Benthic insects of the El Tala River (Catamarca, Argentina): longitudinal variation of their structure and the use of insects to assess water quality

Colla, MF.[a, c*], *César, II.*[a,c] *and Salas, LB.*[b]

[a]División Zoología Invertebrados, Facultad de Ciencias Naturales y Museo – FCNYM, Universidad Nacional de La Plata – UNLP, Av. Paseo del Bosque, s/n, 1900, La Plata, Bs. As., Argentina
[b]Cátedra de Diversidad Animal I, Facultad de Ciencias Exactas y Naturales, Universidad Nacional de Catamarca – UNCA, Av. Belgrano, 300, 4700, San Fernando del Valle de Catamarca, Catamarca, Argentina
[c]Comisión de Investigaciones Científicas – CIC, Calle 526 entre 10 y 11, CP 1900, La Plata, Buenos Aires, Argentina
*e-mail: flo4bio@gmail.com

Received February 14, 2012 – Accepted June 4, 2012 – Distributed May 31, 2013
(With 4 figures)

Abstract

The aim of this work was to determine the structure of the benthic entomofauna and its variation along the El Tala River (Catamarca, Argentina). Five sampling stations were established, considering the location of nearby housing with respect to the watercourse. The following variables were determined *in situ*: altitude, latitude and longitude, bedstream width, river depth, river-current speed, water and air temperatures. Benthic insects were collected with a square parcel sampler of 0.09-m^2 area and 300-µm net opening and identified to the family level. Faunal density, richness, and diversity exhibited a longitudinal variation. From sampling Stations 1 (reference site) to 3, the number of orders and families decreased, whereas in sampling Station 4 those values increased and continued to do so through to Station 5 (downstream station). Station 5 showed the highest family richness (17) and the highest value for the Shannon-Wiener index (2.74) and the lowest value in Simpson's Dominance index (D = 0.22). These values could be explained because of the self-cleansing capabilities of the river downstream. The water quality of El Tala River is Class I (very clean and non-impacted), according to the results obtained from the application of the biotic Biological-Monitoring–Working-Party and Average-Store-per-Taxon indices.

Keywords: benthonic insects, longitudinal variation, biotic indices, bioindicators, mountain rivers.

Insetos bentônicos do Rio El Tala (Catamarca, Argentina): variação longitudinal de sua estrutura e seu uso para avaliar a qualidade da água

Resumo

O objetivo deste trabalho foi determinar a estrutura da entomofauna bentônica do Rio El Tala (Catamarca, Argentina) e sua variação longitudinal. Cinco estações de amostragem foram estabelecidas considerando-se a localização da habitação em relação ao curso de água. As seguintes variáveis foram determinadas *in situ*: altitude, latitude e longitude; largura do leito; profundidade do rio; velocidade da correnteza, e temperatura da água e do ar. Insetos bentônicos foram coletados em cinco estações de amostragem, utilizando-se um coletor tipo Surber de 0,09 m^2, com rede de malha 300 µm, tendo sido identificados em laboratório até o nível de Família. Densidade, riqueza e diversidade da fauna exibiram variação longitudinal. Da estação de amostragem 1 (*site* de referência) à 3, uma tendência decrescente no número de ordens e famílias foi observada, enquanto que as estações de amostragem 4 e 5 apresentaram uma tendência crescente. As amostras da estação 5 (estação rio abaixo) apresentaram a maior riqueza de famílias (17), o valor mais elevado do Índice de Shannon (2,74) e o menor valor de Dominância de Simpson (D = 0,22). Estes valores podem ser explicados pela capacidade de autopurificação de rio a jusante. A qualidade da água do Rio El Tala é Classe I (muito limpo e água sem impacto), de acordo com os resultados obtidos pela aplicação de índices bióticos BMWP' e ASPT'.

Palavras-chave: insetos bentônicos, variação longitudinal, índices bióticos, bioindicadores, rios de montanha.

1. Introduction

The concept of *river continuum* refers to the species distribution in the river from its headwaters to its mouth, according to the water's characteristics; the availability of light and food and the occurrence of predators, among other characteristics (Vannote et al., 1980).

Living organisms are widely used as biotic indicators for the monitoring and evaluation of water quality, with the benthic macroinvertebrates being the most frequently recommended for aquatic ecosystems (Rosenberg and Resh, 1996; Figueroa et al., 2003; Guerrero-Bolaño et al., 2003; Pavé and Marchese, 2005; Giacometti and Bersosa, 2006; Gonçalves Oliveira et al., 1997; Correa-Araneda et al., 2010). In the Catamarca province (Argentina), benthic entomofauna have been used to evaluate the water quality of rivers and mountain streams by the application of the biotic indices from the Biological-Monitoring–Working-Party (BMWP') and Average-Store-per-Taxon (ASPT') (Rodríguez Garay, 2007; Salas, 2005, 2007).

The El Tala River constitutes as one of the principal hydric resources for consumption and recreation, and at the same time, serves as the water reservoir for the city of San Fernando del Valle in Catamarca ('El Jumeal' Dam). In recent years there has been a marked increase in the number of settlements along the river's banks, the majority of these are precarious in construction and lack any system of sewage disposal (Saracho et al., 2002). We expect that the results of this report will indicate whether a health risk exists, or whether the rivers own self-cleansing capabilities are still sufficient to avoid a present threat to the well-being of the city's population. The aim of this study was to determine the structure and longitudinal variation of the benthic entomofauna in the El Tala River, in order to associate those parameters with the physicochemical characteristics of the water and thereby assess the water quality of the El Tala through the use of the benthic insect community as a bioindicator.

2. Material and Methods

2.1. Study sites

The El Tala is a mountain river with a permanent water regime. It is located along the eastern side of the Ambato-Manchao Mountains and drains towards the central valley of Catamarca (Figure 1).

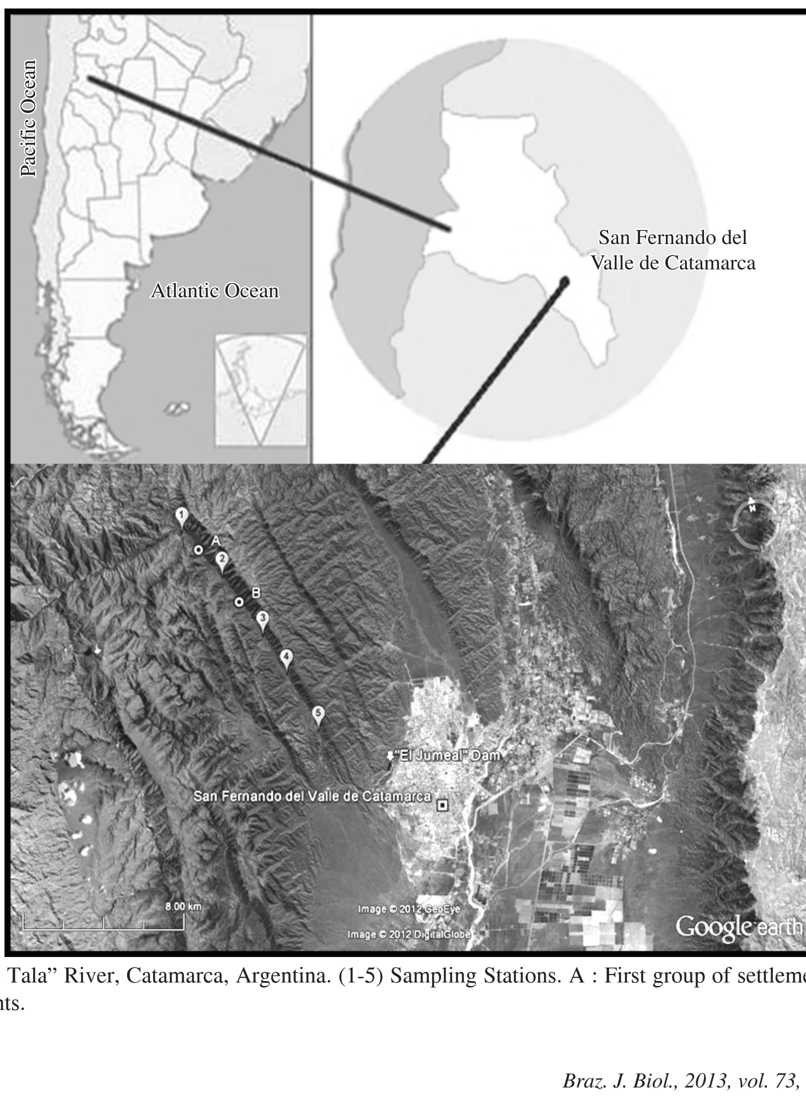

Figure 1. The "El Tala" River, Catamarca, Argentina. (1-5) Sampling Stations. A : First group of settlements; B : Second group of settlements.

Five sampling stations were established along the river, considering the location of nearby housing and the access to the watercourse. Station 1 was located in an uninhabited area and taken as a reference site; Station 2 was located after the first group of settlements; Station 3 was located after the second group of settlements; Station 4 was located in an area without nearby dwellings; and Station 5 was established in an area without anthropic disturbances, where the water inlet for human consumption is located (Figure 1).

The following parameters were determined *in situ* at each station: the altitude, latitude, and longitude were calculated by means of a GPS *e*Trex Legend. The width of the stream bed consisted of a measurement of the stream bed at the water line to the north and to the south of a 15 m stretch. The rivers average depth was measured with a plastic ruler every 20 cm across the river from one bank to the other, and to the north and to the south of the 15 m stretch. The river current speed was determined with a stopwatch by measuring the average time a floating object (*e. g.*, a tennis ball) took to traverse a distance of 15 m. The marginal arbustive and arboreal vegetation were noted by direct observation. The air temperature was determined with a mercury thermometer in the shade at a height of 1 m. The water temperature was measured with a mercury thermometer. The water physicochemical parameters were measured by means of a digital Cibar Corning multimeter (pH, electrical conductivity, total dissolved solids, and dissolved oxygen).

2.2. Collection of benthic entomofauna

A Surber sampler (area, 0.09 m^2; mesh size, 300 µm), was used to collect 3 sub-samples per station. The sampling was conducted in August 2006 (during the low-water season).

The samples were fixed *in situ* in 96% (v/v) aqueous ethanol and processed in a laboratory under a stereomicroscope (PZO Warszawa). The insects were identified at the family level through the use of specialised literature (Fernández and Domínguez, 2001).

2.3. Community parameters and diversity indices

The following community parameters were determined: abundance, density (individuals.m^{-2}), and faunal richness or diversity – *ie.*, the number of families per order of insects collected.

The following indices and software were applied: Shannon-Wiener diversity index ($H' = -\sum pi.\log_2 pi,$), Simpson´s dominance index ($D = \sum pi^2$; Magurran, 1989), and Sorensen´s similarity index ($CN = 2jN/(aN + bN)$; Magurran, 1989); Quantan software (Brower et al., 1997) and Simil (Franja Morada Universidad de Buenos Aires, 1993).

2.4. Water-quality evaluation through biotic indices

The BMWP' index was used after the adjustment in the northwestern region of Argentina (Domínguez and Fernández, 1998). This index gives a score to each macroinvertebrate family on the basis of their tolerance to different levels of organic contamination (higher scores indicate lower tolerances). The final index is obtained by calculating the values assigned to each family (Table 1). The result is then compared to the reference values to determine the class of the water quality. The ASPT' index was also calculated by dividing the value obtained for the BMWP' index by the number of taxa found (Klemm et al., 1990).

2.5. Statistical treatment

Univariate and bivariate descriptive statistical techniques were used. In addition, inferential and bivariate statistical techniques were applied by calculating the Pearson Correlation Analysis by means of the SPSS v.1.10 software. Multivariate techniques such as the Principal Component Analysis (PCA) were also applied through the use of the PC-ORD v.1.4 statistical program (Magurran, 1989)**.**

3. Results

At the 5 sampling stations, the Chironomidae (Diptera) showed the highest density, while the rest of the orders and families exhibited considerably lower densities. The highest diversity corresponded to Tricoptera, with 5 families (Table 1).

The community parameters determined for the benthic entomofauna showed variations throughout the 5 sampling stations. The highest and lowest densities were registered at Stations 2 and 3, respectively. The taxonomic composition fluctuated between 5 orders and 14 families at Station 3, to 7 orders and 17 families at Station 5. The Shannon-Wiener (log2) diversity index ranged from 1.46 to 2.74 bits, with the highest and lowest values being recorded at Station 5 and Station 2, respectively. Simpson's index ranged from 0.22 at Station 5 to 0.59 at Station 2. (Table 2).

The BMWP' index ranged from 78 points at Station 2 to 94 points at Station 1, while the ASPT' index fluctuated from 6 points at Station 2 to 6.75 points at Station 3. In all of the sampling stations, the values obtained for both indices corresponded to Class 1: very clean water with no anthropic impact (see Table 3).

The possible relationship between the water physicochemical variables (Table 4) and the community attributes of the benthic insects was analysed using the Pearson Correlation Analysis and its results are set forth in the discussion. Sorensen's Similarity index indicated that Stations 1 and 5 were the most similar (76%), with 12 families in common; while Stations 2 and 3 were the most dissimilar (41%), with 10 families in common (as shown in Figure 2).

A cluster analysis between the water physicochemical variables and the sampling sites indicated that axes I and II explained 99.99% of the variability (Table 5). Axis I (97.84% of the variability) clearly separated Station 1 from the rest of the stations, where the variables total dissolved solids and the BMWP'index value determined the clustering (as shown in Figure 3).

The results of the PCA conducted between the insect families and sampling sites indicated that axes I and II explained 98.02% of the variability (Table 6). Axis

Table 1. Density of orders and families of benthic insects and BMWP` index score.

Taxa	Density (ind.m^{-2})						
	Station 1	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Total**	**Score BMWP´**
Ephemeroptera	**2,544**	**2,134**	**0**	**933**	**3,122**	**8,733**	
Baetidae	1,544	1,511	0	311	900	4,266	4
Leptohyphidae	467	256	0	522	2,044	3,289	10
Leptophlebiidae	533	367	0	100	178	1,178	10
Plecoptera (Perlidae)	**400**	**178**	**144**	**144**	**156**	**1,022**	10
Odonata (Libellulidae)	**0**	**0**	**11**	**0**	**22**	**33**	10
Megaloptera (Corydalidae)	**11**	**0**	**0**	**0**	**0**	**11**	10
Trichoptera	**300**	**311**	**1,321**	**778**	**1,745**	**5,055**	
Hydropsychidae	11	67	611	200	678	1,567	5
Hydrobiosidae	78	33	44	67	167	389	-
Glossosomatidae	22	0	222	33	222	499	8
Hydroptilidae	167	800	422	378	667	2,434	6
Leptoceridae	22	11	22	100	0	155	10
Odontoceridae	0	0	0	0	11	11	10
Coleoptera	**2,000**	**1,544**	**1,189**	**1,178**	**1,866**	**7,777**	
Elmidae	1,711	1,355	978	1,089	1,744	6,877	5
Psephenidae	289	189	144	89	122	833	10
Staphylinidae	0	0	11	0	0	11	5
Hydraenidae	0	0	56	0	0	56	-
Diptera	**5,389**	**17,567**	**4,211**	**10,400**	**4,834**	**42,401**	
Ceratopogonidae	67	22	0	0	0	89	4
Tipulidae	144	0	0	0	0	144	5
Empididae	0	333	11	211	78	633	4
Simuliidae	78	156	222	122	156	734	5
Stratiomyidae	0	0	0	11	0	11	4
Chironomidae	5,100	17,056	3,978	10,056	4,600	40,790	2
Hemiptera	**0**	**11**	**0**	**0**	**22**	**33**	
Naucoridae	0	0	0	0	11	11	3
Gerridae	0	0	0	0	11	11	3
Veliidae	0	11	0	0	0	11	3
Total	**10,644**	**22,345**	**6,876**	**13,433**	**11,767**	**65,065**	

Table 2. Longitudinal variation of Faunal Richness, Shannon-Wiener diversity index, Simpson's Dominance and biotic indices BMWP` and ASPT` in El Tala River (Catamarca).

Attributes	Station I	Station II	Station III	Station IV	Station V
Nº of orders	6	6	5	5	7
Nº of families	16	15	14	15	17
H' (log_2)	2.45	1.46	2.14	1.59	2.74
Dom Simp	0.28	0.59	0.37	0.57	0.22
BMWP'	94	78	81	83	92
ASPT'	6.71	6	6.75	6.38	6.57

Table 3. Water quality classes and reference values of BMWP` and ASPT` indices.

Class	BMWP' index value	Meaning	ASPT' index value	Meaning
I	>50	Very clean water	>5,1	Non-impact water
	40-50	Clean water		
II	30-40	Slightly contaminated water	4,1-5,0	Slightly impacted water
III	20-30	Contaminated water	2,1-4,0	Impacted water
IV	10-20	Heavily contaminated water	<2,0	Very impacted water
V	<10	Very heavily contaminated water	-	-

Table 4. Morphometric and physicochemical parameters of El Tala River in each sampling station.

Parameters	**Stations**				
	1	**2**	**3**	**4**	**5**
Geographical position	28º19'38,58''S 65º53'44,65''W	28º21'06,93''S 65º52'46,42''W	28º23'01,19''S 65º51'52,81''W	28º24'14,7''S 65º51'23''W	28º26'02,39''S 65º50'44,93''W
Altitude (msnm)	1,424	1,281	1,107	998	864
Stream-bed wide (north) (m)	13	9.2	12.7	5.3	7.4
Stream-bed wide (south) (m)	14	11,2	8.98	10.2	4,7
Average depth (north) (cm)	13.2	18.9	9.9	10.3	12.16
Average depth (south) (cm)	11.8	11.5	9.8	27.2	10.94
River current speed (m/s)	0.61	0.5	0.75	0.64	0.88
Air temperature (ºC)	6	13.5	18	16.5	18.5
Water temperature (ºC)	6	10	13	16	14.5
pH	6.58	7.34	7.15	7.44	6.22
Electrical conductivity ($\mu S/cm^{-1}$)	105	181.6	191.6	205	209
Total dissolved solids (mg/L)	74.1	90.9	95.8	102	104
Dissolved oxygen (mg/L)	8.2	7.8	8.5	10.5	9.6
Marginal vegetation	*Acacia visco*, *Celtis tala*, *Schinus longifolia*	*Baccharis efusa*, *Schinopsis haenkeana*	*Celtis tala*, *Acacia visco*, *Baccharis efusa*	*Prosopis nigra*, *Acacia visco, Celtis tala*	*Lithraea ternifolia* y *Enterolobium contortisilicum*

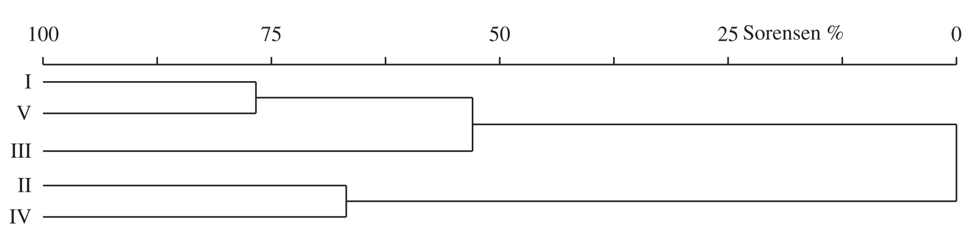

Figure 2. Dendrogram illustrating the clustering of the sampling stations in the light of the taxa collected in each, based on Quantitative Sorensen.

Table 5. Principal Component Analysis (PCA) between the water physicochemical variables and the sampling sites: Axes, Eigenvalues, Variance, Eigenvectors and Components of each axis.

Axes	Eigenvalue	% Variance	% Cumulative variance
1	4.892	97.840	97.840
2	0.108	2.150	99.990
	Eigenvectors		
Stations	Axis 1	Axis 2	
1	–0.4320	0.8994	
2	–0.4512	–0.1933	
3	–0.4509	–0.2202	
4	–0.4503	–0.2730	
5	–0.4513	–0.1752	
	Components		
Variables	Axis 1	Axis 2	
River Current Speed (RCS)	1.6003	–0.1136	
Water temperature (WT)	1.1685	–0.1718	
pH	1.3462	–0.0685	
Conductivity(C)	–5.3374	–0.5063	
Total Dissolved Solids (TDS)	–2.0852	0.1831	
Dissolved oxygen (DO)	1.2693	–0.0605	
Family Richness (FR)	1.0013	0.0328	
Shannon-Wiener Diversity Index(H)	1.5422	–0.0892	
BMWP’	–1.8689	0.8498	
ASPT’	1.3637	–0.0558	

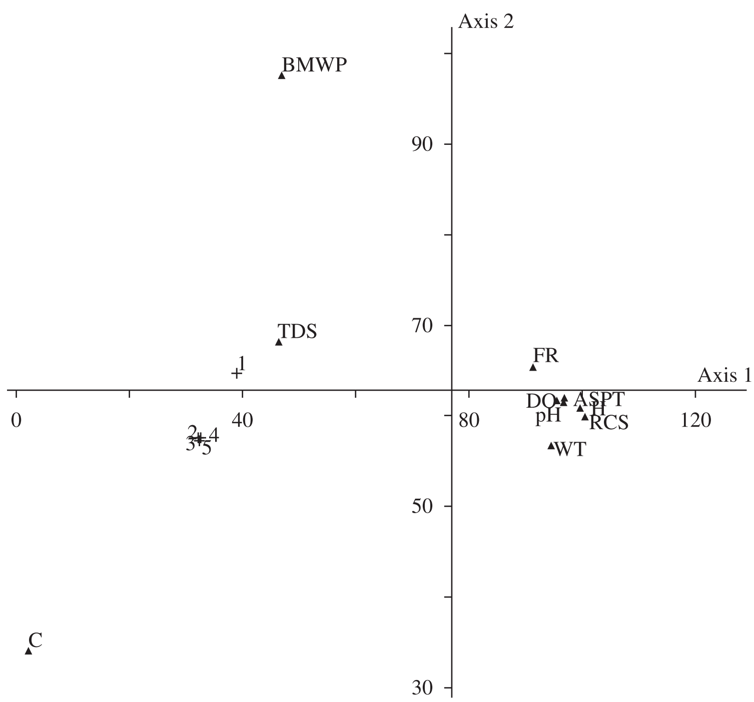

Figure 3. Principal Component Analysis (PCA) between physicochemical variables and community attributes of benthic insects of El Tala River. (1-5) Sampling Stations; (RCS) River Current Speed; (WT) Water temperature; (C) Conductivity; (TDS) Total Dissolved Solids; (DO) Dissolved oxygen; (FR) Family Richness; (H) Shannon-Wiener Diversity Index.

Table 6. Principal Component Analysis (PCA) between the insect families and sampling sites: Axes, Eigenvalues, Variance, Eigenvectors and Components of each axis

Axes	Eigenvalues	% Variance	% Cumulative Variance
1	4.744	94.877	94.877
2	0.157	3.140	98.017
	Eigenvectors		
Stations	Axis 1		Axis 2
1	–0.4467		–0.2093
2	–0.4523		0.3775
3	–0.4497		0.2687
4	–0.4538		0.3248
5	–0.4332		–0.7975
	Components		
Variables	Axis 1		Axis 2
Perlidae (Pe)	0.4099		0.0670
Hydrobiosidae (Hb)	0.6367		0.0589
Hydropsychidae (Hs)	0.0845		–0.1188
Hydroptilidae (Ht)	–0.0104		–0.0923
Leptoceridae (Lp)	0,748		0.1990
Glossosomatidae (Gl)	0.5472		0.0766
Odontoceridae (Od)	0.7827		0.1691
Corydalidae (Co)	0.7829		0.1758
Elmidae (El)	–1.6930		–0.8938
Psephenidae (Ps)	0.4830		0.1079
Baetidae (Ba)	–0.5387		–0.6277
Leptohyphidae (Ly)	–0.4569		–1.4379
Leptophlebiidae (Lf)	0.4103		–0.0124
Staphylinidae (St)	0.7813		0.1818
Hydraenidae (Hy)	0.7813		0.1818
Chironomidae (Ch)	–10.3008		0.4343
Tipulidae (Ti)	0.7262		0.1493
Simuliidae (Si)	0.5108		0.1514
Ceratopogonidae (Ce)	0.7562		0.1673
Empididae (Em)	0.6531		0.1924
Stratiomyidae (St)	0.7850		0.1799
Naucoridae (Na)	0.7827		0.1691
Gerridae (Ge)	0.7827		0.1691
Veelidae (Ve)	0.7861		0.1793
Libellulidae (Li)	0.7764		0.1729
Dissolved oxygen (DO)	1.2693		–0.0605
Family Richness (FR)	1.0013		0.0328
Shannon-Wiener Diversity Index (H)	1.5422		–0.0892
BMWP’	–1.8689		0.8498
ASPT’	1.3637		–0.0558

I (94.88%) separates stations 1 and 5 from 2, 3, and 4. The Chironomidae occupied the negative quadrant with a maximum population peak at Station 2 and a minimum one at Station 3, thus separating them from the other stations. Axes I and II include in the positive quadrant those families that have been recorded at similar densities in the five sampling stations (Figure 4).

4. Discussion

Studies conducted on watercourses in additional regions of the country (Miserendino, 1995; Mangeaud and Brewer, 1994; Scheibler, 2007; Pavé and Marchese, 2005) – and on those in other countries of the Neotropical Region (Gonçalves Oliveira et al., 1997; Baptista et al.,

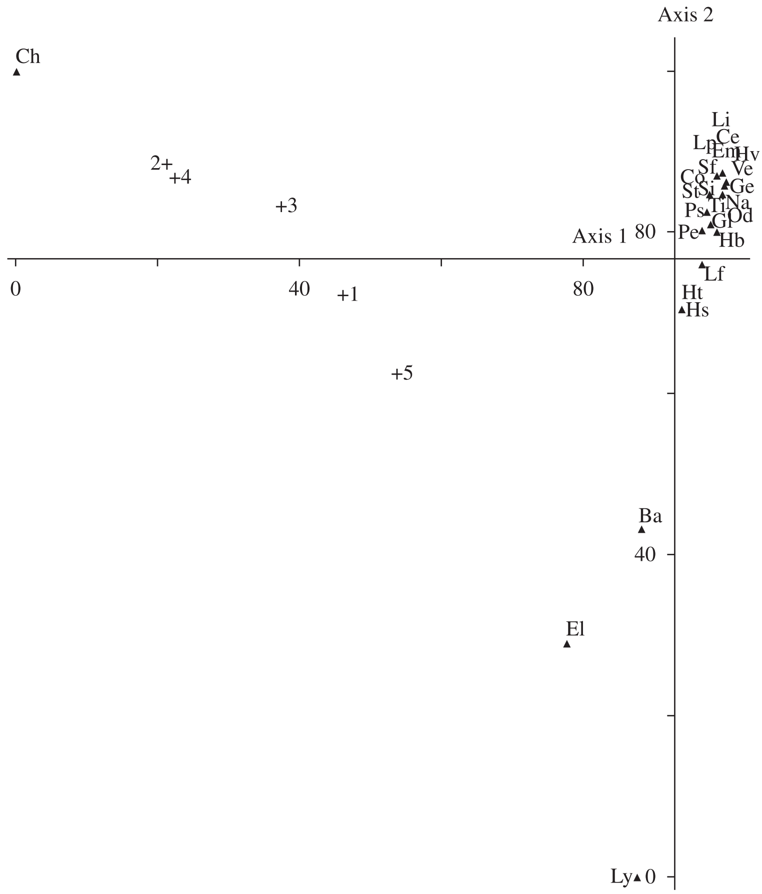

Figure 4. Principal Component Analysis (PCA) between taxa and sampling stations of El Tala River. (1-5) Sampling Stations; (Pe) Perlidae; (Hb) Hydrobiosidae; (Hs) Hydropsychidae; (Ht) Hydroptilidae; (Lp) Leptoceridae; (Gl) Glossosomatidae; (Od) Odontoceridae; (Co) Corydalidae; (El) Elmidae; (Ps) Psephenidae; (Ba) Baetidae; (Ly) Leptohyphidae; (Lf) Leptophlebiidae; (St) Staphylinidae; (Hy) Hydraenidae; (Ch) Chironomidae; (Ti) Tipulidae; (Si) Simuliidae; (Ce) Ceratopogonidae; (Em) Empididae; (St) Stratiomyidae; (Na) Naucoridae; (Ge) Gerridae; (Ve) Veelidae; (Li) Libellulidae.

2001; Bueno et al., 2003) have indicated a relationship between the physicochemical variables of the water and the relative distribution of specific benthic entomofauna throughout a longitudinal gradient of those parameters.

In the sampling stations at the El Tala River, the water temperature was negatively and significantly correlated with the density of Perlidae and Ceratopogonidae and was likewise negatively and highly significantly related to the abundance of Psephenidae. This could be attributed to the preference of those families for cold water (Bachmann, 1995; Archangelsky, 2001).

The pH fluctuations were within the levels established for water-quality guidelines (*i.e.*, 6.5-8.5) for any of the different uses of the resource (Agosba-OSN-Sihn, 1994). This parameter had a negative and significant correlation with the Shannon-Wiener diversity index and a negative and highly significant one with the richness in orders.

The dissolved-oxygen concentration was presumably not a limiting condition for the development of the benthic entomofauna since that parameter was maintained above the levels indicated by the water-quality guidelines (*i. e.*, 4-5 $mg.L^{-1}$; Agosba-OSN-Sihn, 1994).

The electrical conductivity showed a highly significant negative correlation with the presence of Perlidae, Psephenidae, Corydalidae and Tipulidae, and a significant negative one with the occurrence of Ceratopogonidae.

The total dissolved solids showed a significant negative correlation with the presence of Perlidae, Corydalidae, and Tipulidae, and a highly significant negative one with that of Ceratopogonidae and Psephenidae. The accumulation of suspended organic matter could act as a limiting condition for the development of these families; probably because of the concomitant reduction in the densities of the benthic algae (Marin, 2003).

Current velocity is a limiting condition for the colonization of benthic entomofauna (Boltovskoy et al., 1995). This variable was highly negatively correlated with the presence of Hydroptilidae.

With respect to the structure of the benthic entomofauna, the Chironomidae (Diptera) was dominant in the El Tala

River. The chironomid dominance here agrees with the observations of other authors elsewhere (Argañaraz, 1988; Fernández et al., 1995, 2001; Scheibler, 2007; Salas, 2007). The Simuliidae larval density in the sampling stations was low, with a maximum at station 3 and a minimum at station 1. The Tipulidae were collected only at Station 1, probably because of the levels of total dissolved solids. Ceratopogonidae was present at stations 1 and 2, but the absence of this family at the rest of the stations may have resulted from the higher values of water temperature, electrical conductivity, and total dissolved solids; with all three of those parameters acting as limiting conditions. Empididae was collected at all stations except Station 1, while Stratiomyidae was recorded only at Station 4. Although those two families make up part of the typical benthic entomofauna, both usually have low abundances overall (Fernández et al., 2001).

The order of the Ephemeroptera was represented by the Baetidae, Leptohyphidae, and Leptophlebiidae families. Baetidae has the highest density at Station 1, which in turn, has an increased water temperature and higher levels of dissolved oxygen. Leptohyphiidae and Leptophlebiidae had the highest densities recorded at stations 5 and 1, respectively. The absence of the Ephemeroptera species at Station 3 could not be correlated with any of the different environmental variables analysed in this station.

Larvae and adults of Elmidae (Coleoptera) were collected in the present study, which was the most abundant family of the order, exhibiting the highest density at Station 5. The Elmidae larvae are collector-gatherers, whereas the adults are scrapers, mainly feeding here on the organic detritus (suspended material) which was abundant in all the sampling stations. The Psephenidae larvae had the highest density at Station 1 and the lowest at Station 4, in agreement with the low values of the physicochemical variables with which those larvae are inversely associated. Staphylinidae and Hydraenidae were poorly represented and were only collected at Station 3, which is consistent with data reported from other rivers of the northwestern region of Argentina (Fernández et al., 2001).

Trichoptera exhibited the highest level of diversity among the orders. The highest density of Hydrobiosidae occurred at Station 5, probably as a result of a greater availability of food (other benthic organisms) .Hydropsychidae showed the highest density at Station 5 and the lowest at Station 1. Hydroptilidae was recorded at the highest density at Station 2 and the lowest at Station 1, in agreement with the lowest value of the current velocity, variables with which those larvae are inversely associated. The higher density of Leptoceridae was recorded at Station 4, while Glossosomatidae had the highest density at Stations 3 and 5.

Plecoptera was represented by Perlidae. A low larval density of this family was probably attributable to increasing values of water temperature, conductivity, and the concentration of total dissolved solids.

Megaloptera was represented by Corydalidae, which was recorded only at Station 1. This family was furthermore inversely correlated with electrical conductivity and the level of total dissolved solids.

Larvae of Libellulidae (Odonata) were poorly represented and only collected at stations 3 and 5.

Hemiptera was poorly represented in the El Tala River. Veelidae was recorded at Station 2, while Naucoridae and Gerridae were collected only at Station 5 – and in all instances at low densities.

The water quality of the segment studied in the El Tala River as evaluated according to biotic indices (the BMWP' and the ASPT') corresponded to Class I (very clean water with no anthropic impact). The variations observed in the index value at each sampling station cannot be attributed to environmental perturbations since the physicochemical parameters measured in the water were within the reference values for water for diverse uses (Agosba-OSN-Sihn, 1994). The high values of the biotic indices and the Shannon-Wiener diversity index, together with the good physicochemical quality of the water, allow the provisional inference that the section of the river studied manifested a good ecological status. Nevertheless, bacteriological and chemical analyses of the water (*e. g.*, for organic matter and nitrogenated compounds) should be conducted in order to correlate those findings with the results obtained here by the measurement of biotic indices.

Acknowledgements – The authors wish to thank to Dr. Donald Haggerty, a career investigator and native English speaker, who edited the final version of the manuscript.

References

AGOSBA-OSN-SIHN., 1994. Río de la Plata: *Calidad de aguas de la Franja Costera Sur (San Isidro-Magdalena).* Informe de avance. 167 p.

ARCHANGELSKY, M., 2001. Coleoptera. In FERNÁNDEZ, H. and DOMÍNGUEZ, E. (Eds.). *Guía para la Determinación de Artrópodos Bentónicos Sudamericanos.* Serie Investigaciones de la UNT. Subserie Ciencias Exactas y Naturales. Secretaria de Ciencia y Técnica. Editorial Universitaria de Tucumán. p.131-147.

ARGAÑARAZ, M., 1988. Estudio de la composición y variación del bentos del río Medina, desde la cabecera hasta su confluencia con el río Seco, Pcia. de Tucumán. Seminario inédito. Fac. Cs. Nat. Universidad Nacional de Tucumán. 116 p.

BACHMANN, A., 1995. Insecta Plecoptera. In LOPRETTO, E. and TELL, G. *Ecosistemas de Aguas Continentales. Metodologías para su estudio.* Tomo III. Ediciones Sur. Bs. As. p. 1093-1097.

BAPTISTA, DF., BUSS, DF., DORVILLÉ, LFM. and NESSIMIAN, JL., 2001. Diversity and habitat preference of aquatic insects along the longitudinal gradient of the Macaé River basin, Rio de Janeiro, Brazil. *Revista Brasileira de Biología=Brazilian Journal of Biology*, vol. 61, no. 2, p. 249-258.

BROWER, JE., ZAR, JH. and VON ENDE, CN., 1997. *Field and laboratory methods for general ecology*. 4th ed. WBC Mc Grow-Hill. p. 234-249.

BOLTOVSKOY, D., TELL, G., and DADON, JR., 1995. Afinidad entre comunidades bentónicas de un ambiente lótico. In LOPRETTO, E. and TELL, G. *Ecosistemas de aguas continentales. Metodologías para su estudio.* Tomo I. Ediciones Sur. Argentina. p. 203-215.

BUENO, AAP., BOND-BUCKUP, G., and FERREIRA, BDP., 2003. Estrutura da comunidade de invertebrados bentonicos em dois cursos d'agua do Rio Grande do Sul, Brasil. *Revista Brasileira de Zoologia= Brazilian Journal of Biology, vol.* 20, no. 1, p. 115-125.

CORREA-ARANEDA, F., RIVERA, R., URRITIA, J., DE LOS RÍOS, P., CONTRERAS, A. and ENCINA-MONTOYA, F., 2010. Efectos de una zona urbana sobre la comunidad de macroinvertebrados bentónicos de un ecosistema fluvial del sur de Chile. *Limnetica*, vol. 29, no. 2, p. 183-194.

DOMÍNGUEZ, E. and FERNÁNDEZ, H., 1998. *Calidad de los ríos de la cuenca del Salí (Tucumán, Argentina) medida por un índice biótico*. Fundación Miguel Lillo. Tucumán. p. 39. Serie Conservación de la naturaleza no. 12.

FERNÁNDEZ, H. and DOMÍNGUEZ, E. (Eds.). 2001. *Guía para la determinación de los Artrópodos Bentónicos Sudamericanos*. Secretaría de Ciencia y Técnica. Editorial Universitaria de Tucumán. 283 p.

FERNÁNDEZ, H., ROMERO, F., GROSSO L., DE GROSSO M., PERALTA, M. and RUEDA, M.,1995. La diversidad del zoobentos en ríos de montaña del NOA, I: el río Zerda, provincia de Tucumán, República Argentina. *Acta Zoológica Lilloana, vol.* 43, no. 1, p. 215-219.

FERNÁNDEZ, H., ROMERO, F., PERALTA, M. and GROSSO, L., 2001. La diversidad del zoobentos en ríos de montaña del noroeste de Argentina: comparación entre seis ríos. *Ecología Austral,* vol. 11, p. 9-16.

FIGUEROA, R., VALDOVINOS, C., ARAYA, E. and PARRA, O., 2003. Macroinvertebrados bentónicos como indicadores de calidad de agua de ríos del sur de Chile. *Revista Chilena de Historia Natural,* vol. 76, p. 275-285. http://dx.doi.org/10.4067/S0716-078X2003000200012

Franja Morada Universidad de Buenos Aires, 1993. *Programa informático SIMIL.* Soporte magnético.

GIACOMETTI, JC. and BERSOSA, F., 2006. Macroinvertebrados acuáticos y su importancia como bioindicadores de calidad del agua en el río Alambi. *Boletín Técnico*, *Serie Zoológica, vol.* 6, no. 2, p. 17-32.

GONÇALVES OLIVEIRA, L., DA CONCEIÇÃO BISPO, P. and CUSTÓDIO DE SÁ, N., 1997. Ecologia de comunidades de insetos bentônicos (ephemeroptera, plecoptera e trichoptera), em córregos do parque ecológico de Goiânia, Goiás, Brasil. *Revista Brasileira de Zoologia = Brazilian Journal of Biology,* vol. 14, no. 4, p. 867-876.

GUERRERO-BOLAÑO, F., MANJARRÉS-HERNÁNDEZ, A. and NÚÑEZ-PADILLA, N., 2003. Los macroinvertebrados bentónicos de Pozo Azul (cuenca del Río Gaira, Colombia) y su relación con la calidad del agua. *Acta Biológica Colombiana*, vol. 8, no. 2, p. 44-55.

KLEMM, D., LEJIA, P., FULK, F. and LAZORCHAK, J. 1990. *Macroinvertebrate field on laboratory methods for evaluating the biological integrity of surface waters*. EPA/600/4-90/030. U.S. Environmental Protection Agency. Cincinnati: Environmental Monitoring Systems Laboratory. 45268.

MAGURRAN, A., 1989. *Diversidad ecológica y su medición*. Ediciones Vedrá. p. 9-51, 101-110.

MANGEAUD, A. and BREWER, M., 1994. Macroinvertebrados bentónicos como bioindicadores de la calidad del agua en el río Suquía (Córdoba, Argentina). *Tankay,* vol. 1, p. 199-201.

MARIN, R., 2003. *Efecto de la materia en suspensión sobre la fauna béntica y piscícola de los ríos de aguas claras en las Yungas de Bolivia*. La Paz: Centro de Investigaciones en Cambios Globales. 25 p.

MISERENDINO, ML., 1995. Composición y distribución del macrozoobentos de un sistema lótico andino-patagónico. *Ecología Austral*, vol. 5, p. 133-142.

PAVÉ, P. and MARCHESE, M., 2005. Invertebrados bentónicos como indicadores de calidad de agua en ríos urbanos (Paraná-Entre Ríos, Argentina). *Ecología austral,* no. 15, p. 183-197.

RODRÍGUEZ GARAY, G., 2007. Entomofauna bentónica del arroyo Los Pinos (Capayán, Catamarca), con especial referencia al orden Diptera: variación estacional y su aplicación como bioindicadores. Universidad Nacional de Catamarca. 111 p. Trabajo Final de Licenciatura en Ciencias Biológicas.

ROSENBERG, D. and RESH, V., 1996. Use of aquatic insects in biomonitoring. In MERRIT, W. and CUMMINS, K. *An Introduction to the Aquatic Insects of North America*. 3rd ed. Dubuque: Kendall/Hunt Pub. Co. p. 98-107.

SALAS, L., 2005. Biodiversity of mountain stream benthonic insects and their application to test the biological quality of the water. *Biocell*, vol. 29 (1): 89.

-, 2007. *Biodiversidad de insectos bentónicos de un arroyo de Yungas de la Provincia de Catamarca*. Inst. Sup. de Entomología "Dr. Abraham Willink", Fac. de Cs. Nat. e Inst. Miguel Lillo. UNT.112 p. Tesis de maestría en entomología.

SARACHO, M., SEGURA, L., MOYANO, P., ZALAZAR, E., RODRIGUEZ, N. and CARIGNANO, E., 2002. Indicadores de calidad del Río El Tala, Catamarca. Estudios preliminares. In *Libro de resúmenes del I Congreso Iberoamericano de Ambiente y Calidad de Vida*, 2002. Catamarca. p. 222.

SCHEIBLER, E., 2007. *Macroinvertebrados bentónicos como indicadores de calidad del agua en el Río Mendoza, Argentina*. Universidad Nacional de La Plata. 192 p. Tesis Doctoral.

VANNOTE, R., MINSHALL, G., CUMMINS, K., SEDELL, J. and CUSHING, C., 1980. The river continuum concept. *Canadian Journal of Fisheries and Aquatic Sciences*, vol. 37, p. 130-137. http://dx.doi.org/10.1139/f80-017