Macroinvertebrates as 'describers' of morphological and hydrological types of aquatic ecosystems abandoned by the Rhône River

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Abstract

Samples of aquatic macroinvertebrates were taken from abandoned beds of the river Rhône in the Brégnier-Cordon area. This sector of the French Upper Rhône is particularly rich in old beds or 'lônes' which vary in age and morphological type and have more or less direct connections with the river.

Samples were collected using a hand net in eight different 'lônes'. The results concerned five groups of fauna: Mollusca, Crustacea, Ephemeroptera, Coleoptera, Trichoptera. The study revealed a wide range of fauna, and the fact that group of taxa can be used to describe types of 'lônes' defined by morphological and hydrological characteristics. This kind of research adds to our understanding of how such aquatic ecosystems evolve, and may be applied in a more general way to other important river systems.

Introduction

An interdisciplinary research programme centred on the French Upper Rhône was begun in 1975 with the objective of studying a large river and its alluvial plain. In classic studies concerning the typology of small or medium sized rivers the hydrosystem is considered from a linear and static point of view. In the case of the Upper Rhône, we have attempted to perfect a dynamic typology that would lead to a better understanding of how the river evolves in its flood plain. The different parts that make up the Rhône, the river, its backwaters and its interstitial ground-water environment, change and develop both in time and in three-dimensional space. Roux (1982) has published the first synthesis dealing with this approach.

Like other large mid-European rivers e.g. Danube (Rotschein, 1973) or Rhine (Ortscheit, 1975), the French Upper Rhône presents several sectors abounding in old meanders and side arms, which at one time or another have become separated from the main channel, but which may still retain more-or-less direct links whith it. These environments (known locally as 'lônes') are the result of complex hydrological and sedimentological processes (Rust 1982), which were often set off by human activity. These phenomena lead to morphological types which vary according to the geomorphological context, and the impact of river management (Bravard, 1982a).

In the Jons-Villette d'Anthon area (Fig. 1), these ecosystems abandoned by the river have been studied from a hydrological and physico-chemical point of view (Juget *et al.*, 1976, 1979), or as regards their links with interstitial ecosystems (Reygrobellet *et al.*, 1981, Gibert *et al.*, 1981) or as regards the Cladocera and Copepod (Amoros 1980), macroinvertebrate (Richardot-Coulet *et al.*, 1983) and fish (Bouvet *et al.*, 1982) populations.

The present study concentrates on another area of the French Upper Rhône (in the Isère and Ain departments): the Brégnier-Cordon area (Fig. 1). Samples of macroinvertebrates were collected in 1981 in eight 'lônes' of varying morphological types. Our study represents a test of the typology

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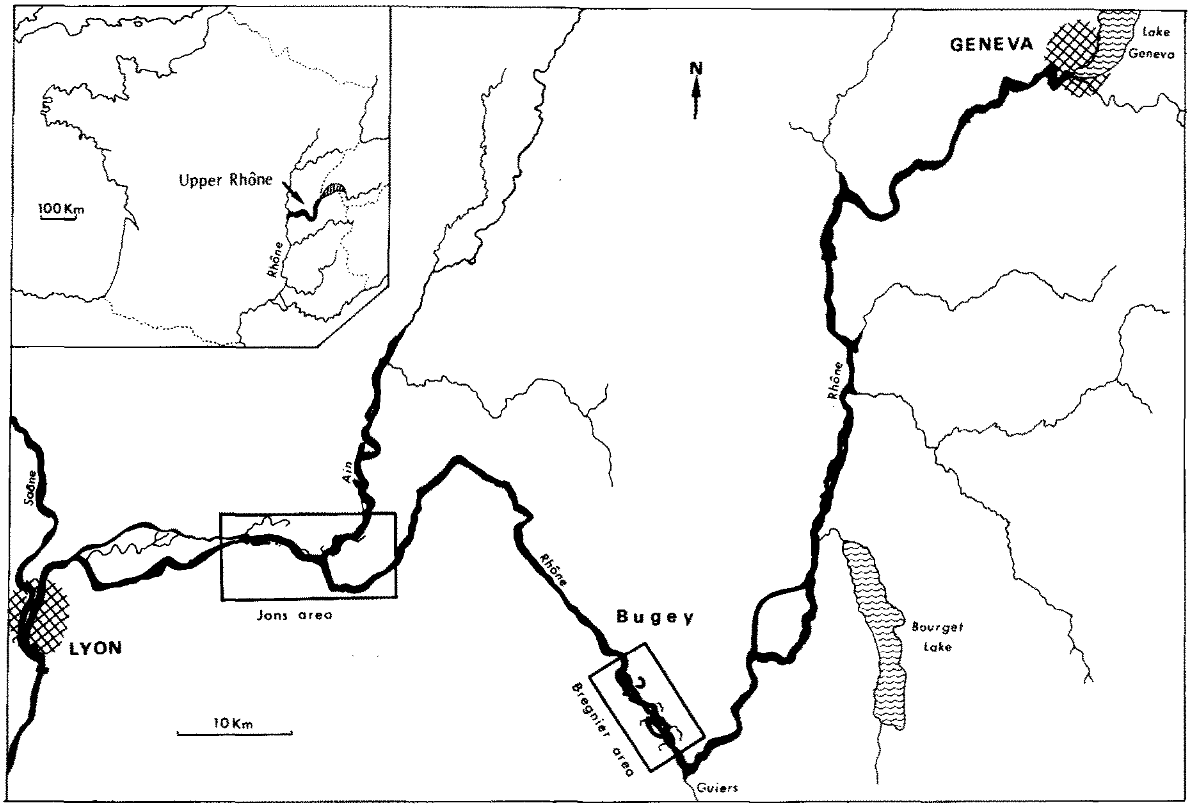

Fig. 1. The French Upper Rhône Map

first put forward in the Jons area, and an assessment of the descriptive value of the five taxonomic groups retained (Mollusca, Crustacea, Ephemeroptera, Coleoptera larvae and imagos, Trichoptera) as regards the morphological and hydrological types of 'lône' and their ages. It can also be considered as a 'rescue-study' i.e. a point of reference which will make it possible to follow more closely the evolution of environments which are going to be disturbed by hydro-electric schemes.

Environmental description

The geomorphology and the dynamics of the river in the Brégnier-Cordon area downstream from the Guiers confluence (Fig. 2) have been described by Bravard (1982a). This author considers that the wide variety of geomorphological units that are to be seen in such a restricted area can be accounted for in part by the juxtaposition of stretches with varied gradients, some of which may be very steep (over 0.5‰). Bravard also shows that in the area studied (between Cordon bridge and Evieu bridge) the different arms of the river, with a high degree of sinuosity, form a complex braided model where in the nineteenth century, civil engineering works (dykes) led to the creation of numerous 'lônes'. The eight 'lônes' investigated within the framework of our study belong to several different types defined by their connections with the main channel (Amoros *et al.*, 1982; Richardot-Coulet *et al.*, 1982).

Parapotamic environments
(A, Lône du Mortier; B. Lône de Rossillon; C, Lône du Dahomey) (Fig. 2)

These 'lônes' have a permanent connection downstream with the river. The current may be perceptible (5 to 10 cm s^{-1}) and can be reversed if there is a difference in level between the waters of the 'lône' and the river water. They also receive underground water (more or less indirectly) up-

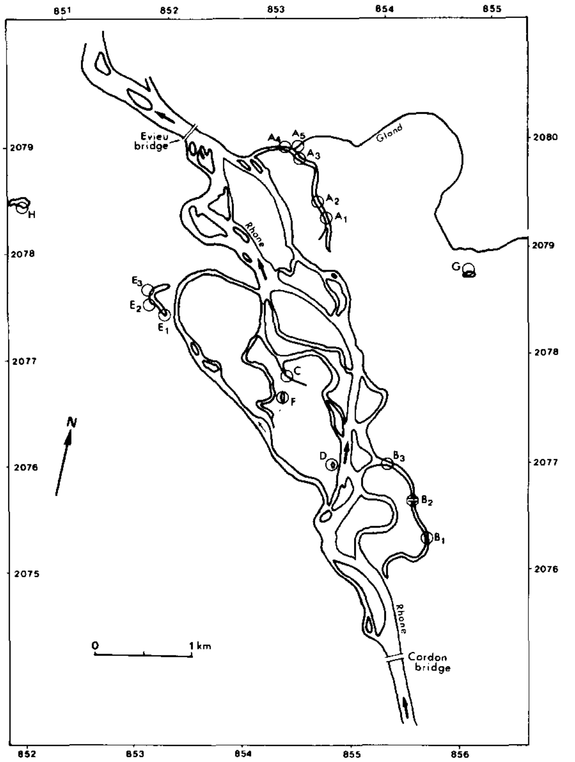

Fig. 2. The Brégnier-Cordon area, sampling sites. The numbers outside the map refer to the Lambert coordinates used on the National Geographical Institute maps of France.

stream from lateral underflow (Juget *et al.*, 1979; Reygrobellet *et al.*, 1981, studies of a 'lône' of this kind in the Jons area). When the Rhône is in spate, the river waters overflow from the minor bed and may temporarily flow in these old arms. The 'Lône du Mortier' is a particular case, in that, just before its confluence with the river, a tributary, the Gland, flows into it from the southern slopes of the Bugey massif. The 'Lône du Dahomey' belongs to this group only because it communicates artificially with the main channel downstream as part of the fight against mosquitoes.

Plesiopotamic environments
(D, 'Creux de Bleu'; E, Lône des Nappes; F, 'Trou à canard ouest') (Fig. 2)

These old channels, shallow and narrow, are no longer permanently connected with the river, except in times of flood. Their eutrophic standing water comes mainly from precipitation (Amoros *et al.*, 1982).

The 'Trou à canard ouest' (F), a temporary environment which dried up during low water in September 1981, is an example of the transition between aquatic and semi-aquatic environments.

Paleopotamic environments
(G. 'Morte' de Glandieu; H. L'Eau Morte) (Fig. 2)

These stagnant environments known locally as 'mortes' ('dead waters') look like ponds, they developed when the deepest zones of old meanders were cut off from the main channel. They are usually situated at the limit of the flood plain, and no longer have any direct contact with the river.

The morphometric characteristics of the 'lônes' we investigated are shown in Table 1. Table 2 contains the features of the substrates and the aquatic vegetation found at the sampling sites.

Material and methods

Sampling was carried out at three different periods (April, July, September 1981). All the sites described in Table 2 were investigated with the exception of A_2 and D in April, A_5 in April and July, and F (which had dried up) in September. Thus 43 samples were taken from 16 sites.

Invertebrates were collected with hand nets; each net was in the form of a parallelepiped (10 × 15 cm, 24 cm deep), with 0.5 mm nylon mesh and a 110 cm handle.

This method provides a good picture of the fauna and has the advantage of being quick and easy to use in shallow environments like the 'lônes' that are often choked with aquatic vegetation.

In our study, we used this method to obtain a qualitative survey of the population of the different environments. Our samples were first sorted out in the field, in order to eliminate any coarse detritus. The organisms were then sorted out using a dissecting microscope and identified in the laboratory.

Only five groups of fauna were retained for this study (Mollusca, Crustacea, Ephemeroptera, Coleoptera and Trichoptera) for two reasons: first, because of their abundance of taxa which have been shown to be 'describers'[1] in previous studies of the

[1] The word 'describers' is discussed in Bournaud & Amoros (1984).

Table 1. Morphometric characteristics of the 'Lônes' studied.

	Estimate length	Average breadth	Maximum depth
A. Lône du Mortier	1500 m	15–20 m	1.5 m
B. Lône de Rossillon	1400 m	12–15 m	1.5 m
C. Lône du Dahomey	200 m	5–10 m	0.8 m
D. 'Creux de Bleu'	50 m	5–10 m	0.5 m
E. Lône des Nappes	300 m	10–15 m	1.5 m
F. 'Trou à canard ouest'	150 m	5–10 m	0.5 m
G. 'Morte' de Glandieu	100 m	20–30 m	2.0 m
H. L'Eau Morte	150 m	50–70 m	1.5 m

same kind of environment, and secondly, because we could identify them to species level.

Results

During the three periods mentioned above, 83 taxa belonging to the five groups were obtained from the 16 sampling sites. Larvae and imagos of Coleoptera were presented and discussed separately because of the differences in distribution that may exist between two stages of the same species.

We have tried to reorganize the initial data using factorial analysis of correspondences in order to define the different types of environment in terms of the fauna found in each, and to bring out any similarities between them.

When we examine the links expressed as correlation ratios, between the three variables ('lône', site, season), and the first four factors of the analysis (Table 3), we can see that interseasonal variability of the structure of the fauna is negligible.

Conversely, the structures of the faunistic groups have been sharply defined by the variables 'lône' and 'site'.

These preliminary results have enabled us to add all the samples taken from the same site for the analysis, and this leads us to a new table (Fig. 3) after data reorganization. Here we have preferred to present a strict table of data rather than the more usual factorial maps which give only a partial image

Table 2. Characteristics of the sampling sites.

		Average depth (m) at sampling site	Bottom feature	Main aquatic macrophytes (from Balocco 1982)
Lône du Mortier	A			
	A_1	0.50–1.00	Clay	*Phragmites australis, Phalaris arundinacea*, dense carpet of *Myriophyllum sp.* and *Ceratophyllum demersum*
	A_2	0.50–1.00	Clay	id. A_1
	A_3	1.00–1.50	Clay + sand	Sparse *Myriophyllum sp.* and *Sparganium emersum*
	A_4	1.00–1.50	Sand	*Sparganium emersum, Sagittaria sagittifolia* and *Potamogeton lucens*
	A_5	1.00–1.50	Sand	id. A_4
Lône de Rossillon	B			
	B_1	0.50–1.00	Silt + clay	Dense *Lemna trisulca* and *Callitriche sp.*
	B_2	0.50–1.00	Silt + clay	*Lemna trisulca, Callitriche sp., Berula erecta*
	B_3	1.00	Silt + sand	*Sparganium emersum, Sagittaria sagittifolia*
Lône du Dahomey	C	0.50–1.00	Clay on pebbles	*Groenlandia densa, Potamogeton natans, Elodea canadensis, Callitriche sp.*
'Creux de Bleu'	D	0.50–1.00	Clay	*Potamogeton natans, Nuphar lutea*
Lône des Nappes	E			
	E_1	0.50	Silt + clay	*Ceratophyllum demersum, Hydrocharis morsus-ranae, Phragmites australis, Carex elata*
	E_2	0.50	Clay	*Carex elata*
	E_3	0.50–1.00	Clay + silt	*Hydrocharis morsus-ranae, Ceratophyllum demersum, Potamogeton natans*
'Trou à canard ouest'	F	0.50–1.00	Silt + clay	none
'Morte' de Glandieu	G	0.50–1.00	Clay	*Ceratophyllum demersum, Hydrocharis morsus-ranae, Utricularia sp.*
L'Eau Morte	H	0.50	Clay	*Ceratophyllum demersum, Myriophyllum verticillatum, Nuphar lutea*

Table 3. Links between the three variables and the first four factors of the analysis, expressed as correlation ratios.

Variables	Factors of the analysis 1	2	3	4
'Lône	45	27	53	52
Site	68	54	75	62
Season	4	2	7	19

Table 4. Number of taxa compared for the five groups of fauna both in the environments studied here (A, eight 'lônes' of the Brégnier-Cordon area) and in the main channel of the Rhône (B, twelve sampling sites in the Upper Rhône Perrin & Roux 1978), C, common taxa between A and B.

	A	B	C
Mollusca	23	6	3
Crustacea	3	4	3
Ephemeroptera	6	8	2
Coleoptera	37	5	1
Trichoptera	14	13	1
Total	83	36	10

of the total information contained in the initial data.

Taxa found in only one sample have been left out of the analysis. The reorganization of the table of data enables us to distinguish three main groups of fauna (Fig. 3).

– Group I (15 taxa). This is made up principally of Coleoptera (9 taxa) and characterises parapotamic environments. We can note the presence of species which prefer water that is constantly renewed, or with a slight current: *Anabolia nervosa, Gammarus fossarum* and *G. pulex*, and the larvae and imagos of the Coleoptera *Laccophilus hyalinus.*

– Group II (26 taxa). Made up mainly of Mollusca (15 taxa), this is the group containing ubiquitous species like *Asellus aquaticus, Cloeon dipterum* and *Haliplus lineatocollis*, to be found in all the kinds of environment we investigated. Here the taxa are linked to standing water and to the amount of aquatic vegetation and organic detritus.

– Group III (16 taxa). This group is made up mainly

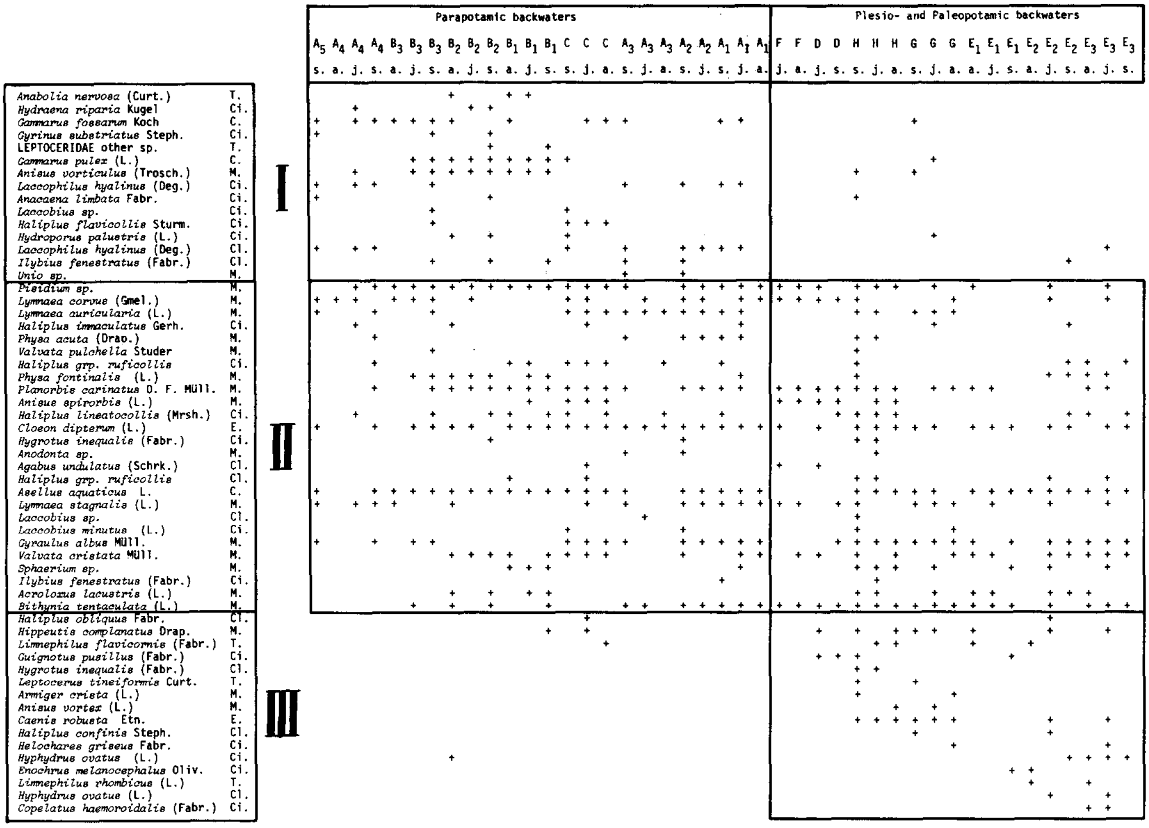

Fig. 3. The reorganization of the faunistic data using the factorial analysis of correspondence shows three different faunistic groups (I, II, III) a: April, j: July, s: September, C: Crustacea, M: Mollusca, E: Ephemeroptera, Ci: Coleoptera imago, Cl: Coleoptera larvae, T: Trichoptera.

of Coleoptera (9 taxa), and identifies plesio- and paleopotamic environments. These two kinds of environment, stagnant and no longer directly communicating with the river, represent the terminal stage in the evolution of permanent aquatic environments, but their origins differ; the former have developed from narrow, shallow channels, the latter from wide, deep channels (Amoros *et al.*, 1982).

The content of the third group emphasizes this evolution. Some taxa are common to both kinds of environment and characterize them (*Hippeutis complanatus, Limnephilus flavicornis*), other distinguish them: *Caenis robusta* for paleopotamons, *Hyphydrus ovatus* for plesiopotamons (Lône des Nappes).

Discussion

There is a correspondence between the faunistic data and the typology of the environments based on the connections between the 'lônes' and the main channel of the river. Groups I and III can be considered as 'describers' of the hydrological and morphological types of environment: parapotamic, plesiopotamic and paleopotamic. It is of interest that the fauna seems to represent a 'describer' which is sensitive enough to show the mixed features of 'La Lône du Dahomey'. The natural development of this 'lône' towards a plesiopotamic type has been slowed down by the artificial channel which maintains the communication of the 'lône' with the river. Its population is thus characterised by elements from group I (parapotamic environments): *Gammarus fossarum, Haliplus flavicollis* denoting a permanent communication with the river, and by elements from group III (plesiopotamic environments): *Haliplus obliquus, Hippeutis complanatus, Limnephilus flavicornis.*

Group II may be considered as the 'common base' of the diverse environments studied, to which characteristics particular to each type of hydrological functioning can be added. 'Trou à canard ouest' (F), which is no longer a permanent aquatic environment, contains a population limited to the taxa in group II.

Whereas the benthic macrofauna of the main channel of the Rhône has been described as 'relatively rich and diversified' (Perrin & Roux, 1978), the benthic macrofauna in the 'lônes' is even more diversified (Table 4). In each case sampling was carried out using appropriate methods: hand nets for the 'lônes' in this study, artificial substrates in the main channel of the Rhône. Similar results have been obtained by Mielewczyk (1973) who compared populations of dragonfly larvae in a Polish river and in its riverine water bodies.

This taxonomic richness of macroinvertebrate populations may be compared with the remarkable diversity of the ichtyofauna found by Nelva *et al.*, (1981) when studying fish in the 'lônes vives'[2] in the Brégnier-Cordon area.

A comparison between the active channel and its backwaters (the eight 'lônes') suggests that as the stretches of channel or meanders are progressively cut off from the active channel, then their evolution towards a lenitic stage and their terrestrialization are accompanied not only by a qualitative modification of the fauna, but also by greater taxonomic diversity. This modification of the fauna can be explained by the difference in the types of biotopes available in the two environments. The active channel is relatively homogenous. Here discharge is the main ecological factor: in the Southern Jura, the average discharge of the Rhône is 450 $m^3 s^{-1}$ (2000 $m^3 s^{-1}$ when the river is in spate). This factor conditions the occurrence of a specialised rheophilous fauna. On the other hand, in the 'lônes', the multiplicity of kinds of water supply and hydrological functioning, the wide range of substrates and the different kinds of aquatic macrophytes all provide a large range of resources – in terms of space and food supply – allowing settlement of very different ecological types. This faunistic comparison between the active channel and its backwaters is still only in its early stages. Our study does not yet allow us to consider macroinvertebrates as evidence of the evolution of the hydrosystem in time.

Conclusion

The first results concerning the invertebrate macrofauna of aquatic ecosystems abandoned by the Rhône in the Bregnier-Cordon area confirm the first typology put forward for the 'lônes' of the

[2] These 'lônes' communicate downstream with the main channel; upstream their opening is partly closed by e.g. a permeable dyke.

French Upper Rhône (Amoros *et al.*, 1982). They enable us to consider certain taxa as 'describers' for the hydrological and morphological types of environment.

The fragmentary nature of this study can be explained by the fact that it was necessary to work rapidly, before the hydro-electric schemes came into operation. The study shows how these environments are complex and rich in fauna. At present our research is directed towards an understanding of the dynamics of the evolution of the 'lônes' and its assessment through faunistic data. The working-out of models of the ways and speed with which aquatic environments evolve is clearly a very effective way of gaining data of use in predicting the behaviour of these zones. The French Upper Rhône where many conflicting management schemes have been put forward (Bravard 1982b) provides an excellent site for developing a methodology that can be applied to other river systems.

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