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VERTICAL DISTRIBUTION AND TEMPORAL EVOLUTION OF THE OSTRACOD ASSEMBLAGE OF THE SEEBACH SEDIMENTS (LUNZ - AUSTRIA)

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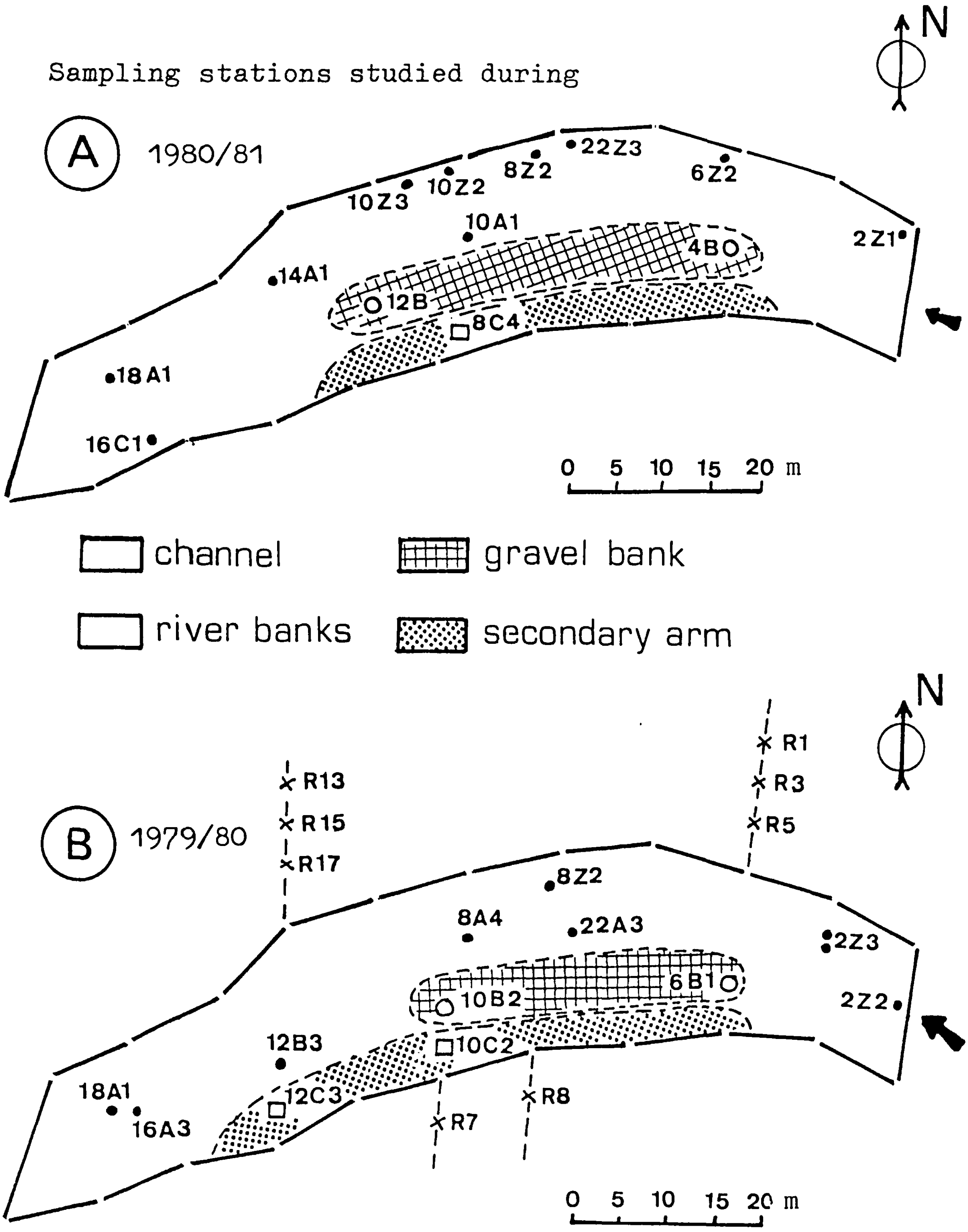
The occurrence of invertebrates in gravel beds of streams has been known for a long time (SASSUCHIN et. al., 1927; KARAMAN, 1935; CHAPPUIS, 1942). In the last twenty years, the movements of benthic invertebrates through the superficial riverine sediments became an important subject of study (ANGELIER, 1953; SCHWOERBEL, 1961; HYNES, 1968). The vertical distribution of the fauna in gravel has been studied also by BOU & ROUCH (1967), COLEMAN & HYNES (1970), BISHOP (1972), WILLIAMS & HYNES (1974), GODBOUT & HYNES (1982), DANIELOPOL (1982), and the horizontal distribution by BOU (1979), and DANIELOPOL (1982).
The ostracods are commonly found in the interstitial habitats of running water systems (DANIELOPOL 1976), where epigean and hypogean dwellers are found. For instance, in the riverine sediments of the Danube, the latter are more common in the deeper layers (DANIELOPOL 1982).

Some of the information on the running water ostracods of Europe pertains to those faunistic and biogeographic studies; viz.WOLF (1919), KLIE (1943), PETKOVSKY (1962 and 1966), LÖFFLER (1961 and 1963).

In the present contribution, the ecology of ostracods living in the river bed sediments of an alpine brook, the Seebach, is dealt with. This project is included in the programme "RITRODAT-LUNZ" (Mountain Stream Ecosystem Research, BRETSCHKO 1978 and 1981a), and has two different approaches:

1 - A study of the horizontal distribution at 20 cm depth in the sediments, carried out at 13 stations chosen at random, spread throughout the RITRODAT area (fig. 1). In a previous study, we



Stations with ● dominance of C. subterranea
o - of C. subterr. and C. candida
□ - of C. candida and Ps. rostrata
✕ - of C. subterr. and Ps. bilobata

Figure 1

Location of the sampling stations in the RITRODAT area and the distribution of the main ostracod species examined the groundwaterostracods along the banks of the brook (fig. 1b). The results, which are published elsewhere (MARMONIER, in print), are summarized at the beginning of this report (first part A).

2 - A study of the vertical distribution of the ostracods, carried out at stations 4B and 12B (fig. 1a), on 12 pipes, set at 4 different levels at each station. Furthermore, these samples enable us to study the temporal evolution of the ostracod assemblage and of the most common species.

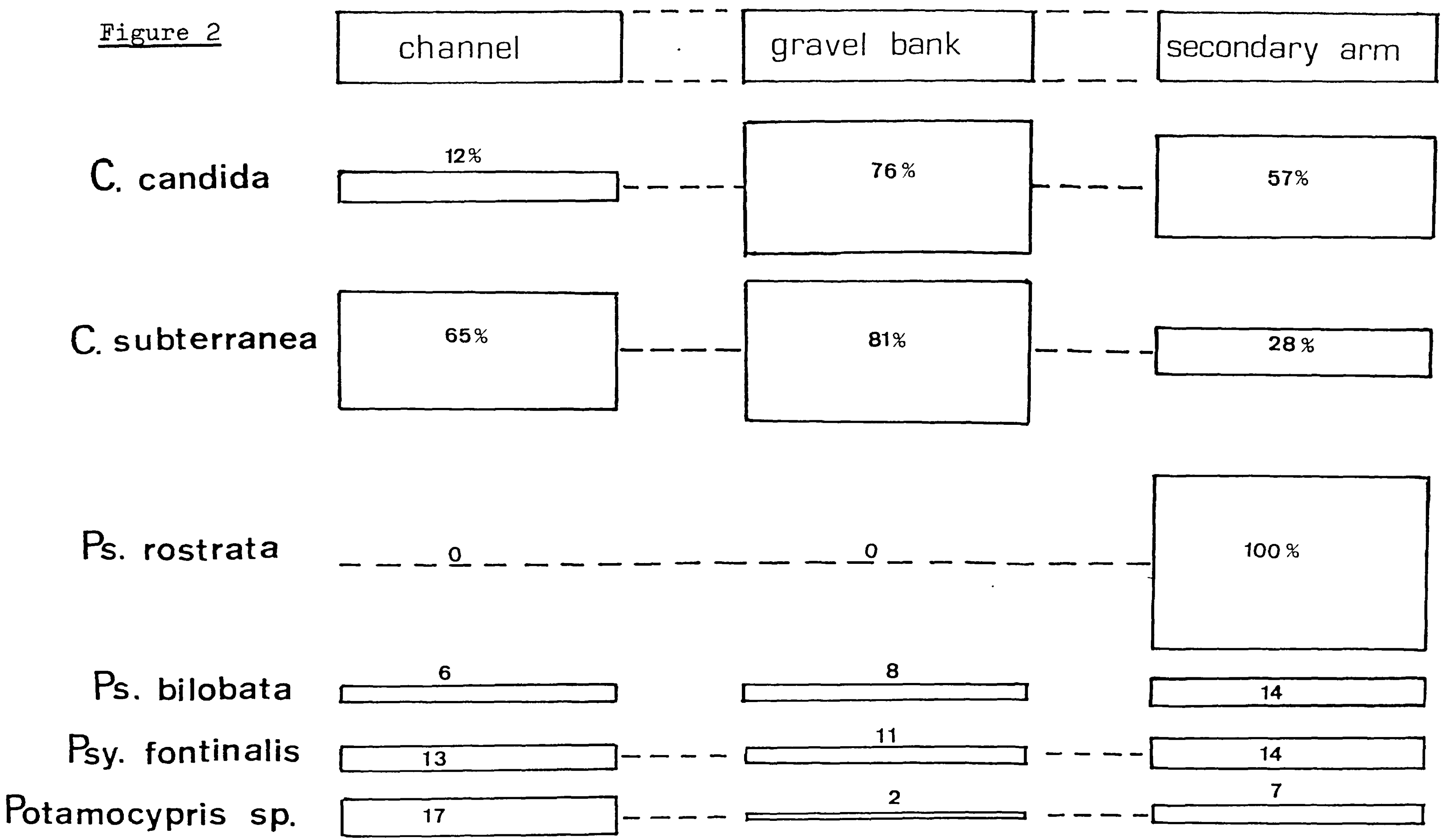
The method used to sample the fauna is that of BRETSCHKO (1980). It consists of catching the animals moving actively and those drifting inside the sediment, because of pipes with a row of holes at their extremities, which can be opened and closed from the surface. These holes are left open for 3 days. Two successive samples are taken almost every two months.

Almost 500 samples have been studied, which were taken between August 1979 and November 1981. Sixteen different species of Ostracoda were found (*: hypogean species):

Cypridopsis subterranea Wolf
Candona candida (O.F.Müller)
Candona neglecta Sars
\+ Pseudocandona bilobata (Klie)
\+ Pseudocandona aff. tyrolensis Löffler
Pseudocandona rostrata Brady & Norman
\+ Pseudocandona aff. brisiaca (Klie)
\+ Pseudocandona n. sp.
Cryptocandona aff. vavrai Kaufmann
\+ Mixtacandona aff. laisi (Klie)
Cypria lacustris Sars
Cyclocypris sp.
Eucypris pigra (Fischer)
Psychrodromus fontinalis (Wolf)
Potamocypris sp.
Limnocythere sancti-patricii Brady & Robertson

This assemblage of species closely resembles the one found by LÖFFLER (1961) and PETKOVSKI (1962 and 1966) in the springs and brooks of central Europe with cold stenothermal waters rich in calcium carbonate;

Figure 2



Frequency of occurrence of various species at -20 cm depth within the sediment for the three macrohabitats. (Percentages calculated on the total number of samples for each macrohabitat during the period 1980/81.)

the Seebach belongs to this type of running water (BRETSCHKO 1981a). Some of these species (Ps. aff. tyrolensis, Ps. bilobata, Mixtacandona aff. laisi) are hypogean species which have been found in other parts of the drainage basin of the Danube and of the Rhine (LÖFFLER and DANIELOPOL 1978).

A - Some remarks about the horizontal distribution of the ostracods in the RITRODAT area

This study made on 16 pipes, pushed down to the depth of 20 cm within the sediment, at the 13 different stations, enable us to observe discontinuities in the distribution of the different species. Figure 1 a shows the location of the pipes and the topography of the RITRODAT area. Three sectors can be distinguished following the morphology of the brook and the distribution of the ostracods (fig. 1a and 2):

a) The main channel, which is particularly heterogeneous and where the ostracod C. subterranea is dominant (fig. 2). The central part of the channel (fig. 1a, stations 8Z2, 10A1, 10Z2, 10Z3 and 14A1) with high water velocity (from 0,52 to 0,92 m/sec, on Nov. 26,1980), retains no permanent ostracod populations. The ostracods caught were most probably drifting in the interstitial water. Ostracod populations are small and fluctuate (tab. 1), the number of caught species is low (tab. 2), the ostracod assemblages are dominated by C. subterranea and therefore the Simpson's diversity index D is high (tab. 3).

Upstream and downstream of this area, at stations 2Z1, 6Z2, and 16C1 (fig. 1a), where water velocity is not as high (from 0,03 to 0,63 m/sec., BRETSCHKO pers. comm.), ostracod populations are more abundant, but with fluctuating densities (tab. 1). The number of species caught is sometimes high (tab. 2). The Simpson's diversity index D is generally high (tab. 3). For the stations 22Z3 and 18A1, where the characteristics of the water current and the sediment grain size are similar to those of the main part of the channel (BRETSCHKO, pers. comm.), the richness of ostracods (tab. 1) and their diversity (tab. 3) is difficult to account for.

Table 1: Abundance of ostracods caught at various stations during the horizontal study survey (-20 cm depth in the sediment) from September, 1980, to November, 1981. The coefficient of variation (c) is calculated after a log(x+1) transformation.
Note: only two pipes were at -20 cm at station 12B during the first part of this study.

Table 2: Number of species caught at the various stations (-20 cm depth in the sediment) during the horizontal study survey from Sept. 1980 to Nov. 1981.

Table 3: Simpson's index of diversity $D = \Sigma(\frac{n_i}{N})^2$ at the various stations of the horizontal study survey (-20 cm depth) from Sept. 1980 to Nov. 1981.

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b) The gravel bank (fig. 1a, stations 4B and 12B), where C. subterranea and C. candida are dominant, harbours abundant populations of ostracods, with less fluctuating densities (tab. 1). The number of species caught is high (tab. 2) as the taxocoene diversity: the Simpson's diversity index D is generally low (tab.3). A detailed description will be given, since vertical distribution was made in stations 4B and 12B.

c) The secondary arm (fig. 1a, station 8C4), where Ps. rostrata and C.candida are dominant, also harbours an important population which changes little (tab. 1) and with a great number of species (tab. 2), and which is well diversified (tab. 3). It can be distinguished from the other macrohabitats of the area by its sediment grain size and by the chemical composition of its interstitial water: the fine sand contains much gypsum, so the interstitial water is rich in SO_4^{--} (BERGER, pers. comm.).

The presence of more abundant and less fluctuating ostracod assemblages in the secondary arm and in the gravel bank can be explained by the lower discharge and the lower velocity of the superficial water. The biotopes where the ostracods develop abundantly are the interstitial spaces of the sediment deposit in the quiet sectors of the brook.

At least for some species, the movements between the three different zones of the RITRODAT area (channel, gravel bank and secondary arm) seem to be limited. Indeed, the percentages of the most common species caught outside their preferential areas are low (fig. 2):

Tab. 1

		2Z1	6Z2	22Z3	8Z2	10Z2	10Z3	10A1	14A1	18A1	16C1	8C4	4B 1	4B 2	4B 3	12B 1	12B 2
1980	5 spt	0	0	4	1	2	0	/	/	8	12	10	22	9	9	18	4
	8 spt	2	0	2	0	0	0	1	/	9	7	12	0	2	/	3	2
	20 oct	3	1	2	1	0	1	/	/	0	0	7	5	19	5	40	23
	23 oct	21	0	6	1	3	1	2	/	52	10	13	6	7	5	17	6
	8 dec	2	1	1	0	0	/	/	1	6	3	2	6	3	2	10	15
	11 dec	11	0	4	1	2	0	13	0	23	3	3	9	3	3	13	8
1981	6 feb	3	0	1	0	0	0	1	0	17	1	1	2	5	7	9	27
	12 feb	3	17	1	0	0	0	2	1	/	3	5	3	9	10	36	11
	30 ap	79	14	14	0	0	0	/	2	79	10	13	/	4	4	5	14
	6 ma	42	/	12	0	0	0	2	/	13	16	3	2	3	3	11	24
	3 jll	/	8	/	0	1	0	8	2	103	8	5	7	1	0		
	9 jll	/	10	/	8	2	1	12	1	206	4	39	10	23	14		
	9 nov	73	20	9	2	3	3	2	3	1	12	8	2	3	7		
	16 nov	28	10	24	2	12	1	2	9	50	2	9	13	29	5		
	X̄	16,4	6,2	6,6	1,1	1,8	0,5	4,5	2,1	43,6	6,5	9,3	6,7	8,6	5,7	16,1	13,4
	C	62,5	98,5	51,7	126,9	126,1	143,1	52,1	80,2	52,6	46,5	37,4	46,6	42,4	39,7	27,9	30,1

Tab. 2

		2Z1	6Z2	22Z3	8Z2	10Z2	10Z3	10A1	14A1	18A1	16C1	8C4	4B 1	4B 2	4B 3	12B 1	12B 2
1980	5 spt	0	0	2	1	2	0	/	/	3	3	4	3	4	2	2	3
	8 spt	1	0	1	0	0	0	1	/	2	2	3	0	1	/	2	/
	20 oct	1	1	1	1	0	1	/	/	0	0	1	2	2	2	3	4
	23 oct	2	0	1	1	1	1	2	/	5	1	4	1	2	2	3	2
	8 dec	1	1	1	0	0	/	/	1	2	1	1	1	1	1	2	2
	11 dec	2	0	1	1	2	0	1	0	2	2	2	2	1	1	3	3
1981	6 feb	1	0	/	0	0	0	1	0	2	1	1	1	2	2	1	4
	12 feb	1	3	/	0	0	0	1	1	/	1	4	2	2	2	3	3
	30 ap	4	2	4	0	0	0	/	1	4	2	6	/	3	1	3	3
	6 ma	2	/	2	0	0	0	1	/	2	2	3	2	2	2	4	5
	3 jll	/	2	/	0	1	0	2	1	7	2	3	4	1	0		
	9 jll	/	4	/	2	1	1	2	1	5	6	2	5	4	3		
	9 nov	4	2	4	2	1	1	1	1	1	3	4		2	2		
	16 nov	3	2	4	1	2	1	1	1	7	1	6	3	3	3		
	$\bar{x}$	1,8	1,3	2,1	0,6	0,7	0,4	1,3	0,8	3,2	1,9	3,1	2,2	2,1	1,9	2,6	3,2
	C	48,9	89,4	39,9	125,3	109,2	190,0	24,0	56,7	44,7	46,3	32,1	45,9	29,3	38,2	20,6	16,2

Tab. 3

Year	Date	2Z1	6Z2	22Z3	8Z2	10Z2	10Z3	10A1	14A1	18A1	16C1	8C4	4B 1	4B 2	4B 3	12B 1	12B 2
1980	5 spt	/	/	0,55	1	0,50	/	/	/	0,59	0,57	0,31	0,55	0,38	0,75	0,89	0,26
	8 spt	1	/	0,50	/	/	/	1	/	0,51	0,87	0,34	/	1	/	0,55	/
	20 oct	1	1	1	1	/	1	/	/	/	/	1	0,68	0,73	0,52	0,77	0,38
	23 oct	0,91	/	1	1	1	1	0,50	/	0,45	1	0,38	1	0,51	0,52	0,51	0,52
	8 dec	1	1	1	/	/	/	/	1	0,50	1	1	1	1	1	0,80	0,59
	11 dec	0,83	/	1	1	0,5	/	1	/	0,65	0,55	0,50	0,59	1	1	0,72	0,59
1981	6 feb	1	/	1	/	/	/	1	/	0,53	1	1	1	0,68	0,59	1	0,35
	12 feb	1	0,44	1	/	/	/	1	1	/	1	0,28	0,33	0,62	0,65	0,84	0,48
	30 ap	0,81	0,55	0,46	/	/	/	/	1	0,55	0,80	0,16	/	0,33	/	0,36	0,59
	6 ma	0,95	/	0,84	/	/	/	1	/	0,72	0,87	0,33	0,50	0,55	0,33	0,45	0,39
	3 jll	/	0,59	/	/	1	/	0,78	1	0,56	0,72	0,37	0,33	1	/		
	9 jll	/	0,38	/	0,78	1	1	0,80	1	0,84	0,35	0,55	0,31	0,40	0,74		
	9 nov	0,87	0,58	0,48	0,50	1	1	1	1	1	0,71	0,26	/	0,33	0,68		
	16 nov	0,74	0,52	0,51	1	0,84	1	1	1	0,54	1	0,43	0,62	0,51	0,44		
	$\bar{x}$	0,91	0,63	0,78	0,89	0,83	1,0	0,91	1,0	0,62	0,80	0,49	0,62	0,64	0,65	0,69	0,45

Ps. rostrata never appears outside the secondary arm, at least in the upper 20 cm of the sediment.

C. candida only appears in 12% of the channel samples.

C. subterranea appears in 28% of the samples from the secondary arm.

Therefore, the ostracods seem to limit their distribution strictly to the areas which are the more propitious. Only C. subterranea is able to colonise most of these macrohabitats, that is the channel sediments and those of the gravel bank.

The samples collected from August 1979 to April 1980, at 13 stations placed in the bed of the brook at different depths (from 15 to 50 cm) give us a similar picture of the ostracod horizontal distribution (fig. 1b) to the one discussed above. The given division in 3 sectors is stable in time, over two years.
During this first study, the ground water of the banks was sampled in 8 stations distributed along 4 transects perpendicular to the brook (fig. 1b, stations noted "R"). These samples show a strong asymmetry between the two banks: those made on the left bank, at stations R7 and R8 (fig. 1b) are empty most of the time (tab. 4), but those made on the right bank, at stations R1, R3, R5 and R13, R15, R17 (fig.1b), are more densely populated (tab. 4). The sediment of the left bank is very thin and rich in gypsum, therefore its porosity is low (BRETSCHKO, pers. comm.). This low porosity could explain the low number of catches in this bank. The most frequently caught species in the groundwater, are Ps.bilobata (36% of the ostracods caught) and C. subterranea (40%).

In the Mittersee (a little lake situated about 5 km upstream from the RITRODAT area), a dense population of the ostracod Limnocythere sancti-patricii has developed. This species never settled or developed a population in the RITRODAT sediments. Only one individual of this species was found in the channel of the Seebach, at a depth of 15 cm. This individual must have passively drifted from the Mittersee.

Abundance of ostracods caught from August, 1979, to April, 1980, in the groundwater pipes located on the banks of Seebach in the RITRODAT Ares.

Tab. 4		R1	R3	R5	R13	R15	R17	R7	R8
1979	17 aug	2	8	2	0	8	0	2	0
	20 aug	0	2	2	0	2	3	0	0
	17 spt	2	/	/	1	13	1	/	0
	20 spt	0	11	4	0	8	7	1	0
	22 oct	0	7	1	0	/	4	0	0
	25 oct	0	4	1	0	8	4	0	0
	19 nov	0	11	3	7	7	7	1	0
	22 nov	0	1	0	0	8	5	0	0
	17 dec	1	0	0	4	/	0	0	0
	20 dec	1	1	0	0	4	0	0	0
1980	18 jan	0	0	0	0	4	0	0	0
	21 jan	0	0	1	0	0	0	0	0
	18 feb	0	0	1	0	0	6	0	0
	21 feb	0	/	2	0	0	/	0	0
	17 mar	0	0	1	0	6	2	0	0
	21 ap	1	/	1	1	3	0	0	1
	24 ap	6	7	9	0	13	/	/	0

	R1	R3	R5	R13	R15	R17	R7	R8
% empty *	64%	35%	25%	76%	18%	40%	80 %	94%
$\bar{X}$	0,76	3,71	1,75	0,76	5,60	2,6	0,26	0,05
C	154,6	92,8	80,3	211,2	56,7	92,2	213,8	23284,3

* empty samples all over the study
c: coefficient of variation (calculated after a log (x+1) transformation)

B - Vertical distribution of the ostracods

1 - Sampling strategy. Duration of the study

This study about the vertical distribution was made using 12 pipes set at stations 4B and 12B (fig. 1a), at 4 different depths: 0, -20, -40 and -60 cm. During the study, the level of the pipes at station 12B was modified, because of movements in the sediments (BRETSCHKO 1982). The samples were collected almost every two months (with two successive samples for each series), between April 1980 and November 1981, representing 22 series of samples taken over 18 months.

2 - Evolution of the ostracod abundance at stations 4B and 12B

To define more clearly the evolution in the number of ostracods caught, the arithmetic mean of 6 samples has been calculated from the bimonthly series, taken at the same depth (fig. 3).

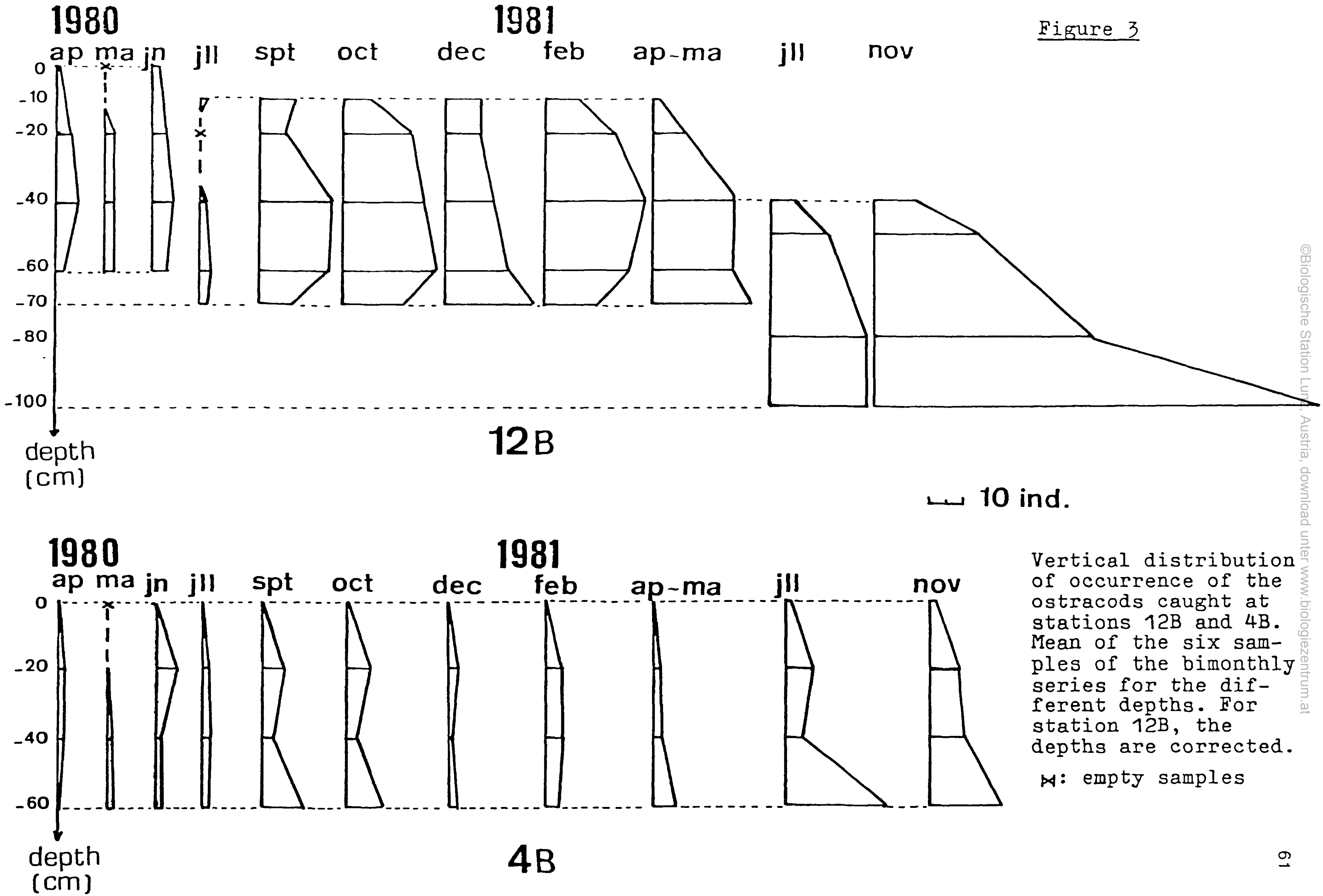
At station 12B, the catches vary greatly according to the time of year (fig. 3):

from April to July 1980, they remain insignificant at all different depths;
from September 1980 to April 1981, the abundance of the ostracods became more important (fig. 3). The greatest numbers are in the -40 and -60 cm depth;
during July and November 1981, an explosion took place with a great increase in numbers of the ostracod populations, especially at -100 cm depth.

This temporal change in abundance is well correlated with the arrival of gravel which progressively covers the station. The increased abundance of ostracods starts with some delay after the arrival of the superficial gravel: note that the sample of July 1980 remains low, whereas 10 cm of superficial gravel have already been deposited.

In comparison, station 4B is less populated (fig. 3): the number of individuals in the samples remains low until July 1980 whereas for station 12B, the number of ostracods caught increases, especially in the deepest layers. This phenomenon is puzzling, because the depths of the pipes, at station 4B, have not been

Figure 3



Vertical distribution of occurrence of the ostracods caught at stations 12B and 4B. Mean of the six samples of the bimonthly series for the different depths. For station 12B, the depths are corrected.

⋈: empty samples

modified by the movements of the sediment, until autumn 1982 (G. BRETSCHKO,pers. comm.). However, the latter did notice that before the arrival of the gravel the sediments around station 4B have been reorganised horizontally.

To better understand the causes of the evolution in the total number of ostracods caught, it is necessary to study separately the various species.

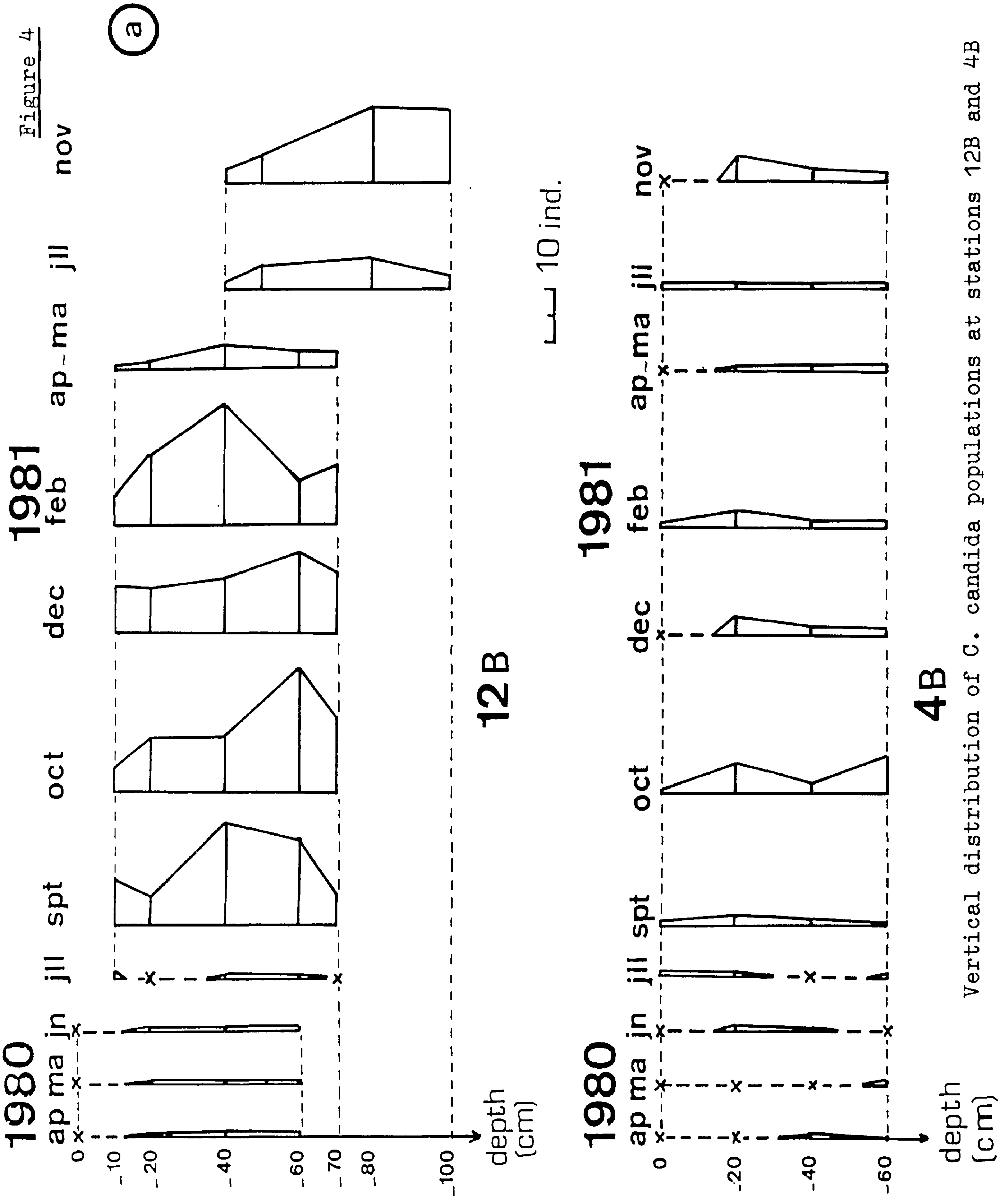
3 - Temporal evolution of the two dominant species: C. candida and C. subterranea

As to C. candida (fig. 4a and 5a), a cyclic evolution can be noted according to seasons: the most significant numbers are caught in autumn and in winter. This evolution is identical at both stations. If the coefficient of linear correlation is calculated between the percentages of C. candida in the samples from stations 4B and 12B, a highly significant value of $r = 0.957$ ($P < 0.001$) is obtained. This evolution which varies according to the season, is without doubt linked to the biological cycle of the species. A maximum of juveniles is generally found in spring and in summer (HILLER 1972), thus in March 1982, a sample taken in the Mittersee, yielded 90% of juveniles. In our "RITRODAT" samples, this maximum of juveniles is slightly delayed towards the summer and autumn, and the maximum of adults was caught during the end of the winter 1980 (fig. 6a and 6b). The first stages, which occurred during the spring are undoubtely under-sampled. The juveniles do not seem to have been lost during the handling of the samples, because the hypogean ostracods with even a smaller size are collected regularly. The first juvenile stages of C. candida may drift less easily than older individuals and might therefore be under-sampled. The problem of the drift of C. candida has already been discussed by VICTOR, DANCE & HYNES (1981) who noticed that this species, which occurred in the benthic samples, did not occur in the drift samples.

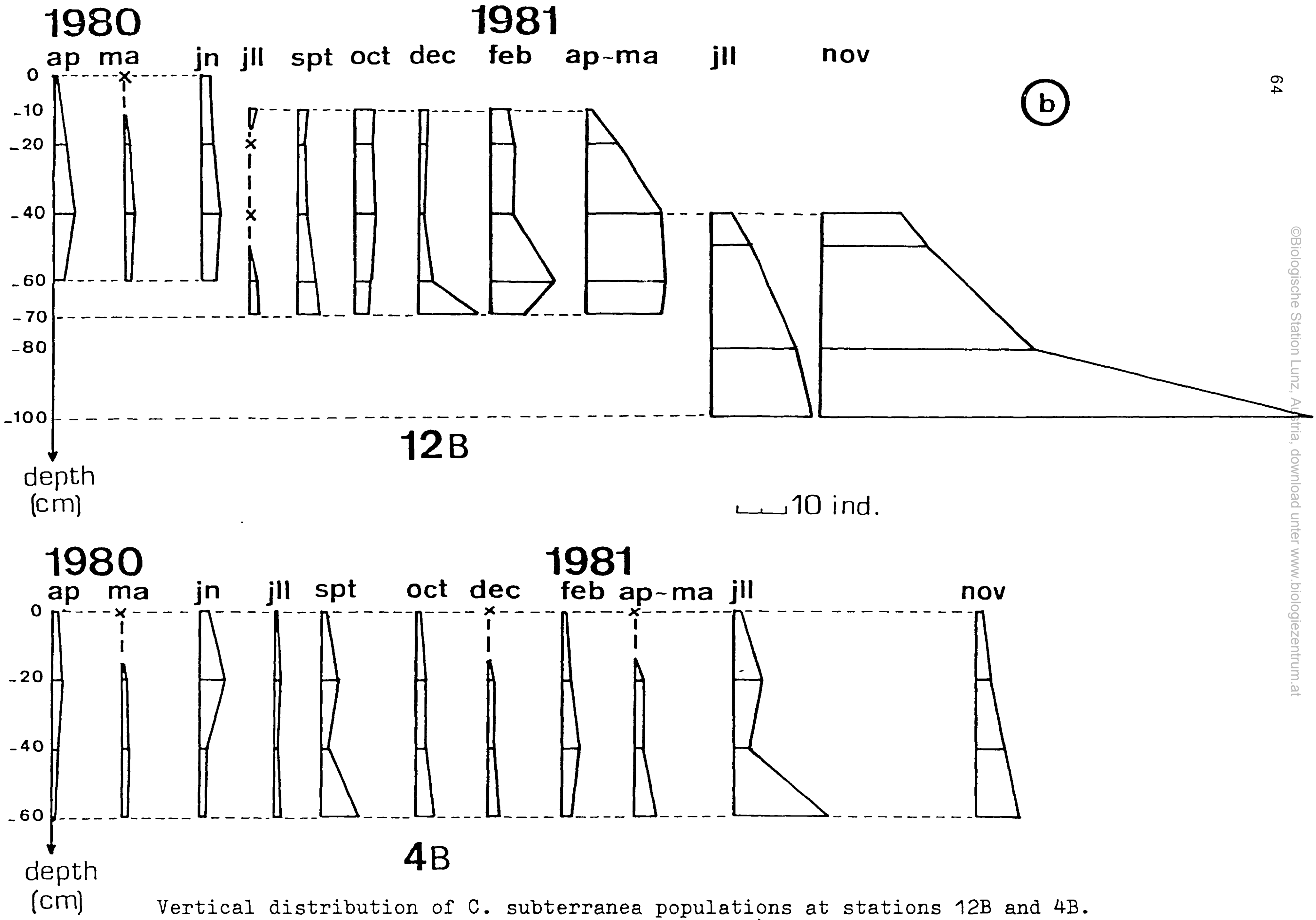
Finally, the most important numbers of C. candida are caught at the intermediate depths in sediment, from -40 cm to -60 cm, and are more scarce on the surface and in the deepest sediments (fig. 4a).

C. subterranea (fig. 4b and 5b) also follows, at stations 4B and 12B, a similar evolution of abundance, but one cannot see any

Figure 4



Vertical distribution of C. candida populations at stations 12B and 4B



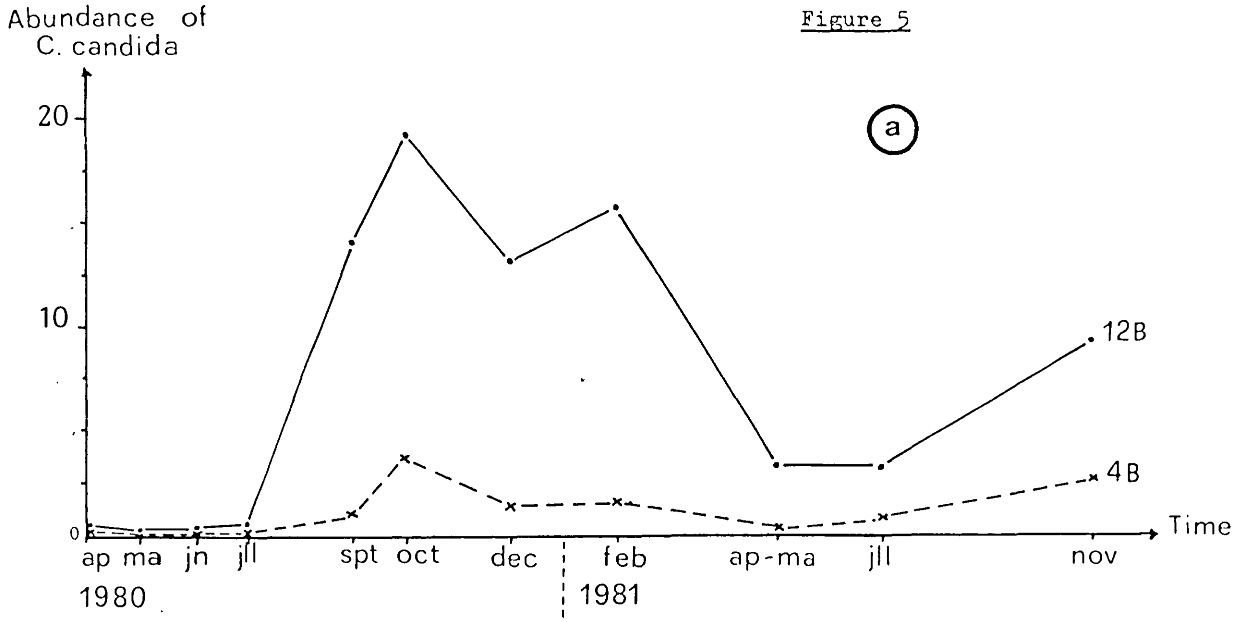
Vertical distribution of C. subterranea populations at stations 12B and 4B.
(For details of the construction, compare fig. 3)

seasonal cycle which could explain this evolution. If we study the evolution of the relative abundance of C. subterranea (percentages calculated on the total number of ostracods sampled at all the different depths, for the two series of the same month, fig. 7), one might imagine that such a seasonal cycle exists. In fact, the decrease in the relative abundance of C. subterranea observed during the winter 1980-1981 was caused by the increase of the number of C. candida caught (fig. 5a) and does not cover any decrease in the abundance of C. subterranea (fig. 5 b). Most probably, C. subterranea reproduces all year round as in most of the samples both adults and juveniles were found.
The numbers of C. subterranea (fig. 4b and 5b) are fairly insignificant until April - May 1981, then the abundance rapidly increases toward the end of the study, in the deepest sampling sites: -60 cm at station 4B and -100 cm at 12B (fig. 4b). This increase occurs at station 12B, after the arrival of the superficial gravel. For station 4B, the horizontal movements noticed in the superficial sediments around this station may explain the increase in the number of C. subterranea from July 1981 onwards (fig. 4b and 5b).

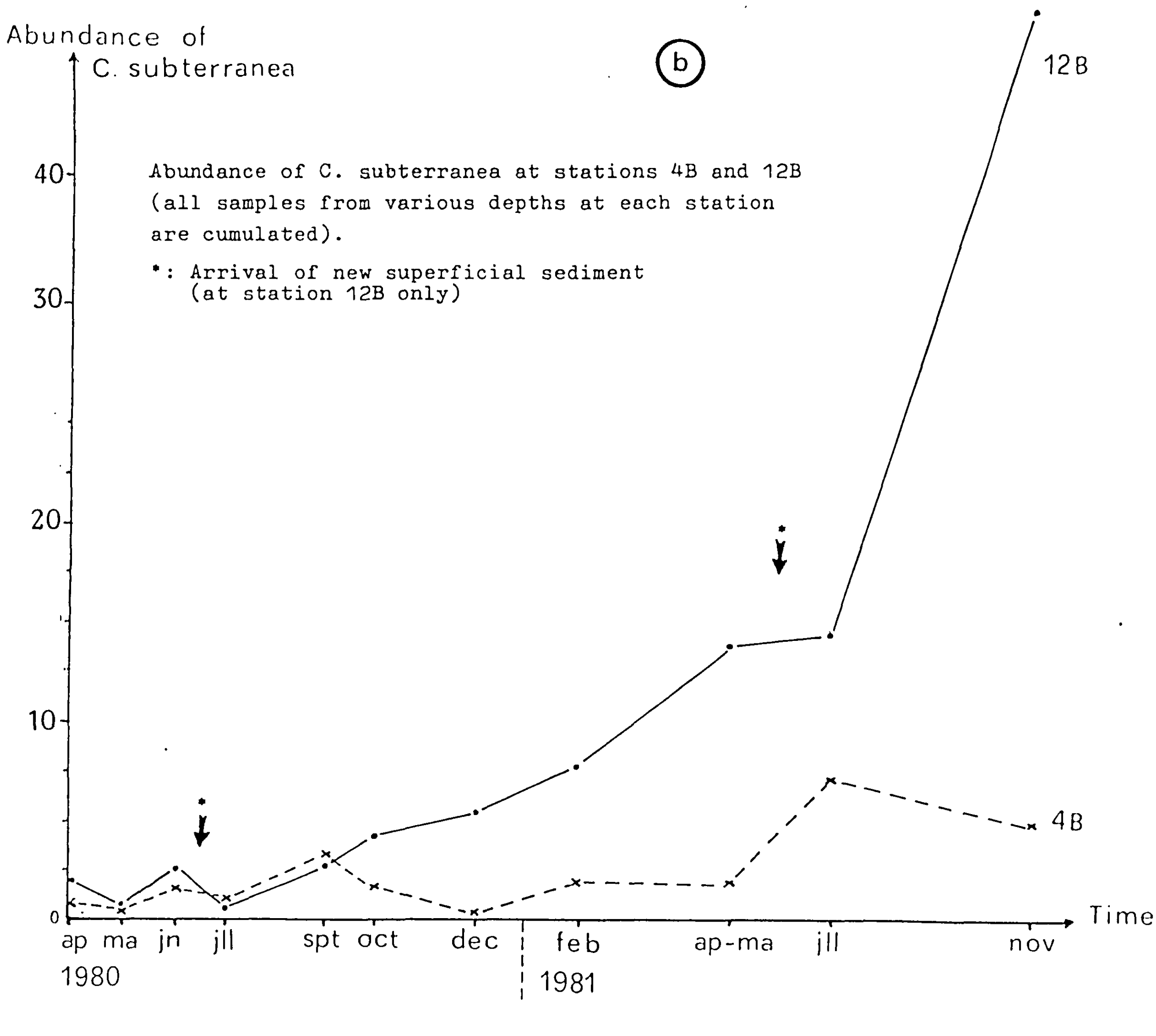
In general (fig. 5a, 5b and 7), until July 1980, C. subterranea dominates in the ostracod assemblages at station 4B and 12B. Then, from September 1980 to February 1981, as the total number of ostracods increases, C. candida becomes dominant. Finally, from April onwards, C. subterranea becomes again the most numerous species. It is difficult to explain this series of replacements. The biological cycle of those species does not explain this phenomenon (especially for C. subterranea, fig. 5b); the assemblage of ostracods is undoubtedly in full evolution (see section 6).

For distinct series of samples, C. candida and C. subterranea cannot be clearly separated according to depth (fig. 4a and 4b), but when the total number of C. candida and C. subterranea sampled at the different depths during the two last periods of the study (from September 1980 to February 1981 and from April - May 1981 to November 1981, fig. 8) is cumulated, it can be noticed that C. candida reaches the maximum abundance at the intermediate depths, whereas C. subterranea, even if present at the surface of the sediment, develops maximum populations at a lower depth

Figure 5



Abundance of C. candida at stations 4B and 12B (the samples from various depths of each station are cumulated).

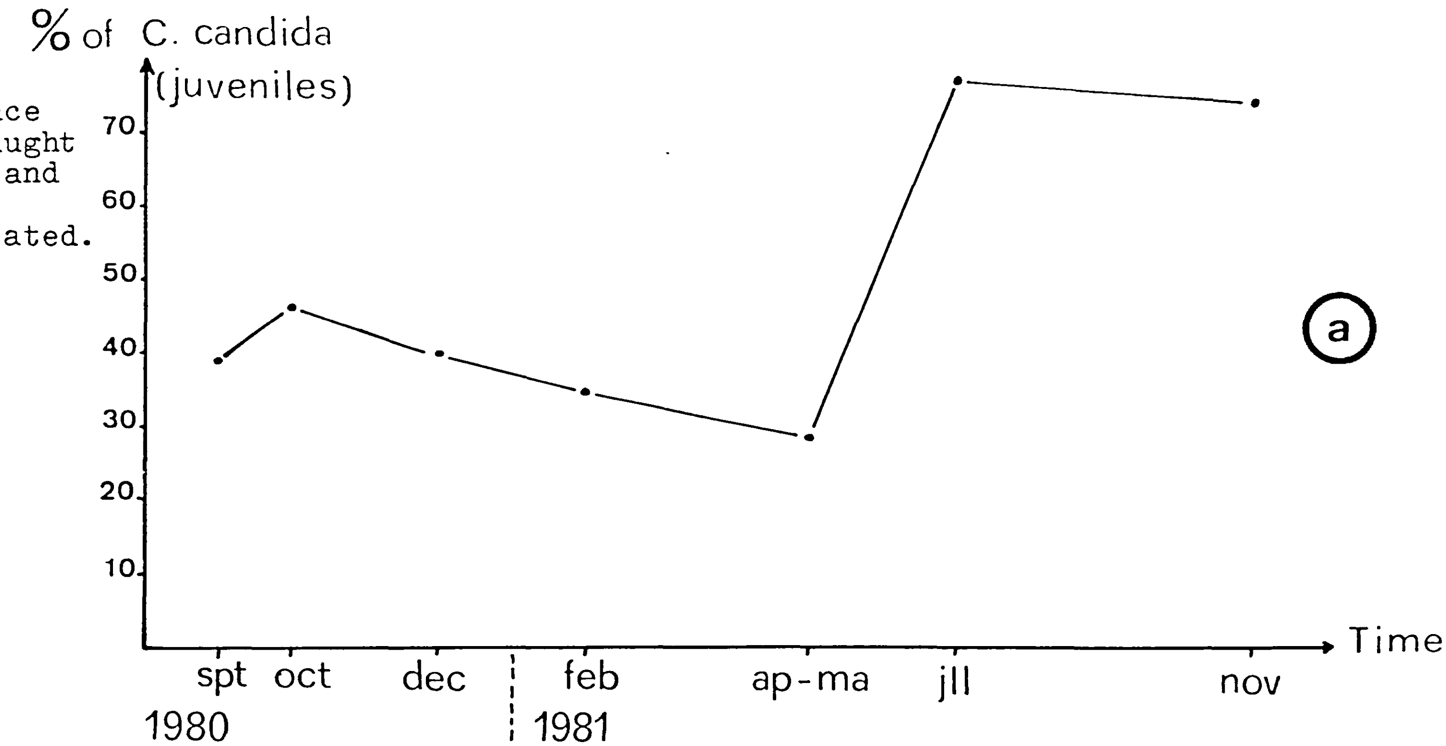


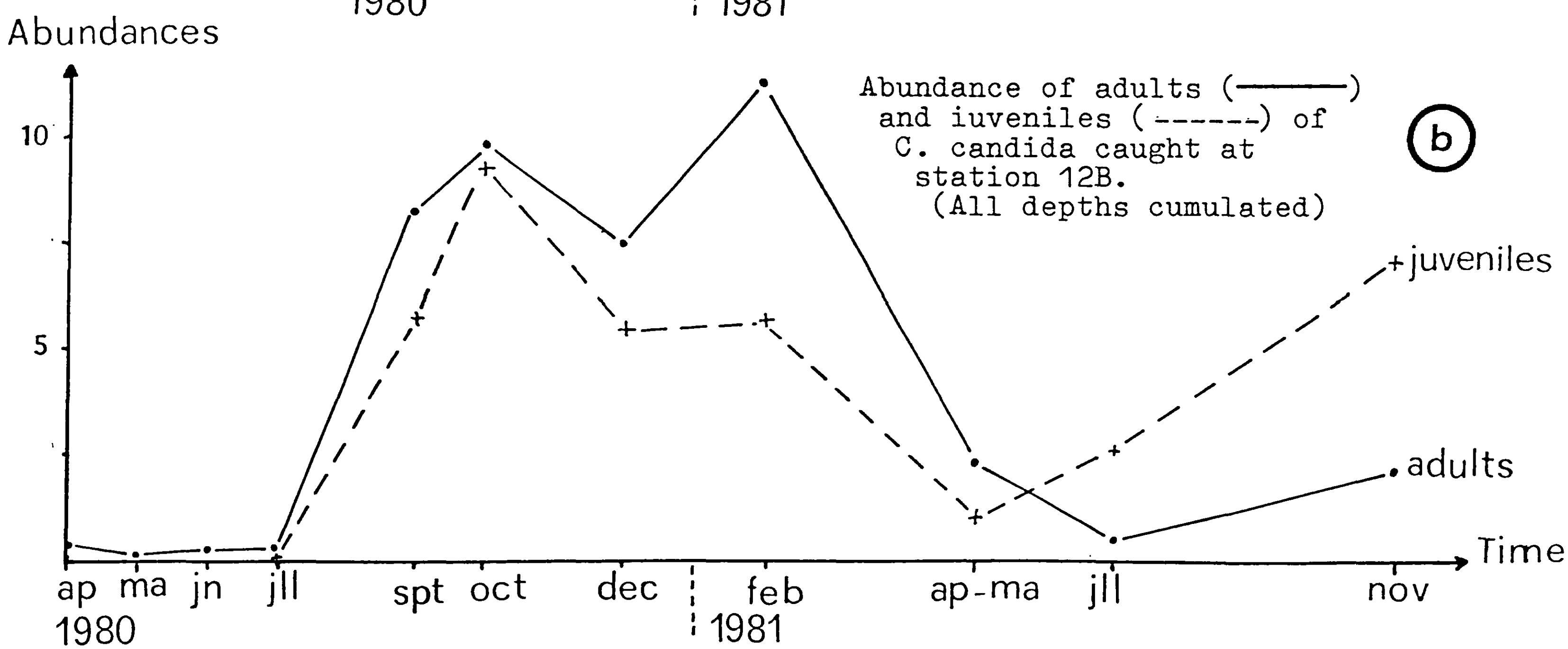
Abundance of C. subterranea at stations 4B and 12B (all samples from various depths at each station are cumulated).

*: Arrival of new superficial sediment (at station 12B only)

Figure 6

Relative abundance of C. candida caught at stations 12B and 4B.
All depths cumulated.





Abundance of adults (———) and iuveniles (------) of C. candida caught at station 12B.
(All depths cumulated)

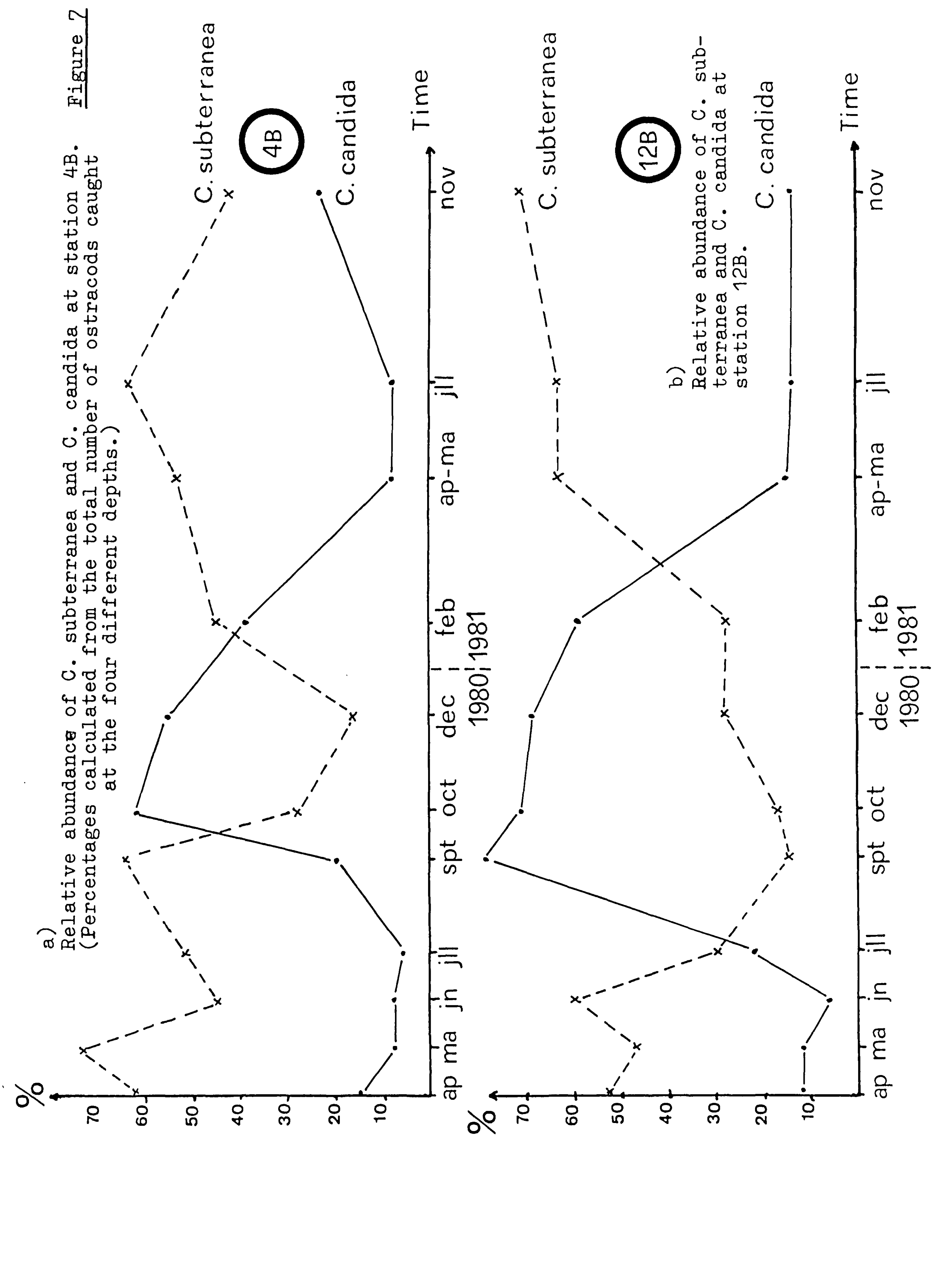


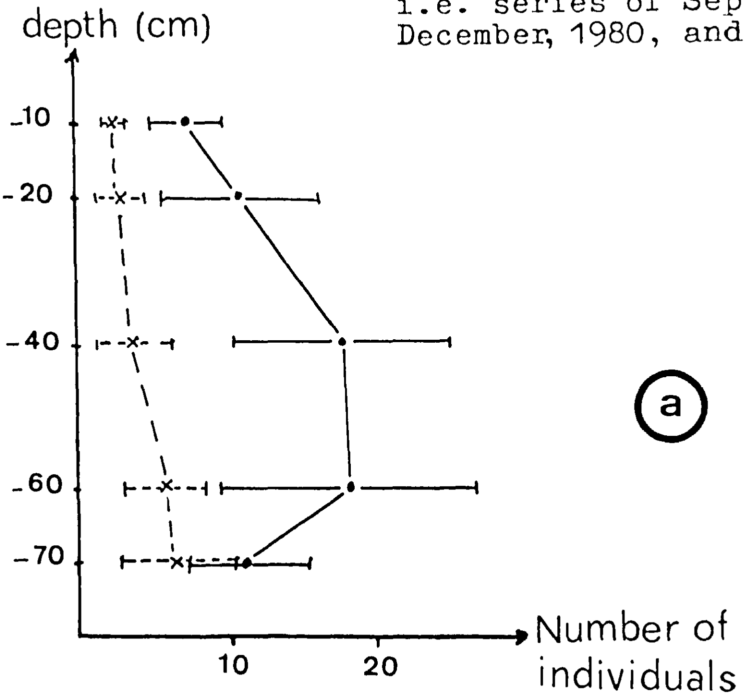
Figure 7

a) Relative abundance of C. subterranea and C. candida at station 4B. (Percentages calculated from the total number of ostracods caught at the four different depths.)

b) Relative abundance of C. subterranea and C. candida at station 12B.

Fig. 8 a

Vertical distribution of abundance of C. candida and C. subterranea at station 12B. Cumulated samples of the period of dominance of C. candida, i.e. series of September, October, December, 1980, and February, 1981.



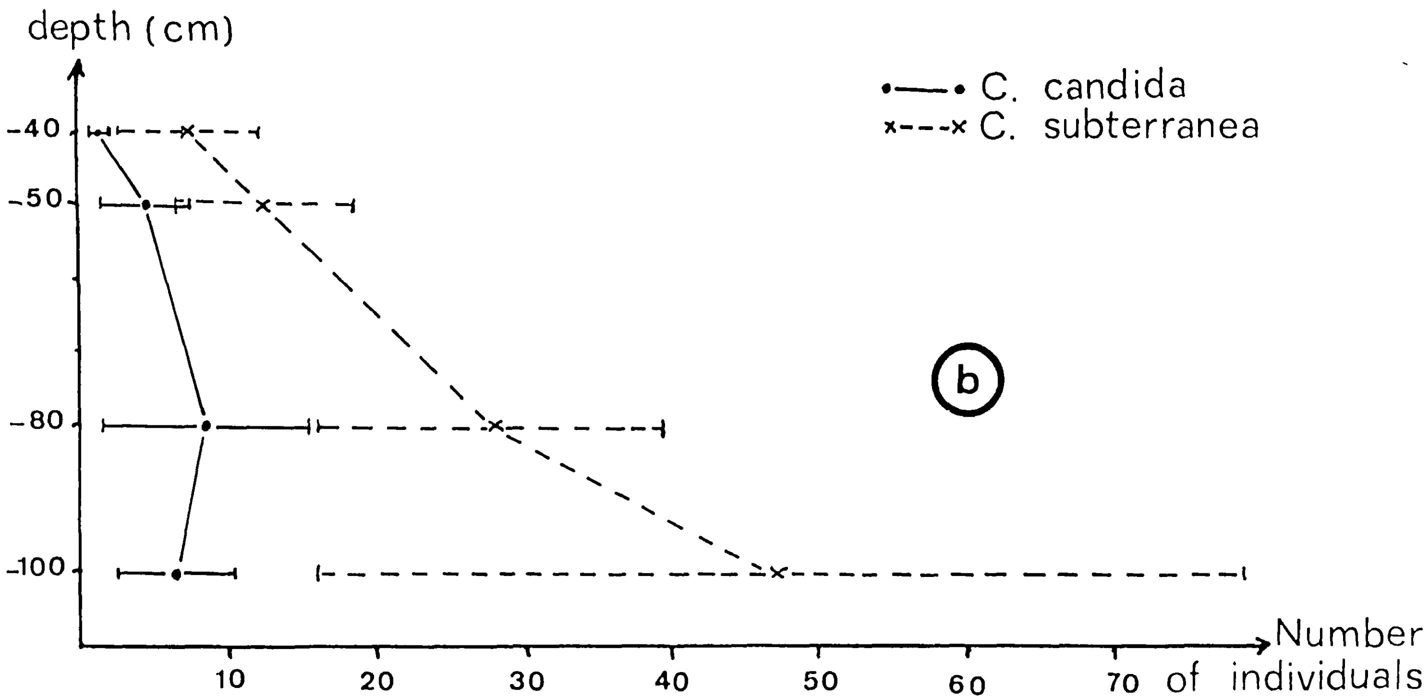
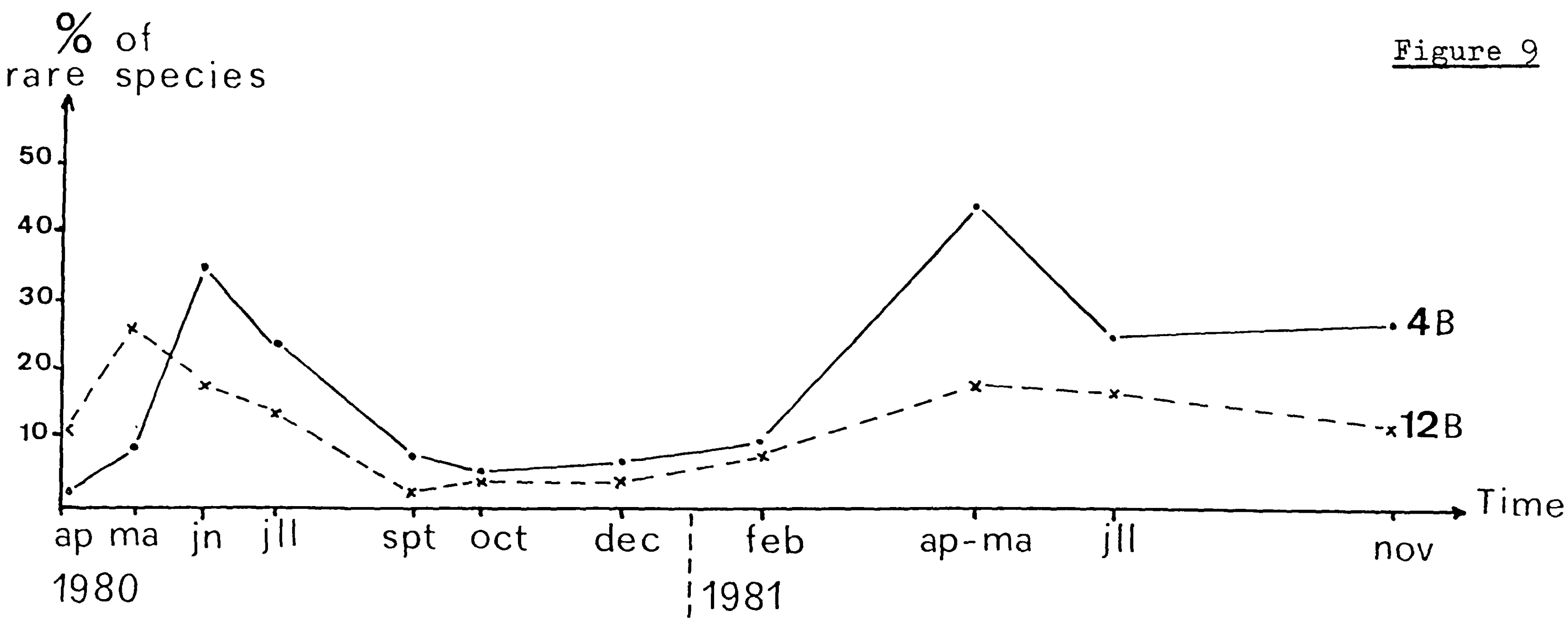


Figure 8b

Vertical distribution of abundance of C. candida and C. subterranea at station 12B. Cumulated samples of the period of dominance of C. subterranea, i.e. series of April/May (depths corrected), July, and November, 1981.

Figure 9



Relative abundance of rare species of ostracods in the RITRODAT Area sites 4B and 12B. Percentages calculated from the total assemblages at the two stations. Rare species: all except Candona candida and Cypridopsis subterranea.

Fig. 10 :
Shannon and Weaver diversity index H' calculated with the mean of all the bimonthly samples at stations 4B and 12B.

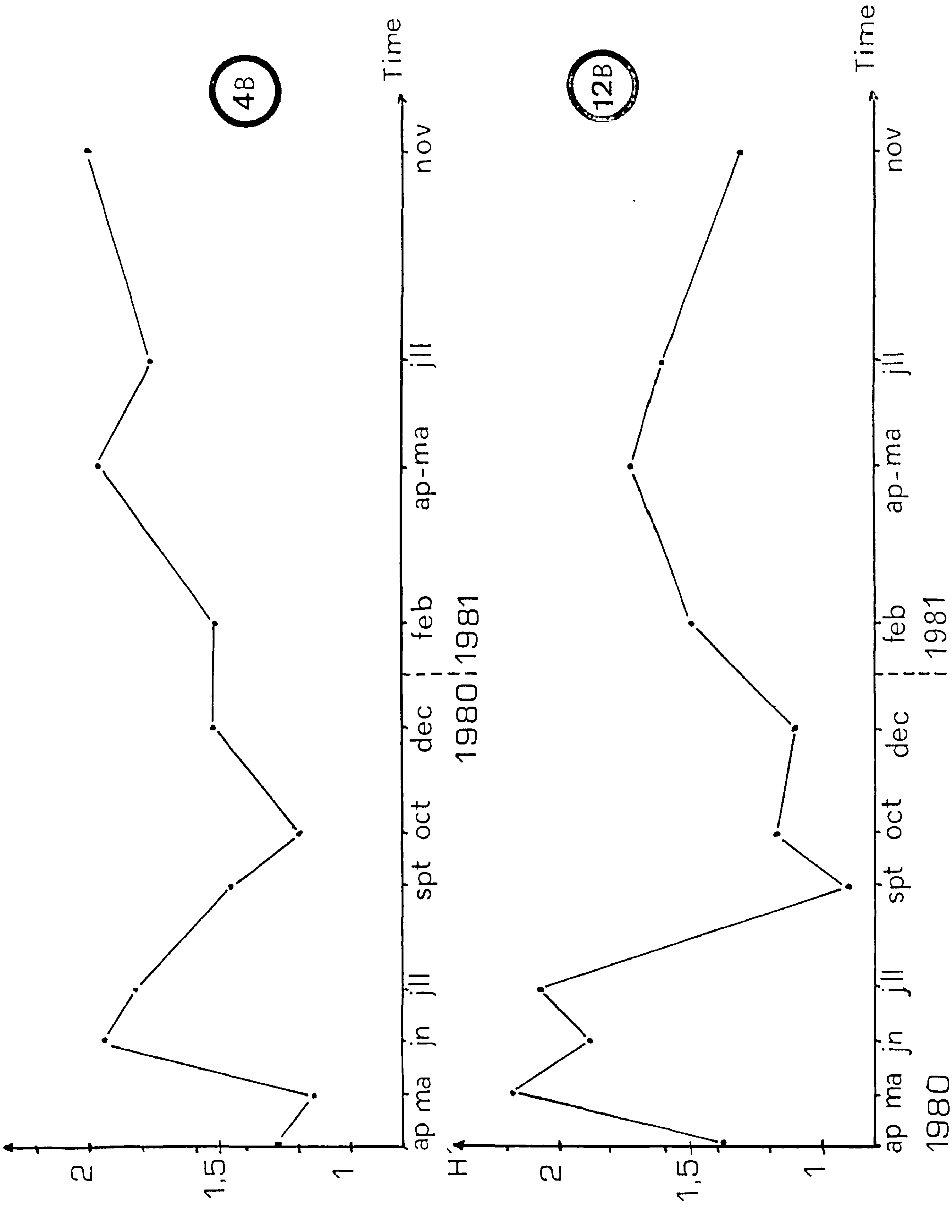

4B
12B
H´
2
1,5
1
Time
ap ma jn jll spt oct dec feb ap-ma jll nov
1980
1981

Figure 10

than C. candida. It must also be remembered that C. subterranea is well distributed in the groundwater of the banks (see above).

This preference of C. subterranea for the deep layers could explain that with the covering of the pipes at 12B by superficial sediment, the catches become more numerous. This hypothesis is perhaps not sufficient to explain this increase. One should note that we have an almost identical evolution of C. subterranea at station 4B with no noticeable covering of the pipes during the course of the study. Besides the depth it might also be the rearrangement of the grains in the sediments or the changes in the flowing of interstitial waters which could lead to an increase in the number of individuals of C. subterranea at both stations.

4 - Diversity of the ostracod assemblages

At both stations 4B and 12B, there are two dominant species, i.e. C. candida and C. subterranea. The other species are rare, often having a reduced number of individuals. Their importance in the taxocoenes expressed as a percentage of the total of ostracods caught (fig. 9), follows a similar evolution at stations 12B and 4B with a maximum in autumn and winter. There is no simple relationship between the variations of their relative abundances and the discharges of the Seebach. The maxima in spring and beginning of summer might be explained by a more precise study of the biological cycle of the various species.

The Shannon and Weaver's index of diversity H',

$$H' = -\sum_{i=1}^{s} p_i \log_2 p_i$$

calculated for stations 4B and 12B for the total of ostracods caught in the 12 pipes for the two series of the same months follows an evolution more or less similar to those of the relative abundances of the rare species (fig. 10). For both stations, there are minima at the beginning of the spring and in autumn 1980. This autumnal decrease of diversity is found in 1981 only for the station 12B. At station 4B, the series of November 1981 remains well diversified (H' is close to 2), because the rare species remain important (27 % of the catches). The diversity H' of the ostracod assemblages is better linked with the importance of the rare species (fig. 9 and 10) than with the total number of species caught. This number fluctuates weakly. The two periods of highest diversity correspond to the one of high water, when floods are frequent (for the discharge of the Seebach during this study, see BRETSCHKO 1981 b and 1982). However, no precise correlation can be found between the abundance of the ostracods caught, the depths where they develop maximal populations, and the discharges of the superficial water of the Seebach.

5 - Temporal evolution of the hypogean ostracods

The dynamics of the abundances of the hypogean species are similar at stations 4B and 12B (fig. 11, where specimens of Mixtacandona aff. laisi, Pseudocandona bilobata, P. aff. tyrolensis, and Pseudocandona n.sp. have been cumulated). The hypogean ostracods remain rare until April - May 1981, then the populations increase until November 1981. They develop preferentially at the lowest depths (-60 and -100 cm). These species have a similar evolution to those of Cypridopsis subterranea as previously discussed (p.65).

	Abundance	numb. of species	m	r	Remarks
spt 1980	143	7	0,420	0,887	n.s.
oct	201	10	0,559	0,881	n.s.
dec	152	6	0,295	0,976	significant
feb 1981	216	8	0,434	0,976	significant
ap-ma	171	9	0,594	0,961	significant
jll	179	10	0,616	0,917	n.s.
nov	510	8	0,465	0,967	significant

Tab. 5 Log-linear distribution of abundance for samples taken at station 12B from September 1980 to November 1981.
m: MOTOMURA's constant; r: coefficient of correlation

6 - Is the Ostracoda taxocoene structured ?

To answer this question an attempt has been made to ascertain whether the abundances of the different species caught at station 12B followed a log-linear distribution (MOTOMURA 1947, DAJET 1979). This model was not chosen at random. The ostracod assemblages found in the alluvial sediments of a dead arm of the Danube followed this distribution over a period of a one year's study (DANIELOPOL 1982). Table 5 shows that the values of the correlation coefficient r between the logarithm of the abundances of the species and their rank are not always significant. So we infer that the taxocoene at station 12B displays no obviously persistent structure.

This lack of clear persistent structure and these alternative dominances of C. candida and C. subterranea in the studied ostracod assemblages, lead to the supposition that this taxocoene is undergoing a period of change. DAJET et al. (1972) observed that the models of distribution of abundances, the log-linear and the log-normal ones, give poor results in areas which undergo changes. It may be the case for the RITRODAT Area also during this study.

7 - Consequences of the movements of sediments

a) The movements of sediments

At station 12B, the "zero" depth has really only remained at the surface of the sediments until June 1980. From July onwards it was covered with a layer of superficial gravel almost 10 cm thick (BRETSCHKO 1982). After a long period of relative stability a thicker layer settled in May 1981. Then the pipes of the original depth "zero" were found at a depth of 40 cm below the new sediments' surface. - At station 4B, no significant depth variation was noticed for the pipes placed at the surface of the sediment, until autumn 1982, one year after the end of this study (BRETSCHKO, pers. comm.).

Fig. 11: Vertical distribution of the abundance of all the hypogean dwellers cumulated for station 12B and 4B. (For details of the construction of this figure, see fig. 3.) Hypogean dwellers: see faunistic list p. 51, the species marked with an asterisk, *.

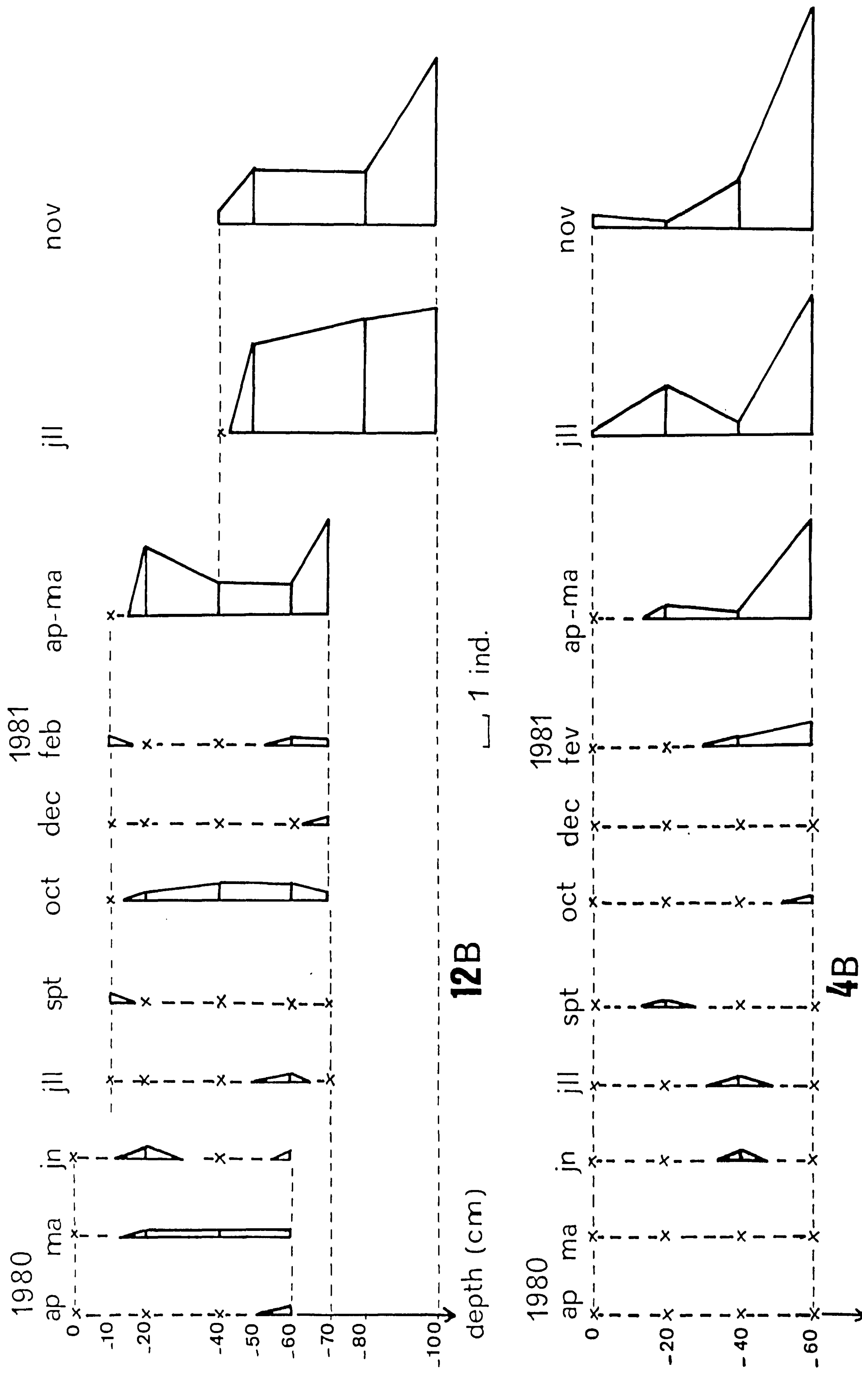
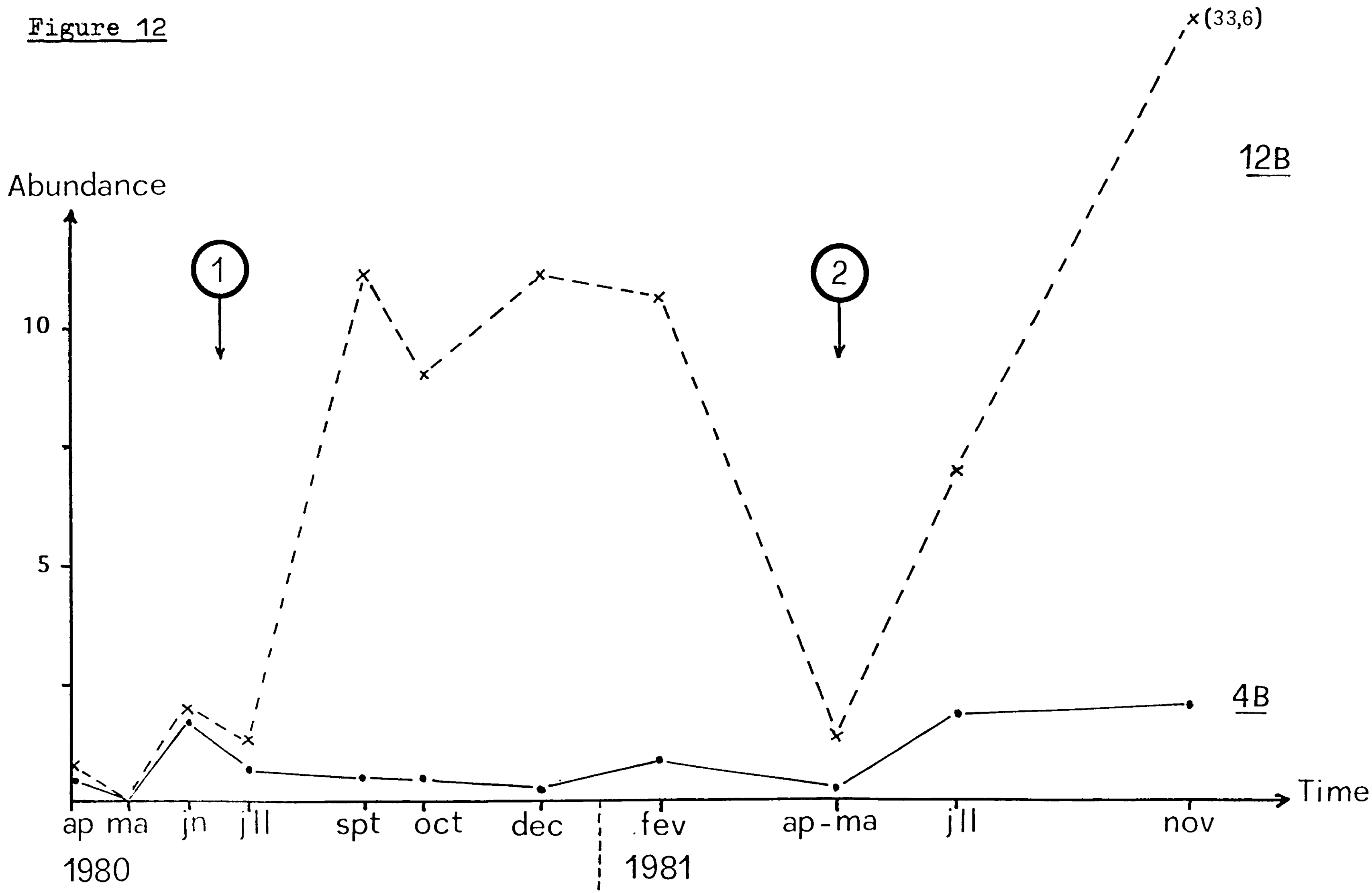

1980
ap
ma
jn
jll
spt
oct
dec
1981
feb
ap-ma
jll
nov
12B
1 ind.
depth (cm)
0
-10
-20
-40
-50
-60
-70
-80
-100
1980
ap
ma
jn
jll
spt
oct
dec
1981
fev
ap-ma
jll
nov
4B
depth (cm)
0
-20
-40
-60

Figure 11

Figure 12



Abundance of ostracods caught at the two stations 4B and 12B at the original "zero" level.
For 12B only: (1): total increase of 10 cm of gravel
(2): total increase of 40 cm of gravel

b) The ostracod abundances at the "zero" depth

Figure 12 enables us to observe the absolute abundance of ostracods caught at the "zero" depth, at stations 4B and 12B. Before the arrival of the superficial gravel both stations exactly follow the same evolution. The settling of the first 10 cm of gravel does not immediately influence the importance of the catches with the samples taken in July 1980 remaining poor. But from September 1980 onwards, differences can be observed between both stations: whereas the number of ostracods caught at station 4B remains small, at station 12B it grows considerably richer (it oscillates around 20 individuals). Surely, the superficial gravel has a stabilizing effect on the sediments originally at the surface and causes this enrichment, due especially to the increase of C. candida and C. subterranea (compare fig. 3 and fig. 4).

c) Are the newly deposited sediments colonized ?

BRETSCHKO (1982) noticed a new movement in the superficial sediments in May 1981. The samples at -10cm depth are extremely poor during this period at station 12B (fig. 12). They represent 1,5% of the ostracods caught at the four different depths. The populations which settled beneath the newly deposited gravel in July 1980 were strongly reduced during the period of April - May 1981, when the high floods occurred and the gravel bank changed again in this area (BRETSCHKO 1982).

In the same series of sampling (April - May 1981), the samples taken at -50cm depth (that is 10 cm below the pipes of the "zero" depth) were slightly less populated, but still reasonably rich in specimens (fig. 3). The movements of gravel only seem to disturb violently the superficial layers of the sediment. In May 1982, a sample of 3 litres of interstitial water and fine sediment collected by manual pumping at -30 cm depth, that is, inside the newly deposited sediment, showed that the ostracod colonization is occurring: 152 specimens were caught, composed of 96% of C. subterranea, 3% of Potamocypris sp. and 0.6% of Pseudocandona bilobata.

d) The ostracod abundance in the deeper layers

The arrival of superficial sediments and the changes it created at the depth of the gravel bank has also had a strong effect on the ostracod assemblages settled in the deeper layers: The dominant species (C. candida and C. subterranea), as well as the hypogean ones, increased in numbers, mostly in the deeper layers (fig. 3 and 11). The obvious effect occurred shortly after the arrival of gravel at station 12B: the series of July 1980 remained poor (fig. 3). At station 4B, an increase of the number of ostracods caught begins in July 1981, whereas no significant changes in the depth of the pipes are noticed until autumn 1982.

The study of the movement of sediment in a series of rapids and pools of North-Californian rivers (LISLE 1982) shows that these movements are discontinuous, with the gravel arriving by different waves at the time of high waters. In the case of the Seebach, the increase in the abundance of various populations and the other changes mentioned above, started at station 4B in July 1981, just after the spring floods. These floods modified the organisation of the sediments around the station, even though no variation was noticed on the pipes themselves. From July 1981 onwards, station 4B was really isolated from the main channel of the brook, being protected from the immediate action of the current by a belt of almost 50 cm of sediment. It may be the formation of this belt which led to the changes noticed in the abundance of the ostracods caught at this station. These changes could be explained on the one hand by the stabilization, even temporary, of the superficial sediments, or on the other by a possible change in the deepest layers of the sediment texture, and of the flow of the interstitial water.

LEICHTFRIED (1981) showed that no increase in the quantity of organic matter occurred at station 4B towards the end of the study. Therefore it cannot be a nutritional gain which causes this increase in the ostracod population.

8 - Final discussion

This study of the horizontal distribution of ostracods has enabled us to subdivide the RITRODAT area into four distinct sectors: the alluvial plain near the brook, the brook's main channel, the central gravel bank and the lateral secondary arm. The Seebach's sectors which have the most abundant and less fluctuating ostracod populations are the central gravel bank, the secondary arm and the sediments of quiet areas of the main channel. A large part of the sediment of the main channel is poorly populated in ostracods. This channel has the largest stability of sediment but the ostracods seem to be adversely affected by the speed of the water current. These results differ from those of BOU (1979) who found a large number of ostracods (Candonopsis boui, an hypogean dweller) in the gravel of the mean channel of the river (the Tarn, southern France) and a few near the bank of the river which sometimes forms a secondary arm.

Considering the vertical distribution of ostracods in the sediments, HYNES (1974) noted that, in the Speed-river fauna, these animals occur in the upper 27 cm of the gravel stream bed. GODBOUT and HYNES (1982) found them down to a depth of -65 cm, but with a maximum of between -35 and -45 cm depth. The large number of ostracods caught at 1 m depth in the Seebach sediments at the end of this study can be explained by the importance of the water circulation between the surface and the underground layers (about 1 cm/min, BRETSCHKO 1980) and by the occurrence in these deeper layers of many hypogean dwellers and dense populations of C. subterranea (this species prefers to live in the deeper layers of the sediment).

DANIELOPOL (1976) showed that the hypogean ostracods in the sediments along the Danube banks are commonly found at depths varying from one to three meters. The hypogean species of ostracods of the Seebach occurred more commonly in the deeper layers as in the case of the Danube.

The ostracod assemblage of the Eberschüttwasser (a dead arm of the Danube near Vienna) followed a long-linear distribution of abundances for the entire study (DANIELOPOL 1982) which means that this taxocoene is well-structured. In the Seebach no persistent structure has been found in the ostracod taxocoene.

VICTOR, DANCE & HYNES (1981) noted that in a Canadian brook no correlation exists between the water discharge in the brook and the number of ostracods sampled. No direct correlation between the water discharge in the Seebach and the number of ostracods caught in the pipes was found. However, for the present study the Shannon and Weaver's diversity index H' and the relative abundance of the rare species living in the sediment generally increase during the period of high water (springs of 1980 and 1981).

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