PRESENT LEVEL OF KNOWLEDGE REGARDING FLUVIAL MACROINVERTEBRATE COMMUNITIES IN SPAIN

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ABSTRACT

A synthetic review examines present knowledge of fluvial macroinvertebrates in Spain. Many works have been strictly dcscriptive, and most have aimed at the application of biotic indices in water quality studies. Nevertheless, new awareness in the 1980s, fostered by the Spanish Association of Limnology, has begun to stir works that carry more profound implications regarding community ecology and lotic ecosystems.

INTRODUCTION

A knowledge of benthic macroinvertebrate communities is widely considered to be vital in understanding the ecology of waterways (MARGALEF, 1947, 1960). The principal necessity in developing the study of macrobenthic ecology is a good taxonomic knowledge of the different faunistic groups involved. In Spain two major problems exist. Firstly, a great diversity of species inhabit fluvial environments. and the role of the Iberian Peninsula as a refuge and/or dispersion zone at different geological moments has made the area faunistically very rich, with numerous endemic species (SANCHEZ-ORTEGA & ALBA-TERCEDOR, 1987). Secondly, if in fact the number of taxonomists who work on these groups has increased, the number is still small, and in any case inadequate (VALDECASAS *et al.*, 1990). One reason for this is the comparatively low value generally placed on taxonomy. For example, studies on the water quality of rivers, using more or less simple biotic indices, abound because of the great acceptability and social interest of this work. Consequently, we are currently reaching a paradox in which we have studied water quality in a good part of our waterways without knowing the composition of species inhabiting those environments.

In Spain a good index of the true situation surrounding faunistic knowledge is the publication of the faunistic lists and bibliographies of the different fluvial macrobenthic groups. Apart from works in preparation, to date there have been publications on Ephemeroptera (ALBA-TERCEDOR, 1981), Plecoptera (SANCHEZ-ORTEGA & ALBA-TERCEDOR, 1987), Heteroptera (NIESER & MONTES, 1984), Coleoptera (MONTES & SOLER, 1986; RICO *et al.*. 1990; VALLADARES & MONTES, 1991), Mollusca bivalvia (VIDAL-ABARCA & SUAREZ, 1985), Hydrachnellae (VALDECASAS, 1988); and a preliminary list of chironomid Diptera (COBO *et al.*, 1987).

In this work we present a general synthesis of current knowledge regarding *sensu lato* ecology of fluvial macroinvertebrates in Spain. For this we have included only those studies which involve macroinvertebrates as a whole, and therefore we have not considered those works that include only one or two faunistic groups, or those that contribute no information other than a list of taxa.

HISTORY

The beginning of the study of fluvial benthic communities can be traced to the works of MARGALEF (1947, 1948, 1949, 1952, 1953, 1955, 1960), which offer descriptions of communities (1946, 1948, 1949, 1952, 1953, 1955) as well as theoretical proposals for the stages in community development and for comparisons between fluvial and lacustrine systems (1947). Professor Margalef's role as founder and

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driving force of limnology in Spain is further demonstrated by the fact that his theories on the functioning and structure of fluvial systems (1960) have been and continue to be models for testing and generating alternative hypotheses. Nonetheless, there is a conspicuous time gap between the work of Margalef and subsequent studies by Spanish researchers. On examining the evolution of studies related to fluvial benthos (fig. 1). we find that published works begin to proliferate in the 1970s and especially at the beginning of the 1980s. coinciding with the foundation of the Spanish

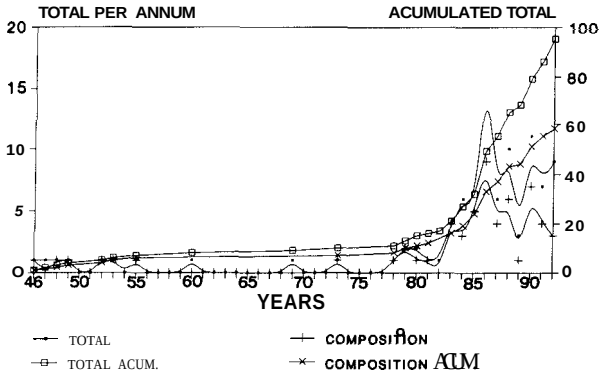


Figure 1. Spanish papers on fluvial macroinvertebrate communities (a) and species composition (b).

Association of Limnology. There were originally three areas of focus, due to the existence of relatively numerous groups: Barcelona, Granada and Madrid. Work in these areas, together with other groups appearing in different parts of the peninsula (Asturias, Basque Country, Murcia) has contributed to a knowledge of certain aspects of benthic communities partly from the hydrographic network of Spain. There are still many zones, however, where no studies on benthic communities have been published (fig. 2). In fact, some of the major hydrographic bodies (Ebro, Tajo and Guadiana Rivers) are still largely to be studied (fig. 3).

If we consider the temporal evolution of the publications (fig. 1), we can find a relationship between the convocations of the Spanish Association of Limnology (every two years) and the rate of appearance of the majority of the works published. The study of fluvial benthic communities reached its high point in 1986, after which, due to its complexity and the greater economic returns (though not scientific) of other approaches, such as water quality biology, interest flagged to some degree. During the last congress of the Spanish Association of Limnology, in September of 1991, there was a clear predominance of works concerned with different aspects of lentic ecosystems (reservoirs, lakes, etc.) (fig. 4).

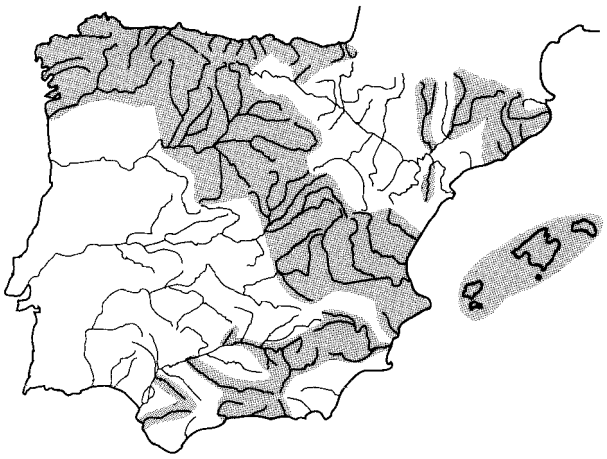
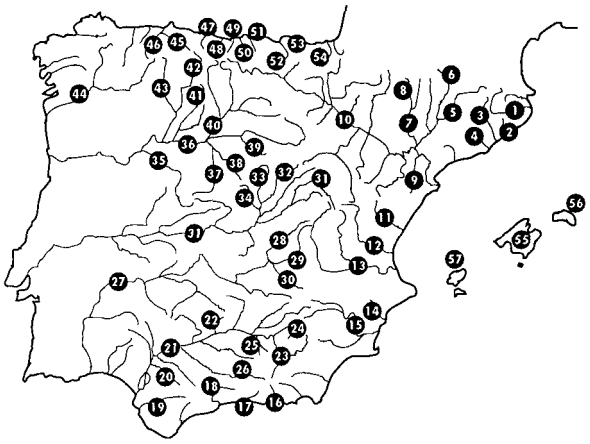


Figure 2. Location of the waterways prospected on macroinvertebiate communities studies.

Up to the present time, the different Spanish fluvial networks have been studied with varying intensity, as can be seen in fig. 5. Certain areas have received particular



1 Ter
2. Besos
3. Llobregat
4. Foix
5 Segre
6 Noguera Pallaresa
7. Cinco
8 Am
9 Matarraña
10. Ebro
11 Mijares
12 Turia
13. Júcar
14 Vinalopó
15. Segura
16. Adra
17. Guadalfeo
18. Guadalhorce
19. Guadalete
20. Guadaira
21. Guadalquivir
22. Yeguar
23. Guadiana Menor
24. High Guadalquivir
25 Guadalbullón
26. Genil
27 Guadina
28 Cigüela
29 Záncara
30 Cócoles
31 High Tajo
32. Henares
33 Jarama
34 Manzanares
35 Tormes
36. Duero
37. Arlanza
38. Eresma
39. Cega
40. Pisuerga
41. Carrión
42. Esla
43 Orbigo
M Miño
45. Nalón
46 Narcea
47 Deva
48. Nansa
49 Besaya
50 Pas
51. Ansón
52. Abra
53. Bidasoyan Rivers
55. Mallorcan Rivers
56. Menorcan Rivers
57. Springs of Ibiza

Figure 3. Estudied catchment basins and major hydrographic spanish rivers.

attention: Catalonian fluvial networks, with a total of 21 works published from the University of Barcelona (MARGALEF, 1948,1952,1953; PRAT *et al.*, 1979-1986; MILLET & PRAT, 1984; GONZALEZ *et al.*, 1985; GROSSMAN *et al.*, 1985; PALAU & PALOMES, 1986 a,b; RIERADEVALL & PRAT, 1986; PUIG *et al.*, 1987-1990); the high Guadalquivir Basin (DOMEZAIN *et al.*, 1987; ZAMORA-MUÑOZ, 1988; MADRID, 1990; UNIVERSIDAD DE GRANADA, 1990; ALBA-TERCEDOR *et al.*, 1990-91; CASTILLO *et al.*, 1991; ZAMORA-MUÑOZ, 1992; ZAMORA-MUÑOZ & ALBA-TERCEDOR, 1992), together with small Mediterranean water courses in the provinces of Granada and Almeria(ALBA-TERCEDOR & JIMENEZ-MILLAN, 1985; ALBA-TERCEDOR *et al.*, 1986), with 14 published works from the University of Granada; the high basin of the Tajo River, with 8 works from the Autonomous and Polytechnic Universities of Madrid (GARCIA DE JALON, 1980; GONZALEZ DEL TANAGO &GARCIA DE JALON, 1980, 1981; GARCIA DE JALON & GONZALEZ DEL TANAGO, 1982; HERRANZ, 1983;CASADO, 1986; HERRANZ & GONZALEZ DEL TANAGO, 1986; BALTANAS, 1990); and finally the Duero River Basin with a general study carried out by the Polytechnic University of Madrid (GONZALEZ DEL TANAGO & GARCIA DE JALON, 1984; GARCIA DE JALON & GONZALEZ DEL TANAGO, 1986; GARCIA DE JALON *et al.*, 1986;) and with certain secondary water courses studied by the University of Leon (LUIS *et al.*, 1986; MANZANERA & ALVAREZ, 1987; PRESA *et al.*, 1988). Furthermore, in the Cantabrian cornice the rivers of the following regions have been studied by the Universities of Oviedo (ABELLA & GONZALEZ, 1986; ORTEGA, 1990) and the Basque Country (BARGOS & MESANZA, 1988; PINKSTER, 1988; RALLO *et al.*, 1988; IMBERT & POZO, 1989; RODRIGUEZ & WRIGHT, 1991; RICO *et al.*, in *press)* and Water Research Authority of North-Spain (ARLUZIAGA & ALZATE, 1984; LOPEZ-LLANEZA, 1984; GONZALEZ *et al.*, 1986 a, b; MIRANDA, 1987).

As a group, the studies on fluvial benthos advance two principal themes: community structure (descriptive phase) and indices (biotic indices and water quality). In addition to these two areas of interest appear some studies on community zonation (cases associated with time) and some works presenting wider ecological proposals (MARGALEF, 1947, 1960; GARCIA DE JALON, 1980; HERRANZ, 1983; MILLET & PRAT, 1984; CASADO, 1986; HERRANZ & GONZALEZ DEL TANAGO, 1986; PRAT *et al.*, 1986; RIERADEVALL & PRAT, 1986; PUIG *et al.*, 1987: GARCIA DE JALON *et al.*, 1988; FANLO *et al.*, 1989; IMBERT & POZO, 1989; BALTANAS, 1990; ORTEGA *et al.*, 1991; PUIG *et al.*, 1991; SOLER, 1991; MALO & PUIG, 1992; PUIG, 1992; ROLDAN & PUIG, 1992; SOLER & PUIG, 1992). These distinct thematic areas, preferred by Spanish researchers, provide reference points in our effort to understand the present level of knowledge of fluvial benthos, as we shall discuss below.

FLUVIAL MACROBENTHIC COMMUNITY STRUCTURE

The first works known which explore the structure of macrobenthic fluvial communities had very particular aims. The majority of these studies were organized according to the relationships between species that make up the community, together with the community's relationship to either the physical structure of the habitat or the degree of water mineralization (MARGALEF, 1946, 1948, 1949, 1953). Between 1978 and 1983 (GONZALEZ DEL TANAGO, 1978; PRAT *et al.*, 1979; GONZALEZ DEL TANAGO & GARCIA DE JALON, 1981; GARCIA DE JALON & GONZALEZ DEL TANAGO, 1982; PRAT *et al.*, 1983) a series of studies appeared which were directed fundamentally at understanding the temporal changes that occur in macrobenthic communities and/or temporal development. The longitudinal distribution of the water courses was also discussed in some cases (GARCIA DE JALON & GONZALEZ DEL TANAGO, 1982; HERRANZ, 1983; PRAT *et* al., 1983; ARLUZIAGA & ALZATE, 1984; MILLET & PRAT. 1984; ALBA-TERCEDOR & JIMENEZ-MILLAN,

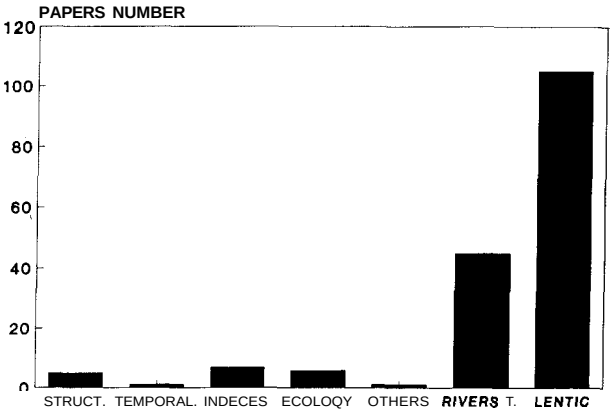


Figure 4. Distribution of papers oii tematic topics presented in the last Congress on Spanish Limnology (1991).

1985; GONZALEZ *et al.*. 1985; ALBA-TERCEDOR *et al.*, 1986; PRESA *et al.*, 1988; ZAMORA-MUÑOZ, 1988).

Of the overall number of works we have compiled, 95, only 58 (61.05%) offer information on the composition of these communities. This situation is primarily because, between 1984 and 1986, works were continued on known courses for which communities had already been described (Catalonia). Beginning in 1986, the year of the major work describing benthic communities (fig. 1), there was an appreciable decrease in the number of new works concerning the composition and structure of the Spanish fluvial benthic communities.

On carefully analysing the state of knowledge of this type of community composition we find that most studies focused on only a part of the problem and not always on the numerically predominant groups. In addition, studies of macroinvertebrate communities that include an identification of Diptera (especially the chironomids), at a level lower than the family, are an exception (PRAT *et al.*, 1983, 1985; PUIG *et al.*, 1984, 1987; RALLO *et al.*, 1988; ROLDAN & PUIG, 1992). For this reason, to provide a general characterization of the composition by taxa according to waterways, we have considered only the six groups that have been most thoroughly studied in most cases: Ephemeroptera, Trichoptera, Plecoptera, Coleoptera, Odonata and Heteroptera. On the basis of specific composition we have looked for tendencies, similarities and differences among fluvial courses which present different structural characteristics.

Various types of faunistic composition have been detected (fig. 6):

1. In the waterways of northeastern Spain (Cinca, Noguera Pallaresa, Ter. Llobregat. Besos, Foix and Mataraña Rivers). that is, the sub-basin of ihe Ebro River and the small Catalonian water courses north of the Ebro.

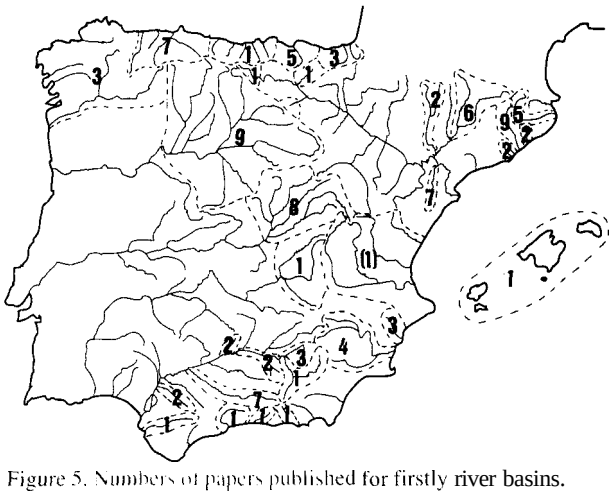


Figure 5. Numbers of papers published for firstly river basins.

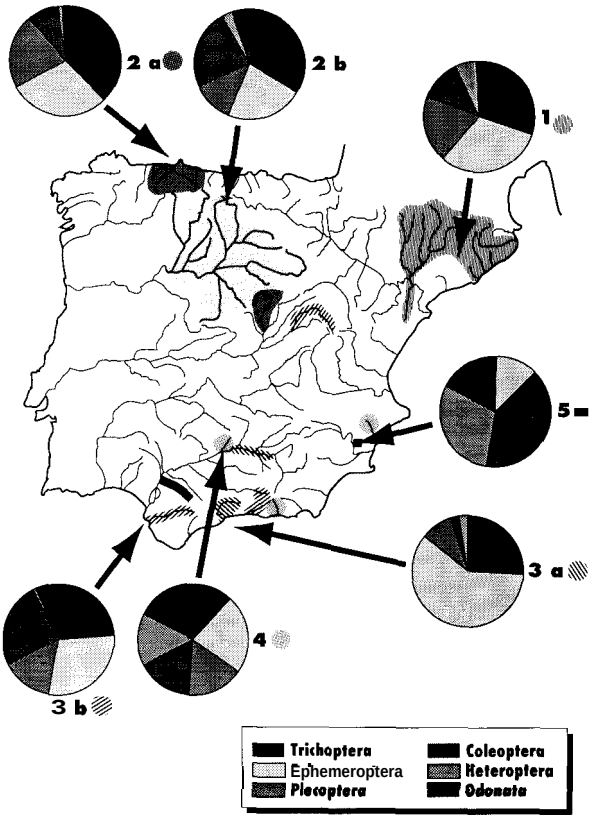


Figure 6. Types of faunistic composition detected in the spanish basins.

dominance is shared by Trichoptera and Ephemeroptera, with Plecoptera as an accompanying species. For the all of the orders combined, moreover, the reophile species constitute the largest part of the community (PRAT *et al.*, 1983, 1985; GROSSMAN *et al.*, 1985; PUIG *et al.*, 1987; GARCIA DE JALON *et al.*, 1988; PUIG *et al.*, 1990; PUIG, 1992).

2. In waterways of the northwestern and central part of Spain (small Asturian courses, Nalón, Duero and Jarama Rivers), Trichoptera remains dominant, with Ephemeroptera as an accompanying group. But two subgroups are distinguishable on the basis of the second accompanying group: small courses with Plecoptera as the second accompanying order (Asturian rivers and the Jarama River) (GONZALEZ DEL TANAGO & GARCIA DE JALON, 1981; GARCIA DE JALON & GONZALEZ DEL TANAGO, 1982; LOPEZ-LLANEZA, 1984; ABELLA & GONZALEZ, 1986); and

large courses of generally little slope with Coleoptera as the second accompanying order (Duero River) (GARCIA DE JALON & GONZALEZ DEL TANAGO, 1986).

3. In all of the permanent waterways in the southern half of Spain Ephemeroptera is the order with the greatest number of species. Two subgroups can be distinguished: courses in which only Ephemeroptera dominates (the medium-high stretch of the Guadalquivir River and the Guadalhorce River) (GARCIA DE JALON & GONZALEZ DEL TANAGO, 1986; ALBA-TERCEDOR *et al.*, 1990); courses with mountain systems, with Ephemeroptera and Coleoptera sharing dominance, and Trichoptera the basic accompanying group (sources of the Genil, Guadalete, Guadalfeo and Tajo Rivers) (ALBA-TERCEDOR & JIMENEZ-MILLAN, 1985; ZAMORA-MUÑOZ, 1988; BALTANAS, 1990; GALLAR-DO, 1991; ZAMORA-MUÑOZ, 1992).

4. In seasonal waterways with permanent reophile stretches (Yeguas, Adra and Vinalopó River) no order appears to dominate having a very balanced representation of species belonging to Ephemeroptera, Trichoptera, Coleoptera, Odonata and Heteroptera. As a whole, lentic species dominate (GARCIA-ROJAS, 1985; ALBA-TERCEDOR *et al.*, 1986; ROLDAN & PUIG, 1992).

5. In completely seasonal waterways (Guadaira River and Moro Guich), systems resembling ponds more than rivers, lentic Coleoptera are clearly dominant (GALLARDO & TOJA, 1988; ORTEGA, 1988; GALLARDO, 1991)

From the groupings of waterways according to community composition, a fairly dintinct typology can be identified, which might be completed in the future when the remaining Spanish fluvial systems have been studied. New data would be especially interesting Spanish fluvial systems have been studied. New data would be especially interesting from general studies of the major river such as the Ebro, Tajo, Guadiana and Guadalquivir, though stretches of some of these have been partialty investigated (Guadalquivir, Guadiana Menor).

BIOTIC INDICES

Of the works published on the benthos of Spain 47.37% concern water quality, and use macroinvertebrate as indices of pollution. These studies, which are still on the rise, have as their precedent the works of MARGALEF (1952, 1969). Not until the 1970s, however, were any Spanish ideas effectively put into practice (GONZALEZ DEL TANAGO *et al.*, 1979; PRAT *et al.*, 1979), and in any case it should be mentioned that the first practica] experiment dealing with Spanish territory was carried out in 1973 by MEYNELL. The major development began in 1984 (fig. 7) and continued its crescendo until the present. Regarding this group of works we should point out that only few authors have used the saprobios system (SLADECEK, 1966; MARGALEF,

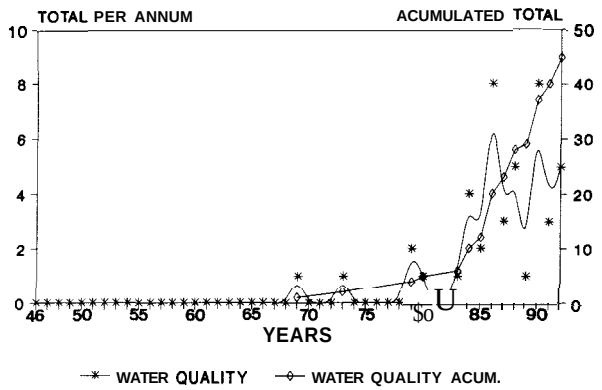


Figure 7. Spanish papers on biological pollution indicators (communities).

1969; GARCIA DE JALON & GONZALEZ DEL TANAGO, 1986; VALDECASAS & BALTANAS, 1990). In the rest of the works authors have tried to test and adapt different European indices (Vernaux and Tuffery, Chandler, BMWP system) (TUFFERY & VERNEAUX, 1967; CHANDLER, 1970; ARMITAGE *et al.*, 1983). There has been an obvious tendency toward obtaining maximum information with minimum effort. Leaving behind the inital use of biotic indices, which require the use of species identification (SLADECEK, 1966; TUFFERY & VERNEAUX, 1967), researchers are at present in more or less general agreement on the use of the BMWP' (ALBA-TERCEDOR & SANCHEZ-ORTEGA, 1988), an adaptation of the english BMWP (ARMITAGE *et al.*, 1983) for the Iberian Peninsula, with quality guidelines which require the recognition of taxa at the family level only.

From the studies considered in this article, concerning both quality and any other perspective of fluvial macrobenthos for which the data allow the application of the BMWP' (GONZALEZ DEL TANAGO *et al.*, 1979; GONZALEZ DEL TANAGO & GARCIA DE JALON, 1980; GARCIA DE JALON & GONZALEZ DEL TANAGO, 1982; PRAT *et al.*, 1983; LOPEZ-LLANEZA, 1984; SOLER, 1984; ALBA-TERCEDOR & JIMENEZ-MILLAN, 1985; GARCIA-ROJAS, 1985; GROSSMAN *et al.*, 1985; PRAT *et al.*, 1979; ALBA-TERCEDOR *et al.*, 1986; CASADO, 1986; GARCIA DE JALON & GONZA-

LEZ DEL TANAGO, 1986; GONZALEZ et al., 1986A; PALAU & PALOMES, 1986B; PRAT *et* al., 1986; PUIG *et* al., 1987,1990; GARCIA DE JALON *et* al., 1988; RALLO *et al.*,1988; ZAMORA-MUÑOZ, 1988; ALBA-TERCEDOR *et* al., 1990; MADRID, 1990; ORTEGA, 1990; ALBA-TERCEDOR & PICAZO, 1990, 1991; CASTILLO *et* al., 1991; GALLARDO, 1991; PUIG, 1992; ROLDAN & PUIG, 1992; ZAMORA-MUÑOZ & ALBA-TERCEDOR, 1992; MUÑOZ & PRAT, *in* press), two maps have been drawn to synthesize the water quality of Spanish rivers. One map represents water quality during the summer (fig. 8) while the other indicates the average annual values from those works spanning more than one season (fig. 9). In fact, due to extent of the territory and the cartographic scale, it has not been possible to include in these maps all the sampling points included in the original works. For this reason the result must be intespreted as an approximation of the general situation (escecially when data was used from widely ranging years) for which partial works should be consulted to gain a more detailed interpretation of specific zones.

In most cases good biological conditions are found in unaltered communities, found only in stretches at the sources of waterways and in waters above the effluents of population centers. Water quality deteriorates abruptly below effluent points, creating altered zones, with degrees of alteration in many stretches which can be classified as "critical" (deplorable) and "very critical" (intolerable). It is also necessary to point out that studies reated in successive years report a definite worsening of the situation (PRAT *et al.*, 1983; ALBA-TERCEDOR & PICAZO, 1990, 1991; MUÑOZ & PRAT, *in* press).

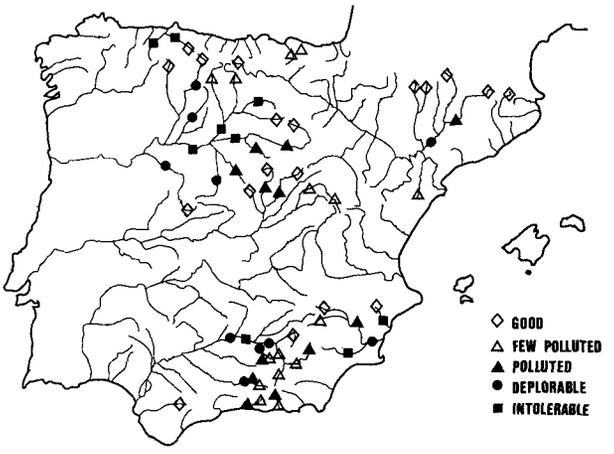


Figure 8. Estimation of the water quality during summer.

ZONATION OF FLUVIAL COMMUNITIES

For the few works that have focused on the division os Spanish river communities into zones, we find two major tendencies. The first is the exhaustive cataloguing of different communities based on the zonation proposed by ILLIES & BOTOSANEANU (1963). The best exponents of this approach in Spain have been GARCIA DE JALON & GONZALEZ DEL TANAGO (1986), working in the Duero Basin. In addition, there have been other studies directed at a more restricted locations (GARCIA DE JALON & GONZALEZ DEL TANAGO, 1982; ALBA-TERCEDOR *et* al., 1986). The second tendency is the consideration of the community structure of fluvial macroinvertebrates as being a longitudinal gradient of group and species substitution, in which the substitution hampers a clear division of the completely isolated macroinvertebrate communities characterizing precise stretches (VERNEAUX, 1973; VANNOTE, 1981). This approach uses different multivariant analyses (PCA and CCA), and has been the most used system since 1984 (GONZALEZ DEL TANAGO & GARCIA DE JALON, 1981; GARCIA-ROJAS, 1985; GARCIA-AVILES, 1990).

Overall, the various studies published on zonation seem to indicate that the known Spanish fluvial systems allow us to differentiate their sources clearly, in contrast to the rest of the basin, where, strongly affected by the pollution in many cases, a gradient is found and therefore clear zonation is impeded (MILLET & PRAT, 1984; PUIG *et* al., 1987, 1991), except perhaps the Duero Basin (GARCIA DE JALON & GONZALEZ DEL TANAGO, 1986).

SPECIAL SYSTEMS (CASES RELATED TO SEASONALITY)

In spite of their singularity and their relative importance in Spanish geography, the seasonal rivers have not been considered important until the middle of the 1980s (GARCIA-ROJAS, 1985; GROSSMAN *et* al., 1985; PRAT *et* al., 1985, 1986; PUIG *et al.*, 1986, 1991; GARCIA-AVILES, 1990; ORTEGA *et* al., 1991; SOLER, 1991; ROLDAN & PUIG, 1992; SOLER & PUIG, 1992). Even since then work has been insufficient, producing only 10 finished studies. The results obtained up to now, however, have refuted two ideas: the concept that diversity in these systems is less than that of permanent waterways (GARCIA-ROJAS, 1985; PUIG *et* al., 1991); and the idea that the structures of these communities are homogeneus.

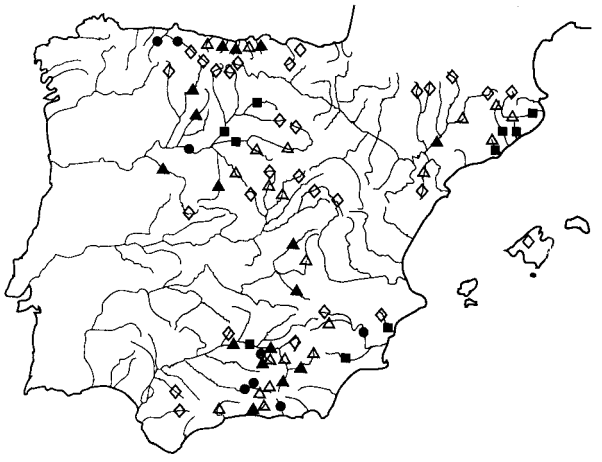


Figure 9. Average annual values of water quality (BMWP' used).

This latter concept can be rejected simply with the observation that seasonal river communities have been studied within three different typological groups defined in the section on community composition. Futhermore this subject is treated in depth in another chapter of this book.

FUTURE PERSPECTIVES

The tendency observed in the communications presented at the VI Spanish Congress on Limnology, showed the dominance of the works on biotic indices, although we can see a greater stant towards carrying our more complex studies on the community ecology of fluvial macrobenthos (fig. 4). Taken altogether, however, the number of works presented has been low (10.19%), and therefore at present Spanish limnology is dominated by studies related to lentic systems, as opposed to those focused on lotic systems.

The needs involved in the study of the macroinvertebrate communities is Spain include the exploration of large waterways which are still completely unknown. This requires taxonomic work as a base. It must in fact approach a study of community ecology, scarcely begun and concentrated at the moment primarly on rates of colonization and displacement.

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