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MACROINVERTEBRATES OF LOTIC SYSTEMS - MALCATA NATURAL RESERVE - (PORTUGAL)

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ABSTRACT

A study on the composition of macroinvertebrate communities was carried out on three streams - Coa, Basagueda and Meimoa - of a protected landscape area (NE Portugal). Spatial and temporal changes in abundance, *taxa* richness, diversity, eveness an functional organization are discussed. In general longitudinal patterns in the trophic structure agree with the continuum hypothesis (Vannote et al, 1980). Spatial differences in the structural and functional organization in headwater communities were found and attributed to habitat characteristics and some local disturbances, such as agriculture and domestic effluents.

INTRODUCTION

Lotic macroinvertebrate communities integrate populations whose structural and functional organization reflect all the environment where they develop, and so, have been used in several aquatic studies. The majority of these works focus on the impact of human perturbations, on the available fish food and on the knowledge of freshwater ecosystem structure and function (Cummins, 1974; Cummins 1975 & Vannote, et al., 1980). A contribution for this knowledge was given by the river continuum hypothesis, which predicts that longitudinal variations in the communities organization should happen in response to different hydrological and physical conditions. This hypothesis was essentially developed for undisturbed lotic systems, but it may accommodate some disturbances, such as changes in the degree of autotrophy/heterotrophy (Vannote et al., 1980).

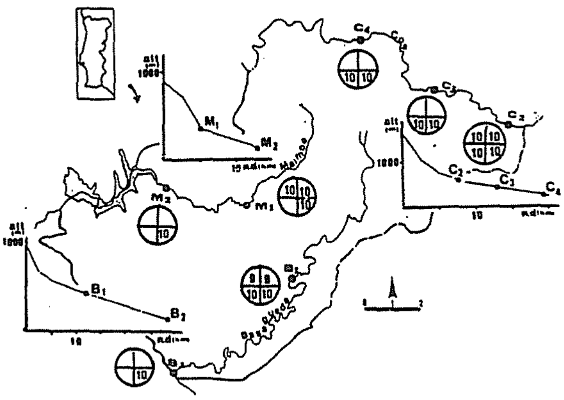
STUDY AREA

Basagueda, Coa and Meimoa (Fig.1) are the main watercourses of a protected landscape area - Malcata Natural Reserve -. All of them have a torrential regimen with great flow reductions during warm periods. They run in valleys of schistose and grauvaquic substratum with reduced slope and consequently have a moderate current velocity. Basagueda and Meimoa have their origin in the reserve and they are practically undisturbed streams. Basagueda flows through an undisturbed watershed, covered by natural vegetation, essentially mediterranean woods (*Cistus sp*, *Erica sp*, *Arbutus unedo*, *Chaesmaespartium tridentatum* and some *Quercus rotundifolia* and *Q. pyrenaicus*) and exhibits a well developed riparian zone composed principally by *Fraxinus sp*, *Almus glutinosa* and *Salix sp*. Meimoa runs across a catchment which the majority of its natural vegetation was replaced by industrial forests (*Pinus negra* and *Pseudothesugas sp*). Due to land pastures, agriculture, small-sized ponds and domestic effluents from near villages Coa river flows through a more disturbed watershed, especially at sites C3 and C4.

MATERIAL AND METHODS

The macroinvertebrate communities were sampled once in each season between Spring 88 and Winter 89. Sampling stations are shown in Fig. 1. Benthic macrofauna was collected with a handnet (mesh size of 500µ) during three minutes and all the different habitats were prospected. The samples were stored in plastic flasks in a 5% formalin solution. Sorting was carried in the laboratory after washing in a range of mesh sieves. The detrital and vegetable material was separated from the macrofauna. The individuals were counted and identified; for some groups and, whenever possible, up to species level (Table 1). The detrital vegetable biomass (D.V.B) was evaluated (Westlake, 1974). The communities structure were evaluated by the total richness of *taxa*, the total abundance (total numbers of individuals), the Shannon-Wheaver diversity (H') and the Eveness (J) index (Pielou, 1975). BBI index was assessed (De Pauw & Vanhooren, 1983). Animals were assigned to functional levels (Garcia de Jalón & Gonzalez del Tanago, 1986).

Fig. 1 - Sampling stations, streams slope and values of BBI index (Spring, Summer; Autumn, Winter).



RESULTS

A total of 173 animal *taxa*: 36 families, 67 genera and 70 species was recorded. Table 1 presents the spatial and temporal distribution of the main *taxa* in terms of their relative frequencies. On the table only 40% of the total *taxa* collected are included, revealing a high specific richness, common in natural streams systems, where the biological communities can be characterized "as composing a temporal continuum of synchronized species replacements" (Vannote et al, 1980).

Diptera, Ephemeroptera and Plecoptera were the most abundant zoological groups (Table 1). In most of the communities Chironomidae and *Baetis sp* were dominant; in Coa, however, their quantitatives were much higher, particulary at the stations C3 and C4. This can be related with a higher availability of organic matter due to the agriculture and the domestic effluents, in this river. So, these organisms may have an important role, in terms of the energy flow and the maintenance of the water quality in this system. The lowest abundance was recorded in Basagueda.

Among the Plecoptera, *Nemoura sp* and *Protonemoura sp* had higher abundances and distribution ranges. Basagueda and Meimoa present the highest abundance of *Perla marginata*. *Rhythrogena gr loyalea* and *R. gr semicolorata* were exclusive of B1 and only in Winter, as *Epeorus torrentium*.

In spite of their low abundance the Tricoptera and the Coleoptera, were determinant to the communities structure. Their high taxonomic richness (Coleoptera - 24 genera; Tricoptera 50 *taxa*, which 38 species, 10 genera and 2 families) have contributed to the high diversity verified.

Abundance and *taxa* richness were higher at all times in Coa, increasing in downstream communities (Fig.2). Also temporal variation of these parameters was

Table 1.- Relative composition (%) of the macrofauna collected at each station during each sampling period. Only those taxa with a relative frquency >1% are given for each sampling site. (* = > 1% < 2% ; ** = > 2% < 5% ; *** => 5%).

	Spring			Summer			Autumn				Winter						
	B1	M1	C2	B1	M1	C2	B1	C2	C3	C4	B1	B2	M1	M2	C2	C3	C4
Tricladida								**	*						**	**	
Enchytraeidae																**	
Lumbricidae															**		
Lumbriculidae									***							**	
Naididae											*					**	*
Stylaria lacustris										*							***
Tubificidae								***									*
Hirudinea									***	*							
Baetis sp	***	**	***	***	***	***	***	***	***	***		*	***	***	***	***	***
Calliarcys humilis									**								
Ephemerella ignita															**	**	
Ephemerella sp	**																*
Ephemera sp			***														
Ecdyonurus sp	***		*	***	***		***	***	***					***		***	***
Epeorus torrentium											***	**	***	***		**	***
Epeorus sp									*	**							
Habroleptoides sp	***	**					***		***	**							
Habrophlebia sp				***	***	***											
Heptagenia sp			**	***						***							*
Heptageniidae		**													***		
Leptophlebiidae				***	**	***	***	***									
Paraleptophlebia sp											***		***	***	***	***	***
Thraulus sp								**									
Rhithrogena gr. hybrida											*	**	**	**			
Rhitrogena gr. loyalaea											***						
Rhithrog.gr.semicolorata											***						
Amphinemura sulcicolliis											**						
Amphinemura sp							*					***					
Nemoura sp			**				***	***	***	***	***	***		*	*	*	**
Protonemura sp			**					**		*	*	***		**	**	*	
Siphonoperla sp			***			**	*				*	**					
Isoperla sp															*	*	**
Perla marginata		**			*							*					
Leuctra sp			*	***	***	***	*										
Boyeria irene	**			*	*												
Onychogomphus uncatus	**			**	**					**							*
Elmis sp										*				*			
Esolus sp								*						*			
Hydraena sp				**	*	*	**				**	**				*	
Hydrocyphon sp				*													
Limnius sp		**								*							
Macroplea sp		*															
Orectochilus sp											*					*	
Oulimnius sp									***	*						**	
Stenelmis sp	*	***		*													
Allogamus sp															*		
Beraea sp		***		*	**								**	*			
Chaepteryx sp										*							
Hydropsyche tibialis		*															
Hydropsyche siltalai									**		*	**	***				
Hydropsyche lobata							*										
Hydropsychye sp					*									***		*	
Ithythrichia sp																	*
Limnephilys sp														*			
Micrasema longulum													*				
Micrasema minimum																**	
Micrasema moestum		**															
Oxyethira sp										*						*	**
Psychomyia pusilla				*													
Rhyachophyla sp		*										*					
Sericostomatidae										**							
Setodes argentipunctellus				*	*												
Tinodes waeneri				*													
Wormaldia sp					*								**				
Chironomidae	**	*	**	***	***	***	*	**		***	***	***	***	***	***	***	
Empididae						*							*				
Limoniidae		*															
Simulidae		**	***		*	***		***	***	***		***	*		***	**	*
Tabanidae		*															
Tipulidae	*	*															

observed. For the communities regularly sampled, the highest values were recorded in Winter and the lowest in Summer. Station B1 denoted communities with lower variations, specially in terms of *taxa* richness.

Both *taxa* richness and abundance follow detrital vegetable biomass variations (Fig.2). A significant positive correlation was found between the two first parameters and D.V.B. (Table.2).

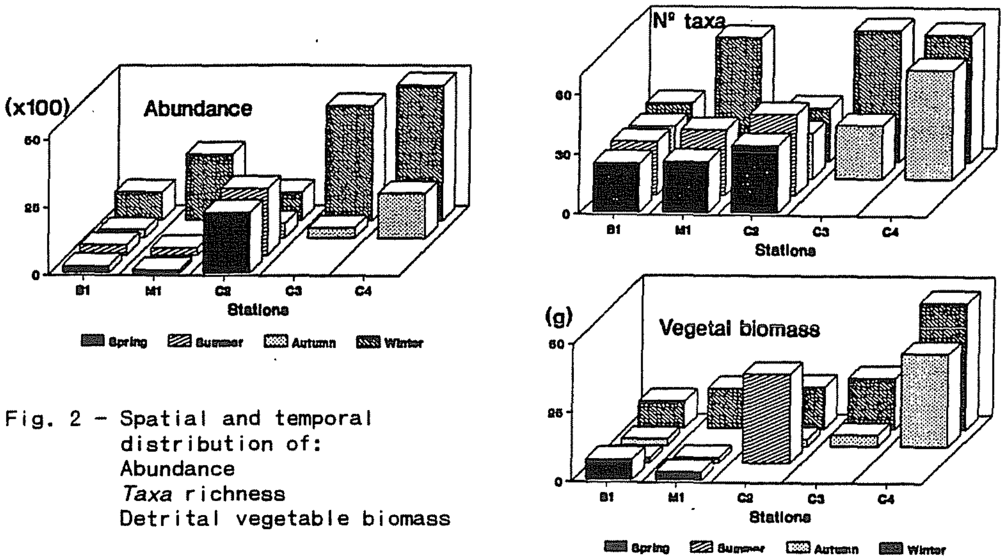


Fig. 2 - Spatial and temporal distribution of:
Abundance
Taxa richness
Detrital vegetable biomass

According to the results of BBI index the biological quality of the water was always good (Fig. 1).

Shannon's diversity (H') agrees with the results of the BBI and Eveness index, considering the high diversities and consequent inexistence of dominance in the majority of the communities. In terms of diversity (H'), the lowest values recorded correspond to upstream communities (Fig.3), which agrees with the continuum hypothesis (Vannote et al. 1980). The highest values correspond to the downstream Coa communities.

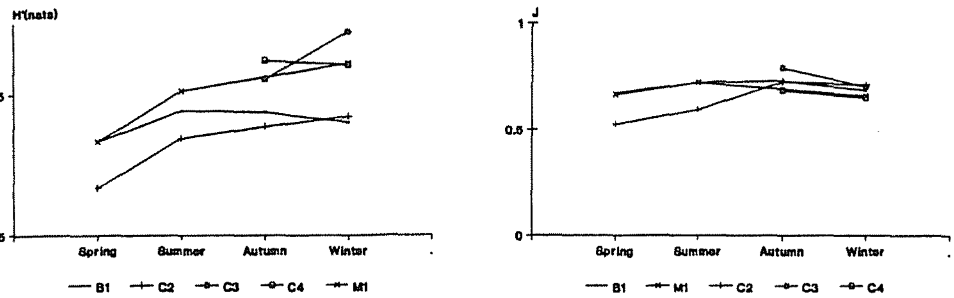


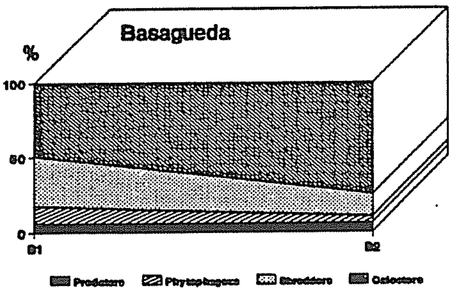
Fig. 3 - Values of Shannon's diversity (H') and Eveness index (J).

Table 2. Values of the correlation coefficient *r* for several parameters.

	Abundance	*Taxa* rich.	Altitude	Water-spring distance	D.V.B.
Predators	0.81***	0.67	-	-	-
Shredders	-	-	-0.21	0.38	0.69**
Collectors	-	-	0.24	0.31	-
Phytophagous	-	-	0.25	-	0.59*
D.V.B.	0.79***	0.78***	-	-	-
H'	-	-	-	0.46	-

P< 0.001***, P< 0.01**, P< 0.05*, not significant, - not evaluated

According to the functional organization, collectors were dominant in the majority of the communities, their number increasing downstream (Fig. 4, Table 3). An inverse trend was observed for shredders, which is conform to the river continuum concept. The lowest abundance of collectors and the highest of shredders were found in the Basagueda upstream community (B1), and so, an almost codominance between them was denoted. This pattern is hypothesized for the headwater communities of undisturbed streams (Vannote et al, 1980).



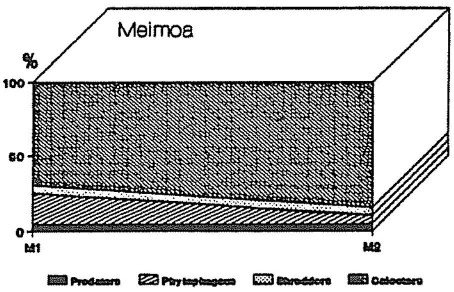


Fig. 4 - Relative distribution of the trophic groups at each station in Coa, Meimoa and Basagueda streams.

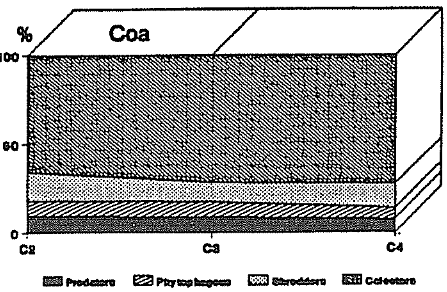


Table 3. Ratios for the trophic groups (Ph-phytophagous, Sh-shredders, Co-collectors, Pr-predators, T-total abundance) (adapted from Cummins & Wilzbach, 1985).

Stream order	1	1	2	2	2	3	3
Station	M1	M2	B1	B2	C2	C3	C4
Ph/Sh	3.9	0.97	0.3	0.3	0.5	0.8	0.4
Sh/Co	0.07	0.06	0.7	0.2	0.3	0.1	0.2
Pr/T	0.05	0.05	0.07	0.06	0.1	0.09	0.08
Co/T	0.7	0.7	0.5	0.8	0.7	0.7	0.7
Sh/T	0.05	0.05	0.3	0.1	0.2	0.1	0.1
Ph/T	0.2	0.05	0.1	0.04	0.08	0.08	0.06

Despite the low abundance of predators in most of the communities, they showed an increase in the Coa communities (Fig. 4, Table 3).

Phytophagous were at their highest abundance in Meimoa, decreasing downstream.

Seasonal patterns were denoted (Table 4): an increase for shredders during Autumn and for phytophagous during Summer, and a decrease for predators during Summer. Collectors showed their highest abundance during Spring and Winter. A significant positive correlation was found for collectors and phytophagous with the detrital vegetable biomass (Table 2).

Table 4. Relative abundance pattern (as % composition) of the trophic groups collected in each season and ratios between phytophagous (Ph) and shredders (Sh) and collectors (Co).

	Spring	Summer	Autumn	Winter
Collectors	78.0	49.5	49.0	75.2
Shredders	7.2	28.7	32.5	9.3
Phytophagous	5.0	18.2	9.8	7.2
Predators	9.8	3.6	8.8	8.3
Ph/Sh	0.7	0.6	0.3	0.8
Sh/Co	0.09	0.6	0.7	0.1

DISCUSSION

Communities structure, together with the high values of diversity, *taxa* richness and abundance, reflect the low degree of disturbance on these streams.

Seasonal variations, such as, the low values of the structural parameters in Summer may suggest the influence of biological and hydrological features. Life cycle events, such as, adult emergence in Summer and the torrential regimen, with drastic reduction of the river flow during this season may be the main causes for these variations.

Spatial differences, mainly the richest Coa communities suggest the influence of major inputs of nutrients an organic matter, from farming and domestic effluents. This is probably the main cause of the high values of vegetable biomass recorded at C2 during Summer, corresponding to a high development of macrophytes, and suggests an eutrophication in this stream. The positive and significative correlation between vegetable biomass with abundance and *taxa* richness (Table 2) supports the hypothesis that vegetation, changes in the flux of organic materials and food, are the main factors that control the distribution of the macroinvertebrate populations (Cummins, 1979; Hynes, 1970).

Longitudinal patterns observed of functional organization (Table 3, Fig.4) agree with the river continuum concept: reflects the decrease of the allochthonous inputs along the streams, as well as an increase of FPOM. Also suggests the increase of the role played by organic materials transported from upstream, which shredders activity is determinant (Vannote et al., 1980).

Considering the stream size (order), all the communities could be grouped into headwaters (Vannote et al., 1980).

Nevertheless, according to that hypothesis and the trophic patterns found, only the upstream community Basagueda (B1) agrees with a headwater community structure:

This community presented a heterotrophic pattern (Table 3) evaluated by Ph/Sh ratio (Cummins, 1974; Cortes, 1989). It also presented a high relative importance of shredders (Table 3, Fig.4). According to the river continuum concept, the well developed riparian vegetation of this station was determinant for the structure found: shading and the inputs of the allochthonous materials showed in an almost codominance between the shredders and the collectors (Scheiring, 1984; Vannote, et al., 1980).

The upstream Meimoa community (M1) denoted a degree of autotrophy (P/R>1), reflected by Ph/Sh ratio (Table 3) with higher phytophagous abundance (Fig.4). This is probably related with some station characteristics: a low riparian vegetation, lots of light and a moderate current velocity. Thus, autochthonous production is stimulated, probably phytobenthos. Considering the longitudinal pattern in trophic structure, the shift from heterotrophic to autotrophic is essentially dependent upon the degree of shading and for some altitudes and latitudes the transition may be in order 1 (Minshall, 1978 in Vannote, et al. 1980; Vannote, et al. 1980).

Coa communities also suggest an upper influence of nutrients and organic matter inputs. The inputs of organic materials and nutrients from agriculture and domestic effluents (i.e. cultural eutrophication) affects the functional organization of the macroinvertebrate communities as predicted by the river continuum concept (Dudgeon, 1984).

The higher abundance of predators in the Coa communities can be related to their high richness and a relationship may be found between the predators and the communities richeness, considering the significant correlation found (Table 2). This relation may also explain low relative abundances during Summer (Table 4). According to Scheiring (1984) decreasing abundances in this season will probably influence the quality and the quantity of food available to the immature instars.

Seasonal patterns observed, such as, higher shredders importance during Autumn, may be related to the increase (Table 4) of the leaf fall. The lowest abundance of collectors in Summer and Autumn may suggest the decrease of FPOM. Probably in Summer it had already been used and the processing of new CPOM (Autumn) is just beginning (Vannote et al., 1980; Scheiring, 1984). The higher abundance of phytophagous during Summer may suggest an increase in autochthonous production, denoting a probable phytobenthos production increase.

CONCLUSION

All the streams studied presented a good biological quality of the water. The high diversities and richness found, allow a high capacity of the benthic fauna redistribution, permiting a fast absorption of the environment stress (Towsend & Hildrew, 1976).

Longitudinal patterns in the trophic structure agreed with the river continuum concept.

Spatial differences in the communities structure were related to habitat characteristics and some local disturbances, in result of human intervention.

These features were also responsible for changes in the characteristics of the headwater communities. However, the river continuum concept also accommodated these changes, responsible for the shift autotrophy/heterotrophy.

Human impact in Coa river didn't appear to have a negative influence in its communities. However, the influence in the downstream communities during Summer wasn't evaluated. The results of this study are being processed.

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