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Spatial distribution and temporal evolution of Gammarus fossarum, Niphargus sp. (Amphipoda) and Proasellus slavus (Isopoda) in the Seebach sediments (Lunz, Austria)

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Riverbed sediments are an interface between superficial and underground habitats, where one can find a mixed assemblage of epigean and hypogean dwellers (DANIELOPOL 1976 a, GIBERT e.a. 1977, DOLE 1983 a). The study of ostracod assemblages at Seebach (MARMONIER 1984) has demonstrated the divergent evolution and distribution of epigean and hypogean species. Therefore, it is interesting to compare these results with other epigean and hypogean crustacean groups such as amphipods and isopods, which are frequently captured together in the interstitial habitats of brooks and rivers (DANIELOPOL 1976 a, MESTROV and LATTINGER-PENKO 1981, DOLE 1983 a,b).

This paper deals with the spatial distribution of amphipods and isopods in sediments of an alpine brook, from a horizontal and vertical viewpoint. The temporal evolution of populations with regard to superficial sediment movements in one station will also be considered.

There are two species of amphipods in the Seebach:

o Gammarus fossarum, an epigean dweller; this species has a large biogeographical distribution (from the south of the Netherlands to the Mediterranean, ROUX 1982); it is frequently captured in alpine brooks and the interstitial water of bed sediments (DOLE 1983 a).

o Niphargus sp. (species determination is in progress) is a hypogean genus.

The isopods are represented by only one species:

o Proasellus slavus (determined by Dr. J.P. Henry, Université de Dijon), a hypogean species that can be found all along the middle and inferior part of the Danube valley, from Yugoslavia to the Black sea (LATTINGER-PENKO 1976, HENRY 1976, DANIELOPOL 1976 b).

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1 - Material and methods

The area studied (the RITRODAT Area), which has been described by BRETSCHKO (1983), is appr. 100 m long and 30 m large, with three different parts : a curved main channel on the right, a central gravel bank, and a secondary

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															12B	
	2Z1	6Z2	22Z3	8Z2	10A1	10Z2	10Z3	14A1	16C1	18A1	8C4	1	2	3	1	2
5/9/80	2		1		37					1			9		1	
8/9		3				5	1		14	1				8	1	
20/10		5		5		23	1		22	1		2	4	1		
23/11		13		3	4	21	3		29	5		13	4			1
8/12	2	3	2	11		14			16	3	1	5	9	11	5	1
11/12		7	2	16	7	13		1	41	5		23	20	24	8	22
6/2/81		2	6	12	2	3	2	2	14	5		4	8	10	3	4
12/2		1		8	1	7	5	1	21	2		5	6	20	4	3
30/4		2	9			1		1	21	1			1	6	21	16
6/5	1		1						19	4		2	1	5	23	9
3/7		2			12	4	3	1	26			1	2	4		
9/7		1		2	6	9	7		15					1		
9/11		1	4	1	1	3	1	3	4		1	1				
16/11		1	1	1	3	10	2	1	11	3		12	6	4		
19/2/82						5	2		10				1	1		
25/2			1		2	3		1	28	1		1	4	5		
21/5				1	21	11		4	17	2		3	9	9		
28/5			2		10			1	4	1	1	5	5	3		

Table I : Abundance of Gammarus fossarum caught at various stations during the horizontal study survey (-20 cm depth in the sediments) from September 1980 to May 1982. (Only two pipes were at -20 cm at Station 12B during the first part of this study.)

arm on the left (Figure 1). The surface water has a low temperature level (annual mean: 6,5°C), and high alkalinity (annual mean: 2,19 mval, BRETSCHKO 1981).

The sampling method used ("stand pipe method"), described by BRETSCHKO (1981 and 1983), collects animals that are either moving actively or drifting inside the sediments. A plasic pipe with 7 cm diameter and a row of holes at its extremity was pushed down into the sediment; these holes can be opened and closed from the surface. Two samples were taken at each station and the pipes were left open during two periods of three days. The animals collected were then pumped out with a hand pump. Thus, the capture abundance was linked with the real abundance of animals surrounding the pipe and with their horizontal activities during the sampling period.

The spatial distribution was studied according to two different approaches:

- a horizontal distribution study, at 20 cm depth at 13 stations (Figure 1): 10 stations with one pipe in the main channel, 2 stations with 3 and 2 pipes, respectively, on the gravel bank, and one station with one pipe in the secondary arm of the stream. This study was carried out from September 1980 to May 1982 with 18 sample series (Table 1).
- a vertical distribution study was carried out at the two stations in the gravel bank (4 B and 12 B, Figure 1), from April 1980 to August 1982, with 28 sample series at different depths. At station 12 B, the depth varied during the study because the gravel bank sediments moved downstream and covered the pipe. Thus, the sampling depth increased, in relation to the surface, although the pipe itself did not move (Table II).

2 - Spatial distribution of amphipods and isopods

a - Results

From a horizontal perspective, the epigean amphipod Gammarus fossarum appears numerously in all stations of the research area (Figure 1, Table I), except in Stations 8C4 and 2Z1.

Hypogean crustaceans, P. slavus and Niphargus sp., are quite rare (Figure 1) as they are caught regularly at Station 2Z1 only, and very infrequently elsewhere (only one sample in 18 series at the other stations).

From the vertical viewpoint, if we disregard the temporal evolution of populations and only consider the mean distribution (Figure 2 ; for Station 4 B all samples were summed up and clustered in 3 groups for the three different

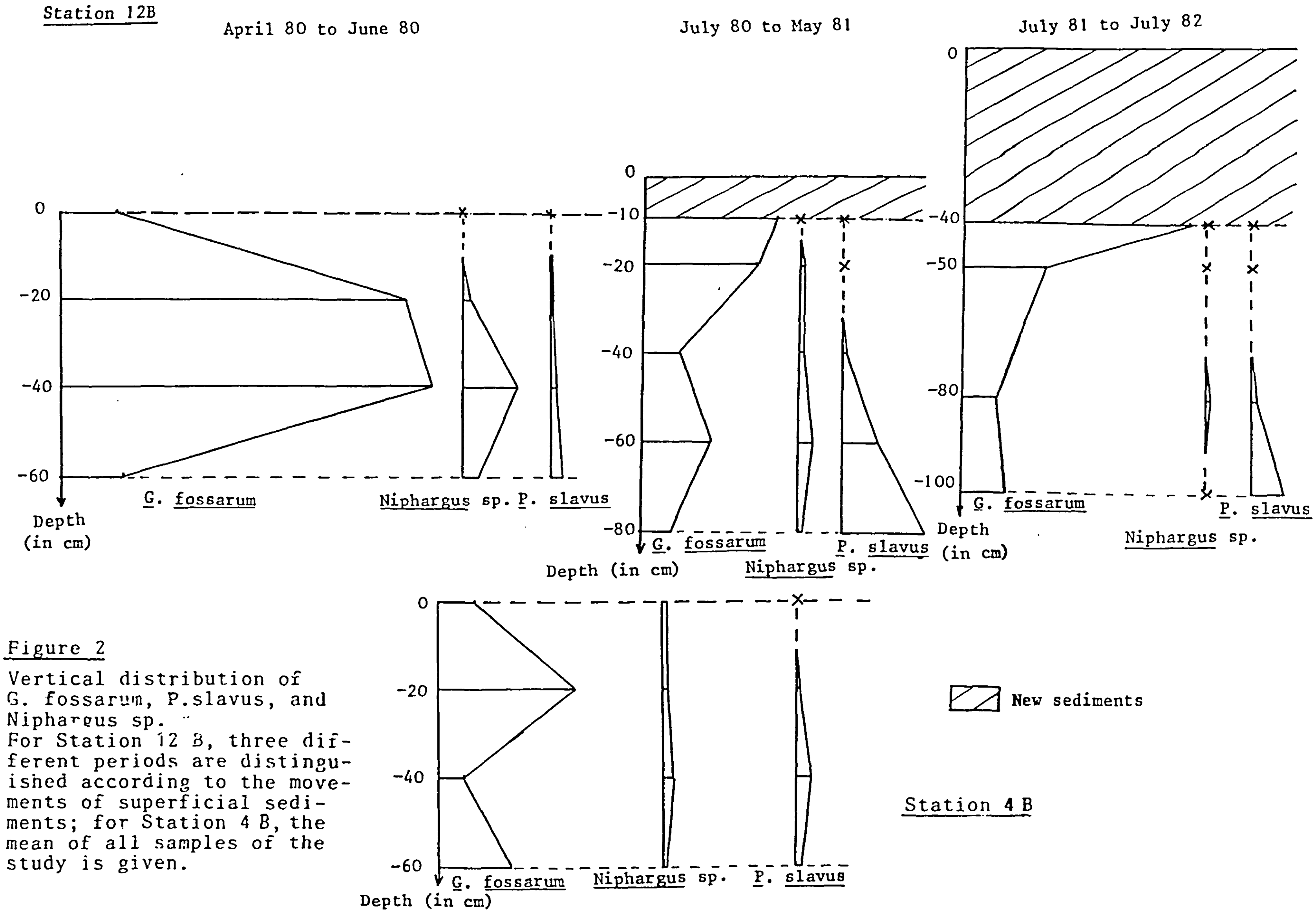

Figure 2

Vertical distribution of G. fossarum, P.slavus, and Niphargus sp.
For Station 12 B, three different periods are distinguished according to the movements of superficial sediments; for Station 4 B, the mean of all samples of the study is given.

periods at 12B), then one can observe that G. fossarum is present at the surface of the sediments but is most abundant between 20 and 40 cm depth at Station 12B and at 20 cm depth at 4B. At Stations 12B and 4B, P. slavus has never been caught at the sediment surface and is most abundant at lower depths (e.g. - 1 m at Station 12B); Niphargus sp. is rare at the surface and more abundant at 40-cm depth.

b - Discussion:

From the horizontal as well as the vertical perspective, one can notice that epigean (G. fossarum) and hypogean crustacea (Niphargus sp. and P. slavus) have contrary distribution.

The horizontal distribution of G. fossarum can be explained partly by sediment texture; G. fossarum is abundant in the main-channel stations where sediments are coarse and porous but is never found at Station 8C4 where sediments are fine with a lot of gypsum sand (BRETSCHKO pers. comm.). The absence of G. fossarum at Station 2Z1 is difficult to explain.The pipe was driven into the sediment at the bottom of a depression where the water is turbulent; there, G. fossarum was absent and Niphargus sp. and P. slavus were abundant.

The vertical distribution of these three crustacea is also opposite. G. fossarum is more abundant near the surface of sediments, although it is caught in the deeper layers down to the depth of 1 m. Niphargus sp. has an intermediate position as it is rarely collected at the sediment surface but is more frequent at 40 cm depth. These results agree with DOLE (1983b) who observed the same vertical distribution pattern for Niphargus rhenorhodanensis in Rhône River sediments. P. slavus has never been captured at the sediment surface and was more numerous at the lower depths; at Station 12B, P. slavus was most abundant at 1 m depth. The vertical distribution was a little bit different at Station 4B: at 60 cm depth, the G. fossarum frequency increased whereas the abundance of P. slavus decreased (Figure 2). One of the three pipes driven to a 60 cm depth always provided samples with many very young Gammarus, from June 1980 to July 1981 (with a maximun of 28 individuals for one sample). Perhaps this pipe was driven into an interstitial micro-habitat favourable to G. fossarum.

However, it is impossible to conclude if contrary distribution of G. fossarum and the hypogean crustacea Niphargus sp. and P. slavus is caused by direct competition or by ecological differences between epigean and hypogean species.

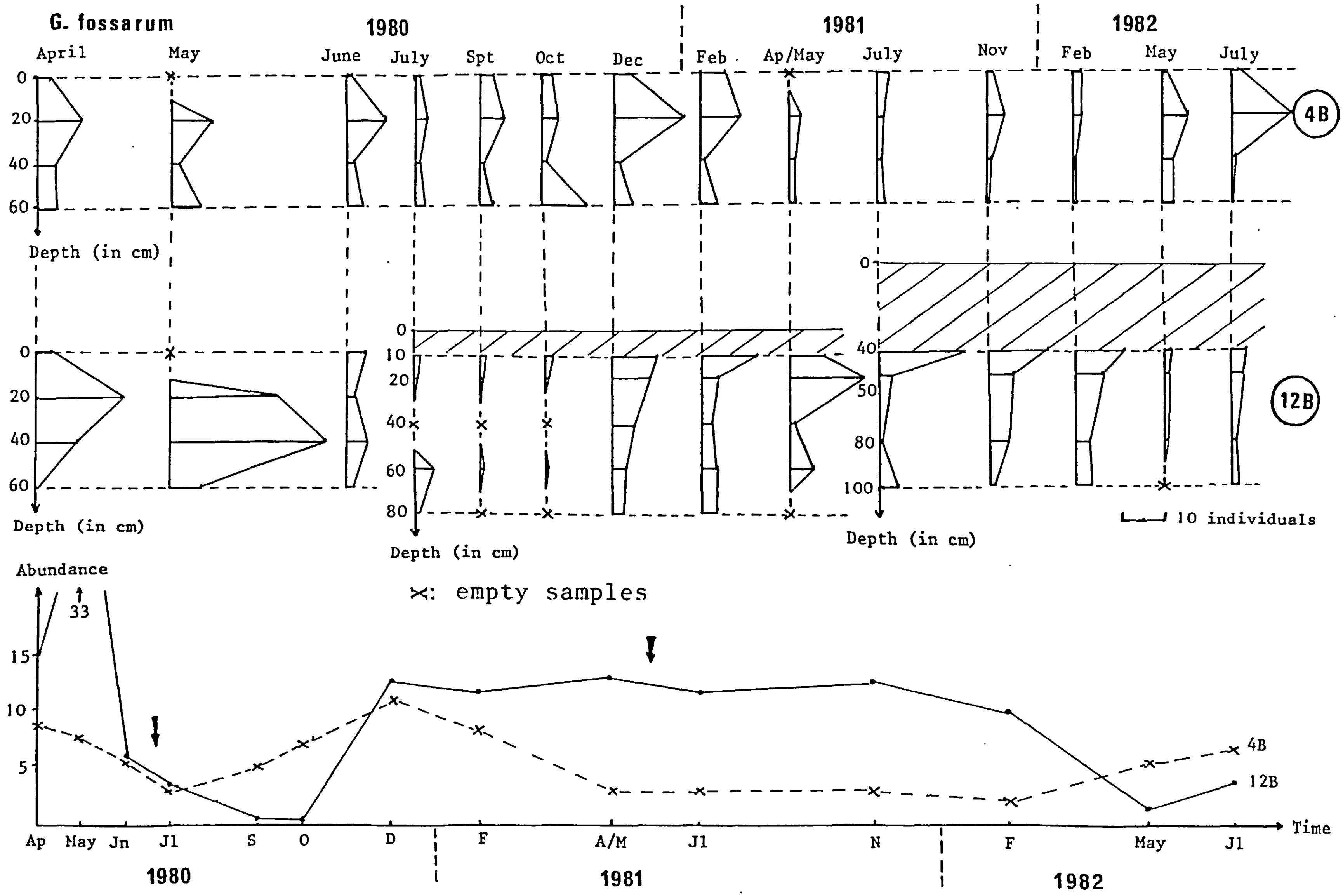

Figure 3 Vertical distribution of occurence of G. fossarum at Station 4 B and 12 B; the mean of the six samples of the bimonthly series for the different depths. For Station 12 B, the depths are corrected.

Table II : Sampling dates and depths of the vertical distribution study

Stations	Number of pipes and sampling depths	dates
4B	3 pipes at 0, -20, -40, -60 cm	all the study
12B	3 pipes at 0, -20, -40, -60 cm	April, May, June 1980
	3 pipes at 0 cm 2 pipes at -20, -40, -60, -80 cm	July, September, October, December 1980; February, April/May 1981
	3 pipes at -40, -50, -80, -100 cm	July, November, 1981; February, May, July 1982.

Table III : Occurence of Niphargus sp. and P. slavus in the samples taken at Stations 4B and 12B

	TOTAL number of samples where the species is present	Number of sample where the species is present ALONE number	%
Niphargus sp.	5I	37	72 %
P. slavus	82	68	82 %

Table IV : Abundance of G. fossarum before and after a flood at Station 4B (February 1981, mean of 3 samples at each depth).

Depths	Before the flood 6-2-81	After the flood 12-2-81
0	2,3	7,6
-20	7,3	10,3
-40	1,6	o
-60 cm	4,6	2,3

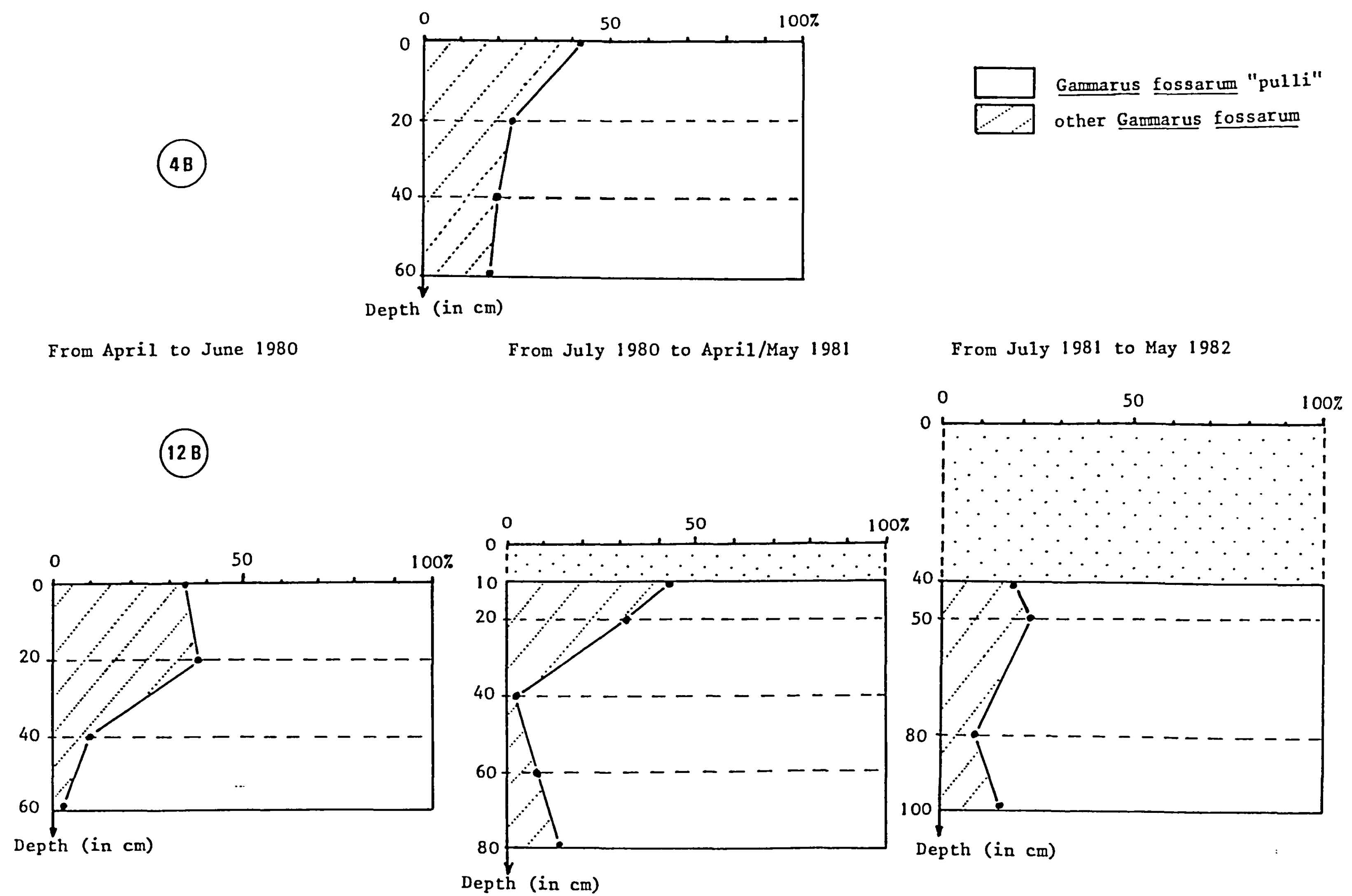

Figure 4 Vertical distribution of occurence of Gammarus fossarum "pulli" (individuals with a length ≤2mm) and of other G. fossarum (individuals with a length >2 mm). For details, see Fig. 2.

During all of this study we have noticed that Niphargus sp. and P. slavus have the same pattern of vertical distribution. Could it be concluded that these species co-habit in the Seebach sediments? Instead of considering the spacial distribution of the species, if we now examine every sample taken as a single unity, then we can notice that Niphargus sp. and P. slavus are rarely found together in the same sample, even if they are present at the same depth in the sediments (Table III). Therefore, the ecological preferences of the two species seem to be very close; their spacial distribution is almost identical, but they seem to exclude each other in the Seebach sediments.

3 - Temporal evolution of G. fossarum, Niphargus sp. and P. slavus.

a - Results

The temporal evolution of G. fossarum abundance (Figure 3) is very different at Stations 4B and 12B and does not seem to follow any seasonal cycle. At Station 4B, where no superficial sediment movements have been noticed, the surface samples are smaller, even empty, during the high-water periods (May 1980 and April-May 1981), and catch abundance was greatest in all samples at 20 cm depth. At Station 12B, where the sample depth varied during the study (Table II), the catch abundance was greatest between 20 and 40 cm depth during all the study: the three pipes, originally at the surface of the sediment at the beginning of the study, provided the most numerous samples at the end of the study, by which time they had been covered by 40 cm of gravel.

If we distinguish two different size-groups in G. fossarum: the "pulli" (around 2 mm long, animals just out from the mother's marsupium) and the older ones, then we can compare the importance of the younger animals at the different depths (Figure 4). At Stations 4B and 12B (at the beginning of the study) the larger G. fossarum were more numerous at the sediment surface (down to 20 cm depth in 12B). But when superficial sediments covered the pipes at the Station 12B, the G. fossarum "pulli" represented about 80 % of the population at each depth.

The catch abundance of Niphargus sp. (Figure 5) follows a similar evolution in Stations 4B and 12B; they were more numerous in the beginning and decreased as study progressed until 1982, when they were very rare.

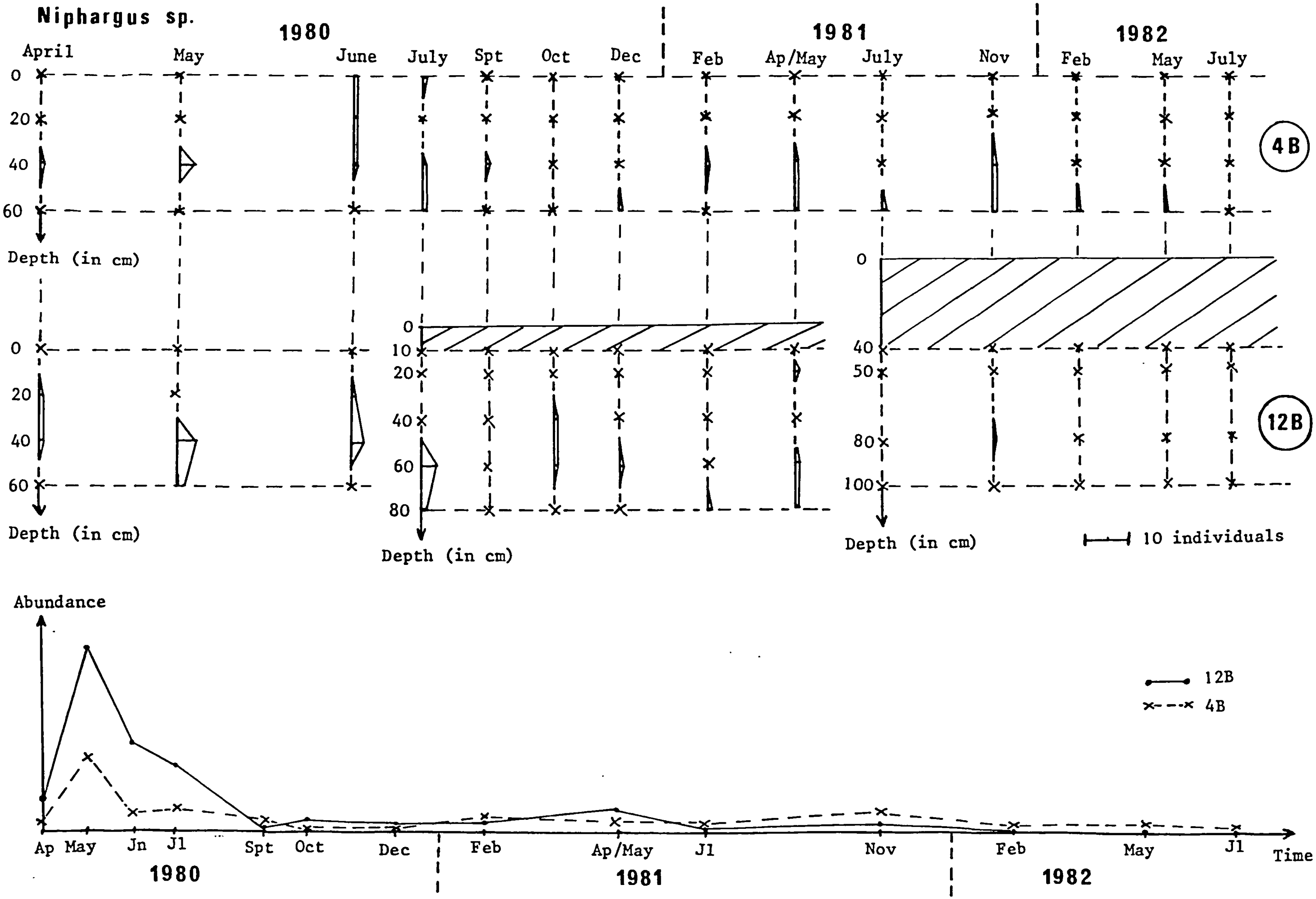

Figure 5 Vertical distribution of occurence of Niphargus sp. caught at Stations 4 B and 12 B. (For details, see Fig. 3)

For P. slavus (Figure 6), the temporal evolution of the samples was different at the two stations. P. slavus were more numerous at Station 12B and continued as such throughout the study.

The vertical distribution of Niphargus sp. and P. slavus does not seem to be affected by the movements of superficial sediments at Station 12B.

b - Discussion:

The interstitial habitats of lotic systems have often been considered as a refuge for the benthic invertebrates with respect to high water velocity and gravel movements during floods (ARGELIER 1953, RUFFO 1961, BISHOP 1973, HYNES 1974, DOLE 1983a, BOISSON 1984 and GASCHIGNARD 1985). In the Seebach, one can envision a flight reaction by G. fossarum during spring high water, when it disappears from the superficial sediments. Nevertheless, we must be careful with this interpretation. Firstly, there is no systematic correlation between the Seebach discharges and the catch abundance of G. fossarum at the surface of the sediments; during the fall high water for example, G. fossarum is still present at the surface. Secondly, if we consider for example the two samples of February 1981, which were before and after a rapid increase of discharge (about 25 cm increase: Figure 7 and Table IV), then the abundance of G. fossarum was greater after the flood than before. The discharge of the brook does not always influence the population of the sediment surface, and some other factors such as species life history or water quality can modify the vertical distribution of invertebrates in brook sediments.

It appears that G. fossarum adjusts its vertical distribution in response to movements of the superficial sediments to maintain the same depth in the sediments. The newly-deposited sediments in Station 12B increased the sampling depth (although the pipes had not moved) and produced a relative increase of G. fossarum. The catch abundance remained highest between 20 and 40 cm throughout the study. This amphipod seems to colonise the newly-deposited sediments, even if it is still present at 1 m depth in the gravel.

As cited earlier (PIPER 1978, GASCHIGNARD 1985), the young G. fossarum often represent 80 % of sample taken lower than 40 cm depth, and the older G. fossarum are more numerous at the surface.

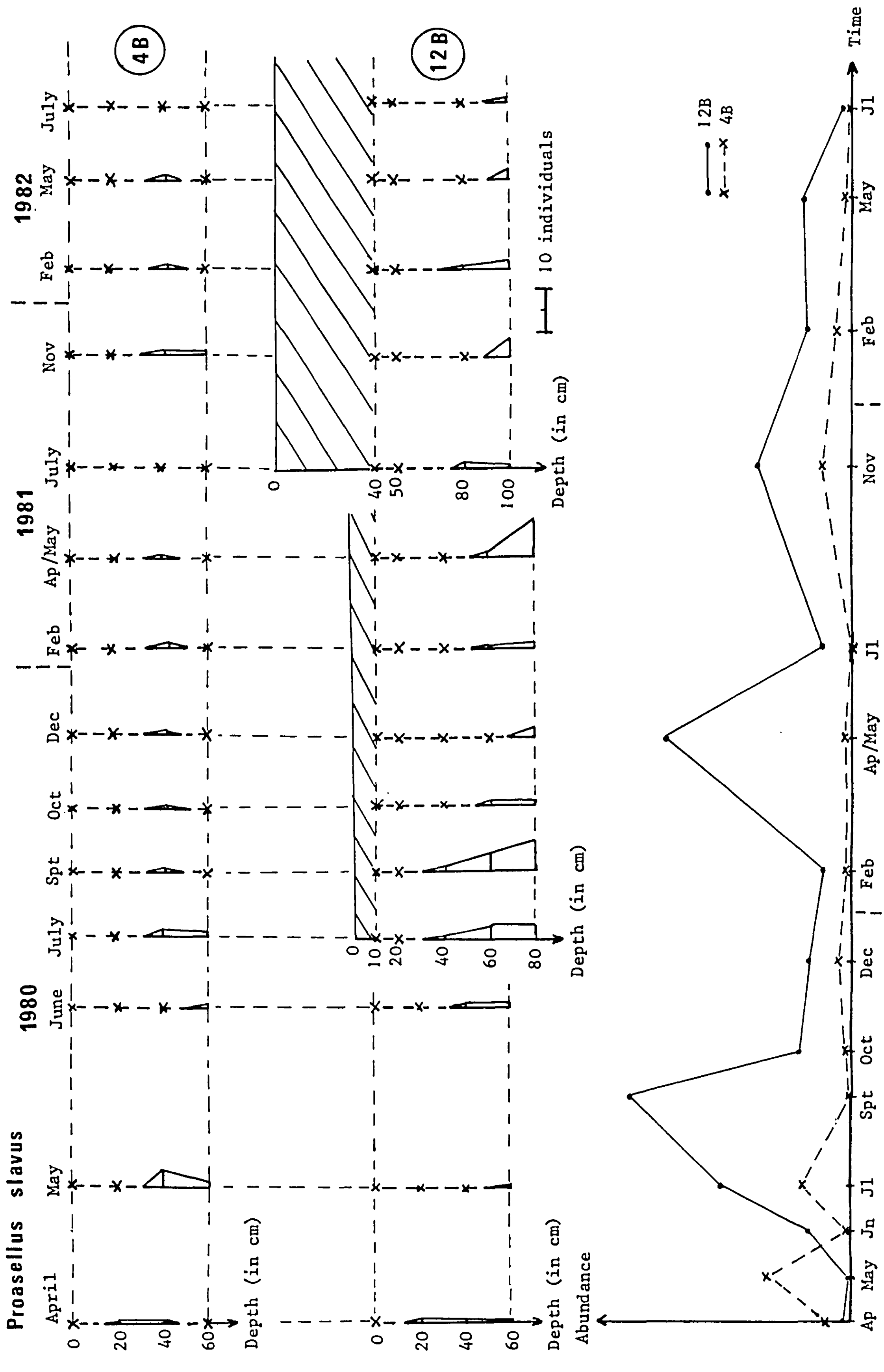

Figure 6 Vertical distribution of occurence of Proasellus slavus caught at Stations 4 B and 12 B. (For details, see Fig. 3)

Finally, the vertical distribution of Niphargus sp. and P. slavus was not modified by flooding nor by sediment movements. These hypogean crustacea do not seem to be affected by modifications in the superficial sediments.

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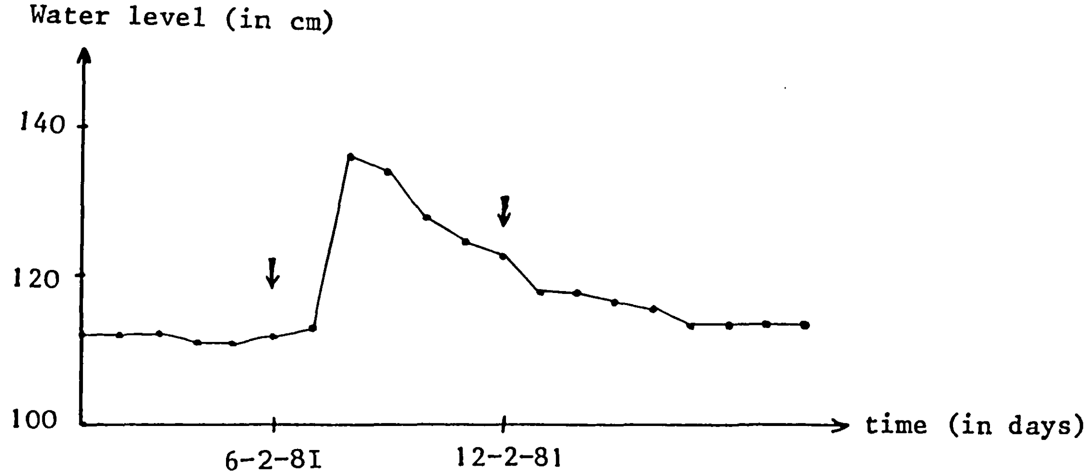

Figure 7 Evolution of water level during the February 1981 sampling period. Arrows: sampling dates.

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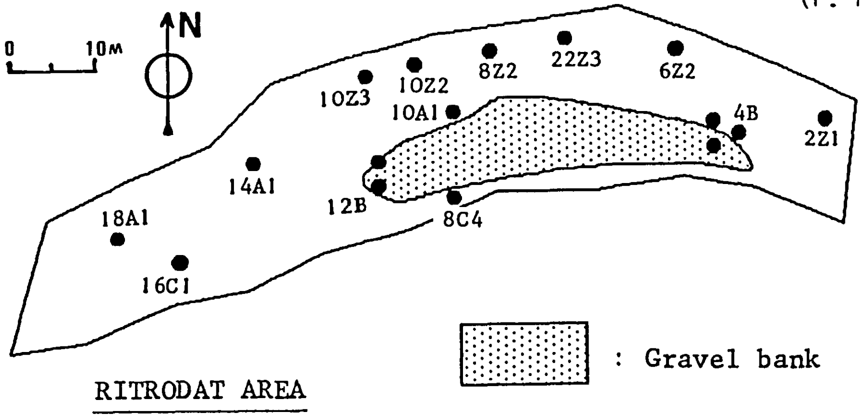

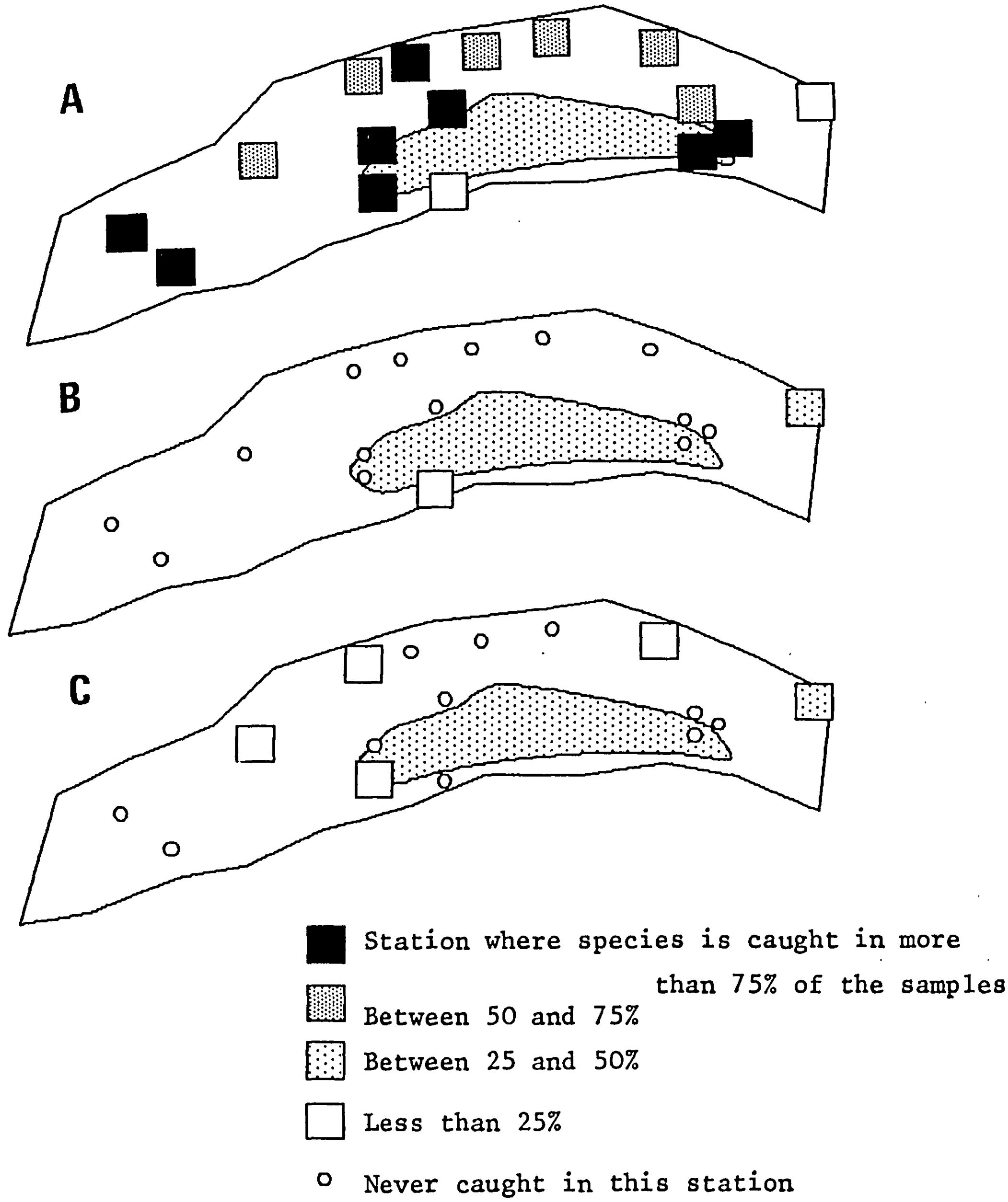

Figure 1 Location of sampling stations in the RITRODAT Area, and horizontal distribution of A - Gammarus fossarum
B - Proasellus slavus
C - Niphargus sp.