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ANALYSIS OF BENTHIC MACRO-INVERTEBRATE SAMPLES COLLECTED BY THE NRA DURING 1989 AND 1990 FROM VARIOUS HABITATS IN THE RIVER DELPH

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1 THE IMPORTANCE OF HABITAT TO MACRO-INVERTEBRATES

1.1 Factors affecting macro-invertebrate distribution

Temperature, flow regime, habitat availability and water quality affect the distribution of aquatic macroinvertebrates. Flow regime determines the nature of the lotic habitat, by combining the effects of current velocity and geology upon substrate particle size. In contrast, the characteristics of lentic environments, which usually feature depositing, less varied habitats, reflect the influence of temperature, depth and water chemistry on production and nutrient transport within the ecosystem. In lentic ecosystems, flow changes affect the rate at which material accumulates in or is flushed from the channel or basin, but have less marked effects on habitat structure than in lotic environments. However, established habitat features such as emergent and submerged vegetation, which are essential for a balanced and stable community, may be threatened by channel engineering and alterations in water quality and sedimentation associated with changes in flow and production.

The macroinvertebrate community is an important component of the freshwater ecosystem and forms a link in the food chain through which energy from primary production is transferred to higher trophic levels. Certain invertebrate species graze algae and other plant material colonising the river, while others feed on faecal and decomposing material. These animals may all be prey to larger carnivorous invertebrates and fish. So, providing water quality is high, a diverse macroinvertebrate fauna may develop, including carnivores, herbivores and detritus feeders, each of which is adapted to exploit a particular habitat niche. In summary, the production and diversity of the macroinvertebrates in a slow flowing channel such as the River Delph will reflect first, the availability of habitat features such as littoral, emergent and submerged vegetation, and secondly, water chemistry, either as base flow from the underlying strata, or via rainfall, surface water discharge or tidal incursion.

1.2 Methods of data analysis

When considering the effects of environmental changes on communities, multivariate statistical methods are often used to analyse simultaneously suites of species collected at various sites and times. Many of these techniques use multivariate ordination and classification routines (Manly, 1986).

Ordination techniques: Ordination methods condense the variation within a data set into components which are easier to manipulate, the hope being that each component will describe a pattern of species abundance determined by a dominant environmental factor. Correspondence analysis is an ordination system which scores species response to an arbitrary environmental gradient. The scores are refined through a system of successive averaging and positioned along a single axis. Further uncorrelated axes can be produced and plotted, so that related sites, indicated by similarities on more than one axis, group together. In this way, sites with similar communities can be revealed. Detrended correspondance analysis (DECORANA) is a refined version in which certain shortcomings in the original routine have been eliminated (Hill, 1979). DECORANA has recently undergone further modifications which may enable the influence of environmental variables on community structure to be established during the analysis (ter Braak, 1988).

Classification techniques: Two-way indicator species analysis (TWINSPAN) groups sites by progressively dividing the total species list into subgroups of two, according to the presence or absence of species. At the same time, the species are classified on the basis of their occurence in site groups. Indicator species are then highlighted, the presence or absence of which demonstrates large differences between sub-groups.

The process can be continued until each site resides in a subgroup of its own, but to have any ecological relevence, classification is stopped when there is still considerable difference between numbers of sites in the subgroups following division. This of course, is arbitrary, and groups so formed are not evidence that discrete communities exist. The analysis is therefore invariably used in conjunction with an ordination.

2 SAMPLING THE BENTHIC MACRO-INVERTEBRATES AND DATA ANALYSIS

2.1 Sampling and species identification

The aim of the present analysis was to determine whether macrobenthos samples, collected by the NRA, presented evidence of changes in species composition and diversity in a section of the River Delph between 1989 and 1990. During this period, the NRA's channel management scheme had sought to retain various habitat features necessary to promote macroinvertebrate colonisation.

Semi quantitative samples were collected by NRA staff during the summers of 1989 and 1990. The samples collected in 1989 were identified by NRA biologists and species lists produced for various habitats. Similar lists were produced by Naiad staff who identified and counted the macro-invertebrates in the samples collected from similar habitats in 1990. Sorted specimens were observed with a binocular stereo microscope and identified with reference to Freshwater Biological Association (FBA) keys.

The following groups were identified to species: Tricladida, Oligachaeta, Mollusca, Hirudinea, Malacostraca, Ephemeroptera, Plecoptera, Trichoptera and Megaloptera. Oligochaetes from 1990 samples were mounted in lactophenol and identified under high magnification (x400).

2.2 Data analysis

Species composition was analysed with multivariate statistics to highlight any differences between the faunas of 1989 and 1990. Data were manipulated by TWINSPAN and DECORANA with the rare species 'downweighted' option in operation.

Species lists were prepared, first, for individual habitats, and secondly, for river sections. For this purpose, the river was divided into four equal-sized sections, the communities of which were compared within and between years. The sections are referred to as 1-4, starting at the most upstream point on the surveyed section (Figure 6).

A better approach would have been to have delineated river sections to contain habitats of particular interest in 1989, bearing in mind the type of channel maintenance that was expected. The sampling points selected in 1989 should then have been resampled in 1990, and separate reference codes allocated to any additional points. Sampling point names should have referred to individual sites and should not have been duplicated. Communities characterising the zones could then have been sought. The river sections could then have been graded on the basis of macro-invertebrate community structure, so that changes between the years could have been detected as an alteration in the grading pattern. The effects of the management strategy for each zone could then have been assessed.

2.3 Results of habitat-related data analysis

TWINSPAN - Species occurring in each habitat within the river channel and the sequence of habitat and species subdivisions comprising the TWINSPAN classifications in 1989 and 1990 are shown in Figures 1 and 3.

In 1989, TWINSPAN generated four habitat clusters, three of which contained more than one sampling point (groups A-C). In 1990, three habitat clusters were generated (groups E-G). The

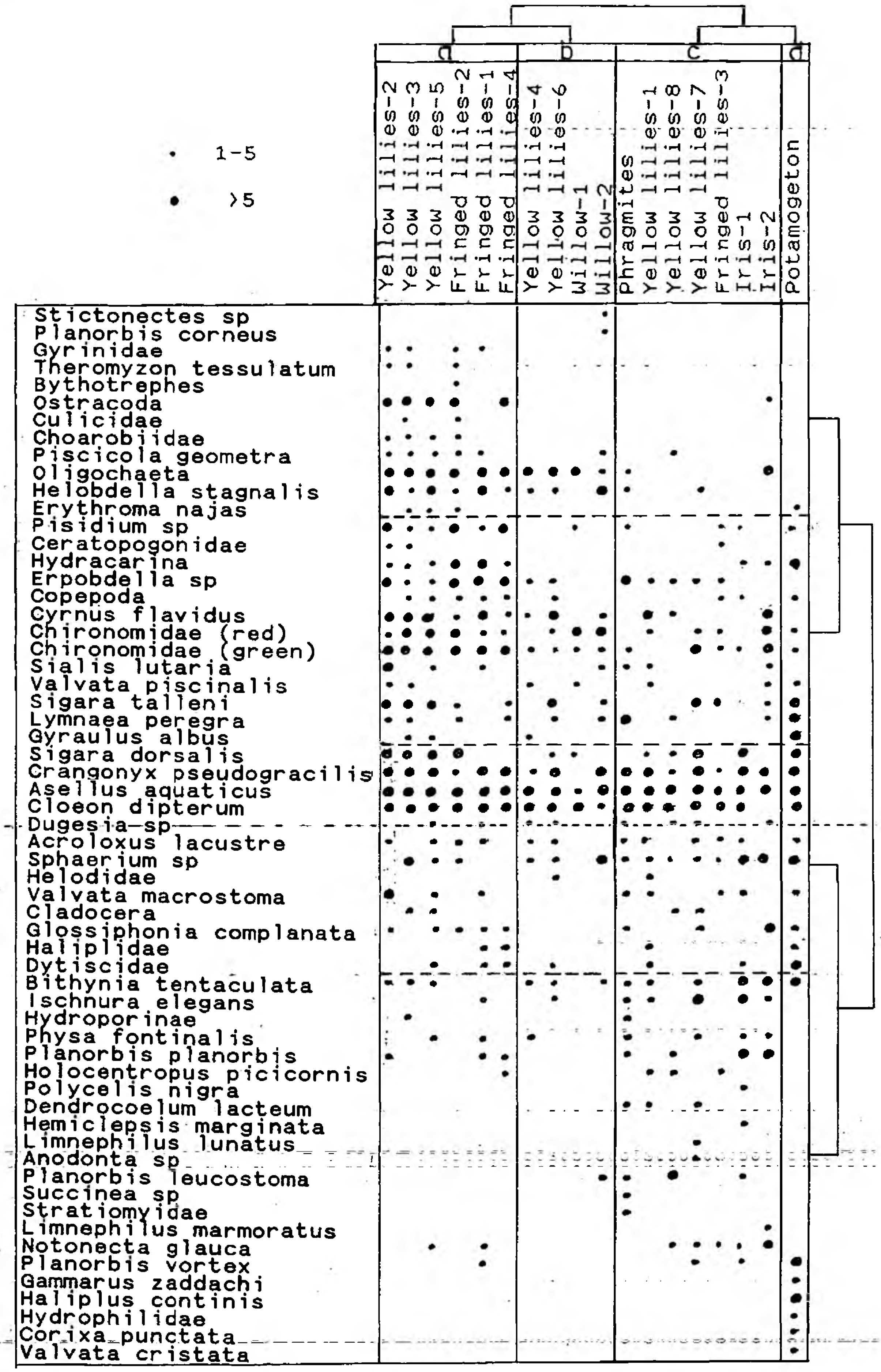

Figure 1 Twinspan classification of eighteen habitats within a stretch of the River Delph sampled by the NRA during summer 1989

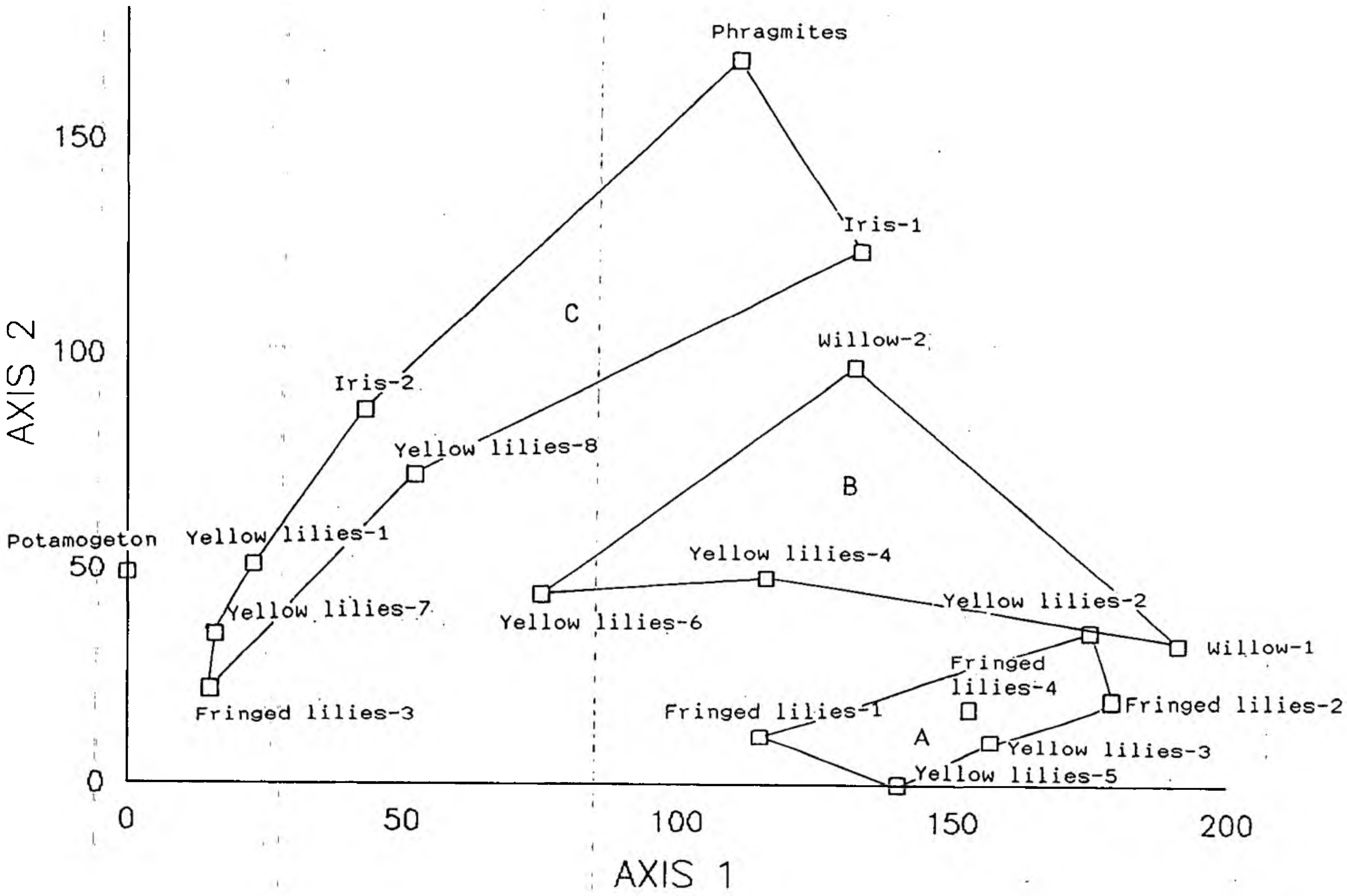

Figure 2 Decorana axes 1 and 2 for eighteen habitats within a stretch of the River Delph sampled by the NRA during summer 1989

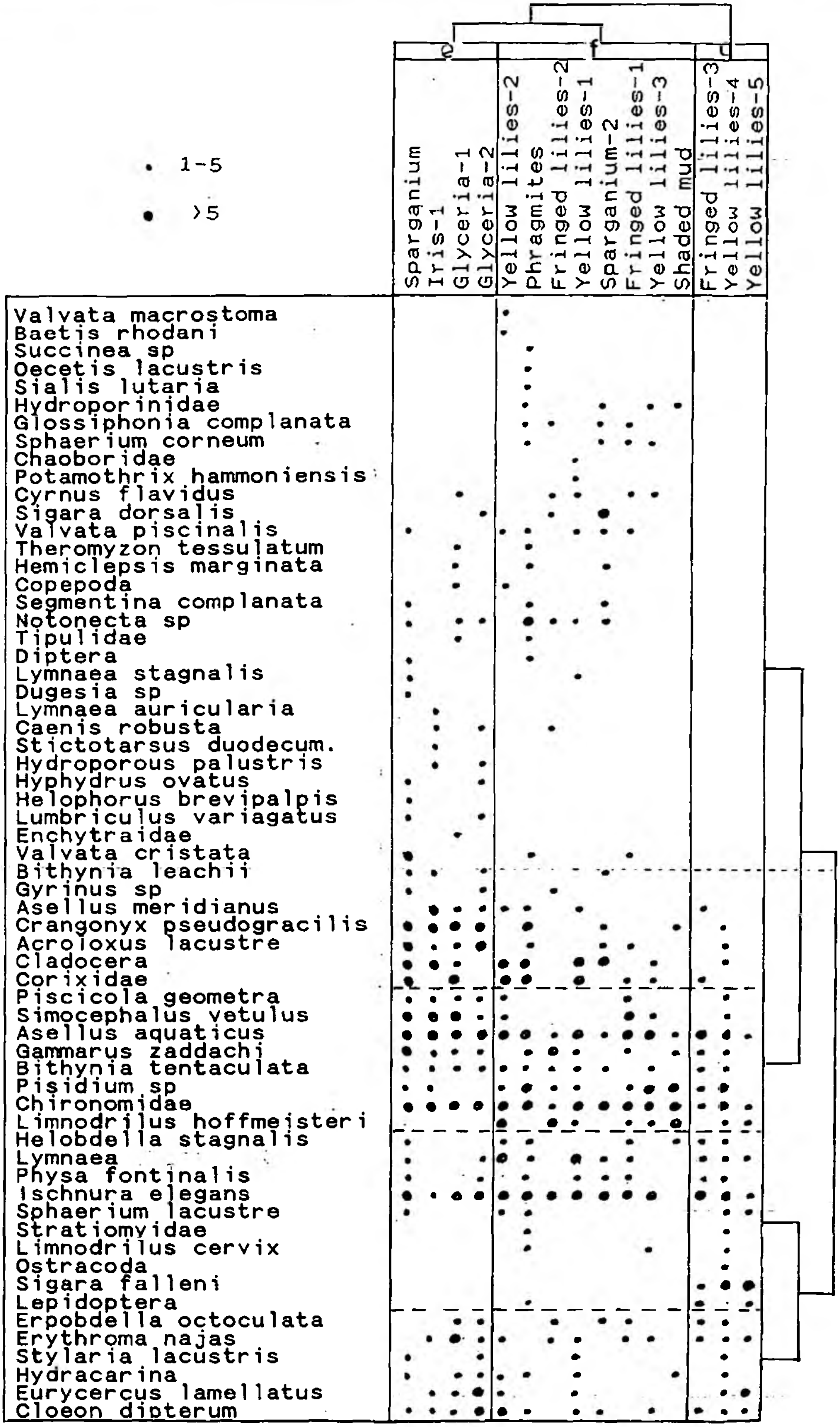

Figure 3 Twinspan classification of fifteen habitats within a stretch of the River Delph sampled by the NRA during summer 1990

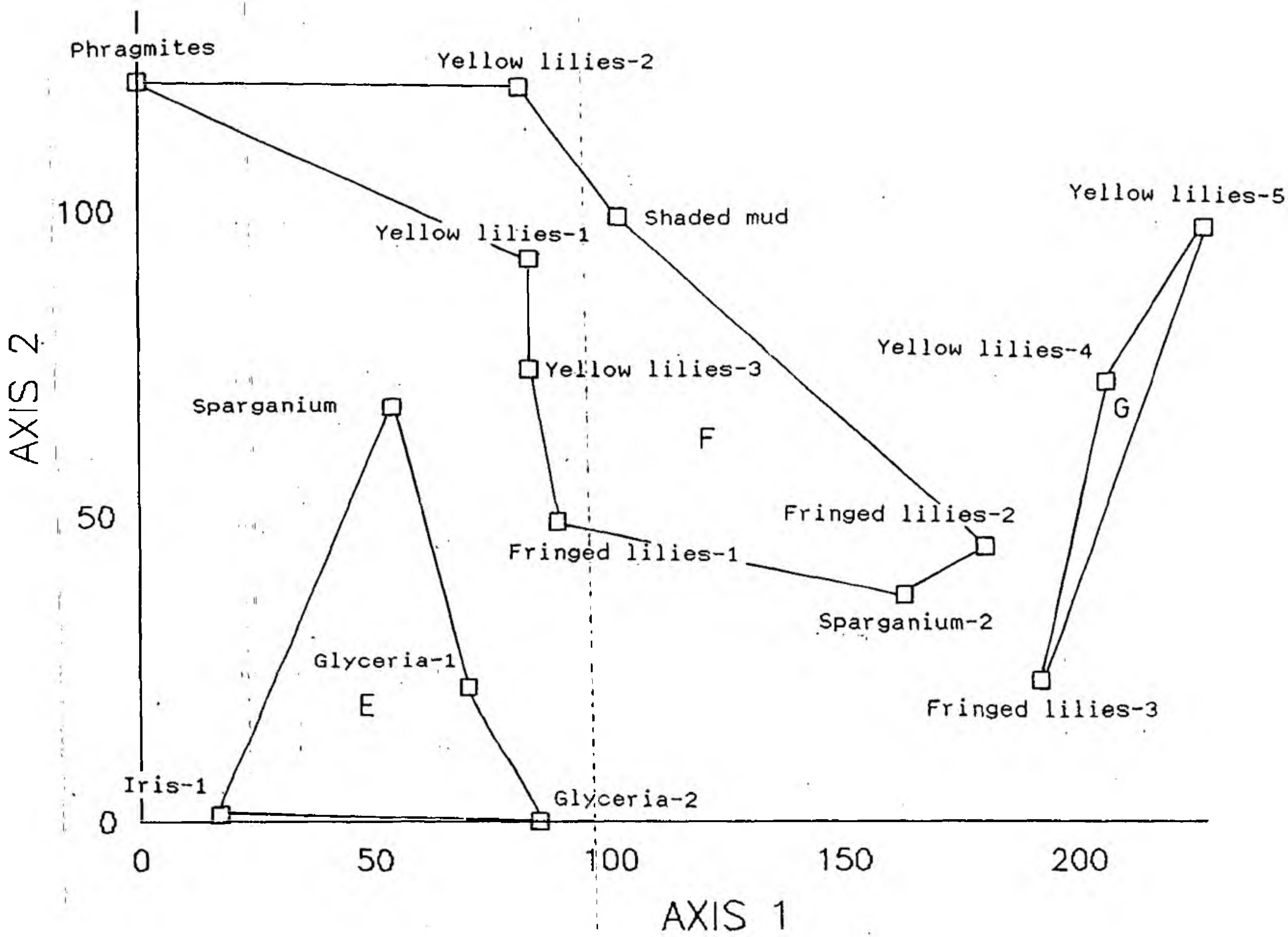

Figure 4 Decorana axes 1 and 2 for fifteen habitats within a stretch of the River Delph sampled by the NRA during summer 1990

distribution of these groups along the surveyed channel during 1989 and 1990 is shown in Figure 6.

DECORANA - The relative strengths of axes 1-4 (in eigenvalues) in the DECORANA ordination and the relative importance of each axis in explaining total variance are given in Tables 1 and 2. (The latter values were derived by dividing individual eigenvalues into the eigenvalue total and multiplying by 100).

Table 1 Proportion of between-habitat variation accounted for by DECORANA axes 1-4 in 1989

DECORANA - rare species downweighted

Axis	Eigen Value	% variation accounted for
1	0.396	68
2	0.118	20
3	0.053	9
4	0.019	3

Table 2 Proportion of between-habitat variation accounted for by DECORANA axes 1-4 in 1990

DECORANA - rare species downweighted

Axis	Eigen Value	% variation accounted for
1	0.358	65
2	0.125	23
3	0.044	8
4	0.022	4

Most of the variance (88%) was accounted for by axes 1 and 2 in both years, so these have been plotted, and the habitats grouped by TWINSPAN linked (Figures 2 and 4).

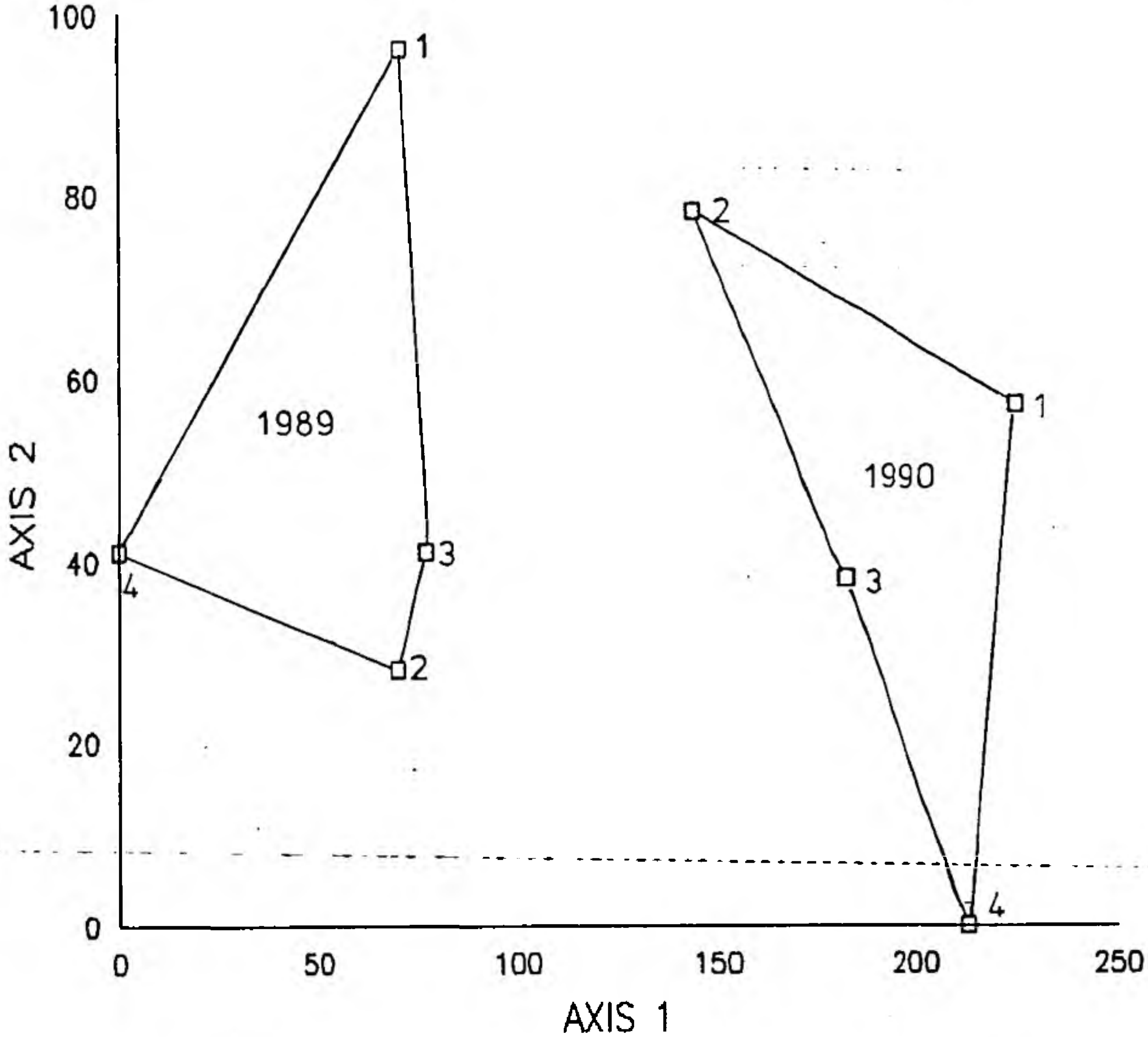

Figure 5 Decorana axes 1 and 2 for four (1-4) zones of the River Delph sampled by the NRA during summers 1989 and 1990

2.4 Results of river-zone data analysis

DECORANA - the relative strengths of axes 1-4 (in eigenvalues) and the relative importance of each axis in explaining total variance are given in Table 3.

Table 3 Proportion of between-zone and between-year variation accounted for by DECORANA axes 1-4

DECORANA - rare species downweighted

Axis	Eigen Value	% variation accounted for
1	0.446	86
2	0.050	10
3	0.014	3
4	0.007	1

Most of the variance (96%) is accounted for by axes 1 and 2 so these have been plotted. River zones sampled in each year have been linked (Figure 5).

3 DISTRIBUTION OF BENTHIC MACRO-INVERTEBRATES WITHIN HABITATS AND ZONES OF THE RIVER DELPH BETWEEN 1989 AND 1990

Multivariate analysis of the data did not demonstrate any consistent habitat-related changes in the macroinvertebrate community between the years. For example, had the yellow lilies habitats clustered in 1989 on the basis of a particular community, and clustered similarly in 1990 on the basis of a different community, then a consistent change in community structure could have been implied.

In addition, analysis of the river-zone data separated the 1989 and 1990 data sets. There was no overlap. In other words TWINSPAN and DECORANA found greater variance between years at all sites than between sites in either year. This may indicate habitat and community changes along the complete river length between 1989 and 1990, but may also reflect inconsistencies in the season in which the samples were taken, the sampling effort and the identification system used in each year.

The data did not demonstrate any clear improvement or deterioration in community structure along the river length. Communities in both years contained 'scraper' species such as molluscs which consumed detritus and periphyton associated with the depositing habitat, as well as filter feeding collectors such as chironmid larvae and various bugs and beetles which thrived in the generally quiescent conditions. Leeches preyed upon the detritivores. There were few 'shredders' such as the larvae of mayfly and caddisfly species. In both years, Cloeon dipterum occurred throughout, whereas the Caenis robusta was found only in 1990.

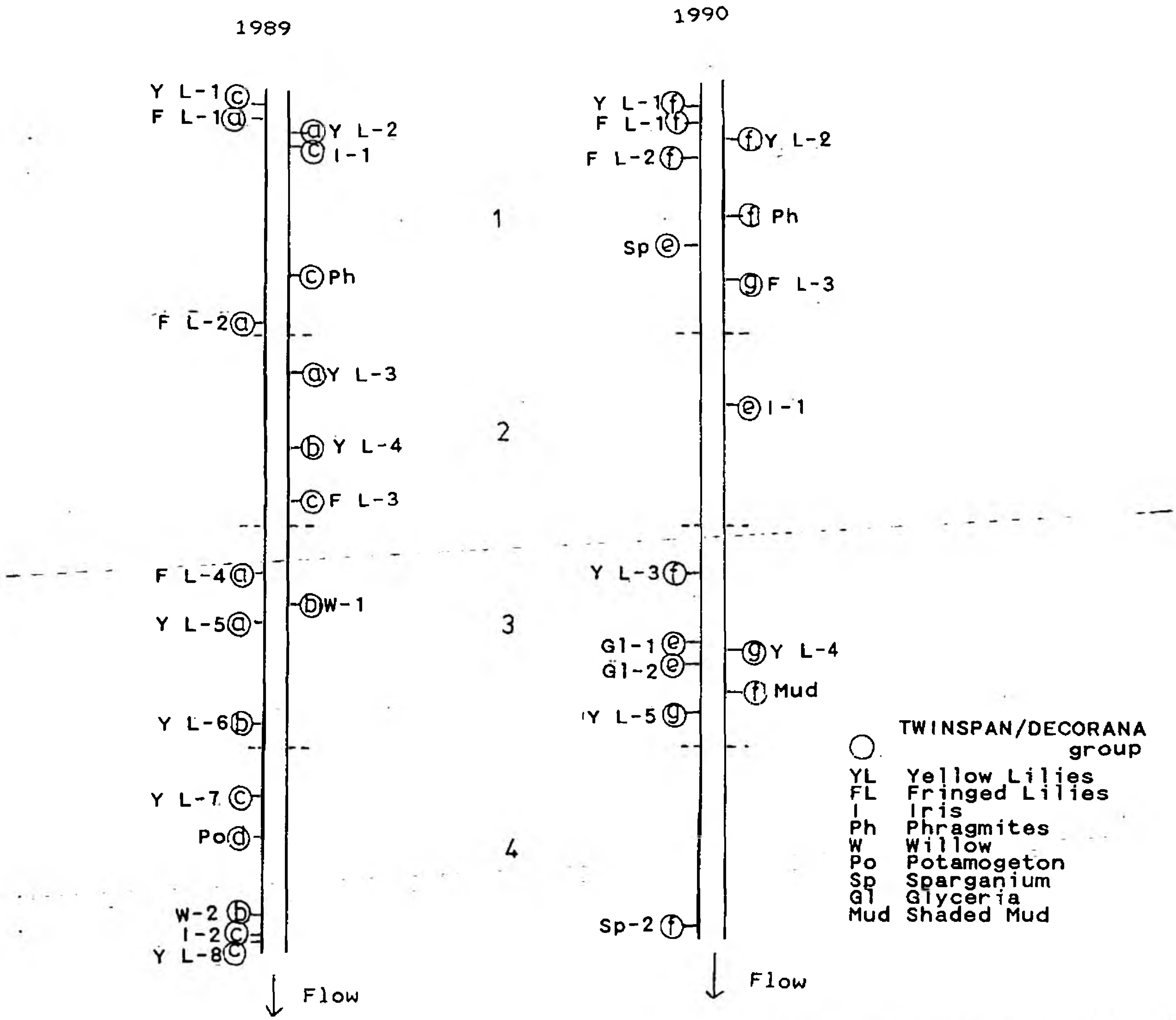

Figure 6 Classification of habitat sites by TWINSPAN/DECORANA on the basis of macro-invertebrate community structure

References

ter Braak J.F., (1988). CANOCO - an extension of DECORANA to analyse species-environment relationships. Vegetatio, 75, 159-160

Hill, M.O. (1979). DECORANA - A fortran program for detrended correspondence analysis and reciprocal averaging. Ecology and systematics, Cornell University, Ithaca, New York.

Hill, M.O. (1979a). TWINSPAN - A fortran program for arranging multivariate data in an ordered two-way classification of the individuals and attributes. Ecology and systematics, Cornell University, Ithaca, New York.

Manly, B.F.J., (1986). Multivariate statistical methods - a primer. Chapman and Hall, London, New York.