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Hydroécologie (plancton)

CONTROL FACTORS OF ZOOPLANKTONIC COMMUNITIES IN RIVER (THE SEINE). RIVER-HYDRAULIC ANNEXES RELATIONSHIPS

by

Anne MIQUELIS

Introduction

Fluvial processes are complexes and make them difficult to understand plankton dynamics. The widely held opinion since the work of HYNES (1972) seems to be that planktonic communities in rivers were physically controlled. But, recent studies of large rivers showed that postulated factors affecting these communities had an hydrological, chemical, physical and biotic nature (PACE *et al.*, 1992; THORP *et al.*, 1994; BASU & PICK, 1996; 1997; GOSSELAIN *et al.*, 1998; KOBAYASHI *et al.*, 1998; MIQUELIS *et al.*, 1998).

In the present study, the temporal and the spatial dynamic of the zooplankton community were analyzed in the Seine river (France) during two years. In the same time, the fluctuations of the flow intensity, the total solar radiation and the water temperature were recorded. Furthermore, in addition of the algal biomass, assessment of the not pigmented and inorganic parts present within the suspended matter was realized. In order to determine the impact of these different parts of the suspended matter on the zooplanktonic community, differential analyses were realized on the fraction 0-25 µm (CYR & PACE, 1992).

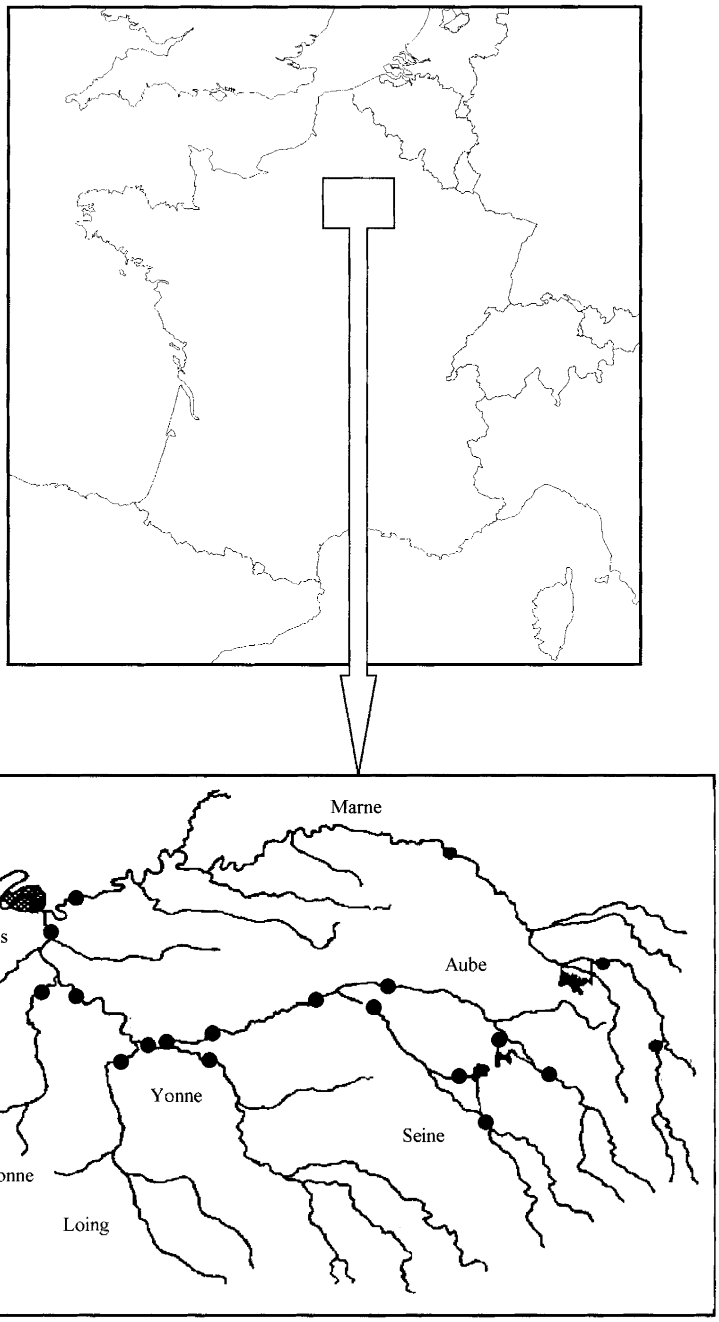


Figure 1
Map of the part of the Seine river system studied including sampling stations (●).

Materials and methods

Study area

The Seine River is located in north of France and flows northwest for 776 km from its headwaters in the « Plateau de Langres » before discharging into the « Channel ». Its catchment area drains a surface of 78900 km^2. The Seine river and all its tributaries have a pluvio-oceanic regime. Parallel to their regulation of natural origin, the use of four storage dams allows the support of the low water levels and the crest lowering of rising.

Samples and analyses methods

Between March 1991 and October 1992, a weekly sampling was carried out in the Seine river, in Paris (on the « Quai St Bernard ») (Fig.1). Moreover, on three occasions in 1992, a water parcel was followed during downstream transport from the upper of the dams located on the Seine river and on the Aube river, to Paris (Fig.1). Samples were taken in the Seine river and from its tributaries- the rivers Aube, Yonne, Loing, Essonne and Marne- just before their confluence with the Seine river (Fig.1).

In order to sample zooplankton, ten water liters were filtered (RUYTER van STEVENINCK *et al.*, 1992; VIROUX, 1997) using a 40-µm-mesh Nylon net before addition of 5 % of formaldehyde (4 %) for conservation. Then, the zooplanktonic organisms were identified (KOSTE, 1978; DUSSART, 1967; AMOROS, 1984) and their biomass was estimated (RUTTNER-KOLISKO, 1977; POURRIOT & ROUGIER, 1991; BOTTRELL *et al.*, 1976).

For the suspended matter sampling, the Seine's water was previously filtered on a 200-µm-sieve. The fraction 0-200 µm obtained, was filtered on a second sieve (25 µm). Three replicates are carried out for each kind of analyses. The suspended matter was analyzed by the « losses by fire » method (THIBERT, 1994). The contents in Particulate Organic Carbon (POC) are determined by combustion and detection of the carbon dioxide to the infra-red (BARILLIER, 1992). The acetone extraction of chlorophyll 'a', 'b' and 'c' was done according to the method of SCOR-UNESCO (1966), whereas that of chl.a* and pheopigments is done according to the method of LORENZEN (1967). The use of the method developed in the Rhine by ADMIRAAL *et al.* (1992), allow to find a value of 26.74 ($p<0.05$, $n=33$) for the ratio (POC Total/$\sum$(chla+chlb+chlc)).

The ammonia, the nitrite and the orthophosphate analyses were realized following the AFNOR standard (1979). The nitrate contents were determined with the Jones method (1984).

One records simultaneously, temperature of the water and flow intensity of the Seine river, as well as the value of the total solar radiation received on ground.

Statistical analyses

The variables analyzed in this study are interrelated. Then, we use the factorial analysis of correspondence method to define their relationships (STATSOFT Inc., 1995).

Appendix

Classes of the various variables used in the AFC analyses. pK: kilometric point (km), Nrot: rotifers density (NL^{-1}), Ncop: copepods density (NL^{-1}), Ncla: cladocerans density (NL^{-1}), Nzoot: total zooplankton density (NL^{-1}), T: temperature (ºC), chl.a*: active chlorophyll a (μgL^{-1}), pheo: pheopigments (μgL^{-1}), NAC: non algal carbon ($mgCL^{-1}$), ISM: inorganic suspended matter (mgL^{-1}), N: nitrogen ($mgNL^{-1}$), P: phosphorus ($mgPL^{-1}$), D: flow ($m3s^{-1}$), Rg: total solar radiation (Mjm^2).

Variables		Surveys			
		Paris	June	July	September
Pk	1	-	353-543	353-543	353-543
	2	-	543-568	543-633	543-651
	3	-	568-656	633-656	651-656
Nrot	1	6-24	1.4-13.6	1-11.9	3-13.86
	2	24-77	13.6-38.7	11.9-34.58	13.86-38.64
	3	77-1737	38.7-609.6	34.58-244.2	38.64-1719
Ncop	1	1-8	0.4-2.4	0.1-1.4	0-3.78
	2	8-51	2.4-17.94	1.4-11.88	3.78-22.64
	3	51-187	17.94-62.5	11.88-64.35	22.64-42.75
Ncla	1	0-2.7	0.2-0.6	0-1.4	0-0.8
	2	2.7-6.3	0.6-6.25	1.4-24.2	0.8-7.14
	3	6.3-80.3	6.25-17.16	24.2-101.79	7.14-55.35
Nzoot	1	14-76	2.1-20.8	1.53-31.5	3.3-32
	2	76-154	20.8-88.75	31.5-111.2	32-59.13
	3	154-1770	88.75-620.8	111.2-271.92	59.13-1766.25
T	1	7.6-15.8	14.4-18.8	18.9-20.6	13.4-15.5
	2	15.8-21	18.8-20.4	20.6-23.7	15.5-16.5
	3	21-24.8	20.4-20.9	23.7-24.8	16.5-19.1
pH	1	-	-	7.59-7.74	7.56-7.9
	2	-	-	7.74-8.17	7.9-8.08
	3	-	-	8.17-8.3	8.08-8.47
chl.a*	1	1.78-4.91	0.02-0.06	0.04-0.053	0.02-0.07
	2	4.91-7.19	0.06-0.12	0.053-0.101	0.07-0.23
	3	7.19-48.95	0.12-0.54	0.101-0.42	0.23-0.88
pheo	1	0.9-2.6	0.03-0.07	0.012-0.041	0.01-0.06
	2	2.6-4.79	0.07-0.112	0.041-0.099	0.06-0.12
	3	4.79-12.7	0.112-0.21	0.099-0.2	0.12-0.36
NAC	1	0-0.77	0.33-0.41	0.24-0.4	0.17-0.35
	2	0.77-1.106	0.41-0.636	0.4-0.73	0.35-0.57
	3	1.106-2.095	0.636-2.29	0.73-0.88	0.57-0.87
ISM	1	3-5.2	1.4-4.6	0.8-3	2.75-5.4
	2	5.2-8.8	4.6-5.8	3-8	5.4-7.6
	3	8.8-18	5.8-9.2	8-10.8	7.6-14.4
N	1	-	1.96-2.69	1.74-2.33	1.62-2.47
	2	-	2.69-2.89	2.33-2.52	2.47-3.14
	3	-	2.89-4.96	2.52-2.79	3.14-5.04
P	1	-	0.025-0.081	0.052-0.144	0.036-0.06
	2	-	0.081-0.189	0.144-0.197	0.06-0.149
	3	-	0.189-0.363	0.197-0.376	0.149-0.72
D	1	70.4-101	10-10	4-15.1	5-25.1
	2	101-121.3	10-38	15.1-44	25.1-63.3
	3	121.3-451.3	38-110	44-87.5	63.3-110
Rg	1	1.7-13.5	-	-	-
	2	13.5-17	-	-	-
	3	17-25.9	-	-	-

Results

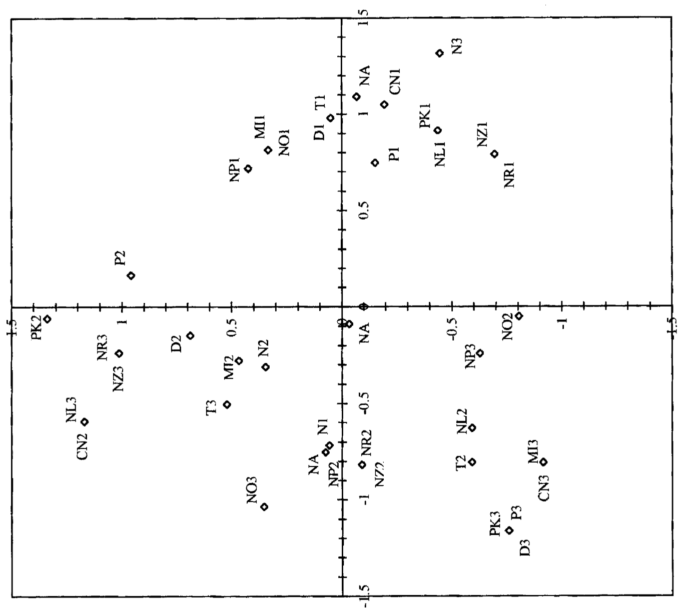
One hundred and two species and/or taxa of zooplanktonic organisms were determined in the Seine system. The rotifers represent 74.5% and the micro-crustaceans 25.5% of these determined organisms.

Temporal survey

The table analyzed for this temporal survey comprises eleven variables whose values were respectively shared among three classes (appendix). The percentages of inertia explained by the first five axes were respectively 18; 16; 11; 10 and 8%. The observations of the affine groups shows whatever the plan of projection, the existence of a seasonal evolution on axis 1 doubled by a food gradient on axis 2 (Fig. 2A). The variables contributing more to the formation of the first axis were the temperature of the water, the total radiation and the flow. The strongest values of the temperature and the total radiation are located on the positive side of the axis whereas the strongest values recorded for the flows were situated on the negative side of this first axis. These analyses highlight the connections existing between these variables and the densities of the copepods and cladocerans communities which also evolves along this first axis. Whereas the density of the rotifers community evolves parallel to the rate of chl.a* and inversely to the rates of inorganic suspended matter (both amounted on the fraction 0-25 µm) which defined mainly the second axis. The maximum (class 3) and minimum (class 1) densities recorded for the rotifer community are both located in the negative part of the first axis, i.e. negatively affected by the strongest flows and the lowest temperatures. The principal difference was due 1) to the joint presence in the maximum case (named 'NR3') of the class 1 of inorganic suspended matter and 2) the simultaneous presence of the class 3 of the SM and the class 1 for the rotifer density.

Spatiotemporal survey

The table analyzed during the spatiotemporal survey comprises fourteen variables whose values were respectively arranged in three classes (appendix 1). The percentages of inertia explained by the first five axes are respectively for each of the three campaigns: June = 30; 19; 15; 11; 10 %; July= 31; 16; 13; 10; 8% and September=25; 13; 11; 10 and 8% (Fig. 2B, 2C, 2D). The observations of the affine groups shows whatever the plan of projection, the existence of an upstream-downstream gradient which persists during the three campaigns. In addition to the temperature of water, the distances (pK, km) contribute more to the formation of the principal plan of the AFC realized in June and September when the flows were high. Whereas in July, the flows, lowest, contributed more to the formation of the plan of the AFC. The upstream part of the network was detached clearly with all the classes 1 of the variables except for the pH for which the third class is located in the upstream part of the network. The classes 3 of the rotifers, the cladocerans, the chl.a* and the temperature were recorded in the intermediate portion of the hydrosystem studied. In the downstream part we observed the highest densities for the copepods and the intermediate classes for the zooplanktonic community and the cladocerans.



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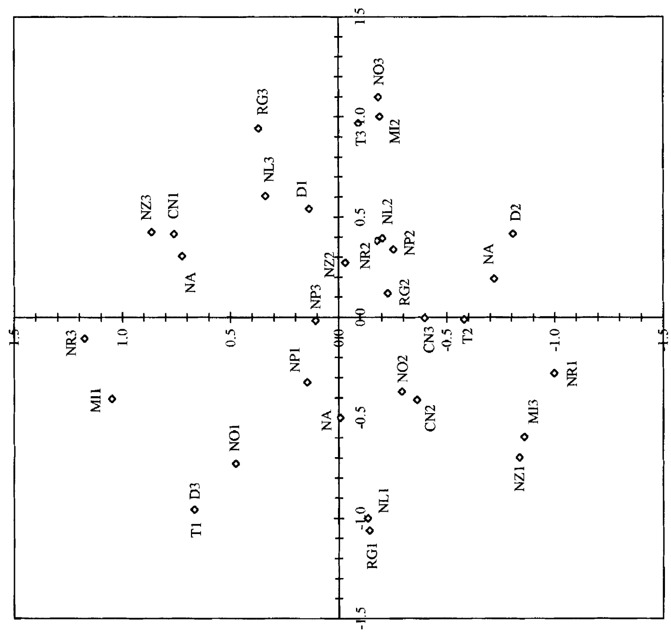

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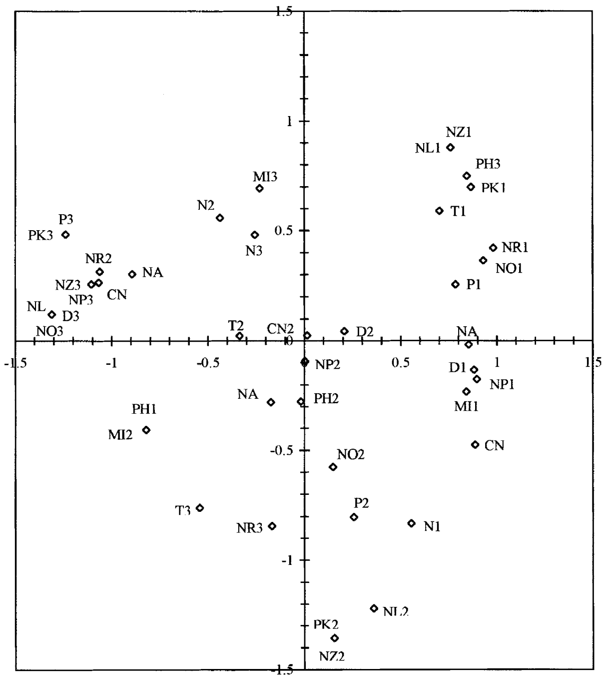

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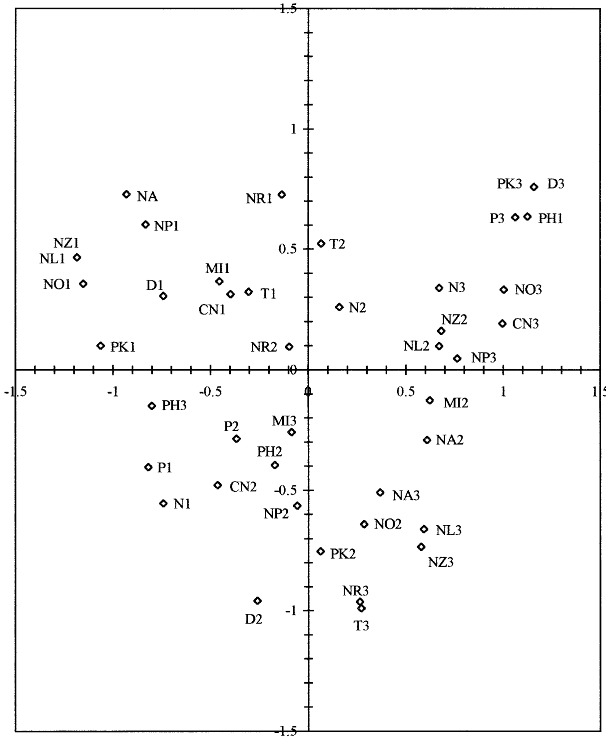

D

Figure 2

Factorial analyses of correspondence realized in the Seine river. In each analysis we represented the axes 1 and 2 : A. Temporal survey in Paris. B. June campaign: the dams do not restitute. C. July campaign, during which the flow of release was about 10 to 11 m^3s^{-1}. D. September campaign: the flow of release was of 17.5 m^3s^{-1}.

Discussion - Conclusion

The distribution of the organisms within the three groups of zooplankton: rotifers, copepods and cladocerans were very close to those observed in other rivers (José de PAGGI, 1980 ; POURRIOT *et al.*, 1982 ; FERRARI & MAZZONI, 1989 ; RUYTER van STEVENINCK *et al.*, 1990). The clear prevalence of the rotifers has been observed since the upstream of the dams located on the Aube river and the Seine river. We demonstrated the existence in the Seine river of a longitudinal successions assigning each of the three zooplanktonic groups. These zooplanktonic groups were correlated to the variations of the flow, the rates of inorganic SM and chl.a* (both amounted on the fraction 0-25 µm), and the fluctuations of temperature of the water. Recruitment phenomenon from many hydraulic annexes were added to the longitudinal successions of zooplankton (SHIEL & WALKER, 1985; SHIEL, 1986; VASQUEZ & REY, 1989). Nevertheless, the zooplancton, coming from these annexes, tends to disappear quickly towards the downstream (BEACH, 1960; KUCZYNSKI, 1989; AKOPIAN *et al.*, 1999). The superposition of these longitudinal successions and recruitment of zooplanktonic organisms was partly responsible of the seasonal successions observed in Paris. The results showed that the increase in times of residence and the temperatures supported the development of the copepods (POURRIOT & CHAMP, 1982). Moreover, we demonstrated the existence of a strong correlation between the densities of the rotifers community and the rates of inorganic SM and chl.a* amounted on the fraction 0-25 µm.

E.A. Biodiversité 2202
Case 36, 3 place Victor Hugo, 13331 Marseille.

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