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STRUCTURE AND DYNAMICS OF THE FRENCH UPPER RHÔNE ECOSYSTEMS

XII. AN INVENTORY OF HELMINTH FISH PARASITES FROM THE UPPER RHÔNE RIVER (FRANCE)

Marion J. VAN MAREN

ABSTRACT

Eleven species of helminth parasites (five acanthocephalans, five cestodes and one trematode) are reported from altogether sixteen fish hosts in the Rhône River, N.E. of Lyon.

The most common parasite is *Pomphorhynchus laevis*, which occurs in all fish species examined. *Echinorhynchus borealis* seems to be restricted mainly to Burbot. *Metechinorhynchus truttae* was not frequently met with, but was very numerous in Grayling from the river Furans. *Acanthocephalus anguillae* was found in fishes from the so-called "lônes" (backwaters). *A. lucii* was rarely encountered during the present study. Of Cestoda, *Caryophyllaeus laticeps* is confined to fishes feeding on muddy substrates, *Bathybothrium rectangulum* was found in Barbel, and *Eubothrium rugosum* in Burbot. *Proteocephalus torulosus* is recorded from Dace and Chub, and *Cyathocephalus truncatus* from Trout and Grayling. The trematode *Crepidostomum farionis* occurred in the latter as well.

INTRODUCTION

Up to now hardly any data on the parasite fauna of the fishes from the Rhône River were available. The need for more information on this subject might become urgent in the future on account of an important thermal pollution caused by nuclear plants constructed on this river. According to Eure & Esch (1974) temperature is a major factor determining the population dynamics of helminth parasites in an aquatic ecosystem. During their investigations on the helminth fauna of Large-mouth Bass, they found that fishes in a thermally polluted area had significantly higher parasite burdens than those in non-polluted waters.

The present study was carried out within the scope of long term investigations on the upper

Rhône ecosystems, undertaken by members of the Zoological Department of the University of Lyon.

At several localities in the Rhône river system, upstream of Lyon, samples of the fish population were taken by means of electric fishing. The data presented in this paper were obtained by dissecting a number of fishes (table I) available from these "pêches électriques".

RESULTS AND DISCUSSION

The position of the sampling stations is presented on the map in fig. 1 and in table IV.

The following intestinal helminth parasites have been found during the present study:

Acanthocephala

Pomphorhynchus laevis (Müller, 1776)

Metechinorhynchus truttae (Schrank, 1788)

Echinorhynchus borealis Linstow, 1901
(= *Echinorhynchus clavula* Dujardin, sensu Lühe, 1911)

Acanthocephalus anguillae (Müller, 1780)

Acanthocephalus lucii (Müller, 1780)

Cestoda

Caryophyllaeus laticeps (Pallas, 1781)

Cyathocephalus truncatus (Pallas, 1781)

Proteocephalus torulosus (Batsch, 1786)

Bathybothrium rectangulum (Bloch, 1782)

Eubothrium rugosum (Batsch, 1786)

Trematoda

Crepidostomum farionis (Müller, 1784)

Table II gives a survey of the different fish species examined and the helminth parasites found in their intestinal tract. None of the fishes investigated was free of parasites. The intermediate hosts of these worms are recorded in table III (after literature data).

Pomphorhynchus laevis (Müller)

This acanthocephalan is the most common helminth parasite met in the fishes from the upper Rhône (table II). It is especially abundant in fishes captured in moderately or fast running waters: e.g. the rivers Ain and Albarine near Gévrioux (sta. 10a and sta. 10b) and in the main stream of the Rhône River itself. In the backwaters,

the so-called "lônes", *P. laevis* occurs much less frequently. This might be explained by the fact that larvae of the present acanthocephalan develop in gammaridean Amphipoda like *Gammarus fossarum* C.L. Koch, 1836, and *G. pulex* (Linnaeus, 1758), two species living in running waters (table III).

Infestation peaks for *P. laevis* have been established during autumn and spring both in the intermediate and final hosts from the upper Rhône river system (Van Maren, 1979). Kennedy et al. (1978) found this parasite to be widespread in Ireland. They presume that *Gammarus duebeni* Liljeborg, 1852, serves as an intermediate host, since it is the most common fresh water gammarid in that country, where *Gammarus pulex* is absent.

During the present investigations *P. laevis* was found in all 16 fish species examined. However, as was stated earlier (Hine & Kennedy, 1974a; Van Maren, 1979), this parasite reaches maturity in a few hosts only, especially in Barbel.

P. laevis seems not to be limited to fresh water biotopes. Several times it has been recorded from fishes captured in brackish waters: Lestage (1937) found it in Flounder (*Platichthys flesus* Linnaeus, 1758) in Belgium and Petrochenko (1956) in Sole (*Solea solea* Linnaeus, 1758); it was met in a young Sturgeon (*Acipenser sturio* Linnaeus, 1758) from the Etang de Vaccarès in the South of France (Kiener, 1968) and in a Sea Trout (*Salmo trutta* Linnaeus, 1758) captured near Marseille (Fabre & al., 1974). In the two latter cases, however, there might be some doubt if not *Pomphorhynchus tereticollis* (Rudolphi, 1806), a sibling species of *P. laevis*, was involved.

Metechinorhynchus truttae (Schrank)

This acanthocephalan is much less common in the Rhône River than the previous species. Only in one of the Rhône's tributaries, the river Furans (sta. 1), Grayling was found to be heavily infested by this worm. Very small numbers of *M. truttae* occurred in Trout and Grayling from the river Ain and in Barbel and Ruffe, *Gymnocephalus cernua* (Linnaeus, 1758), from the Rhône.

The present parasite is known to develop in several gammarid species (table III). Dorier

(1931) mentions its occurrence in *Gammarus pulex* from a Trout farm in northwestern France. Larvae of *M. truttæ* were found also in *Echinogammarus berilloni* (Catta, 1878) from a small stream in the same part of the country (Van Maren, 1977). Trout and *E. berilloni* from fish ponds in the South West of France yielded also a large number of *M. truttæ* (Van Maren, unpublished). Awachie (1965) found it in *Gammarus pulex* in North Wales. In Italy larvae are recorded by Bertocchi & Francalanci (1963) from *Gammarus pulex* and by Parenti et al. (1965) from *G. pungens* f. *padanus* Maccagno & Cuniberti, 1956.

Echinorhynchus borealis Linstow

During the present study this acanthocephalan was found almost exclusively in Burbot, *Lota lota* (Linnaeus, 1758). Among the large number of Barbels examined from the Rhône River near Brégnier-Cordon (sta. 4), only one fish harboured 4 small specimens of *E. borealis*. This parasite was found also in a Perch, *Perca fluviatilis* Linnaeus, 1758, from the same area (2 small worms). Besides in Burbot from station 4, the worm occurred in the same fish species captured in the Rhône River near Leschaux (sta. 2), near St. Génix (sta. 3) and near Miribel (sta. 7), as well as in Burbot from the river Loue (sta. 12), a tributary of the Rhône. The number of *E. borealis* counted in *Lota lota* varies from 9 to 136.

Grabda - Kazubaska & Chubb (1968) have demonstrated that the description of *E. borealis* Linstow, 1901, corresponds with that of *E. clavula* Dujardin, 1845, as given by Lühe (1911). According to these authors, worms corresponding with the original description of *E. clavula* by Dujardin (1845) should be called *Acanthocephalus clavula* (Dujardin, 1845).

Because of the nomenclatorial confusion, earlier literature data on the distribution and hosts of this parasite should be treated with caution. Lühe (1911) found *E. borealis* in Burbot and Pike, *Esox lucius* Linnaeus, 1758, from northern Germany. Nybelin (1924) sampled *Gammarus pulex* harbouring larvae of this worm, and found adult specimens in Burbot (many worms), in Pike and in Perch. Under the name of *Pseudoechino-*

rhynchus clavula (Dujardin, 1845), Petrochenko (1956) gives a description of *E. borealis* and records a large number of fish species, both from fresh and brackish waters, as final hosts. Besides *Gammarus pulex*, *Pontoporeia affinis* Lindström, 1855, is mentioned as intermediate host in which larvae of *E. borealis* have been found by Bauer (1953). It should be noted, though, that the data given by this author are seriously questioned by Petrochenko. According to Meyer (1933), *Gammarus locusta* (Linnaeus, 1758) serves as intermediate host for *E. borealis*. As final hosts he mentions brackish and fresh water fishes from North Germany and the Baltic area. The acanthocephalans described by Dujardin (1845), from N.W. France (Brittany), concern *Acanthocephalus clavula* and not *E. borealis*. Delphy (1963) mentions *Echinorhynchus clavula* Dujardin from France without any further details on its geographical distribution. Moreover, it is not clear from its description whether *E. borealis* or *A. clavula* is meant.

Acanthocephalus anguillae (Müller)

This acanthocephalan was found in small numbers in Trout and Dace from the river Ain near Gévrioux (sta. 10a) and in Grayling from several localities on this stream (sta. 8, 9 and 10a). Considerable numbers of this parasite occurred in Barbels from the Lône des Sables (sta. 4c), one of the backwaters of the Rhône River. Over 350 worms have been counted in one fish.

As was established by Nybelin (1924), the intermediate host of *A. anguillae* is *Asellus aquaticus* (Linnaeus, 1758). This isopod is commonly encountered in the slowly running parts of the Rhône River, but replaced by gamma-ridean Amphipoda (mainly *Gammarus fossarum*) in the moderately to fast running waters ("le Rhône vif").

Lühe (1911) mentions *A. anguillae* to occur in many freshwater fishes from Central Europe, in particular in Cyprinidae. According to Petrochenko (1956) the present parasite is widely distributed in the U.S.S.R., western Europe and in North America.

Acanthocephalus lucii (Müller)

This acanthocephalan was found only on rare occasions during the present study. Only one specimen was met in Grayling from the river Ain near Villieu (sta. 9). But a large Eel, captured in the Canal de Miribel, harboured over a hundred *A. lucii* together with numerous *Pomphorhynchus laevis*.

According to Lühe (1911), the larva of *A. lucii* develops in the isopod *Asellus aquaticus*. During his study on the biocoenosis of Druzno Lake (Poland), Styczynska (1958) also found the larvae in *A. aquaticus*. In this lake, where gammarids are rare, *Acanthocephalus lucii* is the most common acanthocephalan.

Caryophyllaeus laticeps (Pallas)

This cestode was met in Chub, Dace and Barbel from the Lône des Sables near Brégnier-Cordon (sta. 4c). Furthermore, it occurred in Barbels from another backwater of the Rhône River, the Lône Grand Jean (sta. 4b), near the Digue des Noyés (sta. 4a) and in the Canal de Jonage (sta. 6b) not far from Lyon. Not seldom infestations of Barbel by several hundreds of worms were observed, obstructing the fish gut almost completely. The occurrence of *C. laticeps* in large numbers without causing visible harm to its host seems not to be unusual (Mackiewicz, in litt., 1979). Plehn (1924) states that the mucosa of the fish intestine is not seriously affected by the presence of *C. laticeps*.

All four species of tubificid Oligochaeta (table III), mentioned by Joyeux & Baer (1936) as intermediate hosts of the present cestode, are known to occur in the upper Rhône (Groupe de Recherche sur le Haut-Rhône, 1978). The final host becomes infested by ingesting mud or grazing muddy substrates as Cyprinidae do. Salmonids, living in clear, fast running waters with sandy or stony substrates devoid of Tubificidae, become rarely infested by *C. laticeps*.

C. laticeps is reported to be a common parasite of cyprinid fishes in Europe (Anderson, 1974). Its occurrence in France was already mentioned by Joyeux & Baer (1936).

Cyathocephalus truncatus (Pallas)

This cestode has been observed in Grayling and Trout from the river Ain (sta. 10a) and in Grayling from the river Furans (sta. 1), another tributary of the Rhône River. Always the worms were found in the pyloric region of the fish intestine, which confirms the observations by Lühe (1910), Gauthier (1923) and Bernard (1954).

For its development *C. truncatus* needs an amphipod intermediate host. Its larvae occur in *Gammarus fossarum* from the Rhône river system (Van Maren, 1979). Vik (1958), during his studies on the helminth fauna of Norway, found *Gammarus lacustris* G.O. Sars, 1895, harbouring *C. truncatus* larvae. The amphipod *Pontoporeia affinis* is reported to be its intermediate host in Canada (Degiusti & Budd, 1959). Awachie (1966) observed infested *Gammarus pulex* in a trout stream in Great Britain; Joyeux & Baer (1936) mention the same intermediate host for France. They record *C. truncatus* to occur in Burbot (*Lota lota* (Linnaeus, 1758)), in Char (*Salvelinus alpinus* (Linnaeus, 1758)) and in Whitefish (*Coregonus spec.*) from Lake Geneva and in Trout from the Rhône and the Var, a river in south-eastern France.

Amin (1978) several times observed gravid *C. truncatus* in the amphipod *Pontoporeia affinis* from Lake Michigan (U.S.A.). According to Ginet-sinskaya (1961), the genus *Cyathocephalus* presents an example of neotenic development, leading to a shortening of its life cycle: the reproductive apparatus of the cestode may complete its development within the amphipod host, although normally the worm attains maturity in the fish host.

Proteocephalus torulosus (Batsch)

This cestode occurred in Chub, *Leuciscus cephalus* (Linnaeus, 1758) and in Dace, *L. leuciscus* (Linnaeus, 1758) from the Lône des Sables (sta. 4c).

Of the three copepod species mentioned as intermediate hosts for *P. torulosus* (syn. *Ichthyotaenia t.*) by Joyeux & Baer (1936), at least two, *Diaptomus castor* (Jurine, 1820) and

Cyclops strenuus Fisher, 1851, are known to occur in the Rhône river system (Groupe de Recherche sur le Haut-Rhône, 1978). Since the diet of most fishes changes with age, infestations with parasites of different origin can be established. Young fishes feeding on plankton might become infested with cestodes harboured by copepod Crustacea.

Up to now, the only known record for *P. torulosus* in France was from Lake Geneva, occurring in Bleak, *Alburnus alburnus* (Linnaeus, 1758) (Joyeux & Baer, 1936).

Bathybothrium rectangulum (Bloch)

This cestode was found in Barbels captured near the confluence of the rivers Suran and Ain (sta. 11). The parasite, the development of which is unknown, belongs to the family Amphicotylidae, whose members need two intermediate hosts to develop into the infective stage (Joyeux & Baer, 1961).

Only few worms were met with in *Barbus barbus* from the Rhône River, in contrast to the heavy infestations observed in Barbels from the river Allier, a tributary of the Loire River (Van Maren, unpublished). In these latter fishes *B. rectangulum* was the only helminth parasite present and attained such numbers that clusters of worms blocked the gut almost completely. In the river Ain, however, *B. rectangulum* occurred together with the acanthocephalan *Pomphorhynchus laevis*. With respect to the parasite fauna of *Barbus*, it is interesting to see variations in diet of the fish from different biotopes: in the stomach contents of Barbels from the Rhône river system amphipod and isopod Crustacea are sometimes very abundant (Kraiem, 1979). While the rivers Rhône and Ain are distinguished as "chalk streams", the river Allier is defined as an "acid stream", very poor in gammarids.

Joyeux & Baer (1936) mention the occurrence of *B. rectangulum* in Barbel from the river Rhine near Basle. Lühe (1910) reports it from *Barbus* in Germany:

Eubothrium rugosum (Batsch)

This cestode was encountered only once during the present investigations, viz. in *Lota lota* captur-

ed in the Rhône River near Pont d'Evieu (sta. 4).

The life cycle of this worm has not yet been elucidated, but Kennedy (1978) suggests that there might be one intermediate host, a planktonic copepod.

E. rugosum is mentioned by Joyeux & Baer (1936) from Burbot in Lake Geneva. Under the name of *Abothrium rugosum*, Lühe (1910) recorded it from *Lota lota* and marine Gadidae. According to Kennedy (1978), *E. rugosum* occurs only in Burbot and can survive the migrations of its host into brackish waters. He considers the genus *Eubothrium* to be primarily marine, some species having penetrated into fresh water together with their anadromous hosts.

Crepidostomum farionis (Müller)

This trematode was recovered from Grayling in the river Furans (sta. 1).

According to Brown (1927), who studied the life cycle of this parasite, it uses a bivalve mollusc, either *Pisidium* or *Sphaerium*, as first intermediate host and an insect larva, *Ephemera*, as second. Baylis (1931) found the amphipod *Gammarus pulex* (in Great Britain) to harbour metacercaria larvae of *C. farionis*. In *Thymallus* from the river Furans the present trematode occurred together with the acanthocephalans *Metechinorhynchus truttae*, *Pomphorhynchus laevis* and the cestode *Cyathocephalus truncatus*, all three using a gammarid host for their development. Therefore, metacercariae of *C. farionis* might be expected to be found in *Gammarus* from the Rhône river system¹⁾. Adult worms are known to occur likewise in Grayling from the river Ance, a tributary of the Loire River (Van Maren, unpublished). Since this stream is devoid of gammarids, insect larvae are assumed to serve as second intermediate hosts in this case.

C. farionis is recorded in literature from Salmonidae and *Thymallus* (Lühe, 1909; Brown, 1927; Kennedy, 1977). It is distributed in Europe, Canada and the United States (Dawes, 1946).

¹⁾ Several times cysts of metacercaria larvae have been observed in gammarids from the Rhône river system.

CONCLUSIONS

The distribution of parasites is limited primarily by the occurrence of both their intermediate and final hosts. Since the presence of a particular host is related to the type of habitat, host and habitat specificity are inter-related components (Chubb, 1967). Much more than the fishes, the aquatic invertebrates are confined to a particular biotope. Moreover, most parasites found during the present investigations seem to be more specific towards their intermediate invertebrate host than towards the final host. Therefore, the above mentioned helminth species might be grouped, with respect to their use of a particular intermediate host, into the following categories:

1) intermediate host: *Gammarus* (Amphipoda)

The acanthocephalans *Pomphorhynchus laevis*, *Metechinorhynchus truttae* and *Echinorhynchus borealis*, and the cestode *Cyathocephalus truncatus* occurred mainly in fishes from moderately and fast running waters, like the rivers Ain and Furans and the main stream of the Rhône River.

2) intermediate host: *Aseillus* (Isopoda).-

The acanthocephalan *Acanthocephalus anguillae* was numerous in Barbels from slowly running waters, such as the Lône des Sables. *A. lucii* was found only on rare occasions, but occurred in large numbers in an Eel from the Canal de Miribel.

3) intermediate host: Copepoda.- The cestode *Proteocephalus torulosus* was found in *Leuciscus* from stagnant or slowly running waters harbouring planktonic copepods (Lône des Sables).

4) intermediate host: Tubificidae (Oligochaeta).- The cestode *Caryophyllaeus laticeps* occurred in cyprinid fishes from slowly running waters with a muddy substrate, like the Lône des Sables and the Lône Grand Jean, both backwaters of the Rhône River, and from the moderately running waters of the Canal de Jonage.

5) intermediate host unknown or more than one intermediate host.- The cestode *Eubothrium rugosum* was observed only once in Burbot from the Rhône River itself; *Bathybothrium rectangulum*, another cestode whose life cycle is not known, was found in Barbels from moderately to fast running waters, near the confluence of the rivers Ain and Suran. The tre-

matode *Crepidostomum farionis*, occurring in Grayling from the river Furans, uses a limnophilous bivalve, like *Pisidium* or *Sphaerium*, as first intermediate host and an Ephemeroptera larva or a gammarid, both characterized as rheophilous invertebrates, as second intermediate host.

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RÉSUMÉ

Onze espèces de vers parasites (cinq acanthocephales, cinq cestodes et un trématode) ont été trouvées dans des poissons différents provenant du Haut Rhône français.

Le parasite le plus courant est *Pomphorhynchus laevis* figurant dans toutes les espèces de poissons étudiés. *Echinorhynchus borealis* semble être hébergé surtout par la lotte de rivière. *Metechinorhynchus truttae* ne fut rencontré que rarement, bien qu'un grand nombre de vers soit trouvé dans des ombres de la rivière Furans. *Acanthocephalus anguillae* a été observé dans des poissons provenant des lônes. *A. lucii* est rare. Le cestode *Caryophyllaeus laticeps* est limité aux poissons se nourrissant sur des substrats vaseux. *Bathybothrium rectangulum* figurait dans le barbeau, *Eubothrium rugosum* dans la lotte de rivière; *Proteocephalus torulosus* est signalé dans le chevaine et dans la vandoise, *Cyathocephalus truncatus* dans la truite et dans l'ombre; dans ce dernier le trématode *Crepidostomum farionis* a été également rencontré.

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Marion J. van Maren
Instituut voor Taxonomische Zoölogie
(Zoölogisch Museum)
Plantage Middenlaan 53
1018 DC Amsterdam
The Netherlands

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Table III. Intermediate hosts for the various parasites found in the fishes from the upper Rhône River (based on literature data)

PARASITE SPECIES	INTERMEDIATE HOST(S)	AUTHOR(S)
<i>Pomphorhynchus laevis</i>	<i>Gammarus pulex</i> (A)	Rumpus & Kennedy (1974)
	<i>Gammarus duebeni</i> (A)	Kennedy et al. (1978)
	<i>Gammarus fossarum</i> (A)	Van Maren (1979)
<i>Metechinorhynchus truttae</i>	<i>Gammarus pungens</i> f. <i>padanus</i> (A)	Parenti et al. (1965)
	<i>Gammarus pulex</i> (A)	Awachie (1965)
	<i>Echinogammarus berilloni</i> (A)	Van Maren (1977)
	<i>Gammarus fossarum</i> (A)	Van Maren (1979)
<i>Echinorhynchus borealis</i>	<i>Gammarus pulex</i> (A)	Nybelin (1924)
	<i>Gammarus locusta</i> (A)	Meyer (1933)
	<i>Pontoporeia affinis</i> (A)	Bauer (1953)
<i>Acanthocephalus anguillae</i>	<i>Asellus aquaticus</i> (I)	Nybelin (1924)
<i>Acanthocephalus lucii</i>	<i>Asellus aquaticus</i> (I)	Lühe (1911)
<i>Caryophyllaeus laticeps</i>	<i>Tubifex tubifex</i> (O)	Joyeux & Baer (1936)
	<i>Tubifex barbatus</i> (O)	
	<i>Limnodrilus claparedianus</i> (O)	
	<i>Limnodrilus hoffmeisteri</i> (O)	
<i>Cyathocephalus truncatus</i>	<i>Gammarus pulex</i> (A)	Joyeux & Baer (1936)
	<i>Gammarus lacustris</i> (A)	Vik (1958)
	<i>Pontoporeia affinis</i> (A)	Degiusti & Budd (1959)
	<i>Gammarus fossarum</i> (A)	Van Maren (1979)
<i>Proteocephalus torulosus</i>	<i>Cyclops serratulus</i> (C)	Joyeux & Baer (1936)
	<i>Cyclops strenuus</i> (C)	
	<i>Diaptomus castor</i> (C)	
<i>Bathbothrium rectangulum</i>	unknown	
<i>Eubothrium rugosum</i>	unknown	
<i>Crepidostomum farionis</i>	<i>Pisidium</i> , <i>Sphaerium</i> (M)	Brown (1927), Baylis (1931)
	+ <i>Ephemera</i> (IL), <i>Gammarus</i> (A)	

A = Amphipoda (Crustacea)

C = Copepoda (Crustacea)

I = Isopoda (Crustacea)

IL = Insect larvae

M = Mollusca

O = Oligochaeta (Annelida)

Table IV. Position of the sampling stations in the Rhône river system (see fig. 1)

STATION	POSITION	DEPARTMENT
1	River Furans near Chazey-Bons	Ain
2	River Rhône near Leschaux	Ain / Savoie
3	River Rhône near St. Génix-s-Guiers	Ain / Savoie
4	River Rhône near Brégnier-Cordon	Ain / Isère
	a) Digue des Noyés b) Lône Grand Jean c) Lône des Sables	
5	Lône des Pêcheurs, backwater of the River Rhône	Rhône
6	River Rhône near Pont de Jons	Rhône
	a) near dam in Canal de Miribel b) in Canal de Jonage	
7	River Rhône near Neyron	Rhône
	a) in Canal de Miribel b) near breach between Canal de Miribel and the Vieux Rhône	
8	River Ain near Chazey-s-Ain	Ain
9	River Ain near Villieu	Ain
10	a) River Ain near Gévrioux b) River Albarine near Gévrioux	Ain
11	River Suran near Pont d'Ain	Ain
12 ¹⁾	River Loue near Parcey	Jura

1) This locality is not represented on the map in fig. 1.

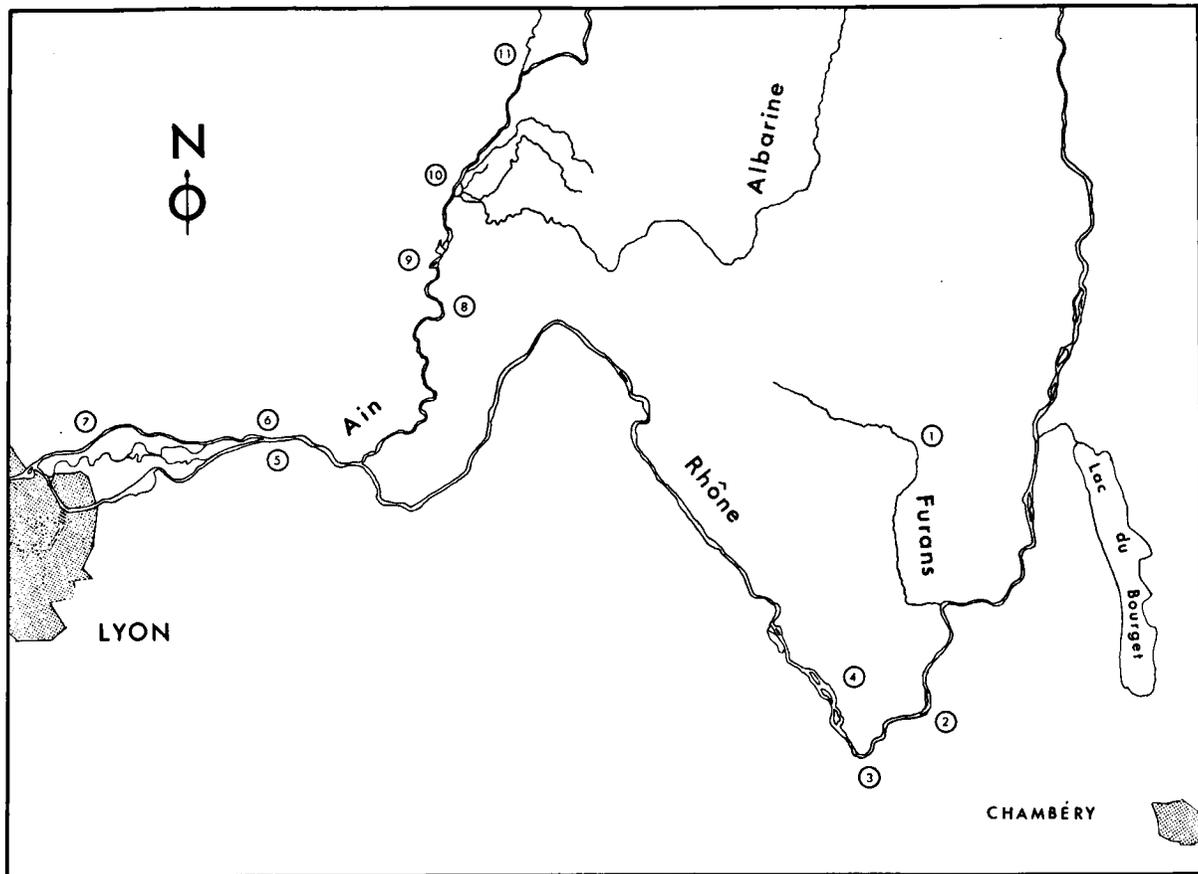


Fig. 1. The upper Rhône river system with the position of the sampling Stations (see Table IV).

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