THE LOW MINERALIZED AND FAST TURNOVER WATERCOURSES OF GALICIA

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Keywords: Running waters, Galicia, Physicochemistry, Soft waters, Communities.

ABSTRACT

The climate of Galicia, which is characterized by its oceanic influence, its geological composition, made up basically granite and schist, and its relief, produce a wide hydrographic network with waters which are generally acid and very soft in this area of the Iberian Peninsula.

A relatively high specific richness with a high percentage of endemisms and a wide spectrum of sexual maturity periods and species distribution ranges form the principal aspects to be taken into account in a characterization of its communities.

INTRODUCTION

Limnological studies in Galicia (NW Iberian Peninsula) are still scarce (see MEMBIELA *et al*., 1990). Yet, available information allows elucidation of the main patterns in the physicochemical characteristics of these waters and the composition and ecological behavior of their communities. The limnological characterization of this area would help to describe the limnetic diversity of Spain, since most limnological research in Spain has been focused on hard waters over calcareous or clay substrates.

This summarizes earlier research on the hydrochemical characteristics of unpolluted watercourses in Galicia (MEMBIELA *et al., in press*), and the ecology of the Plecoptera, Trichoptera, Chironomidae and Oligochaeta that inhabit them.

THE ENVIRONMENT

General characteristics of the study area

The topography of Galicia (surface area 29.434 Km^2; fig. 1B) determines the existence of an extensive hydrographic network (fig. 1A). With the northern and easthern mountain ranges setting the boundary, there are a great number of short watercourses draining into the Cantabrian-Atlantic Sea. The most important of them being the Eo (91 Km long along its main course, catchment area 1032 Km*), the Tambre (139 Km long, catchment area 1770 Km^2), and the Ulla (115 Km long, catchment area 2033 Km^2). The eastern and southeastern ranges, with maximal altitudes of around 2000 m, along with the above-mentioned ranges, delimit a sparser and more hierarchical river network, where most of the watercourses are joined into a single river, the Miño (around 350 Km long), draining an area of approximately 14,000 Km^2 (nearly half of the surface area of Galicia). The most important rivers show steep slopes, even in their lower sections. Some of the profiles are concave (the Miño, Anllóns); others are concave-convex (the Tambre, Eume, Xallas) or concave with a strong convexity (Umia).

The Galician terrain is included in what is known as the Hesperian Massif and shows great lithological diversity (fig. 1C). As a whole, there is an abundance of metamorphic rock outcrops (schist, slate, quartzite, gneiss, migmatite, etc.) and in the central western zone, the granitic rocks. This area also contains complexes of basic and ultrabasic rocks. Most of the sedimentary material and the scarce limestone and dolomite outcrops on Galicia are found in the eastern zone. As a whole, the lithology of Galicia is dominated by hard materials of low solubility.

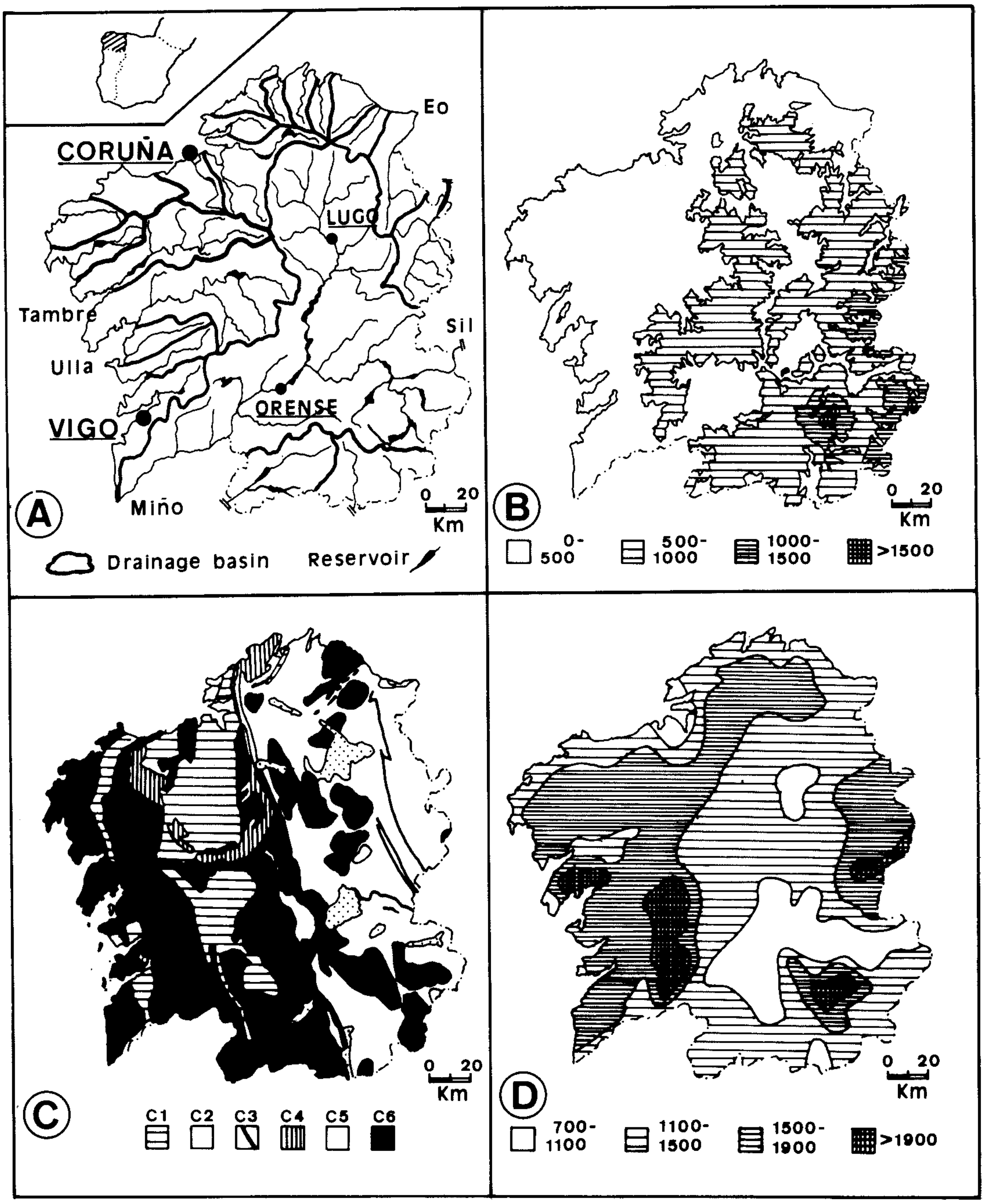

Figure 1. Some setting of the river catchment in Galicia. A) Main drainage basins. B) Relief (Altitude in meters above sea level). C) Lithology. modified from MACIAS (1986): C1, schits and gneisses with low quartz content; C2, slates and schists with high quartz content; C.3, limestones and dolomites; C4, basic and ultrabasic rocks: C5, sediments; C6. granites. D) Annual average precipitations (in mm), modified from CARBALLEIRA et al. (1983).

The prevalling westerly winds extend the influence from the Atlantic to the entire region, and, although the average yearly rainfall varies (fig. ID), most of the Galician territory reaches values of over 1000 mm (CARBALLEIRA *et al.*, 1983). The mountainous strip that runs parallel to the coast has high annual precipitation, particularly in the west, where they intercept the ciouds coming in frorn the sea, causing a significant decrease in the rainfall received in the inland areas of Galicia. Precipitation increases again in the east-southeastern mountains owing to the higher altitudes. In general, maximum rainfall occurs in December-January, with a secondary peack sometime around April, and minimum rainfall is found in July.

There is a clear relationship between rainfall distributiori and the flow regime of the watercourses, although in some cases there is a snow component. On the whole, the low water period extends from July to October, while high waters occur between January and March, and, exceptionally, extends to May (fig. 2).

Physicochemistry of the waters

Most of the hydrochemistry research on Galician watercourses focusses on contaminated watercourses, which represent a small fraction of the fluvial network of Galicia. MEMBIELA *et* al. (1991) describe the main physicochemical aspects of unpolluted waters. This study, made up over a seasonal analysis in 25 sampling stations spread all over Galicia provides a basis to examine the relationships between environmental characteristics and the biotic communities of the unpolluted watercourses in the Galician territory. A multivariate analysis using the Factor Analysis of the BMDP4M (DIXON & BROWN, 1977) points out the relative importance of the 14 chemical parameters analysed in the characterization of the waters as well as the correlations between them, and shows,

- The extent of mineralization of the waters, as accounting for differences among locations, which can be grouped, therefore, into river networks with calcareous material on their catchments, and those on non-limestone geological basins (Table I). The geological substrate of the watershed is, therefore, the main factor constraining the physicochemical characteristics of unpolluted Galician watercourses, as has been described for waters elsewhere (e.g. GORHAM, 1961; GIBBS, 1971; CAPBLANCQ & TOURENQ, 1978).

- Marine influences reflected in the concentrations of Cl^- and Na^+ ions, appear to be of secondary importance in differentiating the chemical characteristics of the watercourses. This influence is best reflected by a strong negative correlation between the concentrations of those ions and distance from the sea (GARCIA *et* al., 1977) in agreement with studies for coastal regions elsewhere (GORHAM, 1961; BALDWIN, 1971; VITOUSEK, 1977).

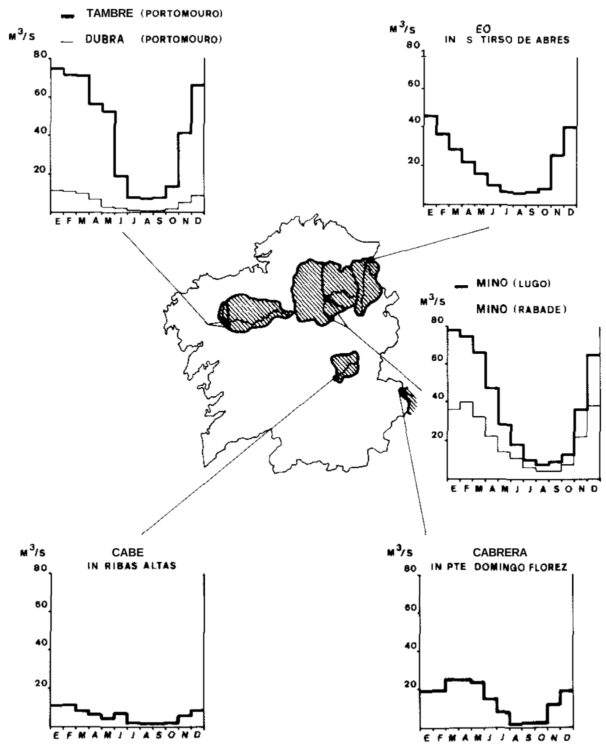

Figure 2. Monthly average volume (in m³/s. E D. January to December) of different Galician watercourses (Tambre. Eo, Miño, Cabe. Cabrera). Data from D.G.O.H. (1979).

- Temporal variability, although smaller than spatial variations, is also important. Physicochemical variability allows the identification of two distinct periods, July to October and January to May, which represent the low and high water periods respectively.

THE COMMUNITIES

Most biological studies in Galician waters focus on their lotic benthic macroinvertebrates, which have increased our knowledge on the major patterns of their ecological behavior.

Specific richness

The running waters of Galicia have a relatively high biotic richness, as can be deduced by the substantial number of species found in the groups that have received the most attention (cf. MEMBIELA *et* al., 1990). The main circumstances that help account for this considerable specific richness are.

- The fact that Galicia is geologically a very old territory, and was little affected by the Pleistocene glaciations.

- Most watercourses are permanent, unlike the temporary nature of most Spanish streams.

- Lotic environments are, in general, unpolluted, with only a few of them being polluted.

- The abundant rainfall and the rugged terrain favour adequate oxygenation of the lotic waters.

- The abundant vegetation cover of the basins, particularly along the banks, which supplies a substantial amount of organic material to the watercourses, particularly in the upper reaches.

Overall, most lotic environments in Galicia fall within the average levels of disturbance, as reported by STANFORD & WARD (1983), resulting in a competitive equilibrium giving rise to the coexistence of great number of species, with only a few of them ever dominating the communities.

However, the presence of a number of reservoirs has had a distinctly negative effect on the watercourses. Their homogeneous bottoms yield a less diversified fauna (cf. PRAT, 1980; MARTINEZ-ANSEMIL & PRAT, 1984) and their management often leads to the population of the lower sections.

Phenology

The small seasonality of physicochemical characteristics in Galician waters, derived from the relative homogeneity of the climatic conditions, appear to influence invertebrate population dynamics. This may be the main reason why approximately one third of the caddisfly species in Galicia develop long flight periods (5 months or more in a year, GONZALEZ, 1981); mature individuals of most Oligochaete species, whose reproduction is essentially or exclusively sexual, are present throughout the whole year (MARTINEZ-ANSEMIL, 1990); and longer emergence periods of some of the Chironomid species compared to other areas (COBO rt al., 1989).

Spatial distribution

Differences in the extent of mineralization of the waters, appear to have little influence on the spatial distribution of the macroinvertebrate fauna, at least in the case of the stoneflies (MEMBIELA, 1991), although soft waters limit the distribution of some species, such as the worm *Nais elinguis* Müller. This species is absent from the Tambre river, appears in small numbers in the more mineralized waters of Galicia and dominates oligochaete communities of the Tambre estuary and hard-water watercourses in the paleartic region, including other areas in the Iberian Peninsula (MARTINEZ-ANSEMIL, 1990).

The longitudinal replacement of populations is less pronounced in Galicia than in other areas, probably because of the small temperature and chemical gradients along the watercourses and the disturbance by dams in the middle and lower sections of the larger rivers. Thus, the main differences in the spatial distribution of the macroinvertebrate fauna are fundamentally quantitative, and appear to be determined, to a great extent, by substrate structure and current speed (MEMBIELA & MARTINEZ-ANSEMIL, 1984; MARTINEZ-ANSEMIL, 1984, 1990).

The lotic macrobenthic communities of Galicia are, therefore, characterized by considerable homogeneity in their

Table 1. Chemical characterization of the Galician river system in relation to the two main types of water mineralization, showing the ranking values for the more discriminating parameters (STD. standard deviation: MIN, minimum value; MAX, maximum value; t, t of Student (N=42)). Each group includes the samples with higher scores for each of the two main axes for factorial analysis (F1, mineralization for solubility of substrate; F2, mineralization via marine influence). From MEMBIELA *et al.*. (1991).

	F1				F2				
	MEAN	STD	MIN	MAX	MEAN	STD	MIN	MAX	t
Alkalinity (meq/l)	0.515	0.295	0.142	1.068	0.098	0.093	0.002	0.328	6.8 ***
Ca^{+2} (meq/l)	0.82	0.55	0.08	2.03	0.14	0.13	0.03	0.52	6.1 ***
Conductivity (µS/cm)	110	49	42	210	52	27	29	124	5.0 ***
pH	7.7	0.4	6.8	8.4	6.6	0.4	5.2	7.1	8.3
Mg^{+2} (meq/l)	0.21	0.12	0.05	0.39	0.11	0.10	0.03	0.41	2.8 **
Na^{+} (meq/l)	0.10	0.05	0.03	0.21	0.20	0.07	0.10	0.38	5.2 ***
Cl^{-} (meq/l)	0.13	0.06	0.05	0.26	0.25	0.08	0.12	0.44	5.1 ***
Si (meq/l)	0.32	0.15	0.01	0.63	0.54	0.21	0.22	0.97	3.6 ***

distribution. However, the stoneflies communities (MEMBIELA, 1991) from large rivers, can be separated from those of smaller watercourses, which constitute a heterogeneous group with clear discontinuities and multiple overlapping distributions. In addition, communities of temporary watercourses are few in Galicia, compared to other peninsular areas, where these watercourses are dominant.

Biogeographical aspects

Galicia contains a substantial fraction of the high number of endemisms present in the aquatic fauna of the Iberian Peninsula. Thus, half of the stoneflies and approximately one third of the caddisflies species found in Galicia are peninsular endemisms, which are largely limited to the northwestern zone of the Iberian Peninsula (GONZALEZ *et al.*, 1987; MEMBIELA, 1990). AUBERT (1956) and GONZALEZ *er al.* (1987) have reported that the Hesperian Massif is the zone containing the highest number of endemisms for the stoneflies and caddisflies respectively. This territory was isolated from the European Pyrenees until the end of the Oligocene. Moreover, the fact that the Iberian Peninsula served as a refuge during the glaciar periods of the Pleistocene (MARGALEF, 1955) has also contributed to the development of a considerable number of endemisms in the fauna of the northwestern area of the peninsula.

REMARKS

We have outlined here the main environmental characteristics of unpolluted watercourses of Galicia, and provided evidence of their influence on their benthic communities. Altough the epicontinental waters of Galicia still have an acceptable level of conservation compared to many other areas of the Peninsula, this situation is threatened by some activities,

(a) The increasing number of dams which are severely influencing the major rivers. The D.G.O.H. (1979) counted 29 reservoirs with a capacity of between 4 and 645 Hm^3. Others which are under construction or planned must be added to this list. Also, a considerable number of small hydroelectric plants, some of which are already opperational and others in various stages of construction, add to the environmental impact of dams.

(b) Increasing pollution from urban and industrial wastes. Galicia has traditionally been fundamentally a rural society with a population that is spread out in a number of small nuclei, and whose main activities have been agriculture, livestock and fishing. However since the early 1960's, a considerable part of the population has been shifting to the urban centers which have undergone industrialization at a fast pace. As a result of this substantial increase in population and industrialization, which has taken place mainly around the large cities (Vigo, A Coruña, Ourense, Santiago, Lugo, etc.), some of tbe watercourses (the Sar, Sarela, Barbaña, Lagares, etc.) have been notably polluted by both organic matter and chemicals. Many watercourses have also been subject to chemical pollution by detergents, acid rain, purine from farms, herbicids, insecticids, etc., about which we have very little data. The low level of mineralization and acidic nature of these waters, which are poorly buffered, increases the fragility of Galician epicontinental waters. There is, therefore, an urgengy to act against the serious threats to these watercourses by the ever-increasing trend towards increased pollution.

(c) Deforestation of watersheds by fires. In the last three decades one third of the total surface of Galicia has suffered the effects of fires. This is certainly causing great changes in environmental conditions, although no evaluations have been carried out as yet. The enormous loss of vegetation will considerably reduce the amount of organic material supplied to the watercourses and may even cause major changes in climate. Soil erosion related to fires, leads to alterations in the aquatic environment with a substantial increase in fine material in the watercourses.

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