ASSESSMENT AND PREDICTION OF BIOLOGICAL QUALITY. 
A DEMONSTRATION OF A BRITISH MACROINVERTEBRATE-BASED 
METHOD IN TWO SPANISH RIVERS

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Keywords: prediction, pollution, macroinvertebrates, Iberian Peninsula.

ABSTRACT

The predictive model RIVPACS which was developed in Britain is used to assess the pollution status of two Galician rivers. All polluted sites were identified by the model which was able to provide a measure of the deviation of a stressed site from the unpolluted state.

INTRODUCTION

Over the past decade the Freshwater Biological Association has accumulated a data base of information on the macroinvertebrates and also the environmental features of 370 unpolluted lotic sites throughout Great Britain. The methods employed in acquiring these data and in developing a site classification system based on macroinvertebrates are described in Wright et al. (1984). Subsequently this information has been used in developing a computer-based model RIVPACS (River Invertebrate Prediction and Classification System) for the prediction of the probability of capture of species at unsampled sites by using environmental features (Moss et al., 1987). Thus it is now possible to go to a previously unsampled site, record certain physical and chemical parameters, enter these into the computer and produce a list of taxa which would be expected to occur at the site if it was unpolluted or unstressed. This technique has application in routine biological surveillance (Wright et al., 1989) and has been used to assess the effects of stream regulation on lotic invertebrates (Armitage, 1987; Armitage et al., 1987; Armitage, 1989) and in the conservation of freshwater sites (Furse et al., 1987).

The model can predict species occurrence, family occurrence, relative abundance at family level and the occurrence of a subset of families used in the Biological Monitoring Working Party (BMWP) score system (National Water Council, 1981).

Although species level data from sites offer the most detailed ecological information, it is frequently impractical because of temporal and financial constraints. Identification to family level alone is faster and less expensive, and has provided sufficient information to categorise and classify river sites in Great Britain (Furse et al., 1984) and has been the basis for several biotic score systems (Woodiuss, 1964; Verneaux & Tuffery, 1967) including the BMWP system. This latter system has been tested in Spain (Alba-Tercedor & Jiménez-Millán, 1985, 1987) and modified slightly to accommodate more families and include some score changes (Alba-Tercedor & Sánchez-Ortega, 1988; Alba-Tercedor et al., in press). Rodríguez & Wright (1988) have compared both the original and modified BMWP system
in three Basque rivers. Although the modified (Iberian) scores for sites were always higher than British BMWP scores because of the extra families the overall trends in quality indicated by the two systems were similar. Since the species within each family appear to be responding to environmental stress in generally similar ways in both countries and all the British families occur in the Iberian Peninsula it is appropriate to examine the performance of RIVPACS in Spain.

MATERIAL AND METHODS

Study area

Two rivers in Galicia (NW Spain) for which physical, chemical and macroinvertebrate data were available, were chosen for study. The rivers, Louro and Tea (fig. 1) are relatively short tributaries of the lower basin of the Rio Miño which forms part of the border between Spain and Portugal. They arise respectively at 500 m and 1000 m above mean sea level and flow through a granitic catchment with sandy, to sandy-loamy acid soils. Data are available from 12 sites in the Louro and 6 in the Tea. The location of these sites, together with the physical and chemical features used in the predictive model are listed in table 1. The main influences on water quality in the Louro occur at site 10 which receives effluent from a soft drink processing plant and seepage from a bankside refuse tip and between sites 6 and 4 where the river receives a variety of effluents from a number of nearby factories including an abattoir, an animal feed factory, and a pottery. The effects of these effluents on water quality (NH₄ and dissolved oxygen) are most pronounced in late summer. These effects are illustrated in fig. 2 and compared with the situation in the Tea, which receives no polluting discharges.

Methods

Lotic biotopes in the Louro and Tea were sampled for macroinvertebrates with a Surber sampler. This differs from the standard 3-minute kick/sweep used in acquiring RZVPACS invertebrate data but in both studies a standardised effort was employed at each site and collections were made throughout the year. Sampling took place on 5 occasions between 1986 and 1987 (28/05/86, 27/06/86, 11/07/86, 08/11/86, 04/02/87) at 12 sites in the Louro and on a further 4 occasions between 1987 and 1988 (25/11/87, 04/03/88, 23/05/88, 14/09/88) at 6 sites on the Louro and 6 sites on the Tea (table 1).

The data used in this study are the lists of families from each site obtained by combining seasonal samples in each year. Thus two separate data sets (1986/87 and 1987/88) were available for analysis. Physical and chemical data were obtained on each site visit and table 1 presents mean values based on all visits.

Data on 5 variables (substratum composition, distance from source, total oxidised nitrogen, al-
Table 1. The location and summary of the environmental characteristics of sites on the Louro and Tea. (BC: boulders and cobbles, PG: pebbles and gravel, S: sand, SC: silt and clay). (*) Louro sites samples in 1987/1988. The distance from source is given to the nearest km.

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Kalilinity and chloride were used in the predictive model. Substratum composition is based on a visual estimate of the percentage cover of particle sizes in the following categories - boulders and cobbles, pebbles and gravel, sand, and silt (Wright et al., 1984). Other combinations of variables (Moss et al., 1987) are available for use in RIVPACS but they refer to the range of values relevant to Great Britain, e.g. latitude and longitude and air temperature parameters. Recent versions of RIVPACS can produce predictions for single seasons but again only for Great Britain.

The environmental data for each site were entered into the computer and the appropriate prediction selected. In this case the BMWP «family» option was used and the printout (fig. 3) lists the probability of capture of each family at the site in the absence of environmental stress.

RESULTS

Fig. 3 presents the printout for site 5 on the Louro (19861987 data). «Families» which were captured at the site are shown thus [✓].

If a site is unpolluted most of the families with a high probability of capture will be found but at the 50% probability level only half of the families listed can be expected to occur after a standard sampling effort. The sum of the probabilities for each taxon down to the 50% level is the expected number of families to that level. This information is provided by the computer program and appears at the base of the printout together with predictions of the British BMWP score and average score per taxon (ASPT). The total number of predicted families can also be taken into account. In this example the total number of expected families is approximately 33 plus the sum...
of the probabilities from <50 % to 0 %, that is 37 in total.

A comparison of the faunal parameters observed (Score, ASPT and number of families) with those predicted provides a means of assessing the biological quality of the site. In addition, the absence of predicted taxa and presence in samples of taxa with a low probability of occurrence may provide information on the type of environmental stress. For example, at site 5 (fig. 3) the absence of Plecoptera indicates low dissolved oxygen conditions and an unsuitable substratum. The presence of some families may be misleading and suggest less environmental stress than actually occurs.

Figure 2.: Dissolved oxygen and ammonium ion concentrations in the Rivers Louro and Tea. O, in Louro: broken line, 12 sites 30/VII/86; solid line, 6 sites 15/IX/88. O, data from the Tea and NH₄ data from both rivers (solid line) were obtained on 15/IX/88 at 6 sites on the Louro and 6 on the Tea.

Concentraciones de oxígeno disuelto e ión amonio en los ríos Louro y Tea. O, en el Louro: línea discontinua, 12 estaciones el 30/VII/86; línea continua, 6 estaciones el 15/IX/88. Los datos de O, del Río Tea y contenidos de NH₄ de ambos ríos (línea continua) fueron obtenidos el 15/IX/88 en 6 estaciones del río Louro y 6 del río Tea.
Figure 3. - Example of printout showing predicted families with their probability of capture for site 5-Eidos, on the Río Louro. Taxa actually observed at the site are indicated with a √.

Ejemplo de salida impresa mostrando las familias estimadas y su probabilidad de captura para la estación 5-Eidos, en el Río Louro. Los taxones observados en dicho punto se indican con √.
This is the case with Leptophlebiidae and Cordulegasteridae which occurred as 1 or 2 specimens only, originating from upstream tributaries where they were common.

Fig. 4 compares the observed number of families with those predicted to occur with a probability greater than 0 % at all sites on the Louro (1986187 data) and Tea (1987188 data). In order to take into account sample variability the predicted target values are shown with 95 percentile ranges which were derived from the use of probability theory and Monte Carlo techniques. Observed values which fall below the lower range indicate a significant deterioration in environmental quality.

![Graph showing observed vs predicted numbers of families](image_url)

Figure 4. - Predicted (bold line) and observed (broken line) numbers of families at the 12 sites on the Louro (198611987) and 6 sites on the Tea (198711988). The 95 percentile ranges are indicated with the fine solid lines. Número de familias estimado (línea gruesa) y observado (línea discontinua) en las 12 estaciones del Louro (198611987) y en las 6 del Tea (198711988). Los rangos del precentil 95 se indican con líneas continuas.
Figure 5. - The values of Environmental Quality Indices based on ASPT, Score, and number of families in the Río Louro and Río Tea (198611987 data - broken line; 198711988 data - solid line). The horizontal solid line represents an EQI of 1 and the horizontal broken line shows the lower value of the 95 percentile range.

Valores de los índices de Calidad Ambiental basados en el ASPT, Score, y número de familias en los ríos Louro y Tea. (Datos de 198611987 - línea discontinua; datos de 198711988 línea continua). La línea horizontal continua representa el EQI de 1 y la línea horizontal discontinua muestra el mínimo valor del rango del percentil 95.
It is clear from fig. 4 that the Louro river fauna does not meet its expected value at sites 10, 5, 4 and 3. The chemical data indicate that the main polluting influences enter at sites 10 and between sites 6 and 4 and the fauna has responded with maximum impact observed at site 5 but with continuing poor quality almost up to the junction of the Louro with the Mino. In contrast, the Rio Tea maintains good quality along the whole of its sampled length and at no time does the observed number of families fall below the predicted range.

If a large number of sites are sampled it is convenient to express the results for each site as a single figure or index. The data above can be expressed as indices which compare the observed and predicted values of the faunal parameters - score, average score (ASPT) and numbers of families (fig. 5). The 198711988 Louro data are also shown in this figure. The horizontal solid line represents an Environmental Quality Index (EQI) of 1 and the broken line shows the lower value of the 95 percentile range. EQI values below this line indicate significant deterioration in quality. Score and family based EQIs are highly correlated but ASPT, although showing the same trends, does not appear to be as sensitive an indicator as the other indices. In this example the family based EQI is the clearest indicator of environmental impact.

DISCUSSION

Running waters are under increasing environmental pressure as a result of reservoir construction, abstraction for supply, irrigation and the discharge of untreated or inadequately treated effluents from both domestic and industrial sources. It is important to identify environmental problems early in order to maintain good water quality.

Aquatic macroinvertebrates identified to family level provide a rapid, low-cost, reliable means of identifying environmental problems which can later be characterised in detail by both chemical and biological analyses (Furse et al., in press).

Biotic score systems (Woodwiss, 1964; Sladecek, 1973; Verneaux et al., 1982; De Pauw & Vanhooren, 1983; Armitage et al., 1983) have been used extensively as indicators of pollution. They have, however, two major disadvantages. Firstly they set the same target for all sites where it is clear that the different physical and chemical regimes of fast-flowing mountain streams and slow-flowing lowland rivers will support totally different faunal communities. Target values will differ, not only from river to river, but also along the same river (Armitage et al., 1983) and this is clearly seen in the Louro at sites 4 and 3. Here the predicted values of faunal parameters are lower mainly due to the character of the substratum which at these two points contains a relatively higher proportion of silt than elsewhere in the river. Secondly, score/index values will increase with increasing sampling effort as more species are captured. Thus the index is frequently no more than a measure of the number of taxa caught if sampling effort is not standardised.

RZVPACS provides an alternative assessment method in which a site specific target value is set, against which the observed value can be compared. ASPT values have recently been predicted at 5 sites in Portugal with some success (Furse et al., in press). In addition the model can be adapted to provide target values for almost any macroinvertebrate index in use.

This study has shown that RIVPACS can be applied in Spain when family level data are used. However, the program may not be applicable to rivers which differ markedly in physical and chemical characteristics from those used to develop the model. When operating the program a warning message is shown on the screen and printout if, on the basis of the physical and chemical data, the site has a probability of less than 5% of belonging to any of the classification groups used to develop RZVPACS. In the case of the Louro and Tea no warning messages were shown, but some rivers in the drier areas of Spain may have physical and chemical characteristics outside the RIVPACS range. Similarly the species composition of families will differ in Spain and Great Britain and this may affect assessment with biotic scores of the pollution status of a site. This was recognised by Spanish workers and an Iberian version of the BMWP score system was proposed in which the scores of some families were changed (Albatercedor & Sanchez Ortega, 1988). An example is seen in the Ephemerellidae which in Great Britain usually refers to Ephemerella ignita, a species
of the upper reaches of rivers which is intolerant to pollution. However, at station 5 on the Louro the Ephemerellidae species recorded was *Eurylophella iberica*. This species does not occur in Great Britain and has a preference for lentic parts of rivers (GONZÁLEZ DE LÁTÁNAGO & GARCÍA DE JALÓN, 1983) and may be more tolerant to organic pollution than *Ephemerella ignita*. Without this knowledge the site could be judged to be less polluted than it is.

Despite the richer faunal complement in Spanish rivers the data used in *RIVPACS* have successfully identified all impacted sites in the Louro and provided a measure of their deviation from the expected state. However, its most efficient application in Spain will require the acquisition of a data-base similar to that available in Great Britain. Although species level data provide the most detailed assessment of biological quality, family data can identify environmental problems in the vast majority of cases (FURSE et al., in press). A nationwide survey of the macroinvertebrates of Spanish rivers with good water quality and identified to family or generic level may provide sufficient information to develop a prediction and classification system with application throughout the country. However, Spain is such a large zoogeographical «block» that it may be better initially to develop a series of smaller independent schemes in identifiable climatic zones which if done using a standard method could be linked at a later date. A national system will facilitate management decisions on the development of water resources and provide a standard against which to compare the environmental quality of rivers in the future.

ACKNOWLEDGEMENTS

The development of *RIVPACS* has been supported financially by the Natural Environment Research Council, the Department of the Environment, the Scottish Development Department and the Welsh Office. We are grateful to these organisations, the many biologists from the Water Industry and our colleagues at the River Laboratory who have collaborated in this project.

RESUMEN

EVALUACIÓN Y PREDICCIÓN DE LA CALIDAD BIOLOGICA. APLICACIÓN EN DOS RÍOS ESPAÑOLES DE UN MÉTODO INGLÉS BASADO EN LOS MACROINVERTEBRADOS

El modelo de predicción *RIVPACS* desarrollado en Inglaterra, se ha usado para valorar el estado de polución de dos ríos gallegos. Se identificaron todos los puntos contaminados mediante el modelo, el cual suministra una medida de la desviación de un punto alterado frente a un estado no polucionado.

BIBLIOGRAPHY


