic diatom composition was seen to assume a high predatory action.

The numerical abundance of *C. affinis* on all the sampling occasions may be related to its capacity to live under low light intensity and to its efficient attachment (Cholnoky 1929). This last characteristic was also shown by *G. parvulum*, abundant in all seasons. The decrease in number of *N. palea* in summer was also noted by Moss (1977) in the River Wey, England.

It is worth mentioning that *C. placentula* in all seasons, was abundant only in those streams (Luna and Giles, Stations 12, 13) which have marginal stands of *Gleditsia triacantha* L. (Fabaceae). This condition brings about both the lower temperature and light intensity necessary for their optimum development (Bowker, Denny 1980).

The differences in diatom density on aquatic macrophytes belonging to the same lotic environment may be related to the position of the host plants with respect to the current. A predominance of different species according to their current requirements has been observed (Luttenton, Rada 1986). For example, *A. minutissima* was important in number only in the Pescado stream (Station 3) which has a low water level and almost no current. These conditions do not alter its weak mechanisms of attachment (Siver 1978).

The configuration of the cluster diagrams is due to the dominance of nine species: *Cymbella affinis*, *Denticula elegans*, *Gomphonema parvulum*, *G. truncatum*, *Melosira varians*, *Pleurosira laevis*, *Rhoicosphenia curvata*, *Synedra amphicephala*, and *S. ulna*. The dominant species constitute the vertical erect layers (adnates and erect-stalked) of the periphytic structure (Hoagland et al. 1982). They represent a later stage of community development (Patrick 1976).

In general, assemblages defined by the host plant or among macrophytes of the same lotic environment were not produced. Blindow (1987) suggested that each diatom shows a different individual response with respect to its macrophyte colonization.

Besides, diatoms did not demonstrate an explicit preference for a special host plant, although minimum densities were recorded on emergent plants. This lack of specificity is in agreement with the results obtained by Eminson and Moss (1980) for lentic eutrophic environments.

The absence of defined groups with respect to the analysed environments and host plants was due to the fact that various factors (light, temperature, current, grazing), whose contribution is difficult to estimate, affect the colonization and establishment of the diatoms on each host plant.

6. Polish summary

Zbiorowiska okrzemek na wodnych makrofitach środowisk lotycznych pampasów (Argentyna)

W okresie 1985—1986 pobierano próby okrzemek związanych z 15 gatunkami wodnych makrofitów (tabela III) z 12 rzek i strumieni północno-wschodniej prowincji Buenos Aires (dorzecze Riode la Plata) (ryc. 1). Próby pobierano w czasie czterech sezonów. Na każdym stanowisku mierzono temperaturę, przeźroczystość, pH i przewodnictwo (tabela I).

Oznaczono 75 gatunków Bacillariophyta (tabela II). Większość z nich była zasadolubna i występowała w eutroficznych środowiskach z wysokim przewodnictwem. Różne gatunki były liczniejsze w zależności od sezonu. Maksimum zagęszczenia i szczyty obfitości gatunków miały miejsce na wiosnę i w jesieni. Mniejszą liczbę osobników obserwowano na roślinach wynurzonych.

Konfiguracja wykresu kępkowego (ryc. 2) jest spowodowana dominacją 9 gatunków. Ogólnie, wśród środowisk jak i wśród makrofitów nie można wyodrębnić wyraźnych grup. Wiele czynników, takich jak poziom wody, prąd i spasanie, wpływało na zbiorowiska okrzemek i przyczyniało się do zaobserwowanych różnic.

7. References

Antoine S., K. Benson-Evans, 1986. Spatial and temporal distribution of some interesting diatom species in the River Wye System, Wales, U.K. Limnologica, 17, 79—86.

Backhaus D., 1968. Ökologische Untersuchungen an den Aufwuchsalgen der obersten Donau und ihrer Quellflusse. 3. Die Algenverteilung und ihre Beziehungen zur Milieuofferte. Arch. Hydrobiol., Suppl. 34, 24—73.

Blindow I., 1987. The composition and density of epiphyton on several species of submarged macrophytes. The neutral substrate hypothesis tested. Aquat. Bot., 29, 157—168.

Bowker D. W., P. Denny, 1980. The seasonal succession and distribution of epiphytic algae in the phyllosphere of *Lemna minor* L. Arch. Hydrobiol., 90, 39—55.

Britton L. H., 1977. Periphyton and phytoplankton in the Sacramento River, California, May 1972 to April 1973. J. Res. E.U. Geol. Surv., 5, 547—559.

CFI., 1962. Recursos hidráulicos superficiales [Superficial hydraulic resources]. En evaluación de los recursos naturales de la Argentina (ira etapa). Buenos Aires, Con. Fed. Invers., 4, 1, 457 pp.

Cholnoky B., 1929. Epiphyten-Untersuchung im Balatonsee. Int. Rev. ges. Hydrobiol., 22, 313—345.

Claps M. C., 1984. Perifiton en *Scirpus californicus* (Meyer) Steud. (Marjal de Ajó — Bahia de Samborombón) [Periphyton on *Scirpus californicus* (Meyer) Steud. (Ajó Marsh — Samborombón Bay)]. Rev. Mus. de la Plata (N.S.), 13, (137), 139—149.

Claps M. C., 1991. Phytomicrofauna of pampasic lotic environments (Argentina). Hydrobiologia, (in press).

Douglas B., 1958. The ecology of the attached diatoms and other algae in a small stony stream. J. Ecol., 46, 295—322.

Eminson D., B. Moss, 1980. The composition and ecology of periphyton communities in frehwaters. 1. The influence of host type and external environment on community composition. Br. phycol. J., 15, 429—446.

Ertl M., S. Juris, J. Tomajka. 1972. Vorlaufige Angaben über jahreszeitliche Veränderungen und die vertikale Verteilung des Periphytons im mittleren Abschnitt der Donau. Arch. Hydrobiol., Suppl. 44, 34—48.

Hoagland K. D., S. C. Roemer, J. R. Rosowski, 1982. Colonization and community structure of two periphyton assemblages with emphasis on the diatoms (Bacillariophyceae). Amer. J. Bot., 69 (2), 188—213.

Hynes H. B. N., 1970 The ecology of running waters. Univ. of Toronto Press, 555 pp.

Kadłubowska J. Z., 1978. Methods of the representative analysis of diatom communities. Verh. int. Ver. Limnol., 20, 1285—1288.

Legendre L., P. Legendre, 1983. Numerical ecology. Elsevier Sci. Publ. Co., 419 pp.

Lowe R. L., 1974. Environmental requirements and pollution tolerance of freshwater diatoms. Cincinnati. U.S. Environ. Protect. Agency, 334 pp.

Luchini L., 1973. Contribución al estudio de la flora perifitica diatómica del lago Mascardi (provincia de Rio Negro). 1. [Contribution to the study of the diatoms of the periphytic flora in Lake Mascardi (Province Rio Negro). 1.]. Physis B, 32 (85), 223—242.

Luchini L., 1974a. Diatomeas epifitas de algunas macrófitas del lago Situación (prov. Chubut) [Epiphytic diatoms from the Lake Situación macrophytes (prov. Chubut)]. Physis B, 33 (86), 127—139.

Luchini L., 1974b. Sobre la presencia de *Stenopterobia intermedia* (Lewis) van Heurck en la Argentina y sus requerimentos ecológica (Bacillariophyta) [On the presence of *Stenopterobia intermedia* (Lewis) van Heurck in Argentina and its ecological requirements (Bacillariophyta)]. J. Physis B, 33 (86), 141—145.

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

Modenutti B. E., M. C. Claps, 1988. Moonogononta rotifers from plankton and periphyton of pampasic lotic environments (Argentina). Limnologica, 19, 167—175.

Moss M. O., 1977. The temporal and spatial distribution of the valves of the diatom *Rhoicosphenia curvata* in the River Wey. Freshwat. Biol., 7, 573—577.

Patrick R., 1976. The formation and maintenance of benthic diatom communities. Proc. Amer. Phil. Soc., 120, 475—484.

Patrick R., C. W. Reimer, 1966. The diatoms of the United States exclusive of Alaska and Hawaii. 1. Acad. of Nat. Sci. of Philadelphia, 688 pp.

Patrick R., C. W. Reimer, 1975. The diatoms of the United States exclusive of Alaska and Hawaii. 2 (1). Acad. of Nat. Sci. of Philadelphia, 213 pp.

Sampóns M. R., 1988. Zoobentos del rio Arracifes (Buenos Aires, Argentina) y sus principales tributarios [Zoobenthos of the River Arrecifes (Buenos Aires, Argentina) and its principle tributaries]. Iheringia, 68, 63—82.

Siver P. A., 1978. Development of diatom communities on *Potamogeton robbinsii* Oakes. Rhodora, 80, 417—430.

Sledečková A., E. Pieczyńska, 1971. Periphyton. In: Edmondson W. T., G. G. Winberg (Eds): A manual on methods for the asessment of secondary productivity in freshwater. Oxford-London-Edinburgh-Melbourne, Blackwell Sci. Publ., 109—122.

Steinman A. D., C. D. McIntire, S. V. Gregory, G. A. Lamberti, 1989. Effects of irradiaince and grazing on lotic algal assemblages. J. Psycol., 25, 478—485.

Stock M. S., A. K. Ward, 1989. Establishment of a bedrock epilithic community in a small stream: microbial (algal and bacterial) metabolism and physical structure. Can. J. Fish. Azuat. Sci., 46, 1874—1883.

Swamikannu X., K. D. Hoagland, 1989. Effects of snail grazing on the diversity and structure of a periphyton community in a eutrophic pond. Can. J. Fish. Aquat. Sci., 46, 1698—1704.

Tell G., 1973. Sobre algunas diatomeas de la laguna Chascomús (prov. Buenos Aires, Argentina) [Some diatoms from the Chascomús lagoon (prov. Buenos Aires, Argentina). Bol. Soc. Arg. Bot., 15 (1), 51—71.

Zalocar de Domitroviv Y., E. R. Vallejos, H. N. Pizarro, 1986. Aspectos ecológicos de la ficoflora de ambientes acuáticos del Chaco Oriental (Argentina) [Ecological aspects of phycoflora from water bodies of the eastern Chaco (Argentina)]. J. Ambiente Subtropical, 1, 92—111.