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TO THE UNDERSTANDING OF QUANTITATIVE RELATIONS OF ZOOBENTHOS IN OUR STREAMS

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INTRODUCTION

In studying the production relations in streaming waters it is necessary to use quantitative indexes. Finding them out and evaluating them results in comming across a great deal of trouble, not only of methodical character, but also other, met particularly in determining and analysing the material. This contribution is to draw attention to some aspects of quantitative investigation into zoobenthos and its relation to the fish stock.

From papers concerning these problems on our territory we should like to refer to: Peňáz 1966, Straškraba 1966, Peňáz et al. 1958, Obrdlík 1968, Sedlák 1969, Zelinka 1969, Sukop 1970, Kubíček et al. 1970.

In determining the material it was necessary in some cases to consult the specialists. They were Prof. Dr. S. Hrabě *(Oligochaeta)*, Doc. Dr. J. Knoz *(Simuliidae)*, Dr. J. Raušer *(Plecoptera)*, Dr. R. Rozkošný and K. Zwyrtek B. Sc. *(Diptera)*, Dr. E. Sedlák *(Trichoptera)* and Dr. M. Zelinka *(Ephemeroptera)*. To all these specialists belong our cordial thanks. We should as well like to thank to Ing. J. Libosvárský and Ing. S. Lusk for consultations concerning the fish stock.

METHODS AND STATIONS

The material was collected in the years 1966/1967 in two streams in the vicinity of Brno, whose basic layer is formed for the most part by the eruptive rocks of the Brno massive (granite, syenite, diorite). The territory of both streams belongs into a moderately warm climatic region with the average yearly temperature of 8 °C. and precipitations of about 550 mm.

1. The Bobrava brook above Želešice, south of Brno. The brook is the right-hand bank tributary of the river Svratka and the followed sector has the character of hyporhitron (sensu Illies). Its bottom is for the most part stony. Besides, there are also sand-mud or predominantly muddy sectors there. Samples were taken from all three substrates of the bottom. The basic abiotic factors are given in Tab. 1. The main fish representatives are the gudgeon (*Gobio gobio* L.), the chub (*Leuciscus cephalus* L.) and the roach (*Rutilus rutilus* L.).

2. The tributary of the Ponávka brook under Mokrá Hora, north of Brno (for the sake of brevity this tributary is marked as "tributary P").

In its lower sector before its mouth into the Ponávka brook it has the character of epirhitron. The monotonous substrate of this brooklet (up to 1 m width) is for the most part formed by sandy deposits, which in places are interrupted by clusters of small stones (the average surface area of each of them being about 15 sqcm). Samples were taken in both substrates. There are no fish in the brook.

The investigated sectors of both brooks are situated in the shadow and in autumn their bottoms are covered with fallen leaves. Besides differences in size, depth and discharge there are also differences in the individual substrates of both brooks. The stony bottom of the Bobrava brook is constituted by major stones which, in spring and in autumn, are covered by algae (*Cladophora glomerata* (L.), Kütz., *Diatoma vulgare* Bory as dominant), the stones in the tributary P are smaller with sparse or no cover *(Diatomeae)*. The sandy substrate of the Bobrava is of a finer grain size and contains more detritus than that in the tributary P.

Benthos was taken on the stony substrate in the Bobrava by means of a water net with the orifice diametre of 24 cm. The stones were measured by means of the Schräder method (1932). On the other substrates the Surber net with total area of 800 sqcm was used. Each collection on every substrate covered the area of about 2,000 sqcm. In the tributary P the Surber net of 1,250 sqcm was used for both substrates. In all cases the mesh of the net was .5 to .7 mm.

The material was classified and fixed with 4 % formaldehyd in the terrain and weighed after 3 months by the Albrecht (1959) and the Hell (1960) methods. For drying the material before weighing the biomass the battery centrifuge was used (Kubíček 1969).

In the Bobrava altogether 59 samples, containing more than 28,000 individuals were taken in the tributary P 133 samples with 9,700 individuals.

RESULTS

In the course of the period of investigation 84 taxa were found out in the Bobrava and 81 taxa in the tributary P (see Tab. 2 and 3 — the taxon being a higher systematic unit than the species. E.g. *Hydracarina* not determined in detail are counted as 1 taxon).

Tab. 1. The basic data of both streams under investigation

	The tributary P	The Bobrava
Length of the sector followed	50 m	200 m
Height above the sea level	342 m	239—240 m
Width	0.9 m	4.5—5 m
Depth	0.08 m	0.25—0.30 m
Substrate surface		
stones	20 %	80 %
sand (sand : mud)	80 %	15 % (90 : 10)
mud (mud : sand)	—	5 % (60 : 40)
Stream speed (min.—max.)	0.28—0.50 m/sec	0.15—1.9 m/sec
Discharge (min.—max.)	0.019—0.040 m³/sec	0.2—4.8 m³/sec
Ice cover	Jan.—Feb.	Dec.—Feb.
pH (min.—max.)	7.5—7.8	7.3—7.5
O_2	not measured	70—110 %

Trichoptera (particularly *Hydropsyche*), *Ephemeroptera* (chiefly *Baetis*) and *Diptera*, *Chironomidae* (mostly *Prodiamesa olivacea* and *Polipedilum scalaenum*) prevail in the Bobrava.

In the trubitary P the most substantial component of the benthic fauna consists of *Amphipoda (Rivulogammarus fossarum)* and *Diptera*, *Chironomidae* (chiefly *Diamesa prolongata* and *Brillia gr. modesta*).

The analysis of the dominant taxa (i.e. those constituting more than 10 % of the total presence) on the individual substrates is given in Tab. 4.

The annual periodicity of occurrence of the individual groups of the zoobenthos passed according to Hynes's results (1961) distinguishing two basic groups of taxa:

1. Quickly developing types with little conspicuous breaks between the individual cycles.
2. Types with clearly separated cycles. This group includes types with short or long development cycles ending at the beginning or towards the end of spring and at the beginning or at the end of summer (for details see also in Schwoerbel 1969).

In our case the first group would include both species of *Amphipoda* and larvae of the *Hydropsyche* genus, further e. g. *Planaria gonocephala*, *Ancylus fluviatilis* and others. Into the second group can be ranked species with early spring emergence, e.g. *Ecdyonurus gr. venosus*, *Baetis vernus* and some midge larvae with late summer emergence *(Orthocladius*, *Prodiamesa olivacea)* and others.

In none of the seasons does the azoic state of benthal of the streaming waters occur, as the individual cycles progress at various speeds; they do not coincide for the most part and, if they do, they differ as far as quantity is concerned. If at the same time several dominant taxa (maximum 3 species) occur, they are types of animals differing in size as well as food claims and other phenomena. E.g. on the stony substrate in the Bobrava the abundance of the dominant groups of the benthos was distributed in such a way that the peaks did not coincide (Tab. 5). On the example from the tributary P an instance of a simultaneous dominance of several taxa not competing with one another is shown (Tab. 5).

Abundance (A) and frequency (F) of species.

In the Bobrava 84 taxa were found altogether. On the stony substrate there were 60, on the muddy 56 and on the sandy 51. The average frequency of the taxon occurrence was 19 % of the total number of taxa, i.e. 16 taxa. The average frequency on the individual substraes varied a great deal. It was highest on the stony substrate (40 %, 24 taxa), lower on the muddy substrate (21.4 %, 12 taxa) and lowest on the sandy substrate (19.6 %, 10 taxa).

In the tributary P altogether 81 taxa were determined; 64 on the stony substrate, which constituted only a minor part of the bottom, and 53 on the sandy substrate. The average frequency was 12.4 %, i.g. 10 taxa out of the total number. On the stony substrate it was 12.5 % (8 taxa) and on the sandy substrate 9.4 % (5 taxa).

Although the total numbers of taxa in both brooks show only a negligible difference (84 and 81), the taxon frequency differs a great deal. Decisive is the part of constant and euconstant taxa in 51 to 100 % of all cases. This part is, due to more stable conditions of the habitat higher in the Bobrava than in the tributary P, whose

Tab. 2. The total species abundance (Tn) and individual abundance (A%) and biomass (B%)

Taxon	the Bobrava			the tributary P		
	Tn	A	B	Tn	A	B
Vermes	13	9.7	2.1	6	1.7	7.2
Mollusca	3	1	4.4	2	1	1
Hydracarina	(1)	1	1	(1)	1	1
Amphipoda	2	11.8	9	1	68	59.4
Isopoda	1	1	1	0	0	0
Ephemeroptera	9	13.6	22.7	5	8	6.1
Plecoptera	7	1	4	17	3	4.6
Heteroptera	1	1	1	1	1	1
Megaloptera	1	1	1	0	0	0
Trichoptera	13	34.6	41.4	13	1	8.6
Diptera	29	24	11.3	29	18	13.5
Coleoptera	4	1	1	6	1	1
S	84	100	100	81	100	100

Tab. 3. A List of Taxa of the Zoobenthos Found Out on All Substrates in Both Followed Streams

Taxon	stream	the Bobrava			the tributary of the Ponávka	
	substrate	stones	mud	sand	stones	sand
Vermes						
Planaria gonocephala Duges		—	—	—	+	+
Gordius sp.		—	—	—	+	—
Nais elinguis Müll.		+	+	+	—	—
Enchytraeidae g. sp.		—	—	+	—	+
Tubifex tubifex Müll.		—	+	+	—	—
Limnodrilus claparedeanus Ratzel		—	+	—	—	—
Limnodrilus hoffmeisteri Clapar.		—	+	—	—	—
Trichodrius sp.		—	—	—	—	+
Euilyodrilus hammoniensis Mich.		—	+	—	—	—
Psammoryctes barbatus Grube		+	+	+	—	—
Stylodrilus heringianus Clapar.		+	—	—	—	—
Phreoryctes gordioides Hart.		+	+	+	+	+
Eiseniella tetraedra Savigny		+	+	+	+	+
Piscicola geometra L.		+	—	+	—	—
Herpobdella octulata L.		+	+	+	—	—
Glossiphonia complanata L.		+	+	—	—	—
Mollusca						
Unio sp.		—	—	+	—	—
Pisidium sp.		—	+	+	—	+
Bythinella austriaca Frauenfeld		—	—	—	—	+
Ancylus fluviatilis Müll.		+	—	—	—	—
Hydracarina g. sp.		+	+	+	+	—
Amphipoda						
Rivulogammarus fossarum Koch		+	+	+	+	+
Gammarus roeselii Gerv.		+	+	+	—	—
Isopoda						
Asellus aquaticus L.		+	+	—	—	—
Ephemeroptera						
Ephemera danica Müll.		+	+	+	—	—
Ecdyonurus gr. venosus Fabr.		+	+	+	—	—
Heptagenia flava Rost.		+	—	—	—	—
Heptagenia quadrilineata Landa		—	—	—	+	+
Heptagenia sp.		—	—	—	+	+
Paraleptophlebia submarginata Steph.		+	+	—	—	—
Ephemerella ignita Poda		+	+	+	—	—
Caenis macrura Steph.		—	—	+	—	—
Baetis rhodani Pict.		+	+	+	+	+
Baetis vernus Curt.		+	+	+	+	+
Baetis buceratus Eaton		+	—	+	—	—
Baetis sp.		—	—	—	+	+
Plecoptera						
Capnia bifrons Newm.		—	—	—	+	—
Capnia sp.		—	—	+	—	—

Tab. 3 contd.

Taxon (stream / substrate)	the Bobrava: stones	the Bobrava: mud	the Bobrava: sand	the tributary of the Ponávka: stones	the tributary of the Ponávka: sand
Nemoura sp.	+	+	+	—	—
Nemoura cinerea Retz.	—	—	—	+	+
Nemoura cambrica Steph.	—	—	—	+	+
Nemoura flexuosa Aubert	—	—	—	+	+
Protonemura auberti Illies	—	—	—	+	+
Protonemura umbrosa Pict.	—	—	—	+	+
Protonemura praecox Mort.	—	—	—	+	—
Amphinemura sulcicollis Steph.	—	—	—	+	+
Leuctra braueri Kempny	—	—	—	+	+
Leuctra hippopus Kempny	—	—	—	+	+
Leuctra prima Kempny	—	—	—	+	+
Leuctra sp.	—	—	—	+	+
Perlodidae g. sp.	—	—	—	—	+
Perla burmeisteriana Claas.	+	+	—	—	—
Isoperla grammatica Poda	+	—	—	+	—
Isoperla difformis Klap.	+	—	—	—	—
Isoperla oxylepis Despax	+	+	+	—	—
Isoperla obscura Zett.	+	+	+	—	—
Isoperla sp.	—	—	—	+	—
Chloroperla torrentium Pict.	—	—	—	+	+
Chloroperla sp.	—	—	—	+	+
Heteroptera					
Sigara sp.	—	—	—	—	+
Gerris lacustris L.	—	+	—	—	—
Coleoptera					
Gyrinus sp.	+	+	+	—	—
Agabus bipustulatus L.	—	—	—	+	—
Platambus sp.,	—	+	—	—	—
Laccophilus sp.	—	—	—	+	—
Hydrobius sp.	—	—	—	+	—
Elmis maugei Bedel	+	—	+	—	—
Elmis sp.	—	—	—	+	—
Lathelmis perrisi Duf.	+	+	+	—	—
Esolus sp.	—	—	—	+	—
Elodes sp.	—	—	—	+	+
Megaloptera					
Sialis fuliginosa Pictet	+	+	—	—	—
Trichoptera					
Hydropsyche pellucidula Curt.	+	+	+	—	—
Hydropsyche sp.	—	—	—	+	—
Plectrocnemia conspersa Curt.	+	+	—	—	—
Psychomyia pusila Fabr.	+	—	—	—	—
Rhyacophila nubila Zett.	+	—	+	—	—
Rhyacophila sp.	—	+	—	+	—
Hydroptila sp.	+	—	—	—	—
Limnophilinae g. sp.	—	—	—	+	—

Tab. 3 contd.

Taxon	stream: the Bobrava			the tributary of the Ponávka	
substrate	stones	mud	sand	stones	sand
Anabolia nervosa Curt.	+	+	—	—	—
Potamophylax rotundipennis Brau.	+	+	+	—	—
Potamophylax sp.	+	—	+	+	+
Halesus tesselatus Ramb.	+	+	+	+	—
Halesus sp.	—	—	—	+	+
Chaetopteryx villosa Fabr.	+	+	+	+	—
Chaetopteryx sp.	—	—	—	+	—
Chaetopterygopsis maclachlani Stein	—	—	—	+	—
Leptocerus albifrons L.	—	—	+	—	—
Mystacides sp.	—	+	+	—	—
Drusus annulatus Steph.	—	—	—	+	+
Drusus sp.	—	—	—	+	+
Sericostoma sp.	—	—	—	—	+
Silo sp.	—	—	—	+	—
Diptera					
Tipula lateralis Meig.	—	+	+	—	—
Tipula luna Westh	—	—	—	—	+
Tipula vittata Meig.	—	—	—	+	—
Tipula (Acutipula) sp.	—	—	—	—	+
Antocha sp.	+	—	—	—	—
Cheilotrichia sp.	—	—	—	—	+
Erioptera sp.	+	—	—	—	—
Hexatoma (Eriocera) sp.	—	—	—	+	+
Dicranota sp.	+	—	—	+	+
Pericoma sp.	—	—	—	+	+
Ptychoptera lacustris Meig.	—	—	—	+	+
Eusimulium costatum Friederichs	—	—	—	+	+
Eusimulium latipes Meig.	+	—	—	+	—
Odagmia spinosa Doby et Deblock	+	—	—	—	—
Odagmia ornata Meig.	+	—	—	+	+
Liponeura cordata Vimmer	—	—	—	+	—
Ceratopogonidae g. sp.	+	—	+	—	—
Chironomus gr. thummi Kieff.	—	+	+	—	—
Cryptochironomus gr. defectus Kieff.	+	+	+	—	—
Tanytarsus gr. gregarius Kieff.	+	+	—	—	—
Tanytarsinae g. sp.	—	—	—	—	+
Polypedilum gr. scalaenum Schr.	—	+	+	—	—
Polypedilum laetum Meig.	—	+	—	—	—
Brillia gr. modesta Meig.	+	+	+	+	+
Brillia pallida Sparck	+	+	+	—	—
Diplocladius cultriger Kieff.	—	—	+	—	—
Orthocladius sp.	+	+	+	+	—
Orthocladius gr. olivaceus Potth.	—	—	—	+	—
Orthocladius gr. rivulorum Kieff.	—	—	—	+	—
Orthocladius gr. saxicola Kieff.	—	—	—	+	+
Orthocladius gr. thienemanni Kieff.	—	—	—	—	+
Orthocladiinae g. sp.	—	—	—	—	+
Epoicocladius ephemerae Kieff.	+	—	+	—	—
Paratrichocladius inaequalis Kieff.	—	+	—	—	—

Tab. 3 contd.

Taxon	stream	the Bobrava			the tributary of the Ponávka	
	substrate	stnoes	mud	sand	stones	sand
Eukiefferiella sp.		+	—	—	+	—
Diamesa gr. prolongata Kieff.		+	—	+	+	+
Diamesa gr. thienemanni Kieff.		—	—	—	—	+
Diamesinae g. sp.		—	—	—	+	+
Prodiamesa gr. bathyphila Kieff.		—	+	—	—	—
Prodiamesa olivacea Meig.		+	+	+	—	+
Ablabesmyia sp.		+	+	+	—	—
Anatopynia sp.		—	+	—	—	—
Procladius sp.		—	+	—	—	—
Dixa maculata Meig.		—	—	—	—	+
Dixa sp.		—	—	—	+	+
Atherix ibis F.		+	+	+	—	—
Atherix sp.		—	—	—	+	—
Tabanus sp.		—	+	+	—	—
Beris fuscipes Meig.		—	—	—	+	—
Wiedemannia sp.		+	+	+	—	—
	S1	60	56	51	65	53
	S2	84			81	

variable sandy substrate is inhabited only by an limited number of permanent taxa. In spite of the fact that some groups of the zoobenthos are richer in species in the tributary P than in the Bobrava (see Tab. 2, 3, e.g. *Plecoptera*), the frequency of their occurrence is very low and only two species out of 17 (*Protonemura umbrosa* and *Isoperla grammatica*) were represented more often.

The frequency of occurrence of some identical species was different on different substrates of the same stream. Thus e.g. the frequency in *Amphipoda* was almost 100 % higher on the stony bottom of the Bobrava. On the muddy substrate it was lower, since in the period from the June to August no *Amphipoda* were found. Similar differences in the distribution were found in *Rivulogammarus fossarum* by Obrdlík (1968) and in some species of mayflies by Zelinka (1969). This phenomenon can be explain by both active and passive movements of organisms from their permanent habitats to temporary ones for various reasons (food, reproduction, calm periods etc.) and it is necessary to take them into account in a separate study of distribution in the benthos on individual substrates.

Individual abundance (A) and biomass (B).

More detailed data about the abundance will be published in some other paper (see e.g. Sukop 1970). In this paper only the most important values of both indexes are given (see Tab. 6, 7). In table 6 always the 2 highest and lowest values of abundance and biomass are given as well as the average values calculated for 1 sqm of the bottom area with different substrates.

Tab. 4. Dominance of Outstanding Taxa of the Zoobenthos on Different Substrates in Both Followed Streams
(Taxa marked + were most abundant in the group in question
Dominant taxa are printed in bold letters)

Taxon % / Stream	the Bobrava			the tributary P	
Substrate	stones	sand	mud	stones	sand
Nais elinguis	2.5	**46.1**	3.5	0	0
Rivulogammarus fossarum	0.14	1.2	9.4	**70.3**	**57.2**
Gammarus roeselii	0.11	**10.2**	**45.07**	0	0
Ephemeroptera				4.4	**18.4**
Baetis rhodani	1.7	1.2	<1	+	+
Baetis vernus	5.7	2.3	<1	+	+
Ephemera danica	<1	6.07	<1	0	0
Hydropsyche pellucidula	**39.3**	0.9	0.13	<1	<1
Chironomidae				**18.4**	**19.5**
Diamesa gr. prolongata	<1	<1	0	+	+
Brillia gr. modesta	<1	<1	<1	+	+
Tanytarsus gr. gregarius	<1	0	<1	0	0
Orthocladius sp.	**19.1**	2.8	<1	0	0
Prodiamesa olivacea	<1	5.2	**15.4**	<1	<1
Polypedilum scalaenum	0	**10.1**	1.8	0	0
Euilyodrilus hammoniensis	0	0	6.03	0	0
Limnodrilus claparedeanus	0	0	3.6	0	0
Phreoryctes gordioides	<1	3	<1	0	<1
Ancylus fluviatilis	2.8	0	1.5	0	0
Plecoptera	2.5	<1	<1	3.4	1.5
Protonemura umbrosa	0	0	0	+	+
Isoperla grammatica	0	0	0	+	0
Nemoura + Isoperla sp.	+	+	+	+	0

The final average values of both indexes were corrected according to the proportionality of the areas of individual substrates. That is why these numbers are somewhat lower than the results of a mechanical calculation of the average values. A sector of 50 m in length was taken into consideration in the case of the tributary P and a sector of 200 m in length in the case of the Bobrava. Whereas in the Bobrava the differences between the corrected and the uncorrected values are relatively small, in the tributary P they are considerably higher, particularly in the biomass. This is due to a relatively high biomass of the benthos (big types of organisms) of the stony substrate, which, howerer, takes up only about 20 % of the total bottom area.

The corrected results of the values of abundance and biomass correspond to the values known from other streams in our country (Tab. 8).

The fluctuation of the values of abundance and biomass in the course of the followed period, though there is certain periodicity in it, is not sufficiently conclusive in this material. The changes are due to the species composition of the zoobenthos and its development. Relatively high values of abundance and biomass were also found out in winter months (Tab. 7), which is important for planning the dates of taking samples.

The correlation between the values of abundance and biomass is expressed by a curve whose course depends on the total size of the organisms. Small types of

Table 5. Abundance of the Dominant Groups of the Zoobenthos on the Stony Substrates of the Bobrava and the Tributary P

Bobrava

1966/67 Day Month	2 Apr.	14 May	13 Jul.	4 Aug.	30 Aug.	25 Sep.	15 Oct.	12 Nov.	10 Dec.	21 Jan.	18 Feb.	11 Mar.	9 Apr.	22 Apr.	6 May	26 May	24 Jun.	8 Aug.	27 Aug.	16 Sep,	27 Sep.
Trichoptera	5—26.7 %			46.8—72 %								14.1—28.8 %						76.6—92.2 %			
Diptera	47.3 up to 78.8 %		1.7—24.6 %									31—63.3 %					0.2—2 %				
Ephemeroptera	15.2 up to 16.7 %	62.5 %	1.1—32.2 %														68.5 %	0.2—14.1 %			

Tributary P

1966/67 Day Month	7 Oct.	25 Oct.	12 Nov.	26 Nov.	13 Dec.	14 Jan.	28 Jan.	18 Feb.	25 Feb.	11 Mar.	18 Mar.	15 Apr.	22 Apr.	6 May	17 May	19 Jun.	8 Aug.	24 Aug.	10 Sep.	26 Sep.
Amphipoda	51.7—98.7 %												16.3—25.8 %				71.1—91.9 %			
Diptera	0.2—12.5 %											42.6—66.6 %					1—17.4 %			
Ephemeroptera	3 %	17.4—28.6 %			0.5—6.6 %										8.1—14.3 %				3 %	

Tab. 6. Minimum, maximum and average values of abundance (A) and biomass (B) of the zoobenthos on different substrates of both brooks

Substrate		the Bobrava			the tributary P		
		Min.	Max.	$\bar{x}$	Min.	Max.	$\bar{x}$
Stones	A n/sqm	750 1,168	8,587 7,799	3,696	128 184	5,800 4,352	1,333
	B g/sqm	6.6 6.7	57.9 46.6	21.1	1.2 2.3	36 33.1	9.5
Sand	A	50 53	4,728 1,900	651	48 128	2,568 1,904	708
	B	0.04 0.1	19.5 12.1	4.2	0.3 0.4	7.2 6.5	2.7
Mud	A	204 248	6,633 5,473	2.412	—	—	—
	B	1.4 2.3	109.7 29.6	19.8	—	—	—
Total average without correction				A 2,253 B 15.03			1,020 6.1
After correction				A 1,733 B 14.1			832 3.68

organisms (e.g. midges, some mayflies-*Baetis*) have a relatively low biomass even if their abundance be great (see Fig. 1). Bigger types of organisms (caddis flies, *Amphipoda*) have a proportionally big biomass in high abundance. Therefore the first instars of the insect larvae *(Chironomidae, Baetis)* or tiny forms of other benthos representatives (e.g. *Elmis, Hydracarina*) occurring sometimes in great quantities are negligible from the point of view of the total calculation.

These first development stages of water animals have also a high mortality rate, so that they are of no value in the later production balance. It is therefore useless to adapt the methodics of taking samples and classification for this purpose. The classification, in spite of all attempts at symplifying it, remains the most laborious and least effective part of the investigation.

When comparing the average weights of the main groups of the zoobenthos from the stony bottom and the sandy bottom (Tab. 9) one can see that the maximum weight per piece was reached by *Trichoptera* (1 n = 0.02 to 0.03 g) and *Vermes* (0.0164 to 0.0166), whose relatively high biomass was influence by the frequent occurrence of big types of *Oligochaeta (Eiseniella)*. The other groups showed a lower order in weight and according to the substrate their weights differed from one another. E.g. *Amphipoda* of the stony substrate reached duble the weight of the population on the sandy bottom. Obrdlík (1968) found out by means of the morphometric analysis that on the stony bottom bigger individuals of *Rivulogammarus fossarum*

Tab. 7. Changes in Abundance (A, n/sqm) and Biomass (B, g/sqm) of the Zoobenthos on Different Substrates in the Bobrava and in the Tributary P in the Course of the Followed Period 1966/1967

Bobrava

Substrate	Day Month	2 Apr.	14 May	13 Jul.	4 Aug.	30 Aug.	25 Sep.	15 Oct.	28 Oct.	12 Nov.	10 Dec.	21 Jan.
Stones	A	1,158	7,799	3,070	1,492	1,503	2,299	2,152	—	2,634	2,786	750
	B	9.6	17.1	26.2	15.6	9.3	13.1	13.5	—	17.6	13.9	6.6
Mud	A	—	—	—	—	—	5,472	6,633	1,863	505	4,782	906
	B	—	—	—	—	—	28.2	109.7	29.6	5.2	16.1	2.6
Sand	A	107	4,728	175	120	50	53	67	341	95	68	434
	B	1.2	7.0	2.5	0.1	0.04	1.1	0.7	1.0	0.4	0.6	8.8

Substrate	Day Month	18 Feb.	11 Mar.	9 Apr.	22 Apr.	6 May	26 May	24 Jun.	8 Aug.	27 Aug.	16 Sep.	27 Sep.
Stones	A	1,168	4,822	2,038	3,571	2,896	8,587	2,999	5,431	5,522	7,435	7,561
	B	6.7	11.4	7.4	18.3	17.5	57.9	56.7	22.4	26.0	30.7	46.6
Mud	A	—	—	—	2,596	—	4,428	2,583	204	347	248	782
	B	—	—	—	20.9	—	16.0	16.4	3.6	2.3	1.4	5.9
Sand	A	712	739	329	1,229	1,900	1,838	428	—	111	80	74
	B	7.2	4.8	2.3	8.7	12.1	19.5	1.5	—	2.3	4.5	1.9

Tributary P

Substrate	Day Month	7 Oct.	25 Oct.	12 Nov.	26 Nov.	13 Dec.	14 Jan.	28 Jan.	18 Feb.	25 Feb.	11 Mar.	18 Mar.
Stones	A	1,576	552	1,664	1,176	600	4,352	1,808	128	5,800	976	472
	B	19.2	3.3	13.2	6.8	8.8	36.0	8.8	2.4	33.1	7.6	4.1
Sand	A	432	320	464	1,512	2,568	328	1,280	200	128	48	304
	B	0.8	0.7	1.6	7.2	6.5	1.3	3.2	0.8	2.5	0.3	1.0

Substrate	Day Month	15 Apr.	22 Apr.	6 May	17 May	19 Jun.	8 Aug.	24 Aug.	10 Sep.	26 Sep.	12 Oct.
Stones	A	1,688	3,472	1,704	2,032	392	496	664	184	972	480
	B	8.0	10.6	9.2	9.6	2.3	2.9	2.8	1.2	5.1	4.2
Sand	A	696	424	888	1,904	368	264	888	144	704	1,000
	B	3.9	2.8	4.0	4.0	1.6	2.0	3.3	0.4	2.3	4.5

Tab. 8. Average abundance and biomass of the zoobenthos in some of our streams

Stream	A n/sqm	B g/sqm	Author
The Svratka above the dam, sector Dalečín The Svratka below the dam, sector Štěpánov sector Kasany	1,290 2,390 2,720	10.73 16.32 16.02	Peňáz 1966
The Loučka	1,086	13.3	Sedlák 1969
The Bobrava	1,733	14.1	Sukop 1968
The tributary P	832	3.68	Obrdlík 1968
The brooks on the Vihorlat (June)	666	6.6	Obrdlík 1968

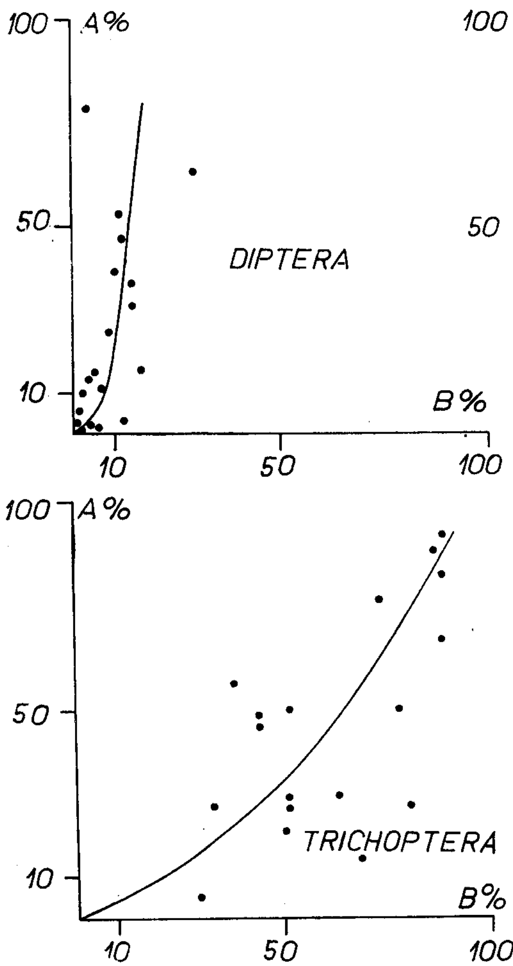

Fig. 1. Correlation between abundance (A %) and biomass (B %) of the main groups of the zoobenhtos (stony substrate, the Bobrava).

(size 5—10 mm) occurred than on the sandy bottom (5—8 mm). Similar difference in weight was also found out in the larvae of mayflies. While on the stony bottom there were more species of the *Baetis* and *Heptagenia* genera, only individuals of the *Baetis rhodani* species were found out on the sandy bottom. In the same way one can explain higher weight parts in the biomass in *Plecoptera* and *Diptera* by the presence of bigger types of animals *(Isoperla grammatica, Tipula, Atherix, Dicranota)*.

These weight data are, howerer, valid only for actual cases and it is not possible to use them for the mechanical calculation of the biomass.

Tab. 9. Average weight per piece (1 n) of the main groups of the zoobenthos of the stony bottom and sandy bottom of the tributary P

Taxon	Substrate	
	Stones	Sand
Vermes	0.0164 g	0.0166 g
Amphipoda	0.0070 g	0.0030 g
Ephemeroptera	0.0047 g	0.0022 g
Plecoptera	0.0075 g	0.0100 g
Trichoptera	0.0300 g	0.0200 g
Diptera	0.0164 g	0.0036 g

DISCUSSION

In the study of biological conditions in streaming waters it is necessary first of all to determine a great number of taxa of various organisms. In the case of zoobenthos in our conditions it is about 100 taxa living on different substrates. In both cases presented here it was shown that out of the total number of taxa only about 1/10 constitute the substantial part of the zoobenthos. From the production point of view it is useless to determine into detail all taxa found. The determination is very lengthy and often very difficult even for specialists.

Another problem is the question of composition stability of benthos on different substrates of the bottom. The same kind of substrate in streams of different sizes does not have the same species composition. Thus e.g. the stony bottom of the Bobrava (width about 5 m) was inhabited for the most part by the net spinning larvae of caddis flies of the *Hydropsyche* genus, whereas in the stony sectors of the tributary P (width about 1 m) *Rivulogammarus fossarum* prevailed. The dependence of communities of the individual taxa on different substrates is given by the offer and competition of food and by the active and passive movements of the animals, which in turn is dependent on many other factors, of the surroundings (stream, light, temperature, detritus, etc., see e.g. Thorup 1966). While the stream is the decisive factor for the occurrence of some species (e.g. *Hydropsyche, Orthocladius, Baetis vernus, Ancylus* and others), in the slowly streaming waters the choice of the dominant species is determined more or less by the food factor (detritus). That is why the species composition of the zoobenthos on fine substrates (sand, mud and their combination) can differ only little. The differences in the species composition of different substrates are small distances between different substrates are easy to overcome by organisms (active and passive movements — e.g. *Gammarus*, *Baetis*, *Chironomidae* and others).

From the point of view of trophic relation (see e.g. Hynes 1961, Cummins et al. 1966, Minshall 1967, Schwoerbel 1969) the part of primary consumers (herbivorous and detritovorous animals) in the Bobrava is lower than in the tributary P (see Tab. 10).

Tab. 10. Percentages of trophic groups of animals in the composition of the benthos of both streams

Trophic group	Stream	the Bobrava			the tributary P	
	Substrate	Stones	Sand	Mud	Sand	Stones
Primary consumers		55	> 80	63	> 96	93
Secondary consumers		45	< 20	37	< 4	7
Fish		present			absent	

Tab. 11. Quantitative Indexes of Zoobenthos and Fish Stock of Some of Our Streams.

Stream	Width	Benthos composition	n/sqm	g/sqm
the Svratka above the dam sector Dalečín	11.5 m	*Trichoptera* 10.5—20 % *Ephemeroptera* 52.8—55.3 % *Diptera* 12.6—16.3 % Varia 12.1—18.4 %	1,290	10.73
the Svratka below the dam sector Štěpánov	15 m		2,390	16.32
sector Kasany	15.5 m		2,720	16.03
the Loučka sector Podolí	5—6 m	*Trichoptera* 13.3—25.2 % *Ephemeroptera* 53.5—69.8 % *Diptera* 2.5—24.5 % Varia 2.5—8.7 %	1,132	13.1
sector Blažkov	5—10 m		1,015	12.8
sector Skryje	12 m		1,112	14.0
the Bobrava sector Želešice	4.5—5 m	*Trichoptera* 34.5 % *Ephemeroptera* 13.6 % *Diptera* 24.0 % Varia 27.9 % (*Vermes*, *Amphipoda* as dominant)	1,733	14.1

The difference is above all in a higher share of predators in the zoobenthos of the Bobrava and in the presence of fish, missing in the tributary P. The predators are represented chiefly by the predatory caddis fly larvae *(Hydropsyche, Rhyacophila)*, other larvae or grown up insects and others (e.g. *Sialis, Dicranota, Hydracarina*). The predators of the zoobenthos of the tributary P are represented by a small share also on the stony substrate. Their low presence is determined by the unfavourable habitat from the point of view of their size and the requirements of their distribution small size of stones and a small total area of the stony substrate (maximum 20 % of the bottom). A relatively high share of the predators on the muddy substrate in the Bobrava (37 %) is due to a higher number of species for whom the muddy substrate covered with leaves, rests of twigs and bank vegetation was suitable (e.g. *Hirudinea, Coleoptera, Hydracarina, Sialis, Atherix*, some *Plecoptera*). Small streams (without fish) show a prevailing share of primary consumers and their biomass and abundance are relatively low. From the production point of view they seem to be insignificant, but they are an important resource of living matter for the regulation of density and feed of organisms into the main stream (drift, recolonization in calamities, etc.).

(Fish stock data ex Libosvárský J., Lelek A., 1966, Libosvárský J. 1968, Lusk S., 1971)

Fish stock composition	n/ha	kg/ha	Note
Grayling 32.5 %, Roach 23.2 %, Yellow trout 10.4 %, Bullhead 9.4 %, Chub 7.4 %, Chondrostoma 6.3 %, Varia 10.8 %	1,907	281.2	Total 11 species of fish
Yellow trout 84.0 % Grayling 8.1 % Bull-head 7.3 % Varia 0.6 %	1,589	130.1	Total 6 species of fish
Yellow trout 20.4 % Varia 79.6 % (Chub, Bull-head, Stone leach, Gudgeon, Chondrostoma, Minnow, Bleack)	3,396	99.0	Total 8 species of fish
Yellow trout 52.0 % Varia 48.0 % (6 species + Barbel, Roach, Pike, Grayling)	3,220	137.0	Total 11 species of fish (8 from the preceding locality + another 3)
Yellow trout 33.8 % Varia 66.2 %	1,323	74.0	Total 12 species of fish (all from the preceding localities)
Gudgeon 48.2 % Chub 15.4 % Roach 15.4 % Stone loach 13.8 % Varia 9.2 %	3,414	98.3	Total 6 species of fish

Quantitative conditions of the zoobenthos in streams with fish, as have been found in this country so far, have a small variation with both in abundance and in biomass. The maximum values differ from the minimum ones only about 2.7 times in abundance and only 1.5 times in biomass (Tab. 11). This is most probably due to the fact that the streams are situated in aproximately the same geological and climatic region and that the composition of species of the benthos is roughly the same. A greater variability in the river Svratka is due to the dam near Vír.

In comparison with the same indexes in the fish stock, howerer, we found conspicuous differences particularly in the biomass of fish (Tab. 11) and in the composition of their species. Therefore isolated quantitative data about the biomass of the zoobenthos cannot be a measure of the productivity of the streams. The criteria stated so far in literature are based on a one-sided understanding of the food relations. This can be explained by the fact that since their publications much new information has been found out, e.g. about the role of drift in fish food, about the relation between the offer and choice of food, about competition relations and others (see e.g. Müller 1952, 1966, Straškraba 1966, Elliot 1967, Waters 1969, Kubíček 1969, Tuša 1968, 1969). Thus e.g. according to the data in the paper of Albrecht (1969), our streams would belong among medium rich to very poor (Tab. 12) on the base of the biomass of the zoobenthos. As, however, follows from Tab. 11, two streams of the same qualitative and quantitative composition can show very different fish production. Fish production need not depend on the absulute quantity of food, but is more dependent on the species and size composition of the fish stock and its suitable regulation. Optimum fish production can be obtianed where choice and control of the fish stock will correspond to the maximum utilization of food offer.

Tab. 12. Classification of streams according to the quantity of food offered. (Adapted from Albrecht 1959)

Stream	Author		
	Hazzard	Albrecht	Dittmar
rich	> 22 g/m²	30—70 g/m²	> 100 g/m²
medium rich	11—23	6—30	50—100
poor	< 11	< 6	25—50
very poor	—	—	< 25

According to the data from Tab. 11 the least effective utilization of food offer is in the Bobrava, where there are reserves in a high abundance and biomass of the amphipods (see Varia about 28 % of the total benthos) and further big animals, which are little accessible for the prevailing part of the fish stock (gudgeon, roach). Certain reserves in the foof offer still exist in the Loučka, especially in the upper and lower sectors. Still rich food offer even under a relatively high fish biomass exists in the Svratka below the dam, where, due to the more suitable water temperature the ingest of food is extended to almost the whole year.

SUMMARY

The authors present the results of a quantitative investigation of two streams (one with fish, the other without fish) and a survey of the values of the zoobenthos of our streams so far known. The quantitative indexes of zoobenthos were compared with the data concerning the fish stock of the streams in question.

Based on their own results and the papers known up to now the authors assume that out of the total number of taxa of the individual streams only about 1/10 is significant for production biology. This 1/10 determines the substantial part of abundance and biomass of the zoobenthos (Tab. 4). The values of abundance and biomass very according to the composition of species of the zoobenthos and its development (Tab. 5, 7). Relatively high values of abundance and biomass were found out also in some winter months.

According to the composition of the substrate the lowest values were found out on the sandy substrate, the highest on the stony substrate (Tab. 6, 7). The average values of abundance and biomass were close to those of other streams in our country (Tab. 8). Small streams (width about 1 m) are poor on the average, (fewer than 1,000 individuals per 1 sqm). While the values of the benthos of various streams in our country differ only very little, quantitative data about the fish stock of the same streams are much different (Tab. 11). From that fact one can judge that the fish production is not dependent on the absolute quantity of food, but on the ability of its utilization. The maximum utilization of the food offer can be assumed where there is a suitable species and size composition of fish stock.

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Резюме

К вопросу количественных отношений зообентоса в наших течениях

Авторы показывают результаты количественных исследований двух течений (одного зарыбленного, второго без рыб) и перечень о до сих пор известных значениях зообентоса некоторых чехословацких течений. Количественные показатели зообентоса сравнивались с данными о плотности посадки исследуемых течений.

На основании собственных результатов и до сих пор известных работ авторы предполагают, что из общего числа таксонов отдельных течений примерно лишь 1/10 имеет значение для производственной биологии. Эта часть составляет самую большую часть абунданции и биомассы зообентоса (Таб. 4). Значения абунданции и биомассы колеблются в зависимости от видового состава зообентоса и его развития (Таб. 5, 7). Также в некоторых зимних месяцах были обнаружены относительно высокие значения абунданции и биомассы.

По составу субстрата были обнаружены самые низкие значения на песчаном дне, самые высокие — на каменистом (Таб. 6, 7). Средние значения абунданции были близки данным других чехословацких течений (Таб. 8). Небольшие течения являются в среднем бедными (ширина около 1 м, менее 1 000 особей на 1 м²). В то время как значения бентоса разных наших течений отличаются друг от друга лишь незначительно, количественные данные о плотности посадки техже течений очень различны (Таб. 11). Из этого можно предполагать, что продукция рыб не зависит от абсолютного количества пищи, но от способности его использования. Максимальное использование пищи можно предполагать в таких местах, где имеется пригодный состав плотности посадки по видами по величине.