EPILITHIC CHIRONOMID COMMUNITY STRUCTURE: IS IT A MATTER OF ALGAE?

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With 2 figures and 2 tables

ABSTRACT: The chironomid fauna was examined in a Mediterranean stream under different degrees of water enrichment. Epilithic chironomid larvae and algae were sampled during the spring season in order to elucidate the effect of the algae taxonomic composition on the chironomid community structure. It is suggested that epilithic algae may be an important factor structuring the larval chironomid community.

RESUMO: Examinou-se a fauna de quironomídeo num ribeiro do Mediterrâneo em diferentes graus de enriquecimento da água. Durante a Primavera, recolheram-se amostras de larvas de quironomídeo epilíticos e de algas de modo a se elucidar o efeito da composição taxonómica das algas na estrutura da comunidade de quironomídeo. Sugere-se que as algas epilíticas possam ser um importante factor estruturante das larvas da comunidade de quironomídeo

Keywords: Chironomidae, larval community structure, epilithic algae, water enrichment.

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INTRODUCTION

Chironomid communities have been recognized as a reliable water quality descriptor and have been widely studied in anthropogenic impacted ecosystems. Their fast population dynamics and high population densities in enriched streams suggest that chironomid communities play a key role in these impacted ecosystems, providing an important link in the turnover of organic matter within the stream system and at the catchment scale (e.g., through bat and bird predation).

Chironomid community species composition shows qualitative and quantitative differences between habitats, indicating larval selectivity concerning site choice. Chironomid larval preferences for abiotic factors (depth, substratum composition and current velocity) are relatively well documented but the influence of biotic factors such as food availability is unclear due to complex interactions between chironomid larvae and food sources. The diversity of chironomid larval feeding habits and food preferences suggests a low degree of selectivity and generalist habits (BERG 1995). Chironomid larval communities are known to graze on epiphytic algae (DRAKE 1982; TOKESHI 1986; SILVER BOTTS & COWELL 1992) and epilithic algae (GRESENS 1995; GOLDFINCH & CARMAN 2000) with a wide ranging herbivory impacts suggesting that algae play a major role in chironomid larval community structure. BOTTS & COWELL (1992) and BOTTS (1993) showed selective grazing activity of some epiphytic chironomid larvae reduced the biovolume of preferred algal species and increased clumping of non-preferred species.

This study examined the *in situ* structure of an epilithic chironomid larval community inhabiting the surface of stones in riffle zones in stream reaches displaying different degrees of enrichment. The question was: how did the epilithic chironomid larval community respond to changes in the epilithic algal community structure due to the water enrichment?

MATERIAL AND METHODS

The study was conducted in the upper section of the Arc stream catchment (780 km^2), a small coastal Mediterranean catchment in southern France (Fig. 1). Six riffles were selected in three reaches, two riffles per reach. Two reaches were on the main stream course and one on an adjacent tributary. All sites had considerable canopy cover and low slope; water depth did not exceed 50 cm, or 12 cm in the riffle zones. Mean stream width was three metres in the main channel and one metre in the tributary. Reach A, located on the Aubanède tributary is free of enrichment. Reach C is the most enriched site due to an organic effluent situated 7.3 km upstream. Reach B is intermediate, unaffected by point source input but subject to agriculturally derived diffuse nutrient enrichment.

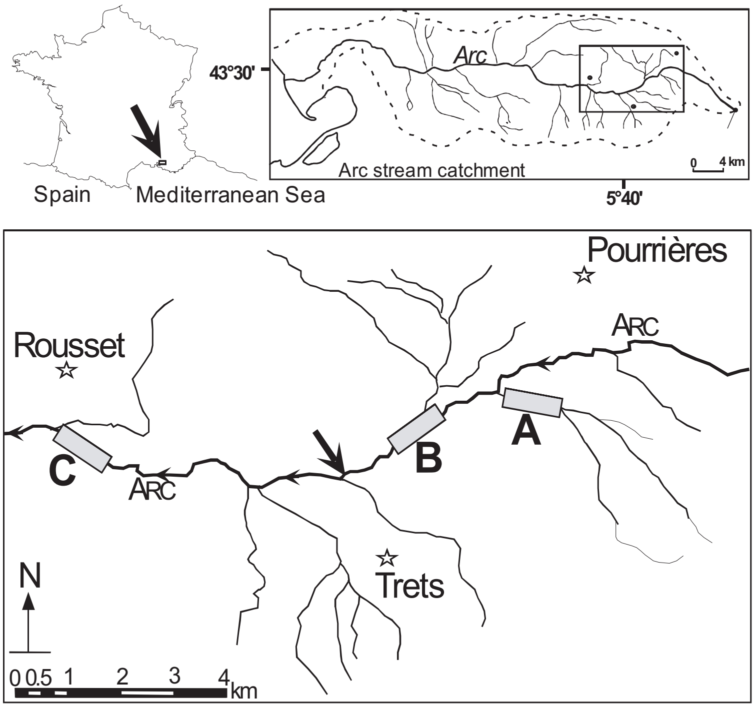

Figure 1. Map of the Arc catchment showing the three reaches. Reach A is situated on the tributary Aubanède, reaches B and C are located on the main channel. The arrow locates the effluent input of the wastewater treatment plant.

Five sampling campaigns were performed from April to June 2004. Electronic probes were used at each site to measure dissolved oxygen (DO), water temperature and conductivity. Water samples were taken for laboratorial chemical analyses of total phosphorus (TP), nitrate (NO_3^-) and organic seston (OS). At each riffle three stones (pebble and cobble) were randomly picked, the bottom surface of each brushed to eliminate non-epilithic chironomid larvae and were then stored separately in a chilled plastic box on site. Current velocity was measured 3 cm above the substrate at the same location after the stone removal using an electromagnetical Flo-Mate®2000 flow meter.

In the laboratory, all chironomid larvae were picked from each stone using tweezers under a magnifying glass and preserved in formalin solution. Larvae were sorted under a dissecting microscope, cleared with a 50% KOH (48 hours at room temperature), rinsed and then dehydrated in 95% ethanol before mounting in glycerin for identification under a binocular microscope at x400, x600.

Following larval removal, a 2 cm² area on each stone surface was scraped with a scalpel and aliquots of suspensions used for taxonomic determination of algae. Stone surface area was estimated by wrapping the upper surface with a closely fitting piece of aluminium foil and using a regression coefficient equation based on the aluminium foil weight of known areas (n = 25) to convert pebble foil wrapping weights to areas.

Water temperature, water conductivity, water velocity and surface areas of the stones were tested for significant differences among reaches (one-way ANOVA, $\alpha = 0.05$).

Data from six stones were pooled and mean chironomid and algae taxa density values per reach were used for the analysis. Canonical Correspondence Analysis (CCA), a direct gradient analysis method (CANOCO for Windows 4.5 (TER BRAAK & SMILAUER 2002)) that allows integrated analysis of taxa and environmental data, was used to relate chironomid species distribution to changes in epilithic algae,assuming a unimodal response. Water chemical parameters (DO, TP, NO_3^-, OS) were used as covariables (explanatory variables that may indirectly affect species distribution). Chironomid larval densities data were $\log_{10}$ (x+1) transformed and rare species were downweighted prior to analysis..

RESULTS

Water temperature (range 9 - 16 °C), conductivity (range 860 - 1024 μScm^{-1}), surface area of stones (mean = 58.6 cm^2, SD = 29.7 cm^2) and water velocity (mean = 34.1 cm s^{-1}, SD = 15.3 cm s^{-1}) did not differ significantly between reaches. However, TP, NO^{3-}, DO and OS significantly differed between the three reaches (Table 1).

TABLE 1. Total phosphorus, nitrate, dissolved oxygen and organic seston mean values in the three reaches (Reach A, B & C).

	Total phosphorus (mgl^{-1})		Nitrate (mgl^{-1})		Dissolved oxygen (mgl^{-1})		Organic seston (mgl^{-1})	
	mean	SD	mean	SD	mean	SD	mean	SD
Reach A	0.44	0.31	5.54	1.5	7.7	2.08	1.46	0.86
Reach B	1.57	0.26	5.37	0.66	9.71	1.24	2.09	0.66
Reach C	3.24	1.62	7.26	0.96	5.56	0.67	3.00	0.89
p	0.006		0.02		0.008		0.04	

A total of 49 algal taxa were recorded: 40 Diatomophyceae, 5 Chlorophyceae, 3 Cyanophyceae and one Rhodophyceae (*Audouinella* sp.), with algal cell densities differing significantly between all three reaches (Friedman test, $\alpha = 0.05$, $p = 0.006$), with a mean density of 5,321 cells cm^{-2} in reach A and 108,310 cells cm^{-2} in reach C. Diatomophyceae had the highest cell densities of the four algal classes in all three reaches, but with cell densities in reach C 34 times greater than in reach A.

Cell densities were significantly different for Diatomophyceae, Chlorophyceae and Rhodophyceae but not Cyanophyceae (Friedman test, $\alpha = 0.05$, $p = 0.015$, 0.0067, 0.0083 and 0.1134, respectively). Rhodophyceae and Cyanophyceae were absent from reach A and had their maximum cell densities in reach C (29,126 cells cm^{-2} and 6,579 cells cm^{-2}, respectively) Maximum Chlorophyceae cell density occurred in reach C and lowest cell densities in reach B.

A total of 2978 chironomid larvae were collected (Orthocladiinae 98.9%, Diamesinae 0.8% and Tanytarsini 0.3%). A total of 34 chironomid taxa were identified (Table 2); 31 Orthocladiinae, two Tanytarsini and one Diamesinae were recorded. Mean chironomid larval densities on stones were 13, 57, and 176 larvae dm^{-2} in reaches A, B and C, respectively. In reach A three taxa, *Eukiefferiella claripennis*, *Orthocladius* (*Orthocladius*) sp. and *Thienemanniella majuscule,* accounted for 15% of the total abundance. The same taxa were also the most represented in Reach B, although proportions of relative abundance differed from reach A. In reach C, *E. claripennis* represented 83% of the community while relative abundances of the other taxa did not exceed 3%. Mean density of *E. claripennis* (145 larvae dm^{-2}) was 23 times higher than that observed in reach A.

The first two axes of the CCA explain 12.4% and 8.9% of the epilithic chironomid larval community variance respectively. Taxa-to-environment correlation coefficients along these two axes were high ($r = 0.81$ and 0.90, respectively). The first two axes explained 50.3% and 35.9%, respectively, of the constrained variance (taxa-environment relation). The sum of all eigenvalues after fitting covariables percentages with respect to residual variances (i.e. variance after fitting covariables) is 0.731.

Three main groups of taxa are discernible (Fig. 2). Group 1 is associated with high cell densities of Rhodophyceae and includes taxa like *Micropsectra* sp., *Cricotopus bicinctus* and *Orthocladius ashei*. Group 2 is highly correlated with high cell densities of the four algae classes and including taxa like *E. claripennis* and *Paratrichocladius rufiventris.* Group 3 is negatively correlated with high cell densities of Rhodophyceae including taxa like *Rheocricotopus fuscipes, Corynoneura coronata* and *Corynoneura lacustris*.

DISCUSSION

High algal cell densities in reach C reflect the usual patterns of enrichment induced algal blooms. High cell densities of *Audouinella* sp. and Diatomophyceae at this site provide favourable conditions for *Eukiefferiella claripennis,* the most abundant chironomid taxa in this study. Similar results were observed by Davies & Hawkes (1981). *Cricotopus bicinctus*, also abundant in the enriched reach, has previously been reported to be abundant at other organically enriched sites (DAVIES & HAWKES 1981; LAVILLE & VIAUD-CHAUVET 1985). DAVIES & HAWKES (1981) and SINGH & HARRISON (1984) reported *E. claripennis* to be a multivoltine species with peaks in emergence between March and May. The higher numbers of *E. claripennis* larvae in this study are due to temporal and phenological factors, as this species occurs mainly in cooler waters while emergent *C. bicinctus* have a temperature preference of 18.9 °C (ROSSARO 1991). Peaks in *C. bicinctus* abundance probably occur later in the year when water temperature increases. However, Mediterranean streams are marked by strong, predictable seasonal patterns of flood and drought. Increased water temperature is usually associated with reduced seasonal flow and reduced habitat availability, limiting the role of high temperature preference riffle taxa such as *C. bicinctus.*

TABLE 2. List of the chironomid taxa with their relative abundance in the three reaches (Reach A, B & C), (-) is for absence.

Chironomidae Taxa	Reach A	Reach B	Reach C
Orthocladiinae			
Corynoneura coronata Edwards, 1924	1.52	-	-
Corynoneura lacustris Edwards, 1924	1.01	-	-
Corynoneura lobata Edwards, 1924	1.52	-	-
Corynoneura spp.	0.5	-	-
Cricotopus (Cricotopus) bicinctus (Meigen, 1818)	-	0.31	1.57
Cricotopus (Cricotopus) trifascia Edwards, 1929	-	-	0.06
Cricotopus (Cricotopus) tremulus (Linnaeus, 1758)	-	-	0.07
Cricotopus (Cricotopus) spp.	0.5	1.26	0.37
Cricotopus (Isocladius) trifasciatus Meigen, 1813	-	-	0.03
Cricotopus (Isocladius) spp.	-	-	0.07
Cricotopus (Nostococladius) spp.	-	-	0.02
Eukiefferiella claripennis (Lundbeck, 1898)	44.7	63.4	82.8
Eukiefferiella coerulescens (Kieffer, 1926)	-	-	0.17
Eukiefferiella minor (Edwards, 1929)	-	-	0.03
Eukiefferiella devonica/ilkleyensis (Edwards, 1929)	-	0.1	-
Eukiefferiella spp.	2.03	6.92	9.77
Orthocladius (Euorthocladius) ashei Soponis, 1990	-	0.21	-
Orthocladius (Orthocladius) sp.	22.3	13	0.2
Paratrichocladius rufiventris (Meigen, 1830)	-	-	0.27
Paratrichocladius spp.	1.02	1.57	0.5
Paratrichocladius sp1	-	-	0.03
Rheocricotopus (Rheocricotopus) fuscipes (Kieffer, 1909)	2.54	-	0.07
Rheocricotopus (Rheocricotopus) spp.	0.51	0.1	-
Thienemanniella majuscula (Edwards, 1924)	17.8	7.65	3.2
Thienemanniella spp.	2.45	0.77	0.11
Thienemanniella vittata (Edwards, 1924)	0.51	0.1	-
Tvetenia bavarica (Goetghebuer, 1934)	-	0.52	-
Tvetenia calvescens (Edwards, 1929)	-	0.1	0.03
Tvetenia discoloripes (Goetghebuer, 1936)	-	-	0.07
Tvetenia sp1	-	-	0.03
Tvetenia spp.	0.57	0.09	-
Tanytarsini			
Micropsectra sp.	-	0.1	0.4
Tanytarsus sp.	-	-	0.03
Diamesinae			
Diamesa sp.	-	3.35	-

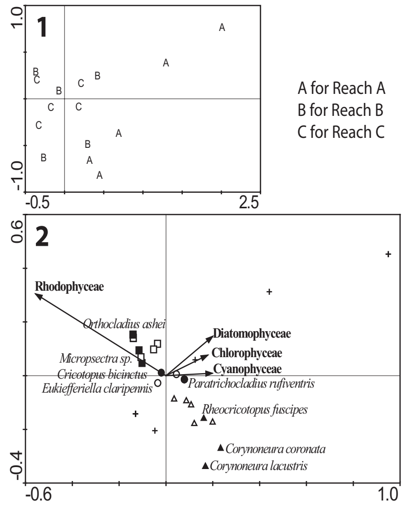

Figure 2. Ordination biplots (CCA) of samples from the three reaches (biplot 1) and the explanatory variables and chironomid taxa (biplot 2). Only chironomid taxa mentioned in the text are shown (filled symbols). (group 1 = squares, group 2= circles, group 3 = triangles. The crosses do not belong to any of the three groups

The CCA results support these findings, indicating that the aforementioned taxa exhibit different correlations to the four algal classes. *E. claripennis* had high correlations with all four algae classes, suggesting some plasticity in feeding preference whereas *C. bicinctus* was associated with the filamentous *Audouinella* sp. We can conclude that epilithic algal composition directly effects epilithic chironomid community structure, with species responding differently to their preferred food type, which is ultimately influenced by the degree of organic enrichment. More investigations are necessary on larvae - algae interactions in order to distinguish trophic interactions from microhabitat conditions created by algal blooms.

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