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

P.D. Armitage,[1] I. Pardo,[2] M.T. Furse[1] and **J.F. Wright[1]**

1. Institute of Freshwater Ecology, River Laboratory, East Stoke, Wareham, Dorset BH20 6BB, England.
2. Departamento de Biología Animal, Facultad de Biología, Universidad de Santiago. Spain.

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 (WOODIWISS, 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

Limnetica, 6: 147-156 (1990)

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 (NH_4 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 samled 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-

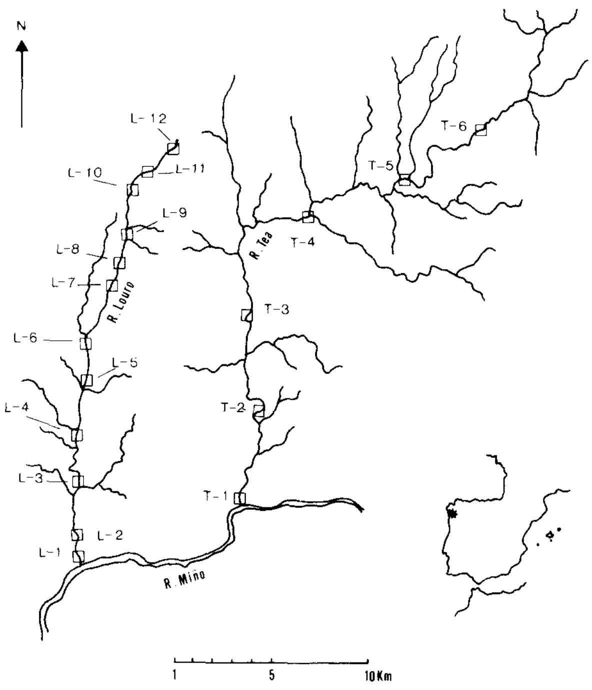

Figure 1.- Geographic location of the study area and distribution of the sampling sites in the Río Louro and Río Tea.
Localización geográfica de área de estudio y distribución de las estaciones de muestreo en los nos Louro y Tea.

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.
Localización y sumario de las características ambientales de las estaciones de muestreo en los nos Louro y Tea. (BC - piedras grandes y piedras, PG - gravas grandes y gravas, S - arena, SC - limo y arcillas). Las estaciones del Río Louro muestreadas durante el período 198711988 se indican con *. La distancia a la fuente se refiere al km más cercano.

	Map reference UTM	Mean width (m)	Mean depth (cm)	Substratum BC	PG	S	SC	Altitude (m)	Distance (km)	Total oxidised nitrogen (mg/l N)	Total alkalinity (mg/l $CaCO_3$)	Chloride (mg/l)
RÍO LOURO												
Arrayal*	1 29TNG 304563	10	50	20	40	30	10	20	30	2.82	47.05	26.83
Tuy	2 29TNG 303574	14	50	20	40	40	0	20	29	3.35	62.08	22.20
Cerquido	3 29TNG 305606	10	50	0	20	30	50	20	25	2.62	55.01	31.74
Gandaras*	4 29TNG 303631	67	50	0	30	40	30	25	22	34.8	85.39	31.82
Eidos	5 29TNG 311671	9	40	0	50	30	20	25	19	1.51	31.42	28.95
Pornno*	6 29TNG 311681	8	80	20	60	10	10	30	17	2.71	32.22	21.21
Mos	7 29TNG 329730	6	60	20	50	30	0	60	10	2.40	39.30	14.83
Zapateira*	8 29TNG 331737	6	25	50	30	20	0	80	9	1.82	26.67	15.52
Acebal	9 29TNG 332749	5	50	40	40	10	10	100	8	1.57	29.84	13.46
Os Valos	10 29TNG 334767	4	50	20	50	20	10	130	6	1.39	28.45	11.69
Nespereira*	11 29TNG 344779	4	30	40	40	10	10	200	4	1.48	22.71	13.20
Cepeda	12 29TNG 332749	0.5	10	0	80	10	10	320	2	1.63	15.96	10.07
RÍO TEA												
Fillaboa	1 29TNG 400596	15	25	20	40	30	10	20	53	1.49	25.41	15.33
Cristiñade	2 29TNG 403663	14	33	0	80	20	0	20	47	1.33	26.87	15.26
Puenteareas	3 29TNG 402713	10	40	20	60	20	0	30	40	1.15	25.39	12.60
Mondanz	4 29TNG 443765	10	50	40	50	10	0	60	30	0.97	22.15	12.36
Vilanova	5 29TNG 496774	10	50	40	30	30	0	80	22	1.39	27.89	9.73
Maceira	6 29TNG 535805	7	20	40	60	0	0	360	15	0.92	21.06	8.80

kalinity and chloride) were used in the predictive model. Substratum composition is based on a viscal 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 (198611987 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.

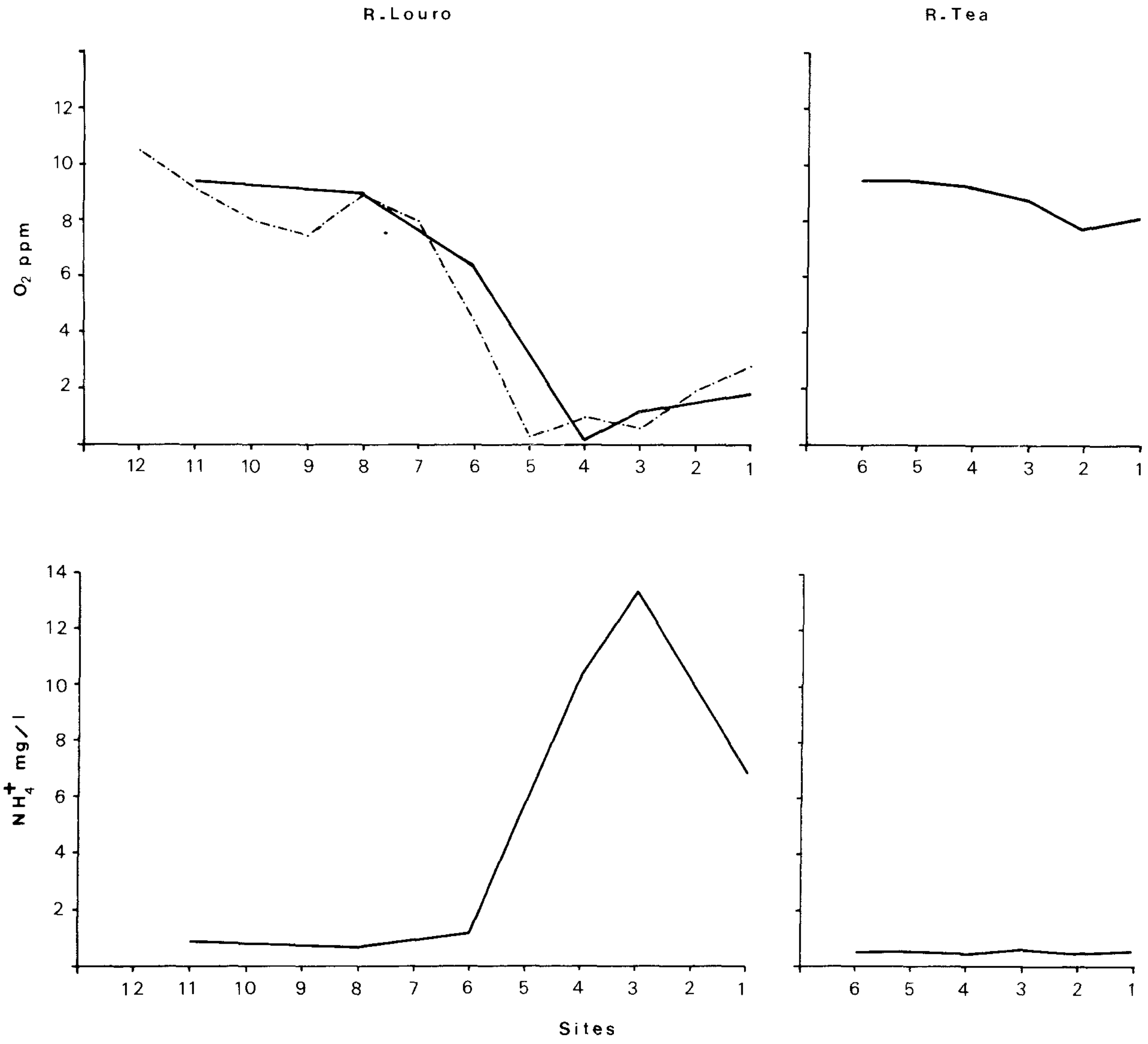

Figure 2.- Dissolved oxygen and ammoniurn ion concentrations in the Rivers Louro and Tea. O, in Louro: broken line, 12 sites 30/VIII/86; solid line, 6 sites 15/IX/88. O, data from the Tea and NH_4 data frorn both rivers (solid line) were obtained on 15/IX/88 at 6 sites on the Louro and 6 on the Tea.

Concentraciones de oxígeno disuelto e ión amonio en los ríos Louro y Tea. O, en el Louro: línea discontinua, 12 estaciones el 30/VIII/86; línea continua, 6 estaciones el 15/IX/88. Los datos de O, del Río Tea y contenidos de NH_4 de ambos ríos (línea continua) fueron obtenidos el 15/IX/88 en 6 estaciones del río Louro y 6 del río Tea.

River : LOURO Site : 5 EIDOS

Environiental data used :

Substratum composition
Boulders+cobbles (%) 0.00
Pebbles+oravel (%) 50.00
Sand 111 30.00
Silt+clav (%) 20.00
Mean substratum (ohi) 0.57
Dist. from source (km) 18.70
Total oxidised N (ppm) 1.51
Alkalinitv (ppm CaCO3) 31.42
Chloride (ppm) 28.95

Grouos predicted from MDA nith 5 ohvsical and chemical variables

42 42.2% 23 28.5% 41 8.8% 44 5.1% 37 5.0%
38 3.3% 40 3.1%

Predicted taxa, in decreasino order of probabilitv

99.72 Oligochaeta ✓
99.71 Chironomidae ✓
99.72 Elminthidae ✓
99.32 Baetidae
99 2% Simuliidae
98.7% Ephemerellidae ✓
96.91 Tipulidae
96.72 Leuctridae
95.4% Sphaeriidae ✓
94.2% Gammaridae
93.9% Hvdropsvchidae
93.91 Limnephilidae
93.1% Perlodidae
90.4% Dvtiscidae
70.11 Polvcentropodidae ✓
89.8% Heptaoeniidae
89.81 Hvdrobiidae ✓
87.71 Erpobdellidae ✓
87.6% Rhvacophilidae
86.21 Leptoceridae
86.2% Nemouridae
85.61 Sericostomatidae
84.8% Lvmnaeidae
84.61 Gyrinidae
80.7% Ancvlidae
78.81 Hydroohilidae
78.4% Caenidae
77.41 Glossiphoniidae ✓
76.71 Ephemeridae
75.3% Leptophlebiidae ✓
73.31 Hvdroptilidae
73.0% Planariidae
72.3% Chloroperlidae
65.0% Sialidae
62.61 Lepidostomatidae
58.61 Corixidae ✓
56.7% Asellidae
56.5% Haliolidae
56.3% Taenioptervgidae
51.91 Agriidae

48.91 Psvchomviidae
18.21 Goeridae
27.2% Planorbidae ✓
24.9% Brachvcentridae
23 91 Aphelocheiridae
22.2% Coenaoriidae
21 5% Odontoceridae
21.1% Perlidae
18.0% Corduleoasteridae ✓
17.11 Gerridae
12 9% Beraeidae
12.3% Helodidae
11.9% Piscicolidae
11.51 Dryooidae
8.41 Phvsidae ✓
7.31 Neritidae
6.2% Capniidae
5.9% Phryganeidae
5.7% Hvdrometridae
4.71 Nepidae
4.7% Siphlonuridae
3.71 Dendrocoelidae
3.6% Philopotamidae
3.4% Valvatidae
2.1% Astacidae
1.1% Molannidae
0.7% Unionidae
0.4% Hirudidae
0.3% Viviparidae
0.2% Notonectidae
0.0% Platvcnemididae
0.0% Aeshnidae
0.01 Libellulidae
0.0% Corophiidae
0.0% Pleidae

A) Predicted number of families to 50% = 33.2
B) Observed number of families to 50% = 11
C) Total observed families = 14
D) Observed BMWP score = 66
E) Observed ASPT = 4.714
F) Fauna! Index 11/33.2
G) BMWP score index 66/234
H) ASPT index 4.714/5.827

Expected taxa nith P >=.75 = 26.9, with P >= .5 = 33.2
Predicted BMWP score = 234
Predicted averaoe BMWP score per taxon = 5.827

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.

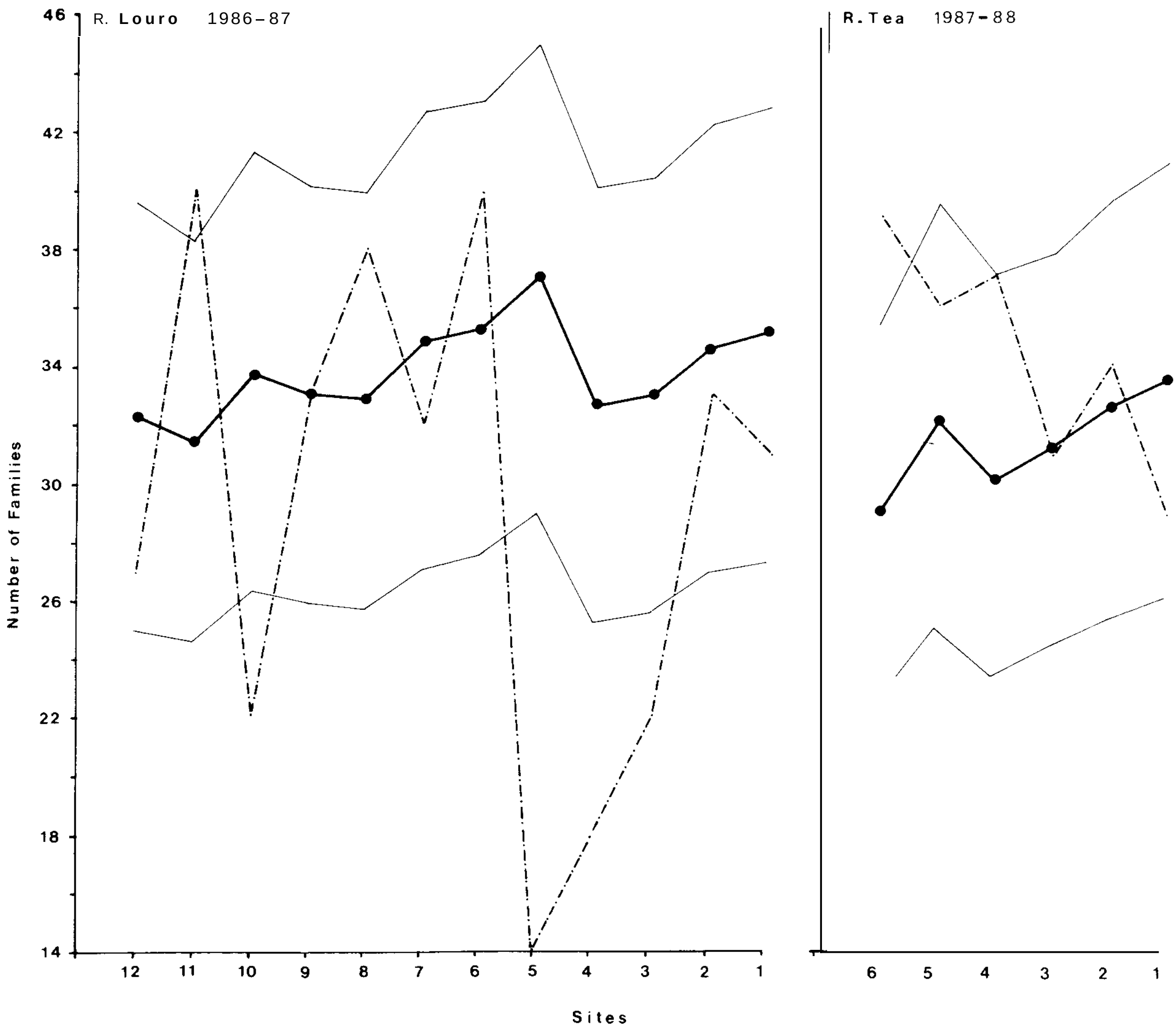

Figure 4.- Predicted (bold line) and observed (broken line) numbers of families at the 12 sites on the Louro (198611987) and 6 sites on the Tea (198711988). The 95 percentile ranges are indicated with the fine solid lines.
Número de familias estimado (línea gruesa) y observado (línea discontinua) en las 12 estaciones del Louro (198611987) y en las 6 del Tea (1987188). Los rangos del precentil 95 se indican con líneas continuas.

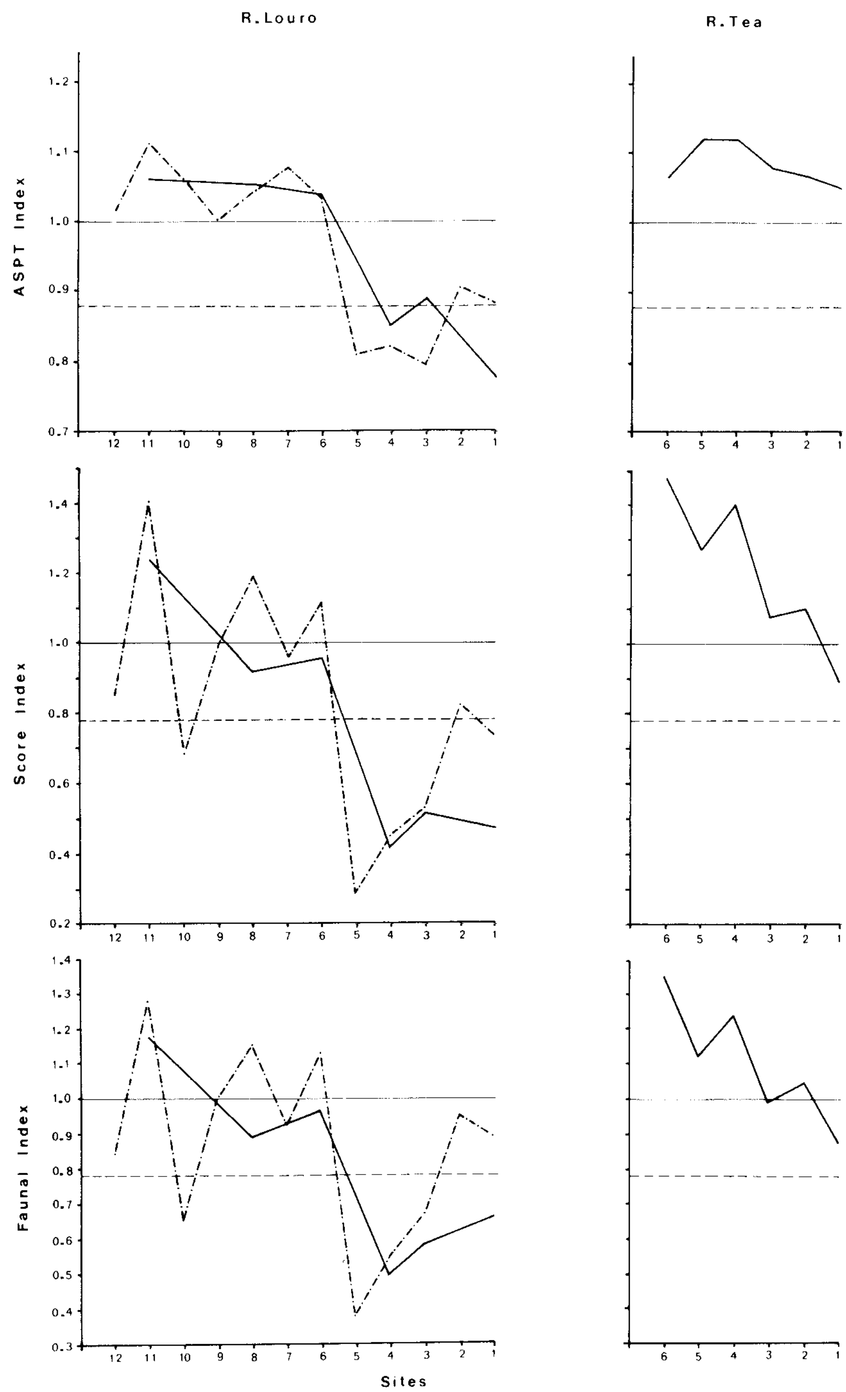

Figure 5.- The values of Environmental Quality Indices based on ASPT, Score, and number of families in the Río Louro and Río Tea (198611987 data - broken line; 198711988 data - solid line). The horizontal solid line represents an EQI of 1 and the horizontal broken line shows the lower value of the 95 percentile range.
Valores de los fndices de Calidad Ambiental basados en el ASPT, Score, y número de familias en los nos Louro y Tea. (Datos de 198611987 - línea discontinua; datos de 198711988 línea continua). La línia 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 *EQI*'s 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 (WOODIWISS, 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 elswhere 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 *RIV*-PACS 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 (ALBA-TERCEDOR & SÁNCHEZ-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 *Eury*lophella iberica. This species does not occur in Great Britain and has a preference for lentic parts of rivers (GONZÁLEZ DEL TÁNAGO & 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 independant 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 nvers 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 Departament 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 BIOLÓGICA. 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

ALBA-TERCEDOR, J. & F. JIMÉNEZ MILLÁN, 1985. ***Biología** y **ecología de insectos indicadores de la calidad de las aguas corrientes. Estudio de aguas del Río Guadalfeo y su Cuenca. (Calidad de las aguas del Río Guadalfeo a lo largo del año)***. Proyecto finalizado, realizado dentro de los convenios entre las universidades andaluzas y el ICONA. Univ. de Granada. 133 pp.

ALBA-TERCEDOR, J. & F. JIMÉNEZ-MILLÁN, 1987. Evaluación de las variaciones estacionales de la calidad de las aguas del Río Guadalfeo, basada en el estudio de las comunidades de macroinvertebrados acuáticos y de los factores físico-químicos. En: ***LUCDEME III. ICONA.*** Monografía 48: 1-91. Madrid.

ALBA-TERCEDOR, J. & A. SÁNCHEZ-ORTEGA, 1987. Un método rápido y simple para evaluar la calidad biológica de las aguas corrientes basado en el de Hellawell (1978). ***Limnética*** 4: 51-56.

ALBA-TERCEDOR, J., A. SÁNCHEZ-ORTEGA & I. GUISASOLA (in press). Caracterización de los cursos permanentes de agua de la cuenca del Río Adra: Factores físico-químicos, macroinvertebrados acuáticos y calidad de las aguas. En: ***Estudio del medio natural de la cuenca del Río Adra.*** LUCDE-*ME*. ICONA.

ARMITAGE, P.D., 1987. The classification of tailwater sites receiving residual flows from upland resewoirs in Great Britain, using macroinvertebrata data. In: J.F. CRAIG & J.B. KEMPER (eds.), ***Regulated Streams, Advantages in Ecology.*** Plenum Press, New York.

ARMITAGE, P.D., 1989. The application of a classification and prediction technique based on macroinvertebrates to assess the effects of river regulation. pp. 267-293. In: J.A. GORE & G.E. PETTS (eds.), ***Alternatives in regulated river management.*** CRC Press Inc. Boca Raton, Florida.

ARMITAGE, P.D., R.J.M. GUNN, M.T. FURSE, J.F. WRIGHT & D. Moss, 1987. The use of prediction to assess macroinvertebrate response to river regulation. ***Hydrobiologia*** 144: 25-32.

ARMITAGE, P.D., D. MOSS, J.F. WRIGHT & M.T. FURSE, 1983. The performance of a new Biological Water Quality Score System based on Macroinvertebrates over a wide range of unpolluted running-water sites. ***Wat. Res.*** 17: 333-347.

DE PAUW, N. & G. VANHOGREN, 1983. Method for biological quality assessment of water courses in Belgium. ***Hydrobiologia*** 100: 153-168.

FURSE, M.T., J.N. FERNANDES, J.F. WRIGHT & P.D. ARMITAGE (in press). The use of aquatic macro-invertebrate assemblages for assessment of the environmental quality of rivers. In: ***River Water Quality, Assessment and Management.*** Proceedings of an International Seminar, Lisbon, 17-19 May 1989, UNESCO.

FURSE, M.T. & D. Moss, J.F. WRIGHT & P.D. ARMITAGE, 1984. The influence of seasonal and taxonomic factors on the ordination and classification of running-water sites in Great Britain and on the prediction of their macro-invertebrate communities. ***Freshwat. Biol.*** 14: 257-280.

FURSE, M.T., D. Moss, J.F. WRIGHT & P.D. ARMITAGE, 1987. Freshwater site assessment using multi-variate techniques. In: M.L. LUFF (ed.), ***The use of invertebrates in site assessment for comervation.*** Proceedings of a meeting held at the University of Newcastle-upon-Tyne, 7 January 1987. Agricultural Environment Research Group. Univ. Newcastle-upon-Tyne.

GONZÁLEZ DEL TÁNAGO, M. & D. GARCÍA DE JALÓN, 1983. New Ephemerellidae from Spain (Ephemeroptera). ***Aquat. Insects*** 3: 147-156.

Moss, D., M.T. FURSE, J.F. WRIGHT & P.D. ARMITAGE, 1987. The prediction of the macroinvertebrate fauna of unpolluted running-water sites in Great Britain using environmental data. ***Freshwat. Biol.*** 17: 41-52.

NATIONAL WATER COUNCIL, 1981 ***River Quality: the 1980 survey and further outlook.*** NWC, London.

RODRÍGUEZ, P. & J.F. WRIGHT, 1988. Biological evaluation of the quality of three Basque water courses. In: ***Biología Ambiental. Actas del Congreso de Biología Ambiental.*** Tomo II, pp. 223-243. Administración de la Comunidad Autónoma de Euskadi, Secretaria de la Presidencia del Gobierno Vasco, II Congreso Mundial Vasco, Bilbao.

SLADECEK, V., 1973. System of water quality from the biological point of view. ***Arch. Hydrobiol.*** 7 (I-IV): 1-218.

VERNEAUX, J. & G. TUFFERY, 1967. Une méthode zoologique pratique de détermination de la qualité biologique des eaux courantes. ***Indices Biotiques. Annals. Scien. Univ. Besançon*** (3e Serie, ***Zoologie)*** 3: 79-90.

VERNEAUX, J., P. GAMICHE, F. JANIER & A. MONNOT, 1982. Une nouvelle methode pratique d'evaluation de la qualité des eaux courantes. Une indice biologique de la qualité générale (I.B.G.). ***Annals Scien. Univ. Besançon (3e Serie, Zoologie)*** 18: 11-21.

WOODIWISS, F.S., 1964. The biological system of stream classification used by the River Trent Board. ***Chemistry and Industry*** 14: 443-447.

WRIGHT, J.F., D. MOSS, P.D. ARMITAGE & M.T. FURSE, 1984. A preliminary classification of running-water sites in Great Britain based on macro-invertebrate species and the prediction of community type using environmental data. ***Freshwat. Biol.*** 14: 221-256.

WRIGHT, J.F., P.D. ARMITAGE, M.T. FURSE & D. MOSS, 1988. A new approach to the biological suweillance of river quality using macroinvertebrates. ***Verh. Int. Verein Limnol.*** 23: 1548-1552.

WRIGHT, J.F., P.D. ARMITAGE, M.T. FURSE & D. MOSS, 1989. Prediction of invertebrate communities using stream measurements. ***Regul. Rivers: Res. & Mgmt*** 4: 147-155.