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1.5

Composition and Density of the Macroinvertebrate Benthic Community in the RITRODAT Experimental Field

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Introduction

The role played by the macroinvertebrate benthic fauna as consumer and transferer in freshwater ecosystems has been pointed out by EDMONSON & WINBERG (1975) and WETZEL (1975). The role played by the benthic fauna in running water ecosystems is an open field of study and one which relies mainly on accurate and reliable estimations of the composition and density of the populations. The difficulties in reaching this goal have been stressed by HYNES (1970).

For one thing the stream benthic community is not restricted to the surface layers of the bottom, having been found in depths up to 70 cm in considerable amount (BRETSCHKO 1978, HYNES et al. 1974, WILLIAMS & HYNES 1974). Up to now however, no fully integrative sampler deals quantitatively with all of the "on-and-in-the-sediment" community. Up till now a complete evaluation of the population densities in stream benthos is only possible using different but complementary sampling methods.

In the framework of the RITRODAT project, the estimation of population densities is assumed to be the basic problem in running water studies. For reason of optimization three methods are used and their respective results compared.

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One of these is the "direct estimation of zoobenthos employing traditional methods and newly developed traps and depth defined corers" (BRETSCHKO 1979).

The Surber sampler (SURBER 1937) is extensively used as a standard device for quantitative studies of stream bottom fauna, as well as for comparing the efficiency of newly developed samplers (JACOBI 1971,1978). In spite of some criticisms concerning its sampling efficiency and reliability (KROGER1972,WATERS & KNAPP 1961), the Surber sampler was selected as one of the traditional sampling methods to be used in the RITRODAT project. In the light of the depth distribution of the benthic fauna (BRETSCHKO 1978, WILLIAMS & HYNES 1974) the impossibility to take depth-defined samples with the Surber has to be pointed out explicitely.

The present study determines the gross taxonomical composition and the Population density, on the basis of Surber samples, of the RITRODAT experimental field at Seebach, Lunz, Biological Station, Austria.

Methods and Materials

The RITRODAT Experimental Field (REF) is a 100 m long segment of the fast running, well oxigenated alpine stream Oberer Seebach. This stream extends along 4 km, between the Lunzer Mittersee and the Lunzer Untersee, with a mean inclination of 4%. REF is located at the lower end of the stream, approximately 600 m upstream from its outlet into the Lunzer Untersee.

The river bed consists of limestone rocks.
The substratum of REF is composed of smooth irregular stones 5 to 14 cm in diameter intermingled with coarse gravel, interstitial sands, silt, clay and organic matter.

Water temperature oscillates during summer period between 10^{o} and 13^{o} C. The discharge regime is typical for the region: low discharges during winter, highest during springtime (snow melting period) and medium water levels during summer though with short but sometimes very high peaks following thunderstorms. According to the high inclination and the composition of the river bed current speed is very variable. At the moment of sampling the water level was rather high, producing a maximum depth of 1 m.

On the basis of stratified random sampling (ELLIOT 1977), a total of 16 samples has been taken between 09 00 and 17 00 hr on July, 11^{th} 1979. Four strata have been chosen freely, omitting all ecological considerations. Four samples have been taken from each stratum (fig. 1). The sampling procedure was carried out working upstream, labelling the samples from 1 to 4 for each stratum respectively. Sampling area is 506 cm^2, mesh size 100 microns. Samples were obtained removing the substrate particles about 5 to 10 cm deep. Samples are fixed in the field with formaline (20%).

In the laboratory samples are counted, on the level of higher taxa, under a stereo microscope at a maximum magnification of 120x *. To facilitate the counting procedure, an eight cells decanting sample-splitter and the "rule of one hundred" are used. Numbers are expressed for sampling units and for m^2. After log (x + 1) transformation routine statistical tests (ELLIOT 1977) are applied to the results in order to compare the number of taxa gathered in each stratum and the population density. If not otherwise stated all probabilities are on the 95% level.

* Because of the short time available and the taxonomical difficulties identification had to be restricted to higher taxa.

Table 1. Gross taxonomical composition of the zoobenthos, estimated mean density and relative abundance of the taxa found in REF, July 11th, 1979.

+ present, - absent, * less than 0.1%

	Strata				Sampling Unit	sq.m.	Relative
Arthropoda	I	II	III	IV	Numbers	Numbers	Abundance %
Insecta							
Chironomidae	+	+	+	+	3820	75483	82.6
Simuliidae	+	+	+	+	30	593	0.6
Ephemeroptera	+	+	+	+	151	2984	3.3
Plecoptera	+	+	+	+	156	3083	3.4
Trichoptera	+	+	+	+	5	99	0.1
Coleoptera	+	+	+	+	22	435	0.5
Collembola	+	+	+	+	2	40	*
Crustacea							
Amphipoda	+	+	+	+	14	277	0.3
Chydoridae	+	+	+	-	1	20	*
Harpacticoidea	+	+	+	+	172	3399	3.7
Cyclopoidea	+	+	-	+	2	40	*
Ostracoda	+	+	+	+	16	316	0.3
Arachnida							
Acari	+	+	+	+	75	1482	1.6
Mollusca							
Gastropoda	+	+	+	+	5	99	0.1
Annelida							
Oligochaeta	+	+	+	+	116	2292	2.5
Nemathelminthes							
Nematoda	+	+	+	+	13	257	0.3
Platyhelminthes							
Turbellaria	+	+	+	+	7	138	0.2
Miscellaneous					18	356	0.4
TOTAL					4625	91390	100

A total of 17 major taxa is recorded in the REF. All of them are present in at least one of the samples for each stratum with the exception of Chydoridae which are absent from the fourth stratum and Cyclopoidea which are absent from the third stratum (table 1). A χ^2-test shows no statistical differences among the strata with regards to the number of taxa present. The same test, applied to a 4×4 contingency table shows that the number of taxa present in each sample is independent of the sampling sequence as well as from the stratum from which the sample has been taken. For this test 17 is assumed to be the maximum number of taxa expected in any given sample. The average numbers of taxa per stratum are:

Stratum	I	II	III	IV
Mean ($\bar{x}$)	13	15	15,25	14
C.V. %	24,3	10,9	6,3	10,1
n (samples)	4	4	4	4

The Student's t-test applied to differences among means proved that there is no statistical differences among strata. Therefore, with the data available it is not possible to show any qualitative differences among samples or strata.

Quantitatively the benthic faunal community is clearly dominated by Chironomids. They are present in all samples, always outnumbering the total of all other taxa (fig.2).

Other taxa well represented by their constancy and high numbers are Ephemeroptera, Plecoptera, Acari and Oligochaeta (table 2). Harpacticoids are found in great numbers but only sporadically. The lowest and highest numbers, per sampling unit, registered for these five groups are:

	Lowest	Highest
Chironomids	1510	6864
Ephemeroptera	20	394
Plecoptera	8	343
Acari	6	192
Oligochaeta	30	439

These five taxa account for between 71,4 and 99,4% of the total sample population (table 3).

The total population per sampling unit ranged between 2003 and 7535 animals, with a mean of 4627 (U.L. 5346, L.L. 3465; n = 16).

Population means between the strata are compared: Student's t-test is used to test difference between means and a one-way analysis of variance (F-test) is spplied to the mean stratum numbers for each taxon. Statistical differences between mean numbers are:

Simuliidae	in stratum	I	and	IV	II and IV
Plecoptera	"	II	and	IV	
Coleoptera	" "	II	and	IV *	
Collembola	"	II	and	III *	
Amphipoda	"	I	and	II *	
Acari	" "	I	and	II	I and IV*
Gastropoda	"	I	and	III	

Dubious cases are signalled by an asterisk. These results may be a statistical artifact, as is the case in Acari. As variances differ widely, small differences between means may be significant while larger ones are not.

Table 2. Quantitative Composition of the Zoobenthic Community of REF; July, 11th, 1979.

	First Stratum				Second Stratum				Third Stratum				Fourth Stratum			
	I-1	I-2	I-3	I-4	II-1	II-2	II-3	II-4	III-1	III-2	III-3	III-4	IV-1	IV-2	IV-3	IV-4
Chironomidae	3178	6864	6533	3392	3813	4332	3928	1940	2105	1510	3811	4840	4567	3754	4875	1685
Simuliidae	7	15	3	0	8	2	2	0	2	46	43	13	31	251	36	26
Ephemeroptera	29	64	155	172	121	134	248	142	20	269	394	127	98	147	150	144
Plecoptera	8	16	176	294	280	231	210	343	22	221	299	171	25	49	117	35
Trichoptera	4	2	2	4	8	4	1	5	2	1	13	9	1	1	6	12
Coleoptera	0	0	60	168	24	14	6	12	3	18	23	15	4	0	8	1
Collembola	2	0	0	2	0	1	1	1	2	2	3	1	4	8	4	0
Amphipoda	1	0	2	4	2	8	25	9	0	11	144	2	1	1	9	5
Chydoridae	0	0	1	4	1	2	2	9	1	0	1	1	0	0	0	0
Copepoda Harp.	0	0	230	23	0	0	32	218	0	465	1580	138	0	0	58	6
Copepoda Cycl.	0	0	0	8	0	0	14	5	0	0	0	0	0	3	0	5
Ostracoda	2	1	26	18	12	32	5	19	1	36	64	24	5	0	13	1
Acari	127	192	144	102	33	50	37	25	6	36	113	68	75	55	112	25
Gastropoda	0	0	5	16	0	1	2	0	5	10	18	8	3	0	10	1
Oligochaeta	32	96	147	80	68	55	439	40	34	87	228	165	75	44	245	30
Nematoda	9	0	8	15	5	10	11	5	13	9	34	43	2	6	30	9
Turbellaria	3	1	10	4	32	2	11	3	1	4	10	7	1	9	8	3
Miscellaneous	4	24	33	11	9	8	15	9	3	14	15	77	12	12	29	15
TOTAL	3406	7275	7535	4317	4416	4886	4989	2785	2220	2739	6793	5709	4901	4340	5710	2003

Table 3. Relative Abundance of the Zoobenthic Community's Components at the RITRODAT Experimental Field; July, 11th, 1979.
= less than 0.1 %

	First Stratum				Second Stratum				Third Stratum				Fourth Stratum			
	I-1	I-2	I-3	I-4	II-1	II-2	II-3	II-4	III-1	III-2	III-3	III-4	IV-1	IV-2	IV-3	IV-4
Chironomidae	93.3	94.4	86.7	78.6	86.3	88.7	78.7	69.7	94.8	55.1	56.1	84.8	93.2	86.5	85.4	84.1
Simuliidae	0.2	0.2	#	#	0.2	#	#	#	0.1	1.7	0.6	0.2	0.6	5.8	0.6	1.3
Ephemeroptera	0.9	0.9	2.1	4.0	2.7	2.7	5.0	5.1	0.9	9.8	5.8	2.2	2.0	3.4	2.6	7.2
Plecoptera	0.2	0.2	2.3	6.8	6.3	4.7	4.2	12.3	1.0	8.1	4.4	3.0	0.5	1.1	2.0	1.7
Trichoptera	0.1	#	#	0.1	0.2	0.1	#	0.2	0.1	#	0.2	0.2	#	#	0.1	0.6
Coleoptera	#	#	0.8	3.9	0.5	0.3	0.1	0.4	0.1	0.7	0.3	0.3	0.1	#	0.1	#
Collembola	0.1	#	#	#	#	#	#	#	0.1	0.1	#	#	0.1	0.2	0.1	#
Amphipoda	#	#	#	0.1	#	0.2	0.5	0.3	#	0.4	2.1	#	#	#	0.2	0.2
Chydoriidae	#	#	#	0.1	#	#	#	0.3	#	#	#	#	#	#	#	#
Copepoda Harp.	#	#	3.1	0.5	#	#	0.6	7.8	#	17.0	23.3	2.4	#	#	1.0	0.3
Copepoda Cycl.	#	#	#	0.2	#	#	0.3	0.2	#	#	#	#	#	0.1	#	0.2
Ostracoda	0.1	#	0.3	0.4	0.3	0.7	0.1	0.7	#	1.3	0.9	0.4	0.1	#	0.2	#
Acari	3.7	2.6	1.9	2.4	0.7	1.0	0.7	0.9	0.3	1.3	1.7	1.2	1.5	1.3	2.0	1.2
Gastropoda	#	#	0.1	0.4	#	#	#	#	0.2	0.4	0.3	0.1	0.1	#	0.2	#
Oligochaeta	0.9	1.3	2.0	1.9	1.5	1.1	8.8	1.4	1.5	3.2	3.4	2.9	1.5	1.0	4.3	1.5
Nematoda	0.3	#	0.1	0.3	0.1	0.2	0.2	0.2	0.6	0.3	0.5	0.8	#	0.1	0.5	0.4
Turbellaria	0.1	#	0.1	0.1	0.7	#	0.2	0.1	#	0.1	0.1	0.1	#	0.2	0.1	0.1
Miscellaneous	0.1	0.3	0.4	0.3	0.2	0.2	0.3	0.3	0.1	0.5	0.2	1.3	0.2	0.3	0.5	0.7
TOTAL	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 4. Mean Density and Relative Abundance of Taxa Found in REF; July, 11th, 1979.
= less than 0.1 % .

	First Stratum		Second Stratum		Third Stratum		Fourth Stratum	
	Numbers	%	Numbers	%	Numbers	%	Numbers	%
Chironomidae	4992	88.6	3503	82.0	3067	70.2	3720	87.7
Simuliidae	6	0.1	3	0.1	26	0.6	86	2.0
Ephemeroptera	105	1.9	161	3.8	203	4.6	135	3.2
Plecoptera	124	2.2	266	6.2	178	4.1	57	1.3
Trichoptera	3	0.1	5	0.1	6	0.1	5	0.1
Coleoptera	57	1.0	14	0.3	15	0.3	3	0.1
Collembola	1	#	1	#	2	#	4	0.1
Amphipoda	2	#	11	0.3	39	0.9	4	0.1
Chydoridae	1	#	4	0.1	1	#	#	#
Copepoda Harp.	63	1.1	63	1.5	546	12.5	16	0.4
Copepoda Cycl.	2	#	5	0.1	#	#	2	#
Ostracoda	12	0.2	17	0.4	31	0.7	5	0.1
Acari	141	2.5	36	0.8	56	1.3	67	1.6
Gastropoda	5	0.1	1	#	10	0.2	4	0.1
Oligochaeta	89	1.6	151	3.5	129	3.0	98	2.3
Nematoda	8	0.1	8	0.2	25	0.6	12	0.3
Turbellaria	5	0.1	12	0.3	6	0.1	5	0.1
Miscellaneous	18	0.3	10	0.2	27	0.6	17	0.4
TOTAL	5634	100 %	4271	100 %	4367	100 %	4240	100 %

	I	II	III	IV
Acari mean ($\bar{x}$)	141	36	56	67
L.L.	90	22	4	21
U.L.	209	55	260	159
lg_{10} $\bar{x}$	2.14174	1.55845	1.57726	1.77426
lg_{10} s^2	0.01296	0.01467	0.27821	0.07295

The F test also showed some statistical significant differences between the variances of the mean of animals per stratum, as well as among sampling units inside one stratum:

	F value	% explained variance	
	(V_1 3, V_2 12)	between strata	between sampling units
Simuliidae	6,56	62,12	37,88
Trichoptera	10,31	2,31	97,63
Chydoridae	8,45	67,86	32,14
Oligochaeta	6,64	3,63	96,37
Miscellaneous	4.23	5,58	93,82

Only two taxa show significant differences among strata. This is more evident in Simuliidae than in Chydoridae:

	I	II	III	IV
Simuliidae mean ($\bar{x}$)	6	3	26	86
Upper Conf.L.	30	12	132	279
Lower Conf.L.	Ø	Ø	1	9
Chydoridae mean ($\bar{x}$)	1	4	1	Ø
Upper Conf.L.	5	10	2	Ø
Lower Conf.L.	Ø	Ø	Ø	Ø

In all other taxa variances inside one stratum are always too large to show differences between strata.

The most populated area is stratum I with a total mean of 5634 animals, the least populated is stratum IV with a total mean of 4240 animals (table 4), but the difference is very small and not statistically significant. Figs. 3 to 5 present means and confidence limits of the six quantitatively most important taxa. Since animals are overdistributed the confidence limits are not symmetrical around the mean and sometimes very wide (f.e. Harpacticoidea, fig. 5). The grand mean ($\bar{X}_T$) has more restricted confidence limits because of the larger sample size (n = 16).

The total mean benthic community density per m^2 in REF is 91390 animals, with confidence limits from 68478 to 105652 animals. Mean numbers of specimens per taxon and their relative abundance in the REF together with population densities per square meter are set out in table 1.

Observations on community structure

In the sorting and counting process it was noted that there is a certain inverse proportionality between the relative abundance of Chironomids and Ephemeroptera, on the one hand, and of Chironomids and Plecoptera on the other. This tendency was tested with correlation analysis and the result was a significant inverse correlation. The regression line for the first case is $y = 17{,}5 - 0{,}17\,x$, with $r = -0{,}837$, $n = 16$. For the second case: $y = 18{,}9 - 0{,}185\,x$, $r = -0{,}677$, $n = 16$ (fig. 6).
No other proportionalities among the relative abundance of the taxa were found.

Conclusions

On the basis of the data collected the following conclusions can be drawn:

1) The zoobenthic community of REF is composed by 17 higher taxa (order or family) of invertebrates.
2) There are no differences in the taxonomical composition between strata.
3) The zoobenthic community of REF is quantitatively dominated by Chironomids. Other numerically important groups are Epemeroptera, Plecoptera, Acari, Oligochaeta and Harpacticoidea.
4) Statistically significant differences in animal densities among strata are scarce.
5) Simuliidae and Chydoridae are the only taxa showing different population densities among strata, the first being more abundant in strata III and IV than in I or II, the second being more abundant in stratum II than in all other strata.
6) The estimated mean total population density in REF is 91300 animals per square meter.
7) The relative abundances of Ephemeroptera and Plecoptera show a significant inverse correlation with the relative abundance of Chironomids.

Discussion

The taxonomical composition of the zoobenthos at REF differs not markedly from other clean, fast running streams in Europe (ALBRECHT 1961 quoted by HYNES 1979, ILLIES 1953, MORGAN & EGGLISHAW 1965, PERCIVAL & WHITEHEAD 1929 quoted by HYNES 1970), at least to the level of taxonomical identification worked out in this case. However, the marked predominance of Chironomids in REF has not been found elsewhere. This fact can be attributed to different reasons but its final explanation requires further research. One explanation could be that the sampling method used in the present work was more efficient than that used by other authors. Since our Chironomids are mostly very small, the mesh size of the sampler becomes very important (JONASSON 1955, 1958). Since Chironomids are predominant during the

whole year (BRETSCHKO 1978, 1979), the predominance reported here cannot be the effect of a possible maximum recruitment time.

It is well known that the distribution of benthic invertebrates is influenced by ecological factors which produce a mosaic pattern of different species populations (HYNES 1970). It may well be a matter of chance that no differences were found in the density of the taxa distributed in REF since the ecological conditions of the bottom were not taken of account when determining the sampling strata. However it is more likely that the findings are mainly the result of the low sample size and poor taxonomical identification

Such crude taxonomical approach is normally unable to show differences in the structure of communities. During the sorting and counting process it became evident that the species composition of Chironomids is not the same for all stations. The same can be said for Ephemeroptera and Plecoptera. The possibility that different community structures could exist in REF is suggested by the relationship between the relative abundances of Chironomids and Ephemeroptera and Chironomids and Plecoptera. No data are available now for explaining such a relationship but it may be connected with factors like the ammount of organic detritus or other ecological interactions.

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Figures' legends

Fig. 1 Sampling sites in REF. Roman numbers denote strata, Arabic numbers sampling units.

Fig. 2 Number of chironomids per sampling unit (clear bars) compared with the pooled populations of the remaining taxa (dark bars)

Fig. 3 Mean number (horizontal line) and confidence limits of the mean per sampling unit. $\bar{X}_T$ is the grand mean for the total REF (n= 16).

Fig. 4 Captions as in fig. 3

Fig. 5 Captions as in fig. 3

Fig. 6 Correlations between the relative abundance of chironomids and the relative abundance of Ephemeroptera (o) or Plecoptera (×). Regression line a: chironomids - ephemeropts. b chironomids - Plecoptera.

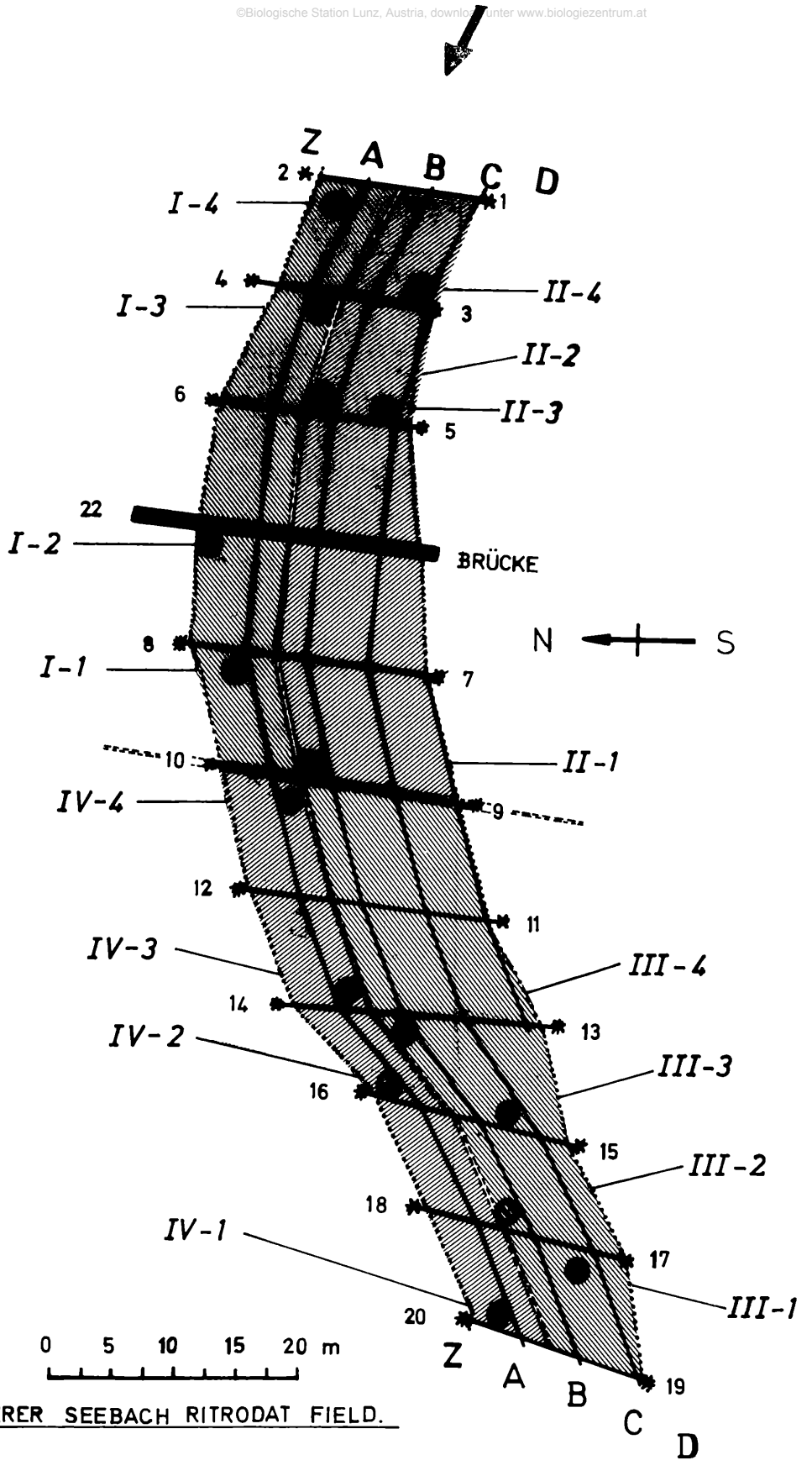
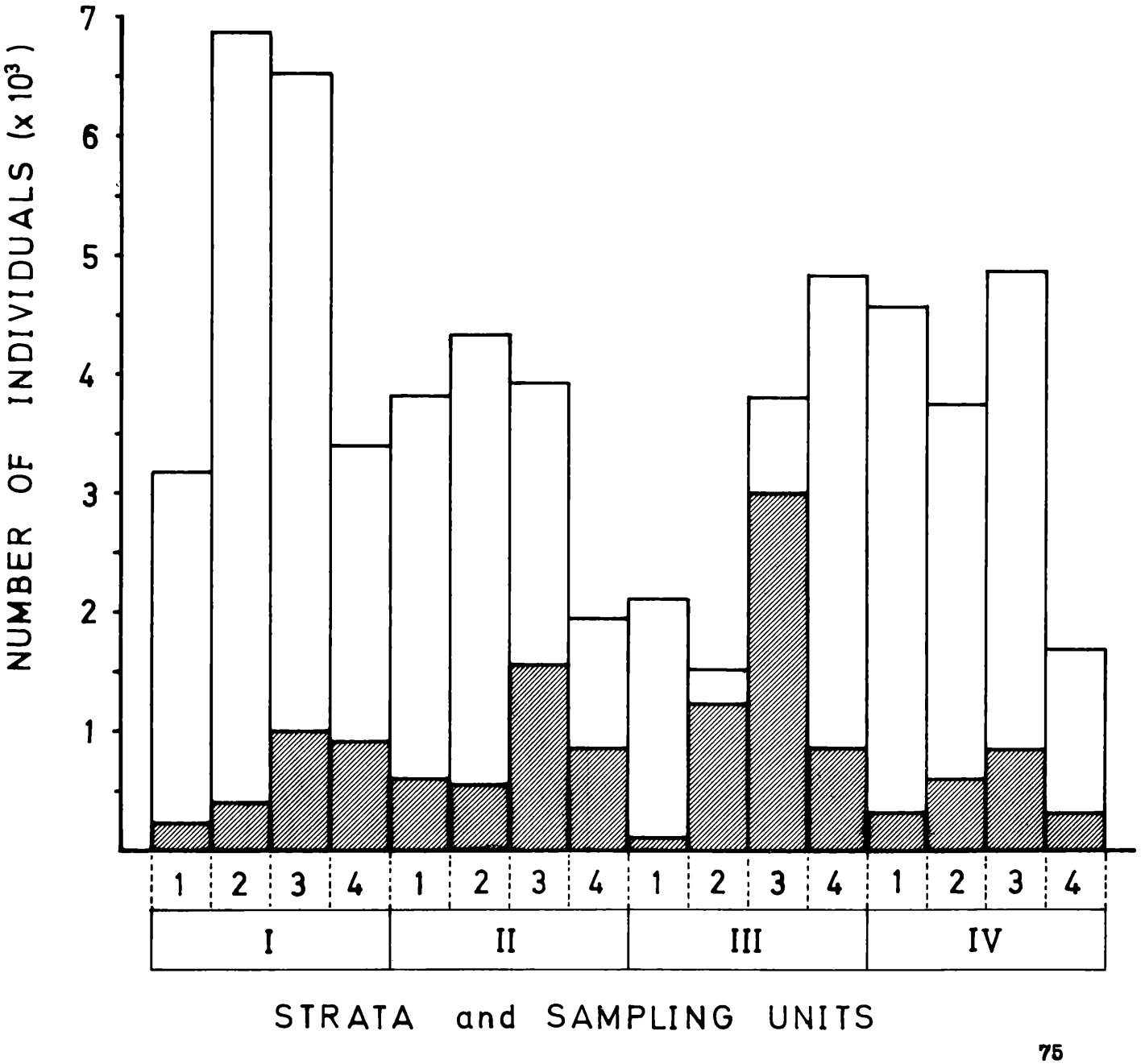


Fig.1

OBERER SEEBACH RITRODAT FIELD.



75

Fig. 2

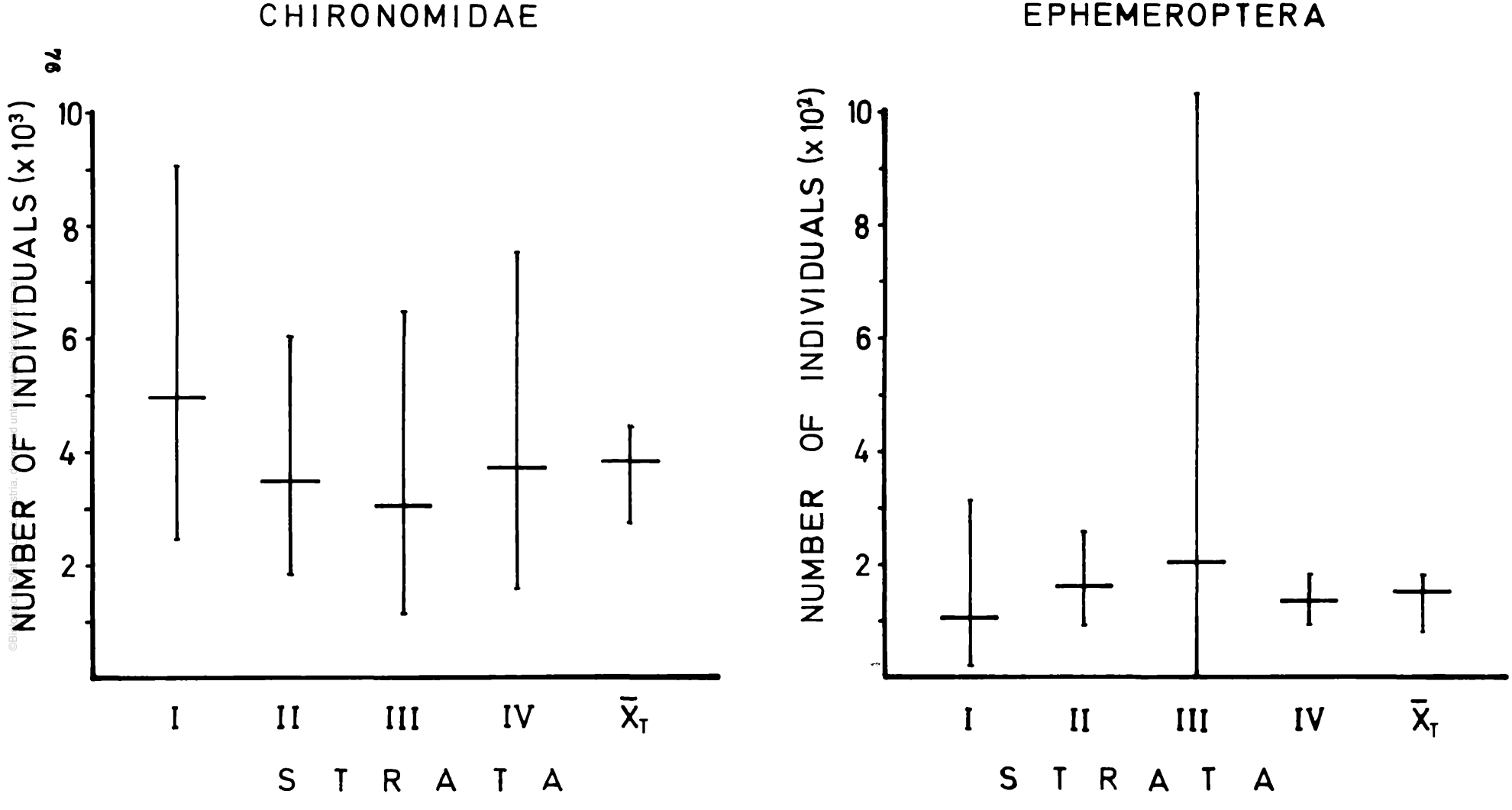
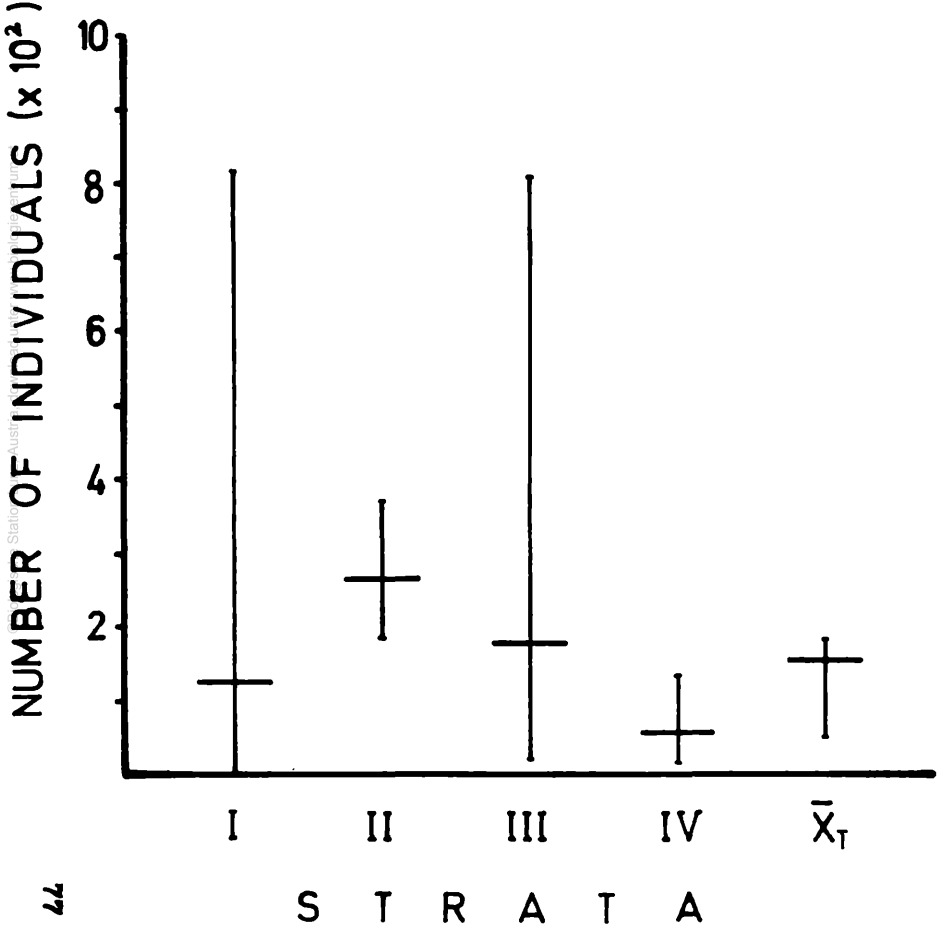
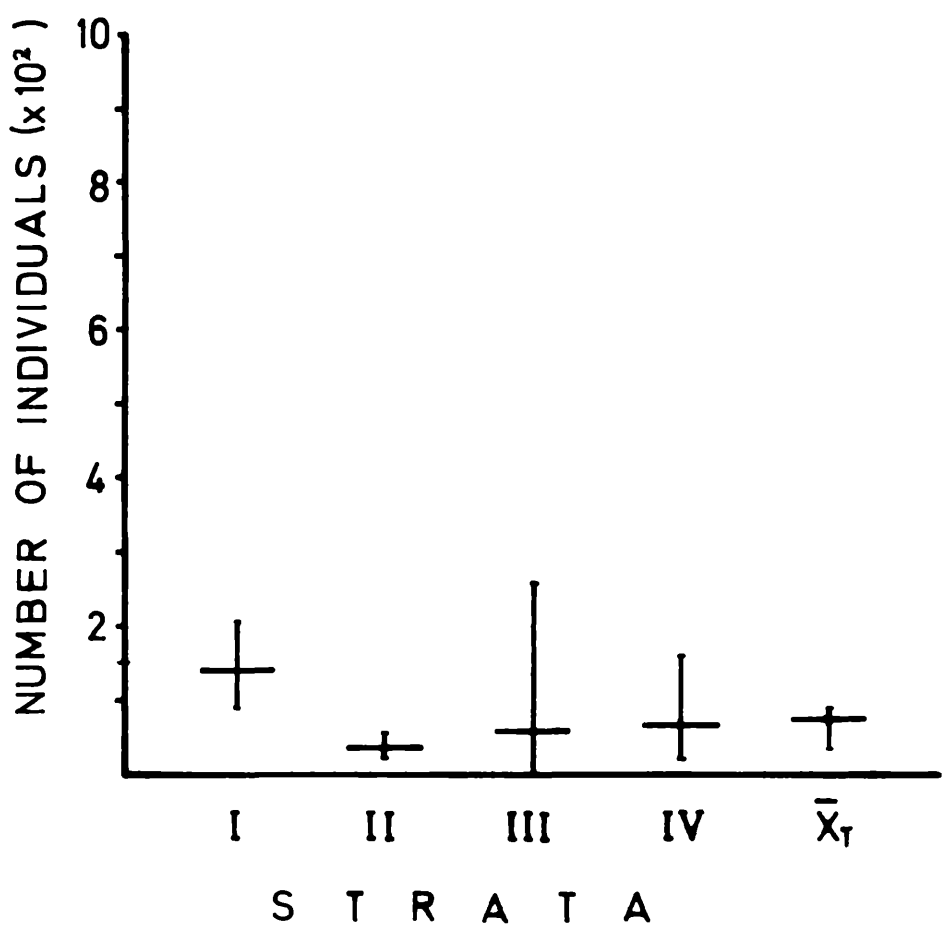

CHIRONOMIDAE
NUMBER OF INDIVIDUALS (x 10³)
10
8
6
4
2
I
II
III
IV
$\bar{X}_T$
S T R A T A
EPHEMEROPTERA
NUMBER OF INDIVIDUALS (x 10²)
10
8
6
4
2
I
II
III
IV
$\bar{X}_T$
S T R A T A

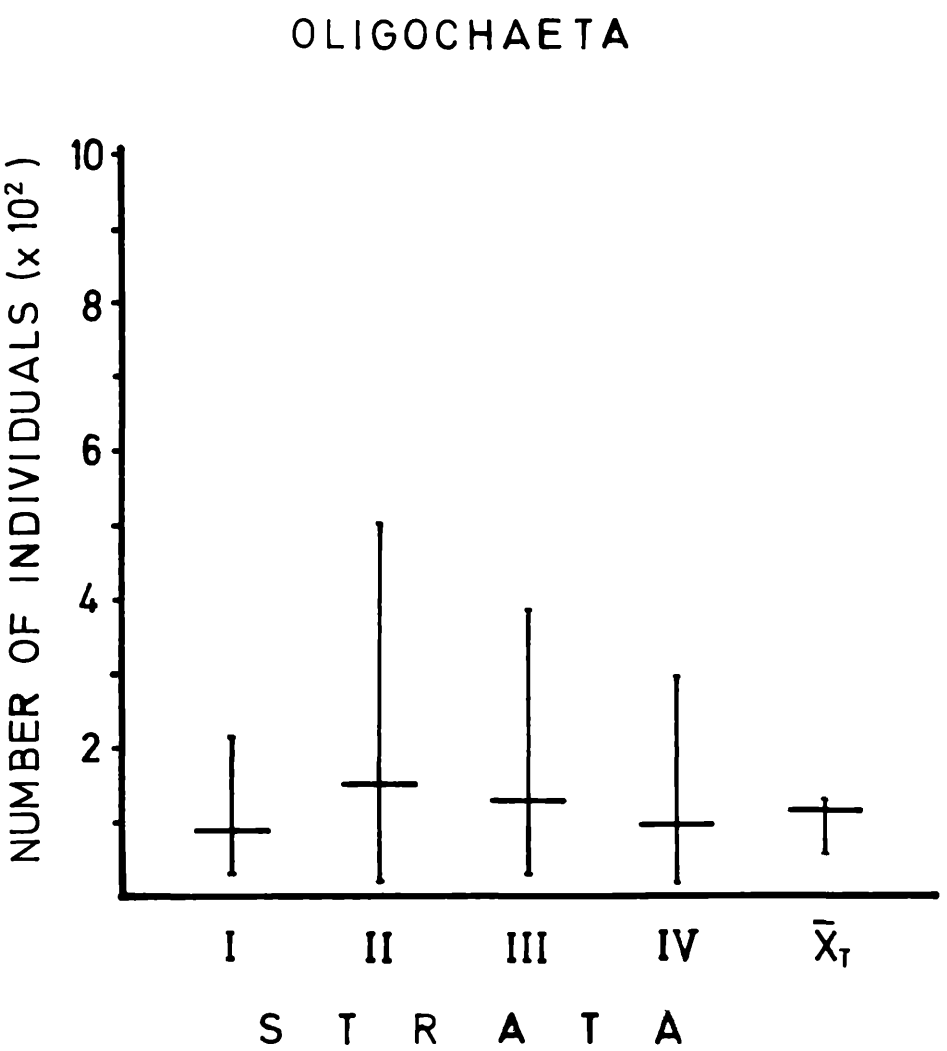
Fig. 3

PLECOPTERA



A C A R I





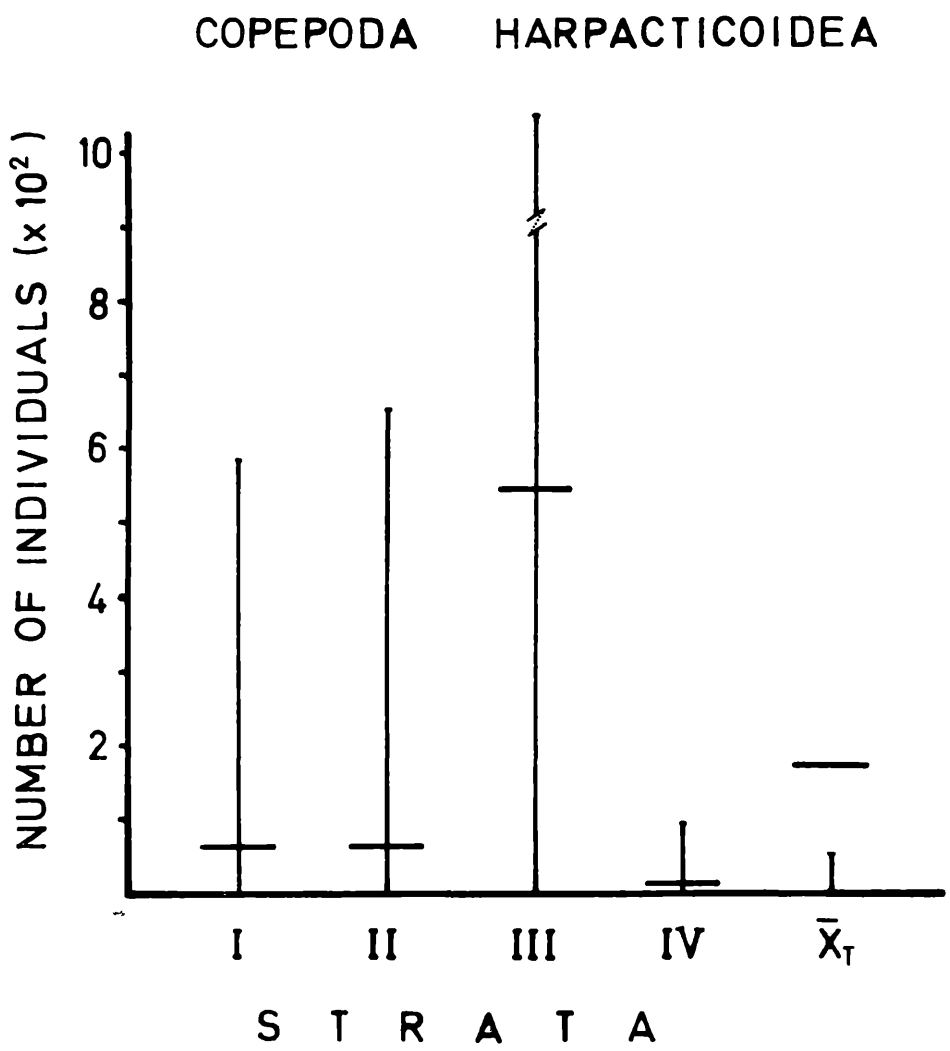


Fig. 5

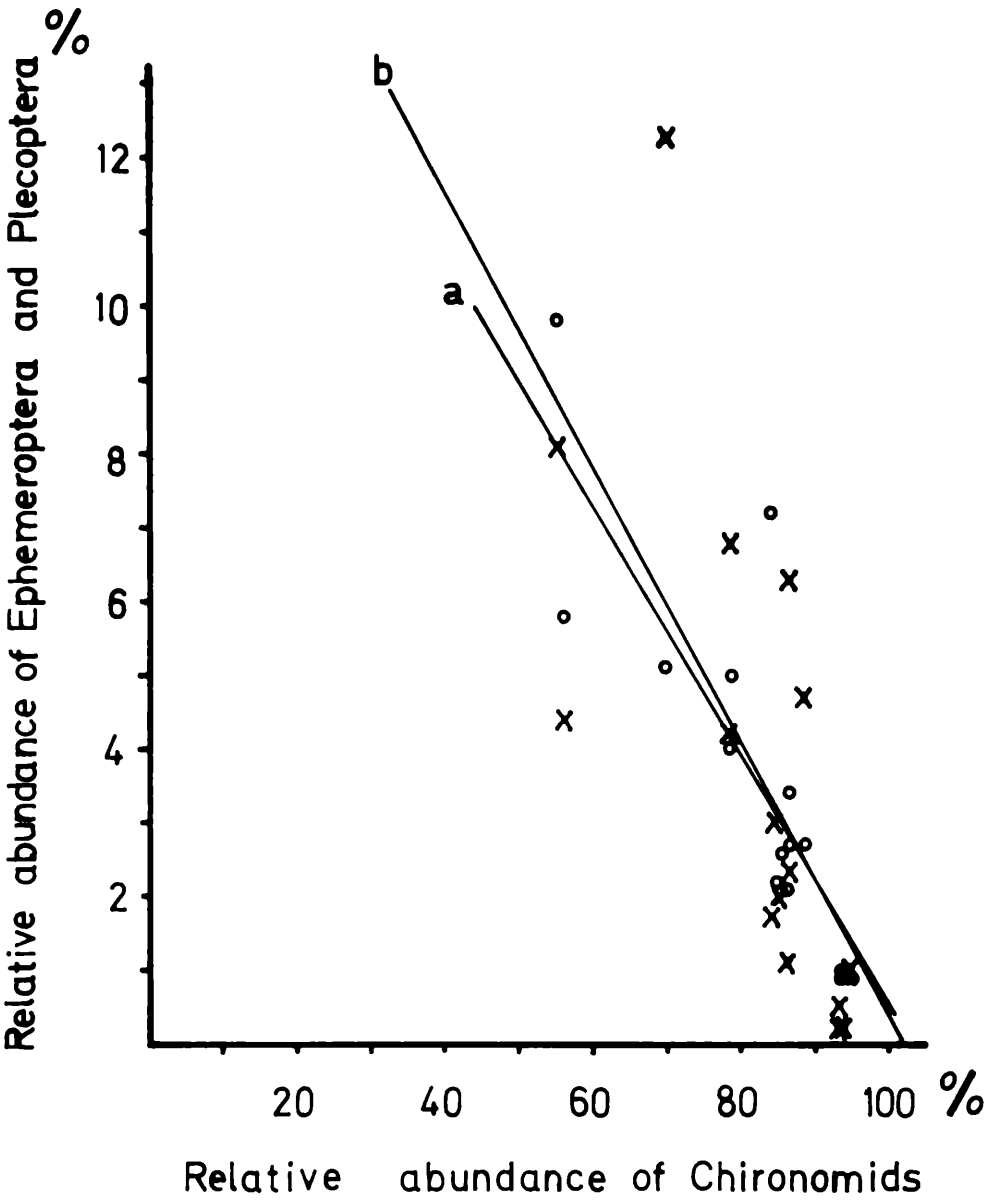


Fig. 6