A NOTE ON THE OLIGOCHAETA COMMUNITY IN A GRAVEL MOUNTAIN STREAM

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Zusammenfassung: Vorläufige Ergebnisse zur Oligochaeta Kommunität in einem Gebirgsbach. Die vertikalen und horizontalen Verteilungsmuster der Oligochaeta im Bettsediment eines Gebirgsbaches wurden als Teil einer Langzeit-Studie am 19. September 1990 untersucht. Die Kommunität setzte sich aus 16 Arten zusammen, wobei die Familie der Enchytraeidae sowohl mit der höchsten Individuendichte als auch mit der höchsten Artenzahl repräsentiert war. Die Artendiversität (H') variierte deutlicher im vertikalen als im horizontalen Profil und die Diversität war sowohl durch die Artenzahl als auch durch die Äquität bestimmt. Ein Vergleich der Probenstellen bezüglich ihrer taxonomischen Ähnlichkeit ergab folgende Ergebnisse: (1) klare Differenzierungen wurden zwischen Riffle versus Pool und Schotterbank, basierend auf der Präsenz von Oligochaeta Arten (Jaccard Koeffizient) festgestellt; (2) Heterogenitäten zwischen den Probenstellen waren mittels eines Index zu definieren, der nicht nur die Präsenz von Arten sondern auch deren Abundanzverhältnisse berücksichtigt. Die Untersuchung der räumlichen Verteilung zeigte, daß die Naididae und Lumbriculidae in höchsten Dichten die ersten 10 cm der Bettsedimente am 19. September besiedelten, während die Enchytraeidae und artspezifisch die Aelosomatidae hauptsächlich in Sedimenttiefen zwischen 10 und 20 cm gefunden wurden. Die Beziehung zwischen den biotischen Parametern (Besiedlungsdichte und Diversität) und einigen abiotischen Faktoren sind auch dargestellt: am 19. September 1990 nahm die Besiedlungsdichte als auch die Diversitätswerte mit steigendem hydraulischem Streß ab.

Introduction

During the last years most of the studies carried out on the Oligochaeta fauna of rivers have focused their attention on the use of the community as water quality indicator (CHAPMAN et al. 1980; CHAPMAN & BRINKHURST 1984; MILBRINK 1980; LANG, 1984 and SLEPUKHINA 1984 among others). These studies have been centered on fine sediment habitats, particularly because of the mass development of Oligochaeta species in places with organic contamination. Nevertheless, LEARNER et al. (1978), reviewing the biology of a family of Oligochaeta, have pointed out that each habitat type plays a role in the population dynamics of oligochaete and therefore on the distribution of the Oligochaeta species.

In stream ecosystems, studies have been done comparing the distribution of oligochaete species usually using surface samplers (DUMNICKA 1976; KASPRZAK 1976; KASPRZAK & SZCZESNY 1976). Few studies have been done regarding the vertical distribution of this group within the substratum in river ecosystems, probably as a consequence of: a) methodological constraints when sampling benthic macrofauna,

particularly in gravel beds; or b) lower abundances of this group within the macro-invertebrate fauna.

On the other hand, it is well known that a community structure can be described by defining species composition, distribution and abundance, and consequently of the underlying interactions among the species. Thus, a major objective of community ecology is to identify the factors that determine the relative abundances of species in communities, and to discern whether recurring predictable patterns of community structure exist (SEIFERT 1984). However, because the community term can be regarded as of a wide range, the working definition in this communication will follow the definition of an assemblage as stated by GILLER (1984). In this context, the present study gives preliminary results as part of a long-term research about the Oligochaeta community in a mountain gravel stream.

Material and methods

The study area RITRODAT covers a 100m stretch of the Oberer Seebach, a second order alpine gravel stream at an altitude of 600m a.s.l. (further descriptions are elsewhere, BRETSCHKO 1983).

Sampling routine is being carried out by taking randomly stratified six cores, at close time intervals (maximum span 16 days). Thus, this paper deals with the results of the first core sampling on the 19th September 1990 (see Figure 1). The technique employed is that of freeze core with electro positioning (BRETSCHKO & KLEMENS 1986). Because the mean extension of macro-invertebrates occurs between 0 to 40cm in the Ritrodat experimental area (SCHMID 1987), each core is divided into four sediment layers.

At the same time, in order to avoid loosing animals into the drift while sampling, a closed Surber sampler is situated surrounding the core. All samples are fixed with 5% formalin in the field, and subsequently washed through a 100 μm mesh net. Concurrently at each sampling ocassion, measurements are recorded with respect to: water temperature and current, an approximation of the surface layer topography and flow characteristics. Surface layer topography was estimated by measuring water levels at six points, in approximately 10cm distance circularly around the core; shear stress was estimated from three measurements with standard hemispheres in front of the core (left, middle and right side), following the technique proposed by STATZNER & MÜLLER (1989).

Animals are sorted out and counted at higher taxonomical levels under a stereo microscope. The Oligochaeta species were identified and counted after mounting in slides accordingly to BRINKHURST (1971). The following parameters were estimated

in the data analysis: a) species diversity index of Shannon-Wiener (KREBS 1988), b) Jaccard taxonomic similarity (CARBONNEL 1964), and c) overlap coefficient of HORN (1966). Multiple and simple regression analyses were carried out on a SPSS^x computer package (NIE et al. 1985).
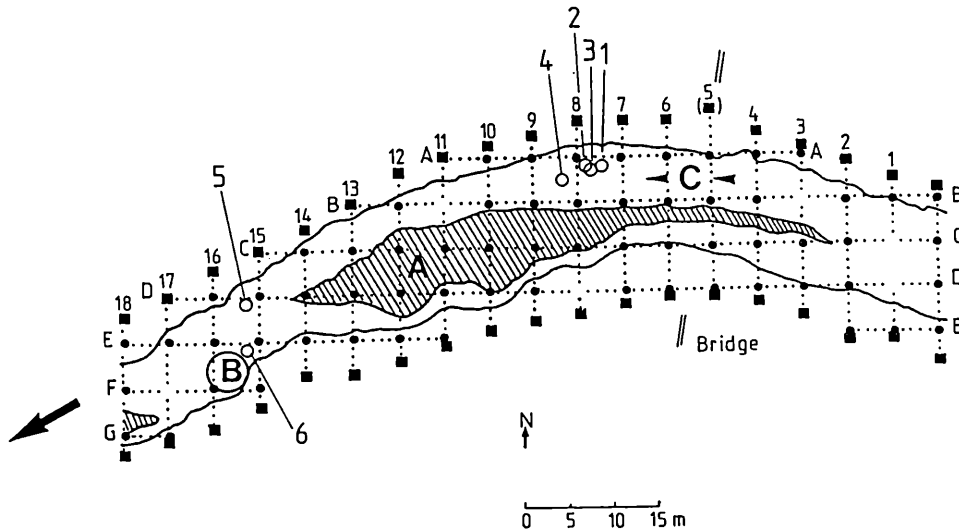

Figure 1. Core sampling positions on the 19th September 1990 in the Ritrodat experimental area. A: gravel bank; B: riffle zone (main current channel); C: pool (debris-dam).

RESULTS

a. Community structure

On the 19th September 1990, the Oligochaeta community of the Ritrodat experimental area is composed by a total of 16 species, two belong to Aelosomatidae, five to Naididae and Enchytraeidae and three to Lumbriculidae (Table 1). At this date, the most important species in abundance and presence were: *Nais pardalis*, *Marionina* sp.cf. *argentea* and *Cernosvitoviella* sp.cf. *atrata* (Table 1). Thus, a high percentage of species (80%) remained less represented and possibly with less incidence within the community.

Similarly, at family level it is clear that a higher percentage is achieved by the Enchytraeidae (69.3%), which is known to occupy a median position between the sequence from aquatic to terrestrial (HEALY 1987). The family Naididae is believed to be a dominant component in some running water systems, but in the Ritrodat it exhibits on the 19th September 1990 only 16.7% of the total percentage. This latter group and Aelosomatidae and Lumbriculidae are typical families found in aquatic systems.

Table 1. The Oligochaeta species composition and their total summed abundances, over four depth layers and six cores, within the experimental area of a mountain gravel stream on the 19th September 1990.

Species	Total no.ind.ln 24dm^{-3}	%
Aelosomatidae		
1. *Aelosoma hemprichi* Ehrenberg	22.90	2.9
2. *Aelosoma sp.*	9.70	1.2
Naididae		
3. *Chaetogaster sp.*	18.50	2.3
4. *Nais alpina* Sperber	12.30	1.6
5. *N. elinguis* Müller	3.30	0.4
6. *N.pardalis* Piguet	65.80	8.3
7. *Naididae gen.sp.*	31.00	3.9
Enchytraeidae		
8. *Marionina sp.cf.argentea*	350.03	44.3
9. *Cernosvitoviella sp.cf.atrata*	181.40	23.0
10. *Enchytraeidae gen.sp.1*	8.53	1.1
11. *Enchytraeidae gen.sp.2*	5.00	0.6
12. *Enchytraeidae gen sp.3.*	1.00	0.1
Lumbriculidae		
13. *Lumbriculus variegatus* (Müller)	29.00	3.7
14. *Stylodrilus heringianus* Clap.	6.70	0.8
15. Lumbriculidae gen.sp.	36.50	4.6
Lumbriculidae gen.juv.sp.	5.00	0.6
Lumbricidae		
16. *Eiseniella tetraedra* (Savigny)	3.00	0.4

Diversity index was used as an indicator of the structural complexity of the Oligochaeta assemblage. Figure 2a,b, shows the results of the mean diversity (H') per sampling position (calculated over the four sediment layers), and the diversity values (H') throughout the sediment layers at each sampling location. In general on the 19th September 1990, Oligochaeta diversity ranged from 0 to 2.601 bits.ind^{-1}, between the different depth layers in the six sampled points. The mean diversity (H) remains rather constant (from 1.374 to 1.516 bits.ind^{-1}), with two exceptions, core 4 and 6, where values were lower (Figure 2a). In the same figure, it can be seen, that there is a strong variability in the species diversity in three sampling locations (cores 1,3 and 6) reflected by the standard deviation. This fact can be observed more clearly in the distribution of diversity values throughout the sediment layers, shown in Figure 2b. In these cores there are sediment levels with 0 diversity, given by the exclusive presence of only one Oligochaeta species. Generally, species diversity tends to be higher at the surface layers (0-10 cm and 10-20cm), with one occasion where the diversity of Oligochaeta at 30-40cm deep in core 5 was higher than the other layers (Figure 2b).
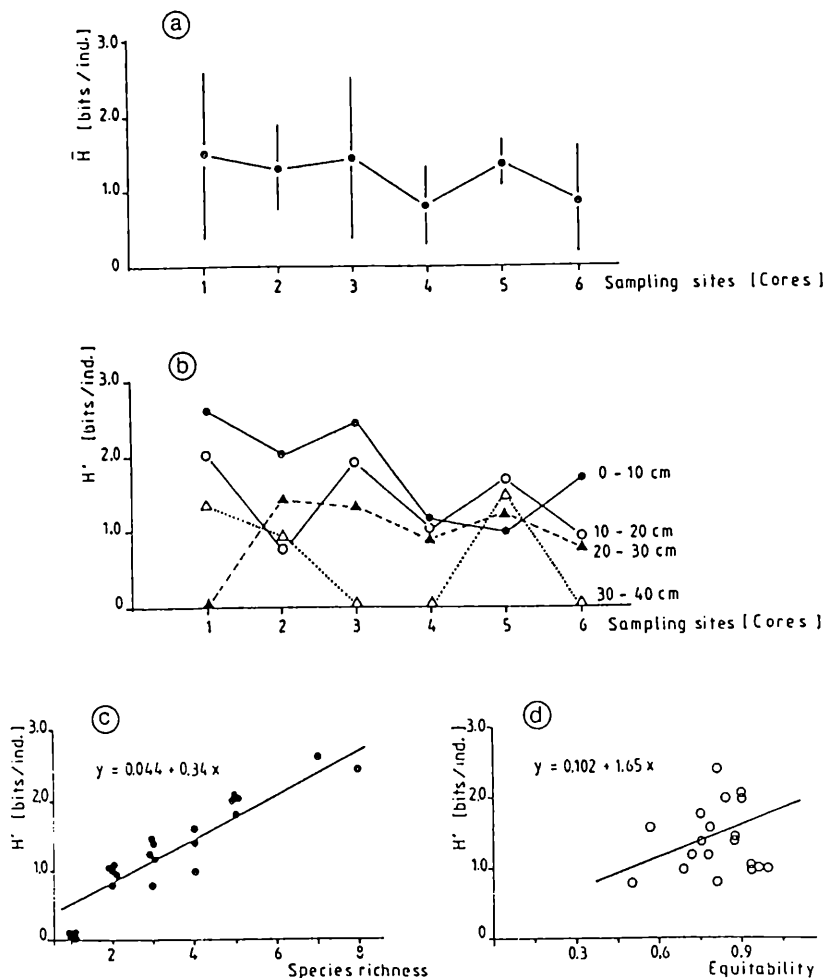
Figure 2. Oligochaeta species diversity on the 19th September 1990 in the study area.
  a. Mean diversity (H) and its standard deviation, estimated at each core location.
  b. Diversity values (H') throughout sediment depth layers at each core site.
  c. The relationship between species diversity and species richness in Oligochaeta in Sept 90
      ($r^2 = 0.831$; $r = 0.912$; $P < 0.0001$).
  d. The relationship between species diversity and equitability in Oligochaeta in Sept 90.
      ($r^2 = 0.534$; $r = 0.731$; $P = 0.0001$).

The dependance of diversity (H') on its component: species richness and equitability was also examined. The results are shown in Table 2 and illustrated in Figure 2c,d. Both components are highly correlated to Oligochaeta species diversity, however the multiple regression analysis indicates that species richness accounts in a higher level than equitability. The deviation of measured values of equitability to the estimated regression (Figure 2d), is probably due to depth layers which have less species number with a non-equally distributed abundance.

The values of the standard deviation of the mean diversity estimated in six sampling positions, could be a result of an heterogeneous Oligochaeta community structure in the Ritrodat area. In order to examine more in detail, whether this heterogeneity is purely random, or it occurs defining zones, two similarity coefficients

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were used: a taxonomical (Jaccard, Sj), and the Horn overlap coefficient (Ro) based on information theory (LUDWIG & REYNOLDS 1988). The results presented in Figure 3a,b, indicate that from the taxonomic composition of Oligochaeta, it is possible to distinguish roughly two zones, one corresponding to cores from a riffle area (1,2 and 3), and those of gravel bank and pool (4 and 6, respectively). Sampling site 5, although is located within a riffle area, it is taxonomically similar to the pool zone (6), probably due to its relative closeness in distance (Figure 1). However, when looking at the results of the values of the overlap coefficient (Figure 3b), it is possible to observe a very heterogeneous pattern on the similarity index among sampling points, with only one clear group, formed by core 2 and 5, both in riffle area. Thus, this demonstrates that if one takes into account only the common presence of the taxonomic components (species), it is possible to detect similar zones. On the other hand, if considering the abundances among these , it is clear that dissimilarity is found between sampling points (Figure 3a,b).

Figure 3. Taxonomic and ecological similarity among sampling points within the study area, based on Oligochaeta species
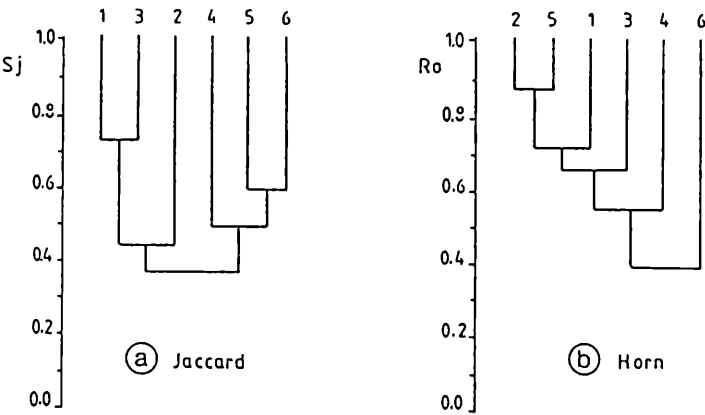

Table 2. Multiple regression equation for the prediction of Oligochaeta species diversity in Ritrodat area. ($n = 24$, $F = 108.275$, $P << 0.0001$).

Variables	Coeff.	t-value	P
Species richness	0.2722	13.987	<<0.0001
Equitability	0.8945	7.583	<0.0001
Intercept	-0.3274		

Coeff. is the regression coefficient associated with each independent variable; the t-value and associated probability (P) indicate the significance of each variable in the prediction of species diversity.

b. Spatial distribution

The results obtained with the diversity values and the overlap coefficient fo Horn (H' and Ro, Figures 2b and 3), suggest that there is a tendency towards an unequal distribution of Oligochaeta species within the study area.   Figure 4, shows the distribution in total percentage of Oligochaeta at each sampling location and also, throughout the sediment depth layers from 0 to 40 cm.   In general, in core 1,3, and 6, the higher percentages are at the surface (from 0 to 10cm), whereas in cores 2,4 and 6 the maximum percentage is between 10 to 20 cm depth.   It is clear that for all cores, except no.5, the lowest densities, and therefore percentages occur at the deepest layers (30 to 40 cm).

Figure 4.   The distribution of the total percentage of Oligochaeta at each sampling point and throughout sediment depth layers from 0 to 40cm.
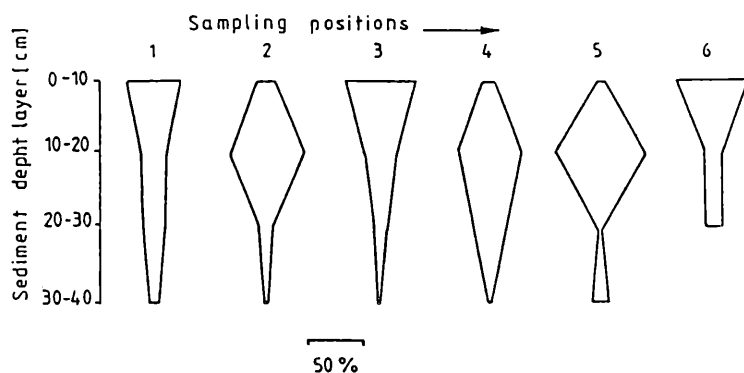
The examination of the distribution at a family level (Figure 5), evidences some hetereogeneity in Oligochaeta, in both horizontal and vertical levels.   However, some generalities are obvious: Naididae and partly Lumbriculidae seem to be responsible for the high densities at the surface, while Enchytraeidae and in a lower degree Aelosomatidae, tend to occur between 10 to 20cm depth (more clear in cores 2,4 and 6).   In the same way, when considering the numerically most important species on the 19th September 1990 (Figure 6), it is possible to distinguish some patterns.   *Nais pardalis, Lumbriculidae gen.sp*. appear together in the same sites (core 2,3), and also in the same depth layer (0-10cm), however the latter species at much lower densities.   A clear pattern is shown by *Lumbriculus variegatus*, which occurs mainly in cores 4,5 and 6; the maximum densities at the surface are only in core 6 (pool zone).   *Marionina sp*. and *Cernosvitoviella sp*. appear also in core sites 2,4 and 5, but their maximal densities are confined to depth layers from 10 to 20cm.

Figures 5 and 6, clearly reveal that the main trend in spatial pattern of at least some oligochaete species is the aggregated form.   In some sampling locations and depth layers, there are notably high densities compared to other sampling points, which obviously may result in a high variance of the number of individuals in any of the spatial coordinates (horizontal or vertical).   The first step involved testing the usual hypothesis that the distribution of the number of individuals is random between both: sampling points and depth sediment layers.   Thus, for these abundant species the common test for agreement with Poisson series was used: the x^2 (chi-square) for variance:mean ratio (ELLIOTT 1977).   Table 3a shows that, at a level of 5% significance, the calculated values of x^2 exceed the tabulated ones between any of the spatial coordinates. Therefore, the agreement with Poisson series was rejected, and due to the high observed variance, it was initially recognized a clumped distribution for these oligochaete species.

Figure 5.   The distribution of oligochaete densities at a family level in different core positions and throughout depth layers in the Ritrodat on the 19th September 1990.
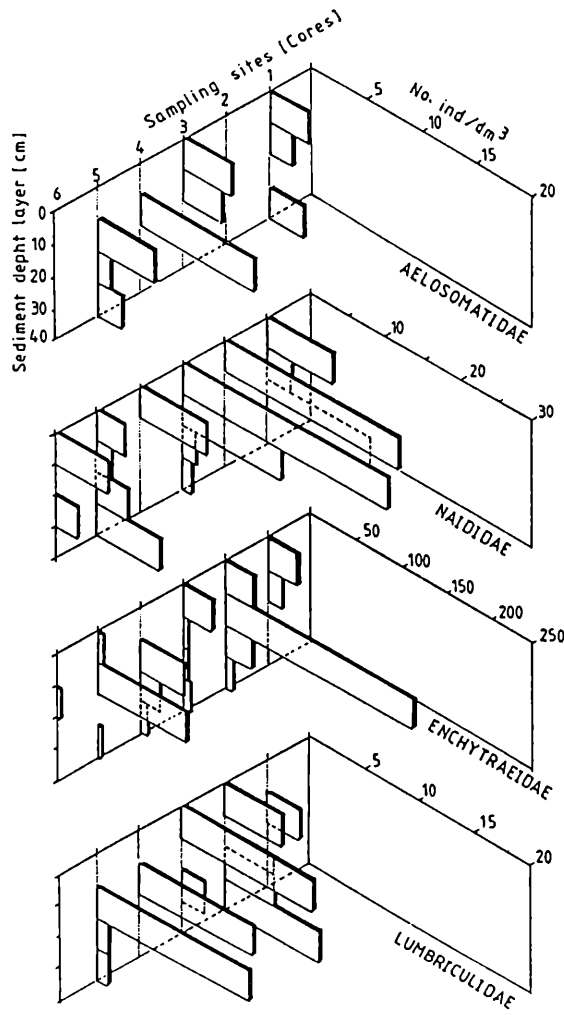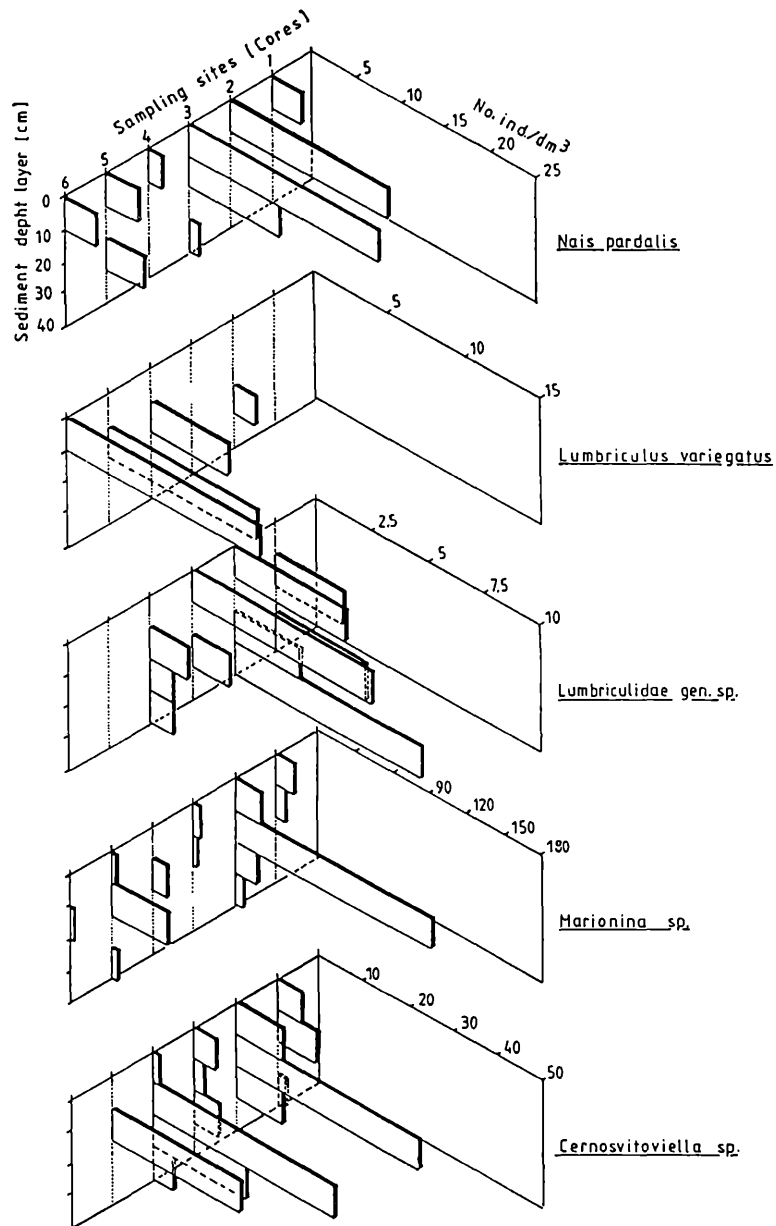
Figure 6. The depth distribution of Oligochaeta densities in different core positions and for the numerically important species on the 19th September 1990.

Nevertheless, the above test is known to be influenced by the number of sampling units and the number of individuals present in each sample.   Thus, a further test was applied to the same same set of data: the non-parametric test of Kruskall-Wallis (Zar 1984).   Table 3b gives the results obtained with this test, where the null hypothesis (Ho) was that the abundances of each of these Oligochaeta species is the same in all samples.   When comparing the five species between core locations, the

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values do not reject the null hypothesis, so that the abundances are similar among sampling points; this would imply that the distribution on that date of September would be at random. On the other hand, the outcome for the depth coordinate indicated in Table 3b is slightly different. The values of two species, *Nais pardalis* and *Marionina sp.*, reject the null hypothesis, so the densities of these oligochaete are significatively different in the vertical profile, and possibly clumped distributed.

The clear discrepancies found between the two statistical tests (Table 3b), when using oligochaete species, can be attributed to the following: the latter is based on equality of the sample means and the test is acceptable under moderate differences in the data variability (POLLARD 1977). Because some of the Oligochaeta species show a high variability in both spatial coordinates, as seen in Figure 6, it is probably this factor which introduces noise in the results of this test.

Table 3. The results of the X^2 (Chi-square) test on the variance:mean ratio for some Oligochaeta species in the experimental area Ritrodat. Numbers within brackets correspond to species number in Table 1.

a. Variance:mean ratio X^2 test.

SPECIES	BETWEEN CORES ($X^2_{0.05,5}=11.07$)	BETWEEN DEPTHS ($X^2_{0.05,3}=7.815$)
(6). *Nais pardalis*	64.51	98.26
(8). *Marionina sp*	655.79	553.96
(9). *Cernosvitoviella sp.*	85.62	169.42
(13).*Lumbriculus variegatus*	30.00	24.11
(15).*Lumbriculidae Gen.sp.*	7.17	15.42

b. Kruskal-Wallis non-parametric test

SPECIES	BETWEEN CORES ($X^2_{0.05,5}=11.07$)	BETWEEN DEPTHS ($X^2_{0.05,3}=7.815$)
(6). *Nais pardalis*	4.13	12.55
(8). *Marionina sp.*	9.04	8.89
(9). *Cernosvitoviella sp.*	8.96	6.19
(13). *Lumbriculus variegatus*	2.34	2.31
(15). *Lumbriculidae Gen.sp.*	8.79	0.50

c. The relationship between some abiotic factors and the Oligochaeta biotic parameters.

Due to the observed differences among core positions on 19th September 1990, two abiotic variables could be related to some of the biological parameters of oligochaete. These were the surface layer topography and the hydraulic stress, whose mean values are shown in Table 4. As expected, the surface topography differs from

core to core, however when looking at the result of the standard deviation, it is possible to visualize that marked variability exists within one specific point (cores 1, 3 and 6). On the other hand, the hydraulic regime also shows a high deviation from mean values within sites, but generally it is possible to observe zones, where the values are lower (cores 1, 2 and 3), compared to the others.

Table 4.   The mean values and their standard deviation of surface layer topography and the hydraulic stress at each core location within the experimental area Ritrodat on the 19th September 1990.

Core	Surface layer topography (water level)		Hydraulic regime	
	x	± SD	x	± SD
	(n = 6)			(n = 3)	
1	46.33	2.94	10.00	2.65
2	63.67	2.25	9.00	2.65
3	47.50	2.74	12.00	1.73
4	52.50	2.17	14.67	0.58
5	46.83	1.60	14.00	2.65
6	52.83	2.64	14.33	0.58

At this date, it was found that the total number of individuals of Oligochaeta between 0-10cm, significatively decreases with increasing hydraulic stress (Figure 7a). Similarly, the diversity values (H') estimated for the same depth layer (0-10cm), were significantly related to the hemisphere numbers, thus Oligochaeta species diversity diminishes at high values of shear stress (Figure 7b).   A significant relationship could be found between these diversity values and the heterogeneity of the surface topography, estimated from the values of standard deviation (Figure 7c).   Conversely to the results obtained with hydraulic stress, diversity increases with increasing habitat heterogeneity in the layer of 0 to 10cm.

Flow regime was further related to densities of those numerically important species in the community. Figure 8, indicates that at least on 19th September 1990, only *Nais pardalis* and *Marionina sp* were significatively influenced by the hydraulic stress.   In both cases, the densities decrease at higher values of hemisphere numbers. The hydraulic preferences for *Nais pardalis*, particularly abundant at surface layers, range from 7 to 13 with a density peak between 10 and 13, whereas *Marionina sp.*

showed high abundances at 7, 8 and 12.   For *Lumbriculidae Gen.sp.* and *Cernosvitoviella sp* there was not significant relationship with the flow regime.

Figure 7. The relationship between some Oligochaeta biological factors and some abiotic parameters on the 19th September 1990 in the study area.
a. Total Oligochaeta densities at the surface layer 0-10cm and the hydraulic stress (hemisphere numbers). Regression equation: Y= 99.899 - 5.477 X (r= 0.73, P= 0.0005).
b. Calculated Oligochaeta species diversity values (H') at the 0-10 depth layer and the shear stress . Regression equation: Y= 3.459 - 0.132 X (r= 0.60, P= 0.0088).
c. The diversity values (H') at 0-10cm depth layer and the standard deviation of surface layer topography. Regression equation: Y= -0.985 + 1.178 X (r= 0.86, P= 0.0280).
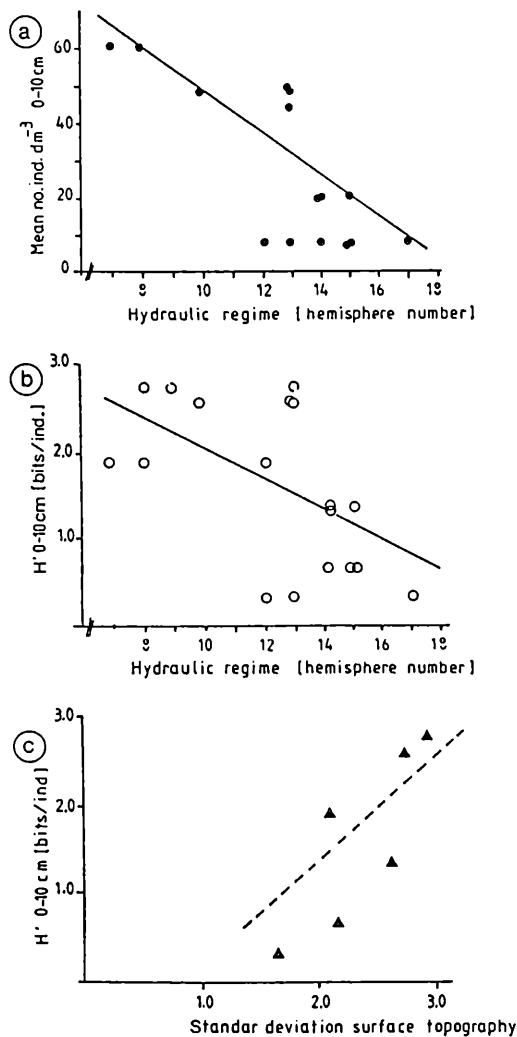
Figure 8. The relationship between densities of those numerically important Oligochaeta species and the hydraulic stress, on the 19th September 1990 in the Ritrodat experimental area.
a. *Nais pardalis* regression equation: Y= 24.200 - 1.275 X (r= 0.45, F= 4.007, P= 0.0626).
b. *Lumbriculidae gen sp.* (r= 0.37, F= 2.509, P= 0.1328).
c. *Marionina sp.* regression equation: Y= 36.922 -2.357 X (r= 0.76, F= 21.560, P= 0.0003).
d. *Cernosvitoviella sp.* (r= 0.09, F= 0.154, P= 0.7001).
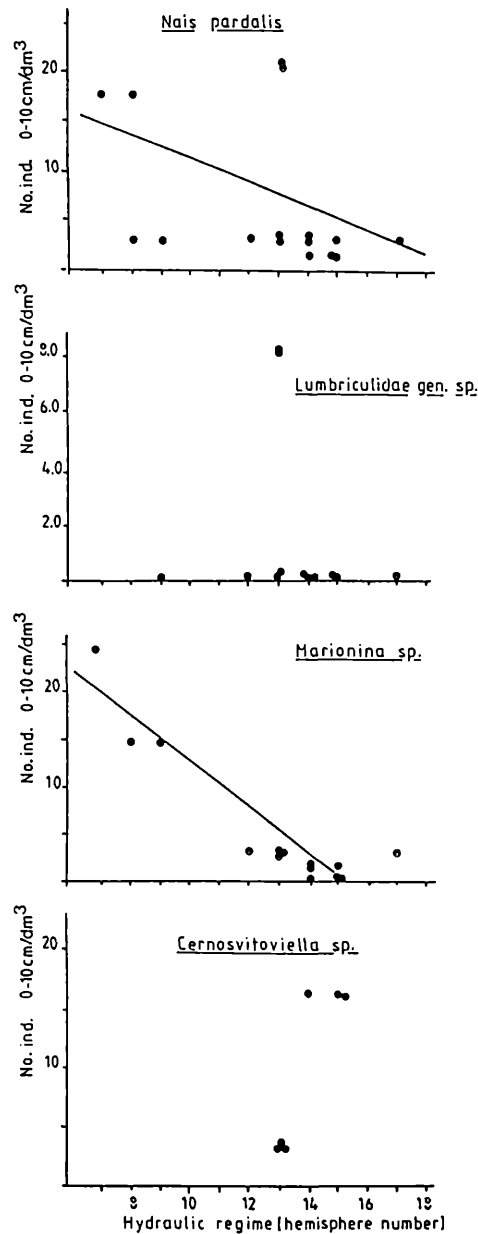
Discussion

The Oligochaeta species composition in the Ritrodat experimental area on the 19th September 1990 was markedly dominated by members of the family

Enchytraeidae (69.1%). This group has been mentioned as terrestrial with some aquatic tendencies (HEALY & BOLGER 1984), but the species inhabiting the Ritrodat *Marionina sp.cf. argentea* and *Cernosvitoviella sp.cf. atrata* are found in semi-aquatic and aquatic situations (HEALY 1987). In the study area, enchytraeids are most abundant between 10-20 cm depth, an indication that sediment layers in the Ritrodat have a high oxygenated saturation. The abundances of enchytraeids within Oligochaeta in sediment surface layers of mountain streams, has been stated as characteristic of fast flowing water and coarse substrate, which might be related to a high level of oxygenation (JOHNSON & LADLE 1989). Due to the lack of information, the comparison of oligochaete depth distribution in similar ecosystems is not possible, however results from quacking marsh (HEALY 1987) have shown that one species of the genus *Marionina* and the genus *Cernosvitoviella* can penetrate even to anaerobic layers. The same work pointed out that naidids and lumbriculids did not penetrate deeper layers. The same is found in this study for Naididae, and it might be connected to their well known association with plants such as mosses or the overgrowing algae on stones (KASPRZAK & SZCZESNY 1976, LEARNER et al. 1978). The Lumbriculidae occurred in the Ritrodat at the surface too, but they could also be found at deeper sediment layers.

In this study, an inverse relationship between hydraulic stress and the total oligochaete abundances was found at the depth layer from 0-10cm. On the 19th September 1990 flow regime (measured as hemisphere number), varied from 7 to 18, so that the results obtained, must await further data collection on oligochaete densities at lower hemisphere numbers. The relation between hydraulic stress and the microdistribution of benthic macroinvertebrates was revised by STATZNER (1981); the work based in either mean size or abundances, demonstrated that the response to hydraulic stress is differential in several species. The results obtained here for Oligochaeta, evidences that unfavourable conditions seem to occur for *Nais pardalis* and *Marionina sp.cf.argentea* from hemisphere number 14 upwards, a range defined as high by PECKARSKY et al.(1990). Other dominant species, such as: *Lumbriculidae gen.sp.*, *Lumbriculus variegatus* and *Cernosvitoviella sp.cf.atrata* show no significant relation to hydraulic regime. These preliminary results would imply that some of the Oligochaeta species are also affected by flow regime and, therefore it could be one of the reasons of their presence in deeper layers of the substratum (i.e. *Marionina sp.*). Moreover, differences between species could also be found, the proportion of variation in densities due to flow regime (r^2) was 20% for *Nais pardalis* and 58% for *Marionina sp.cf. argentea.* Similarly, the r^2 value for the total group Oligochaeta was 53.3% which is slightly higher than reported values for other taxa (PECKARSKY et al. op.cit.).

At the same time, in the Ritrodat the oligochaete species diversity is also influenced by the hydraulic regime and the heterogeneity of the surface layer topography. Diversity is widely regarded as a representative measure of community as it includes the species number and their relative abundance. Oligochaeta diversity values were generally higher at surface layers (0-10cm), and initially were positively related to the habitat heterogeneity (estimated from standard deviation values). Stream ecologists have already shown that aspects of substrate heterogeneity may enhance lotic macroinvertebrate species diversity, but results are found only limited to insects (ALLAN 1975, HART 1978). On the contrary to other assemblages of macroinvertebrates present in the Ritrodat (such as Chironomidae, SCHMID 1987), the Oligochaeta species diversity, on the 19th September 1990, was related to species richness and equitability. Obviously, the Oligochaeta are less diverse compared to chironomids, but the few ocurring species had relatively proportionated abundances.

Respect to the results obtained in spatial distribution, it is clear not only from variance:mean ratio, but also from simple plots of depth abundances distribution, that the most important species in the assemblage were aggregated. Having in mind that HURLBERT (1990) demonstrated the uselessness of the variance:mean ratio as a measure of departure from randomness, it was necessary in this work to use another test for the same purpose. Due to the requirements imposed by the Oligochaeta data, an alternative test was that of Kruskall-Wallis, but results were remarkably discrepant. The test is based on the equality of the means (ELLIOTT 1977, POLLARD 1977, ZAR 1984), and it is insensitive to moderate variability, however oligochaete data were extremely variable showing consequently divergent results. When looking at the figures of Oligochaeta depth distribution, it is not possible to conclude that the species have similar abundances among sampling sites and depth layers, as interpreted from Kruskal-Wallis test, not even infer that the spatial distribution is random. An aggregated pattern of distribution has been obtained in Oligochaeta, particularly with family Enchytraeidae in terrestial systems (ABRAHAMSEN & STRAND 1970). For this purpose, as suggested by HURLBERT (op.cit.) good observant eyes and good graphs remain the indispensable tools when trying to quantify properties and scales of patches in natural populations.

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