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PRODUCTION CONDITIONS IN THE TROUT BROOKS OF THE BESKYDY MOUNTAINS

Results of the research carried out within the framework of the I. B. P. in the years 1966 to 1971

HYDROBIOLOGICAL DEPARTMENT
CHAIR OF THE BIOLOGY OF ANIMALS AND MAN J. E. PURKYNĚ UNIVERSITY,
KOTLÁŘSKÁ 2, BRNO CZECHOSLOVAKIA

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INTRODUCTION

The present paper gives the results of the research of the benthos of two trout brooks in the Beskydy Mountains (Moravia, Czechoslovakia), carried out in the years 1966 to 1971 within the framework of the International Biological Programme. It is not an exhaustive study, such as was reported by French team working at similar problems in the trout waters of the Pyrenees (see e.g. THIBAULT, 1971), but it is a contribution to the characteristics of our medium-sised trout streams, with minimum influence hitherto by the activity of man.

Most materials have been processed. Part of the results were published in preceding years (e.g. ZELINKA 1969, KUBÍČEK et al. 1972), part are stored in the form of diploma theses at our department. The material concerning drift will be processed and published later on.

This paper brings mainly quantitative characteristics of the brooks under investigation and considerations about the influence of fish on the composition and density of the benthos.

Acknowledgements

The autors of the present paper wish to thank all who assisted them in any way in their work throughout the period of investigation. For devoted work in the field and in the laboratory they owe a great deal to the technician E. WAGNER, for the determination of some difficult groups of the zoobenthos they are grateful to Associate Professor Dr. J. KNOZ, CSc., and to Associate Professor Dr. R. ROZKOŠNÝ, CSc. from our chair, for close and friendly cooperation and consultations to Engineer J. LIBOSVÁRSKÝ, CSc., Engineer S. LUSK, CSc. and Dr. P. MARVAN, CSc., from the Academy of Sciences in Brno. We should also like to thank the organisation of the Czech Union of the Anglers in Vsetín for enabling us to carry out the investigation in their trout brooks.

1. The characteristics of the brooks under investigation

The trout brooks Brodská and Lušová are situated in the central part of the Vsetínské vrchy hills, forming a part of the bend of the Carpathian bow starting with the Small Carpathians (Malé Karpaty). They are right-bank tributaries of the river Bečva in its upper stretch (Figs. 1 and 2). The whole drainage area consists of flysch, for the most part sandstone. In the drainage area of both brooks there are no standing waters and it is practically not at all inhabited or influenced by agricultural cultivation of the soil. 90 per cent of the drainage area consists of woods. Coniferous wood forms about 60 per cent of the total wood area. About 8 per cent of the area is formed by meadows and the remaining area are small fields and roads.

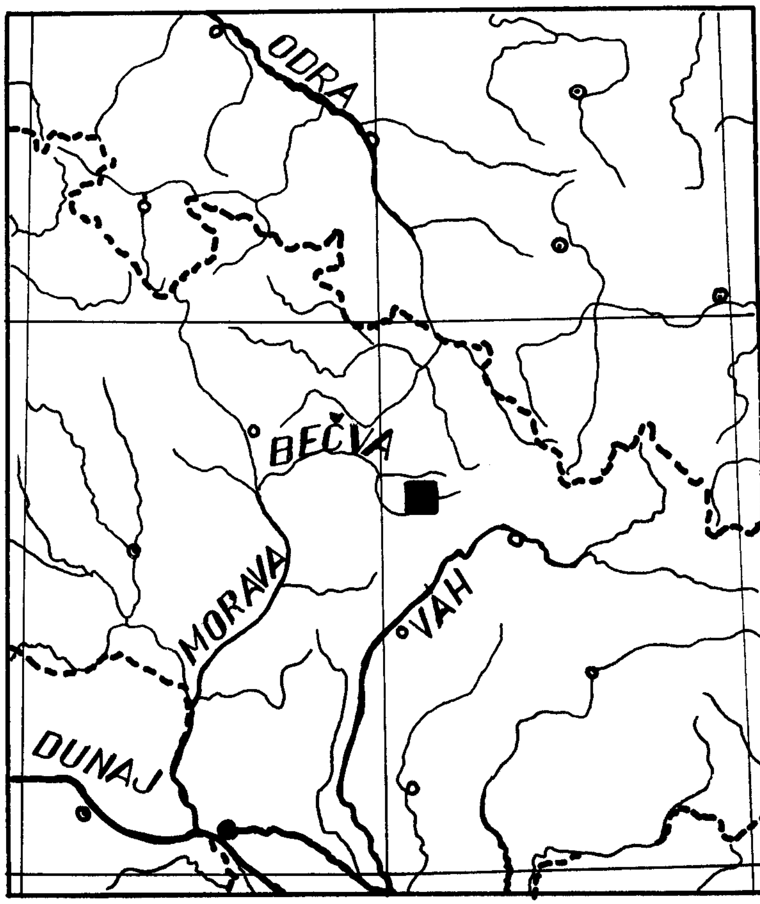

Fig. 1. Situation of the area of the Beskydy brooks under investigation.

Only in the lower stretch of the Brodská (B 1c—see below) slight pollution due to denser settlement occured in the last years of investigation (1969 to 1971).

The height above the sea level varies from 433 m (the estuary into Bečva) to 892 m. The average annual air temperature is 6.0 °C, average precipitations are 1,000 mm. The winds are predominantly north-west, i.e. the valleys are protected by the surrounding hills.

The drainage area of the brook Lušová is 9.75 sq.km, the length of the main stream being 6.00 km. The drainage area of the brook Brodská is 11.80 sq.km and the length of the stream is 5.95 km. The discharge conditions are not systematically followed. The data on characteristic discharge rates have been calculated by analogy according to measurements of many years performed in a similar drainage of the brook Kychová.

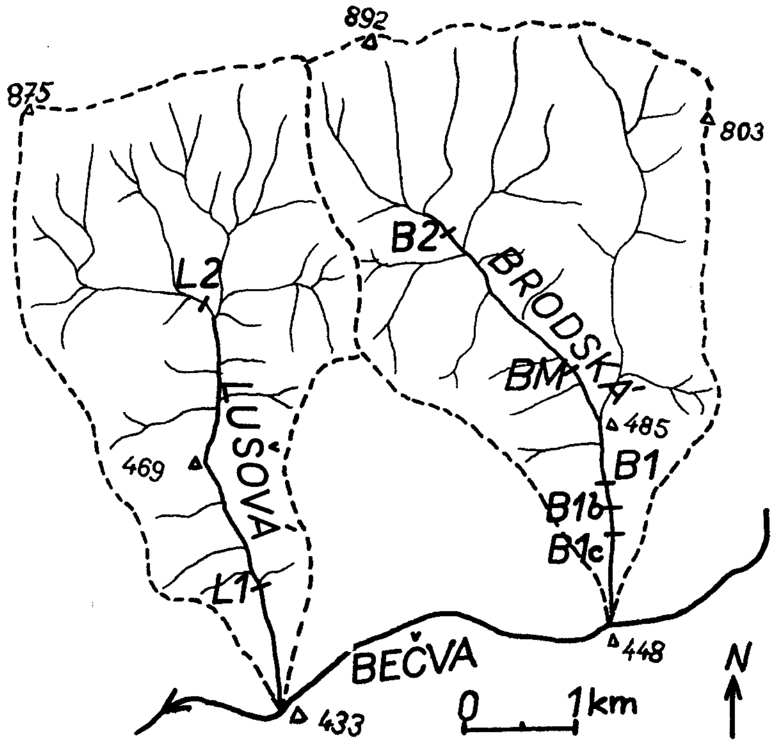

Fig. 2. Situation of the catchment areas of the brooks and the distribution of all stations.

The beeline distance of the centres of the discharge areas is about 8 km (VÁLEK 1953):

	average discharge	minimum
Lušová — upper station	45 l/sec	0.66 l/sec
Lušová — lower station	145 l/sec	2.25 l/sec
Brodská — upper station	38 l/sec	0.56 l/sec
Brodská — lewer station	176 l/sec	2.60 l/sec

The discharge varies a great deal, the difference between the minimum and the maximum is a multiple of several hundred. The samplings in which the discharge was measured by the hydrometric propeller were carried out at average

Fig. 3. Brook Brodská; station—B1.

Fig. 4. Brook Lušová; lower station—L1.

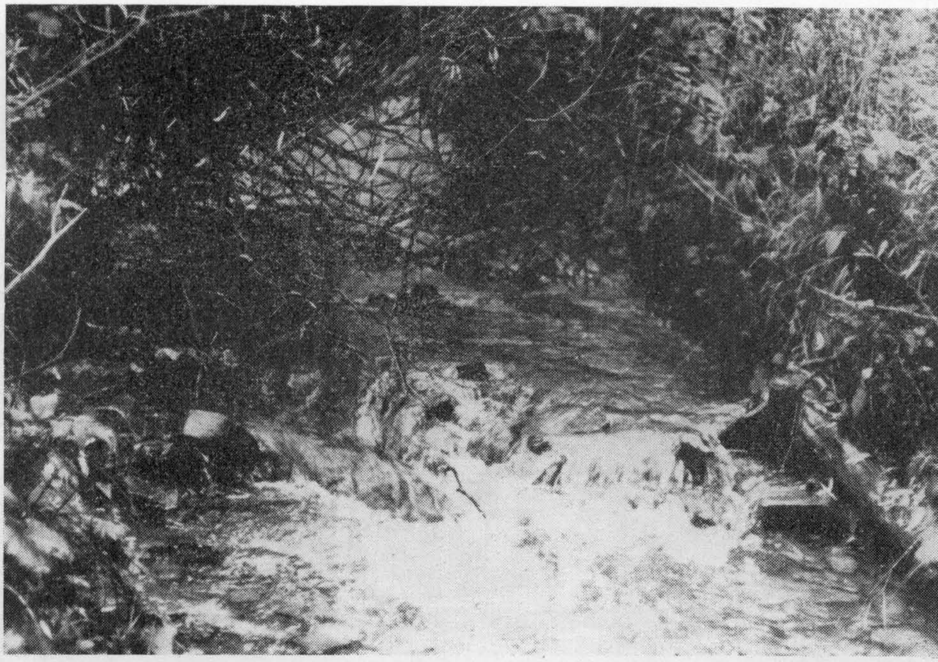

Fig. 5. Brook Lušová; upper station—L2.

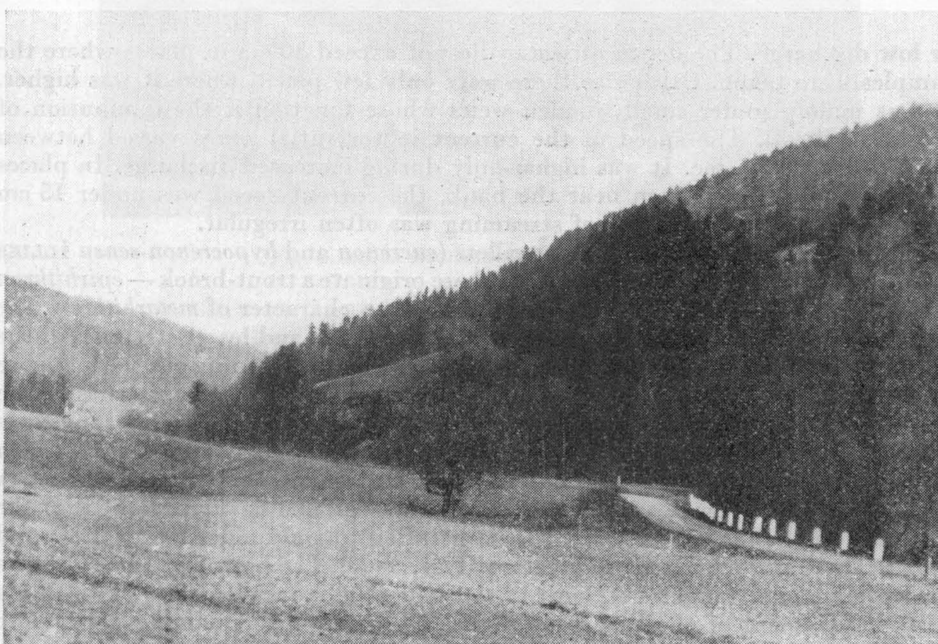

Fig. 6. General wiew of the valley in lower part of the brook Lušová.

Fig. 7. Brook Brodská; lower station—B1b (increased fishstock).

or low discharge. The depth of water did not exceed 30 cm in places where the samples were taken. Otherwise there were only few places where it was higher. It was mainly under small wooden weirs whose function is the diminution of erosion (Fig. 3). The speed of the current in torrential zones varied between (15) 20 and 50 cm/sec. It was higher only during increased discharge. In places where samples were taken near the bank, the current speed was under 15 cm per second and the direction of streaming was often irregular.

Both brooks start as small spring rillets (*eucrenon* and *hypocrenon sensu* ILLIES 1961) and after joining of several rillets there originate a trout-brook — *epirhithron* which flows into the river Bečva which has the character of *metarhithron*. The stations of regular sampling were chosen in the upper and lower stretches of the epirhithron of the two brooks. The investigation aimed at finding out the influence of the fishstock on the zoobenthos was carried out in the lower stretches of the epirhithron of the brook Brodská. In that stretch there were suitable conditions for that purpose, two high weirs dividing the individual stretches. The width of the stream in the upper stations was only little more than 1 m, in the lower stations on the average slightly less than 3 m. The bed is slightly cut into the bedrock, the banks are supported by vegetation (mainly alder and willow) and only in short zones by stone navigation (Figs. 3—8). The bottoms of both brooks are purely stony (sandstone), most of the smoothed stones lie freely. Two thirds of the stones are of the size from 15 to 160 sq.cm; the remaining part up to 500 sq.cm; bigger stones occur only rarely. Smaller stones are situated under stones of the sizes quoted.

Fig. 8. Brook Brodská; upper station—B2.

Fish are represented only by the yellow trout (*Salmo trutta m. fario* L.) and the sculpin (*Cottus poecillopus* HECKEL). The density of the fishstock was also investigated by the workers of the Institute for the Investigation of Vertebrates of the Czechoslovak Academy of Sciences in Brno parallel with our investigation. In the period of 1966/1967 it was, on the average, as follows:

Lušová upper station —	trout 0+	36 specimens per are
	trout 1 and more	40 specimens per are
	sculpin	very rare
Lušová lower station —	trout 0+	?
	trout 1 and more	20 specimens per are
	sculpin 0	300 specimens per are
	sculpin 1 and more	43 specimens per are

Brodská upper station —	fishstock not followed, approximately the same as in the lower station	
Brodská lower station —	trout 0+	6 specimens per are
	trout 1 and more	14 specimens per are
	sculpin 0+	100 specimens per are
	sculpin 1 and more	12 specimens per are

In this account there are not stages up to the size of approximately 2.5 cm. In further years there was an intentional change of the fishstock (see Chapter 2).

The temperature conditions of the brooks under investigation were not followed systematically. During every sampling the actual temperature was measured

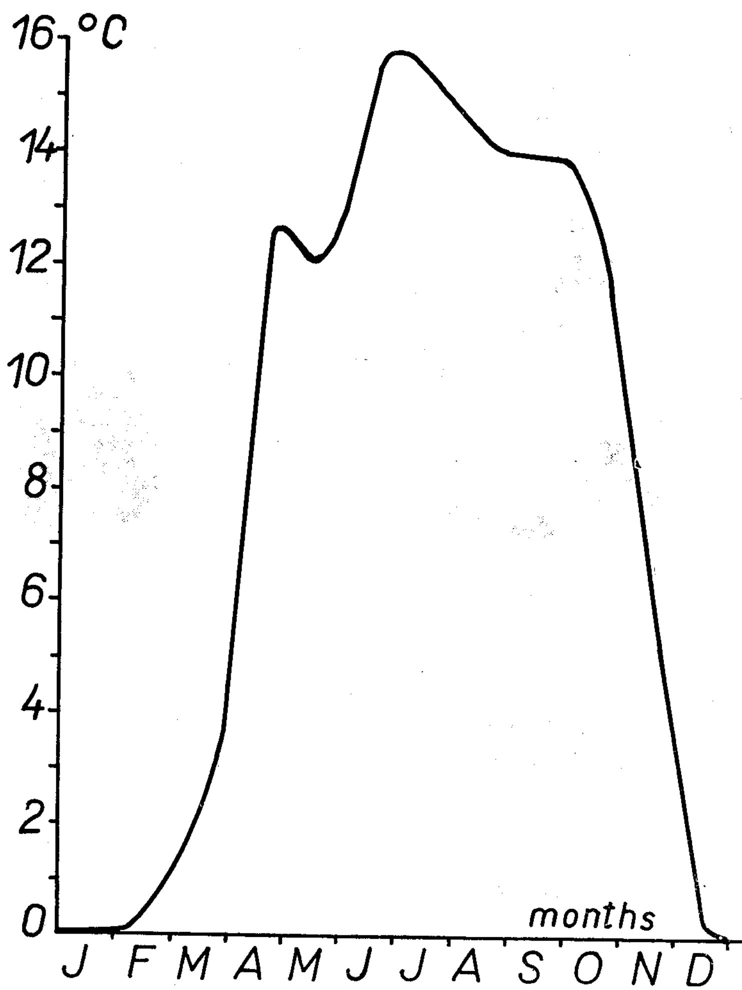

Fig. 9. Maximal average daily temperature in the period of 1966 to 1969.

every month in the course of 3 years. As the quantity of spring water is very small, the annual and the daily course of temperature of both brooks is influenced by outer factors, above all by the temperature of air and by solar radiation. According to our measurements the annual course of temperature in the Lušová as well as in the Brodská can be characterised as follows (Fig. 9). Towards the end of December the temperature of the water sinks towards zero or down to 0 °C and starts rising again towards the end of February. If at that time snow is driven by wind in high layers into the brooks, the temperature of water is slightly higher. Afternoon temperatures (i.e. the daily maxima) in March are on the average 3 °C. A rapid increase in temperature occurs in the middle of April with the average daily maxima over 12 °C and this average persists also in May, in the first half of which there is, however, a decrease. The highest annual temperatures were measured towards the end of June (maxima of the three-year investigation

Tab. 1. **Average values and range (in parentheses) of chemical data of the Lušová and Brodská (1969—1970)**

	Lušová		Brodská	
	upper	lower	upper	lower
pH	7.95 (7.4—8.15)	8.00 (7.4—8.2)	7.92 (7.3—8.2)	8.02 (7.4—8.35)
Oxygen mg/l	10.70 (8.9—12.9)	10.64 (9.0—12.6)	11.22 (9.0—14.3)	11.25 (9.1—14.1)
Oxygen % of sat.	93.0 (89.1—99.6)	93.6 (89.2—102.0)	97.1 (89.8—117.5)	98.2 (90.6—117.9)
Total acidity meq/l	0.05 (0.0—0.10)	0.03 (0.0—0.08)	0.04 (0.0—0.10)	0.03 (0.0—0.08)
Total alkalinity meq/l	2.42 (0.76—3.4)	2.49 (0.76—3.5)	2.14 (0.75—3.6)	2.38 (0.78—3.6)
Total CO_2 mg/l	(33.4—149.6) 106.5	(33.4—154.0) 109.6	(33.0—158.4) 94.2	104.7 (34.3—158.4)
Total hardness °G	8.62 (4.0—11.0)	8.98 (4.4—11.4)	7.76 (4.0—11.1)	8.38 (4.7—11.3)
Ca^{++} meq/l	2.61 (1.22—3.36)	2.72 (1.32—3.43)	2.35 (1.18—3.29)	2.53 (1.36—3.36)
Mg^{++} meq/l	0.48 (0.22—0.72)	0.48 (0.25—0.65)	0.41 (0.25—0.61)	0.45 (0.25—0.72)
PO_4-P mg/l	(0.0—0.020)	(0.0—0.006)	(0.0—0.016)	(0.0—0.002)
NH_3-N mg/l	0.07 (0.0—0.16)	0.05 (0.02—0.08)	0.07 (0.01—0,16)	0.04 (0.0—0.06)
NO_2-N mg/l	0.008 (0.006—0.02)	0.005 (0.003—0.01)	0.005 (0.003—0.01)	0.003 (0.003—0.01)
NO_3-N mg/l	1.04 (0.66—1.70)	1.11 (0.66—1.33)	1.67 (0.84—2.08)	1.15 (0.63—1.63)

Chemical analysis were pursued according to Hofmann et al. (1965)

over 18 °C), the daily maximum at that time being 15.8 °C. In July to September the temperatures are without great oscillations with an average daily maximum about 15 °C. The temperature sinks in October and November to 11.5 °C and 5.1 °C respectively (averages of daily maxima). In the upper stretches of both brooks the summer temperature are on the average lower by about 2 °C, in winter the temperature rarely sinks down to 0 °C.

Chemically the water of the brooks under investigation is characterised by medium hardness, alkalinity and nitrate contents (see Tab. 1). There were minimum differences in the ionic composition of water of the two brooks. The content of dissolved oxygen was not lower than 9 mg per litre (e.g. 89 % of saturation). In the course of the year there are major deviations from the average values only in the time of the snow thaw and in major downpours.

2 Methods

In the first year of investigation (1966/1967) zoobenthos was collected in 4 stations (upper and lower parts of either brook—see Figs. 4, 5, 7, 8). In the second and in the third years of the investigation the upper stations were dropped from the programme and the lower part of the Brodská was divided into 3 neighbouring stretches with different fishstock (see Chapter 5).

In every station samples were taken in the torrential zone as well as in the bank zone. Samples were taken regularly once a month with the exception of December, 1966 and February, 1967 when, for technical reasons, it was not possible to collect.

Uniform station marking:

Upper Lušová (L 2) — only in the first year of investigation
Lower Lušová (L 1) — throughout the period of investigation
Upper Brodská (B 2) — only in the first year of investigation
Lower Brodská (B 1) — throughout the period of investigation, natural fishstock
Lower Brodská (B 1b) — in the second and the third years of investigation, excessive stocking (fishstock)
Lower Brodská (B 1c) — in the second and the third years of investigation without fish

2.1 Periphyton

Qualitative and quantitative observation of periphyton on natural and artificial substrata in the brook Brodská was carried out in the period from February 1970 to March 1971. On the brook Lušová periphyton was observed only qualitatively on natural substrata (stones). On the brook Brodská, besides the upper and lower stations (B 2, B 1c) described above, another station was chosen (Brodská middle—BM, see Fig. 2). It was situated about 1 km above the lower station and it represented the stretch of the brook with a lower speed of the stream, strongly shaded by riparian vegetation. The upper and lower stations were medium shaded, by a wooded ridge and by riparian vegetation respectively.

As artificial substratum was used polyethylene foil wrapped around a transite board, affixed to a brick (Backhaus 1967). This device was situated in horizontal position among bottom stones and secured against overturning. The foils with periphyton were transported in broad neck bottles completely filled with water. Plastic foils were mostly exchanged at intervals of 5 to 7 weeks, samples of periphyton from the stones being taken at the same time.

Periphyton from the stones was taken by removing the periphyton from the surface of the stone limited by the neck of a 100 ml plastic bottle whose bottom had been cut off (Douglas 1958). Released algae were then flushed by a pipette into the collection vessel. An average sample represents periphyton from 10 stones taken in this way. For further analyses performed in the laboratory periphyton from the plastic foils was removed by means of a nylon brush and mixed in a certain amount of water.

Dry weight of the periphyton was then determined gravimetrically after drying at 105 °C, ash-free dry weight as a loss by burning at 650 °C. The quantity of chlorophyll-a was calculated according to Parsons and Strickland (1963) after measuring the extinction of aceton extract at wave lengths of 630, 645, and 665 nm on the spectrocolorimeter Spekol Zeiss.

Abundance was found out by counting the cells of algae in the Bürker chamber. In counting the cells the identification of algae was performed, for an exact identification of diatoms pleurax mounts were used.

The productivity of periphyton on the foils was measured several times by the oxygen light and dark bottles method. 5 to 30 cm^2 of foil with periphyton was placed into exposed bottles of about 120 ml. The duration of exposure was 4 hours at noon.

2.2 Collection and processing of zoobenthos

Zoobenthos was collected both with a bag-like water net with a circular orifice with a diameter of 25 cm (mesh 0.5 mm), the bottom area being determined by measuring the stones by the Schräder method (Schräder 1932), and with a triangular frame net (benthometer) with the surface area of 0.1 sq.m (mesh 0.5 to 0.7 mm) suggested by Kubíček (1967, not published, Fig. 10). The benthometer consists of two metal frames and stretched fabric ended in the rear by the collection bag. The device can be folded (Fig. 11) and the fabric part is stretched on 3 metal bars. Two slanting walls oriented against the current are made of thinner fabric (mesh 1 mm) for a greater efficiency of the current. The lower part of the bethometer being equipped with a dented frame which, during sampling, can penetrate several centimetres in the layer of free stones, it is possible to obtain also organisms from the lower horizonts of the bottom.

The circular net was used in the first year of investigation for collecting all samples, in further years only for the bank zone, where, due to slow current, it is impossible to use the frame net. Comparison tests of both ways showed results lower in the circular net (Trnková 1972).

Mostly we took sample areas of about 2,000 sq.cm (2 × 1,000) from each stretch under investigation. The bottom area of the samples taken in the bank zones was mostly about 2,000 sq.cm, only exceptionally it was smaller.

Our samples were representative both for their number and for the size of the

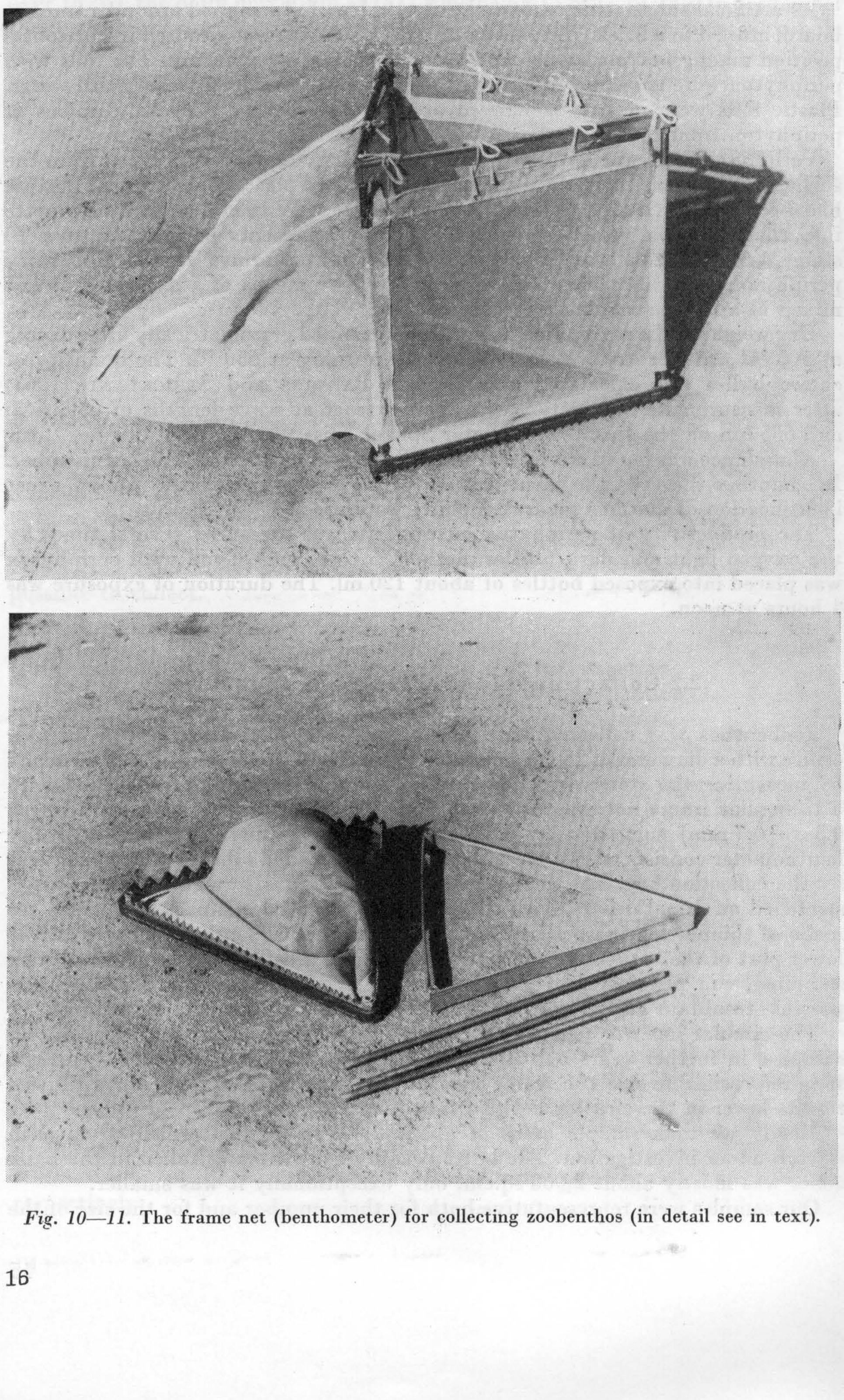

Fig. 10—11. The frame net (benthometer) for collecting zoobenthos (in detail see in text).

collection area and caught about 60 % of all species living in the investigated brooks and 100 % of the species important for the production (TRNKOVÁ 1972).

The organisms collected were taken out and classified on the spot; individual groups of organisms were weighed as fresh weight (for procedure see KUBÍČEK 1969). The material was fixed by 4% formaldehyde.

The determination of the zoobenthos was done mostly by the authors themselves according to literature available. Black-flies were determined by J. KNOZ, some Diptera larvae by R. ROZKOŠNÝ.

2.3 Estimation of zoobenthos production

For determining the production of benthic animals several methods were elaborated (see e.g. EDMONSON and WINBERG 1971), which, however, have not general validity. Their employment in populations with continuous reproduction is particularly problematic. That is why we used a procedure in which we started from the data on the frequency of specimens of a certains species in the individual length classes. For the calculation we used above all the procedure by HAMILTON (1969), in the application of which we did not start from annual mean values but from the values obtained in monthly intervals. In doing this we tried—by individual corrections—respect the fact that longitudinal growth does not proceed in time in the linear way. The losses in the number of specimens between the monthly intervals are evaluated as a 50% increment of the biomass. We also specified the dependence between lenght and weight (ZELINKA, in print). A detailed procedure for determining production is given e.g. in KUBÍČEK and al. (1972), MARVAN (in print).

2.4 Correction for the area of the brook bottom

With the change of the discharge rate there also changes the area of the water level and the area of the inundated bottom. Most species of the benthos are very plastic and quickly populate newly inundated areas or react by withdrawing to more favourable environs before the drop of the water level. Thus the population in the current becomes thinner or denser without a substantial change in the total number of organisms per unit area. That is why we measured the mean breadth of the water level irrespective of the roughness of the ground every time. Based on these measurements we determined a conversion coefficient for a more accurate statement of quantitative data per area unit of the stream. This coefficient equals 1 at the average inundated area in a long-term period (about 300 day water). In higher discharge rates the coefficient is higher than 1, in low water levels it is smaller than 1 (in detail see ZELINKA 1969).

3. Periphyton

Periphyton is important because of its production of organic matter particularly in shallow, quickly running streams. In this type of ecosystem it is practically the only primary producer, since production of other origin (plankton, macrophytes) is missing. Periphyton serves as an important food component of herbivorous benthic fauna.

The study of primary production in running waters was lagged behind the research of standing waters due to considerable difficulty. It has been developed in recent years only; it is however still in the stage of seeking the most suitable methods. SLÁDEČKOVÁ (1962) gave a survey and a detailed description of qualitative and quantitative sampling of periphyton, use of artificial substrata, and various devices in studying periphytic communities. The methods of measuring primary production were summarised in a handbook of I.B.P. by VOLLENWEIDER and al. (1969). According to the approach the methods of determining primary production of periphyton can be divided into three groups.

For measuring production the first approach utilises changes in the chemical composition of water due to metabolism of periphyton, isolated in inclosures. Isolated samples are mostly exposed "in situ". ASSMANOVA (1951) was the first to use the oxygen light and dark bottles method for determining the production of epiphytic periphyton in lake Glubokoe. In running waters this method was applied e.g. by MCCONNELL and SIGLER (1959) who exposed in jars stones covered with periphyton, and KOBAYASI (1961b), who exposed in bottles periphyton loosened from the substratum. BACKHAUS (1967) measured primary productivity of periphyton grown on polyethylene foils by the ^{14}C method. HAUSMANN, LANE and HALL (1971) and BOMBÓWNA (1972) tried to solve in their apparatus the main drawback of that approach—the absence of the streaming of water in the enclosures.

Another approach to finding out primary production in running waters utilises the measurement of metabolical changes in natural conditions on non-isolated communities. The methods of this access were elaborated for running waters by ODUM (1956, 1957). The calculation of the production of the stream from the daily curves of dissolved oxygen found out in two cross-sections was used by e.g. EDWARDS and OWENS (1962), DUFFER and DORRIS (1966) and FLEMER (1970).

A number of authors used indirect methods for the determination of the production of periphyton in running waters. Most of them followed the accumulation of organic matter or chlorophyll on artificial substrata exposed in streams (GRZENDA, BREHMER 1960, WATERS 1961, KING, BALL 1966, CUSHING 1967, BALL, KEVERN and LINTON 1969, BACKHAUS 1969, FLEMER 1970). MCCONNEL and SIGLER (1959) as well as KOBAYASI (1961) calculated the annual primary production from the determined values of chlorophyll, the dependences of the chlorophyll number on the intensity of light and data on solar radiation.

3.1 Results

Algal periphyton in the brooks Brodská and Lušová was formed throughout the whole year above all by diatoms. Dominant were the genera *Achnanthes*, *Diatoma*, *Gomphonema* and *Cymbella*. From green filamentous algae there occurred *Cladophora glomerata* (L.) KÜTZ. in the summer months in torrential zones with sufficient light; from autumn to spring *Ulothrix zonata* KÜTZ. was comparatively frequent.

There being no substantial differences in the species composition of periphytic communities in the individual brooks and stations we give a suvey of the dominant species together in the Chapter 7.

The species composition of periphyton on the foils did not differ from the periphyton on natural substrates from the qualitative point of view. *Cladophora glomerata* was an exception, as it was not found out on the artificial substrate in accordance with other authors (FLEMER 1970). The seasonal periodicity of dominant species was inexpressive.

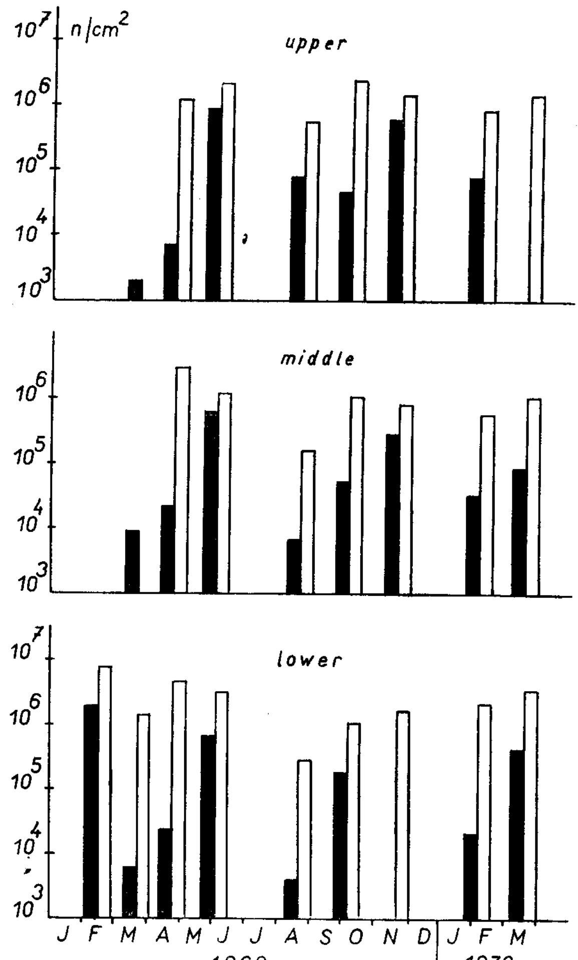

Fig. 12. Seasonal changes in abundance of periphytic algae (number of cells per cm²) on natural (white columns) and artificial (black columns) substrata in the brook Brodská.

The annual courses of the values of abundance, ash-free dry weight and chlorophyll-a content in the periphyton on natural and artificial substrata in the brook Brodská are shown in Fig. 12, 13 and 14.

Tab. 2 gives the average values of the indices of the biomass of periphyton found out.

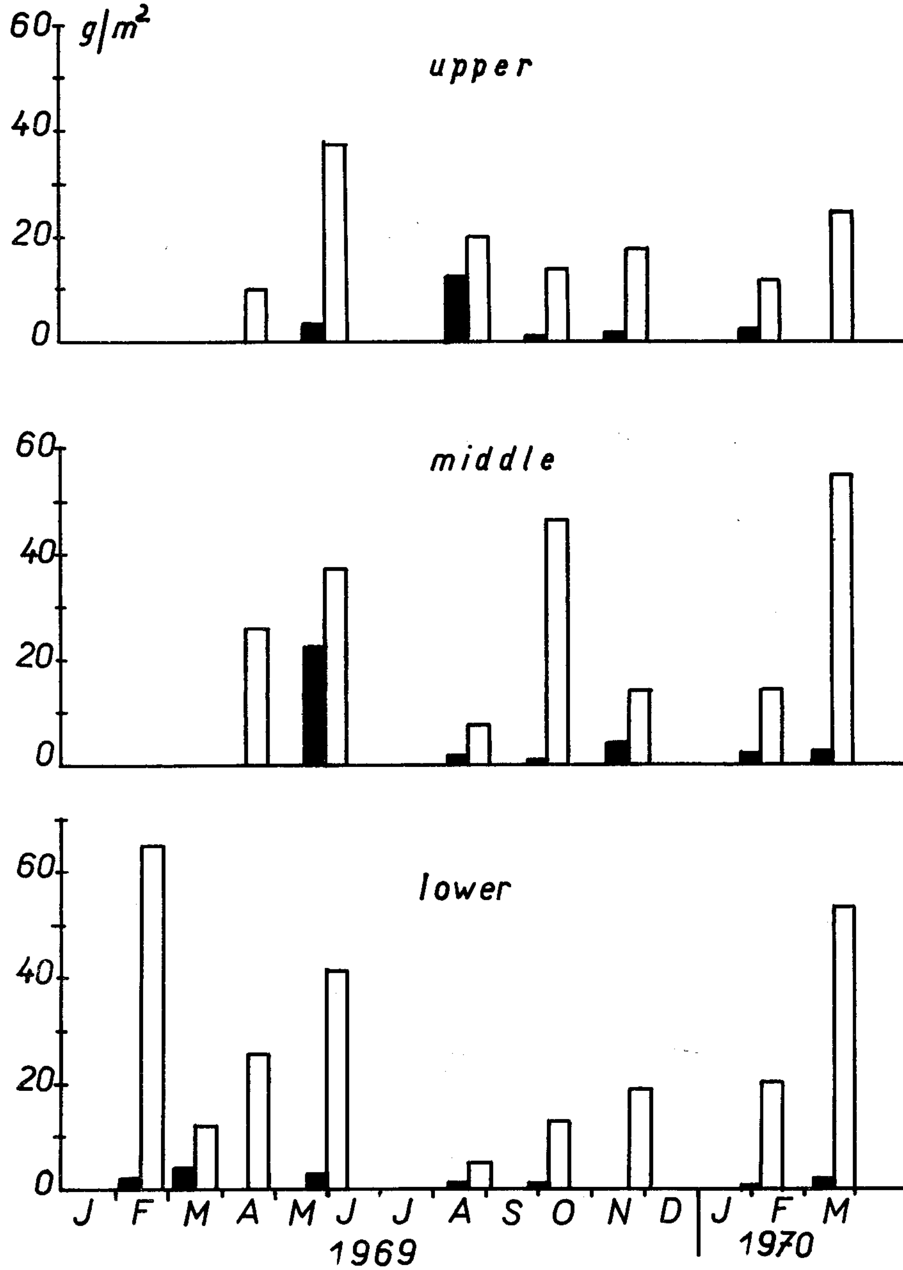

Fig. 13. **Seasonal changes in ash-free dry weight of periphyton on natural (white columns) and artificial (black columns) substrata in the Brodská.**

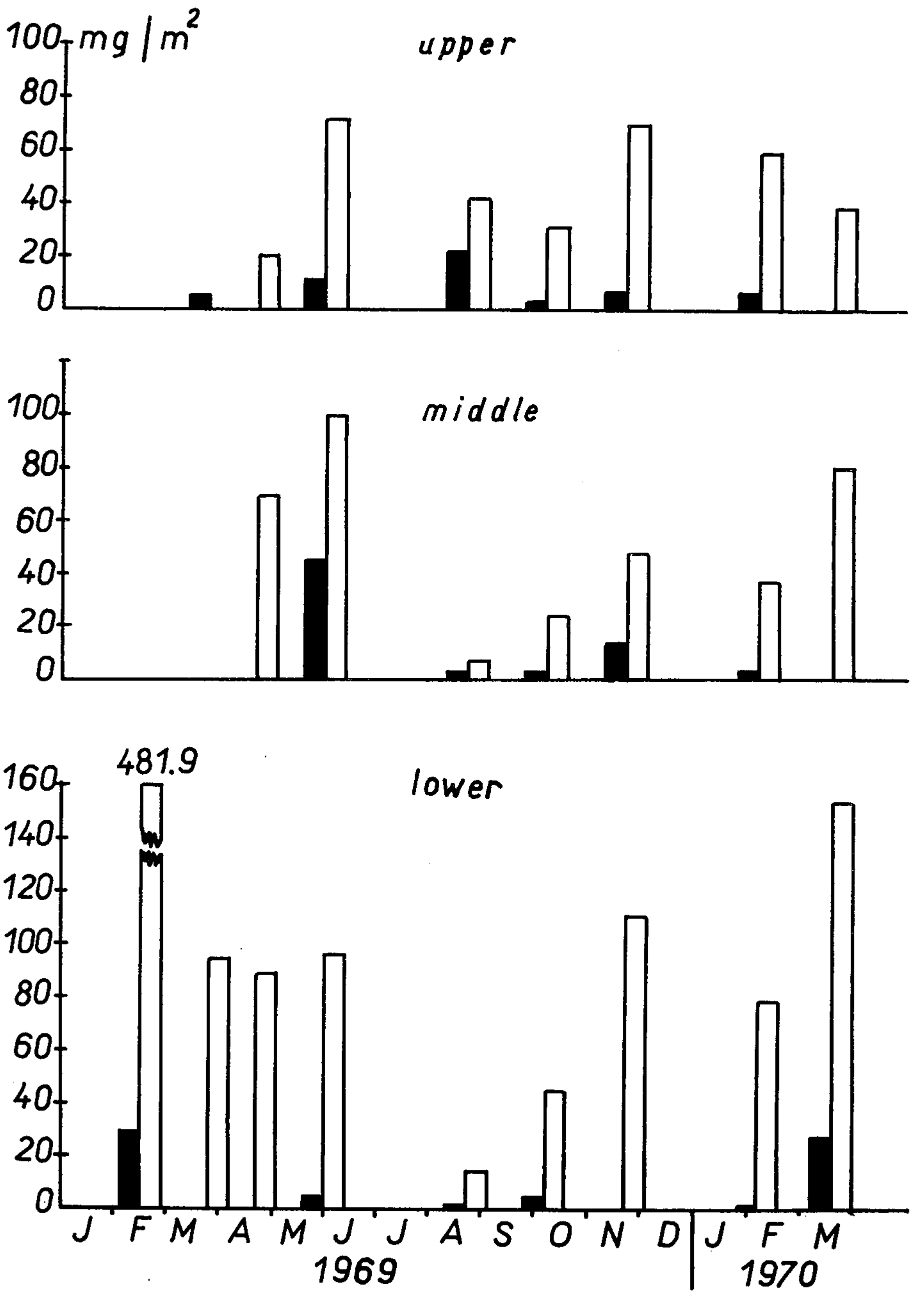

Fig. 14. Seasonal changes in chlorophyll-a content in periphyton on natural (white columns) and artificial (black columns) substrata in the Brodská.

Tab. 2. **Average annual values of abundance, dry weight, ash-free dry weight and chlorophyll-a content in periphyton on natural and artificial substrata in the brook Brodská.**

Substratum	Abundance No. of cells . 10^3/cm²			Dry weight g/m²			Ash-free dry weight g/m²			Chlorophyll-a mg/m²		
	Station			Station			Station			Station		
	upper B2	middle BM	lower B1	upper B2	middle BM	lower B1	upper B2	middle BM	lower B1	upper B2	middle BM	lower B1
stones	1,160	1,011	2,688	66.1	67.5	88.8	14.9	22.1	28.1	37.0	40.7	129.6
foil	195	122	289	9.9	21.7	3.7	2.2	3.6	1.4	6.0	7.8	6.6

The average annual abundance of periphytic algae was highest at the lower station, both on natural and on artificial substrata. It was above all due to more favourable light and hydrological conditions during the winter period, as the other stations froze over and were covered with snow at the beginning of 1970. The abundance at the lower station showed maximum values at the end of winter (February, March), at the other stations the maximum was not outstanding.

The average quantity of chlorophyll-a in periphyton on the stones was highest at the lower station. There was no substantial difference between the annual average values of chlorophyll-a in the periphyton on the foils of all stations. At the lower station there is also the highest average quantity of ash-free dry weight per stone surface unit, unlike foils, where the highest quantity is at the middle station.

The abundance of algae and chlorophyll values on natural substrata ($n = 23$) are significantly correlated ($r = 0.649$) irrespective of the station of the brook Brodská or the season. Significant correlation also exists between abundance and ash-free dry weight ($r = 0.493$) and/or between ash-free dry weight and chlorophyll-a quantity ($r = 0.653$) on the stones.

Tab. 3. **Determined amounts of ash-free dry weight on foils exposed in the brook Brodská and results of measurement of gross primary productivity of periphyton on foils by the oxygen light and dark bottle method.**

Date of sampling	Exposure time (days)	Ash-free dry weight g/m²			Gross primary productivity mg O_2/m². hr		
		Station			Station		
		upper	middle	lower	upper	middle	lower
17 Feb., 1970	103	—	—	2.11			
24 Mar.	35	—	—	3.83			
20 Apr.	28	—	—	—			
3 Jun.	44	3.32	22.68	2.42	76.4	101.3	—
25 Aug.	35	12.22	1.48	0.48	149.5	11.1	79.3
5 Oct.	42	0.32	0.50	0.84	117.9	16.5	24.2
24 Nov.	42	1.42	3.50	—	52.3	31.8	—
5 Feb., 1971	73	2.26	1.78	0.24	25.2	22.8	11.3
18 Mar.	42	—	2.40	1.78	—	7.5	94.5

There are also significant correlations between ash-free dry weight and chlorophyll-a ($r = 0.873$), as well between abundance and chlorophyll-a ($r = 0.655$) on polyethylene foils ($n = 18$). On the other hand, no linear relation between ash-free dry weight and abundance ($r = 0.148$) was found out on artificial substrata.

Tab. 3 summarises the results of the determination of ash-free dry weight of periphyton on foils and the established values of gross primary production of periphyton on foils by the oxygen light and dark bottle method.

3.2 Discussion

In recent years the number of papers dealing with the study of periphyton has grown. Their survey and evaluation is given by SLÁDEČKOVÁ (1962) and WETZEL (1964). For comparison with our results we quote some papers observing the indices of biomass and productivity of periphyton in running waters.

As far as abundance is concerned, results of the same order as those from the Brodská are given by BUTCHER (1946) from the studies of periphyton on glass slides as well as by DOUGLAS (1958) who followed the abundance on natural substrata in a stony brook.

In Silver Spring, YOUNG (1956) calculated the average quantity of chlorophyll-a on glass slides to be 34.7 mg/m^2 at a 16 day exposure of the slides. In the Valley Creek, WATERS (1961) used concrete cylinders as substratum for periphyton. The average value from his data represents 18.5 mg of chlorophyll-a per sq.m. (14 days). A high average quantity of chlorophyll-a (300 mg/m^2) was found out by MCCONNELL and SIGLER (1959) in the mountain river Logan, the values of chlorophyll being even higher in the lower part of the river (under the dams). KOBAYASI (1961a) found a linear relation between the number of cells and the quantity of chlorophyll in the periphyton in the mountain river Arakava. The average quantity of chlorophyll in the periphyton in the caynon stretch of the river was 25 mg of chlorophyl per sq.m, in the lower part 70 mg of chlorophyll per sq.m. of natural substrata.

A considerable influence of the geological origin of the bottom on the value of primary production was found out by DUFFER and DORRIS (1966) in the Blue River. The annual production calculated from the daily curves of oxygen dissolved in water was 2.5 kg O_2/m^2 in the limestone stretch, 7.8 kg O_2/m^2 in the granite stretch, and only 1.1 kg O_2/m^2 in the sandstone stretch per year.

CUSHING (1967) followed the production of periphyton on glass slides in the Columbia River. After an exposure of 14 days he found out the average production of 4.2 g of dry weight per sq.m and/or 22 mg of chlorophyll-a per sq.m The production was highly correlated to chlorophyll-a and also to the quantity of solar energy. There were also highly conclusive correlations between dry weight, ash and chlorophyll-a.

KING and BALL (1966) calculated the average production of periphyton of the Red Cedar River from the increments of organic matter on plexiglass as 281.8 mg of organic matter per sq.m day. In the same river BALL, KEVERN and LINTON (1969) determined the values of organic matter as 10 to 20 mg/m^2. day in winter and 300 to 500 mg/m^2. day in summer. There was a highly conclusive correlation between the so-called phytopigment units and the number of cells.

Backhaus (1969) exposed polyethylene foils in spring tributaries of the Danube. After a 30 day exposure the average production in unpolluted stretches was determined as being about 5 g of organic matter/m^2. 30 days. The highest values were found out in the spring months.

The influence of organic pollution on the extent of primary production was observed by Flemer (1970) in the north branch of the Raritan River. In the upper unpolluted station I the average abundance was 64 . 10^3 cells/cm^2, the average quantity of chlorophyll-a was 6.7 mg/m^2 after a 14 day exposure of microscope slides in the stream. In station II and III, situated below the effluent of the water from an activated sludge plant the quantity of periphyton was higher (station II: 353 . 10^3 cells/cm^2 and 32.7 mg chlorophyll-a per sq.m, station III: 306 . 10^3 cells/cm^2 and/or 21.6 mg chlorophyll-a per sq.m. The author did not find significant correlation between the increments of organic matter on substrata and the results of gross primary production calculated from the daily curves of dissolved oxygen. The highest production was measured in April.

The results of the determination of chlorophyll-a on natural substrata of the brook Brodská roughly correspond to the results published by Kobayasi (1961a). Higher average values were found out by McConnell and Sigler (1959) and in one case also Duffer and Dorris (1966).

The average quantities of chlorophyll found out on polyethylene foils exposed in the brook Brodská are mostly lower than those given by other authors (Waters 1961, Young 1965, Cushing 1967). Approximately the same results were obtained by Flemer (1970) at the upper unpolluted station of the Raritan River.

Primary production of periphyton measured as an increment of organic matter on artificial substrata in the brook Brodská corresponds to the results obtained by Cushing (1967). Similar values were also found out by Backhaus (1969) in the upper unpolluted stretches of the Breg and the Brigach, while in the polluted stretches the production values were higher. High primary production was also found out in the Red Cedar River (King, Ball 1966 and/or Ball, Kevern and Linton 1969).

It is however necessary to bear in mind the fact that an absolute comparison of the results of the studies utilising artificial substrata is difficult due to various times of exposure in the stream, various kind of substrata and their position in the stream. After all, the results obtained in that way are only relative, representing the value of nett primary production of periphyton reduced by losses due to e.g. current, grazing, in long exposures dying of cells. These losses can be partly avoided by using a series of substrata with a graded time of exposure (Grzenda, Brehmer 1960), which helps to obtain a curve of colonisation and production of periphyton.

Kevern, Wilhm and van Dyne (1966) found out a close correlation between the results of production of the laboratory brook calculated from the changes of dissolved oxygen and the accumulation of organic matter on artificial substrata, if they did not take into consideration the beginning phase of the colonisation of the substratum for the calculation of production.

The speed of the stream has a considerable influence on the growth of periphyton. The streaming of water supports the growth of algae by a continuous supply of nutrients and by removing vaste products of the metabolism. A high speed of the current, howerer, causes a considerable wear and removal of periphyton and a more difficult colonisation of artificial substrata. From comparing the results in the brook Brodská it follows that the losses due to streaming were higher on smooth foils than on uneven and rough stones. The July sample, where the losses of periphyton due to floods were almost absolute, was not included into total results (19 Jul., 1970—81 mm of precipitation). The high values of the indices of the biomass of periphyton towards the end of winter under minimum discharge rates, dropped sharply during the increased rate in the period of the snow thaw. Great losses of periphyton in above-average discharge rates were also observed by e.g. BACKHAUS (1968, 1969) and BOMBÓWNA (1970). BALL, KEVERN and LINTON (1969) determined as optimum for the growth of periphytic communities in the Red Cedar River the current speed of 0.3 to 0.9 m per second.

The determination of the productivity of periphyton by the oxygen light and dark bottle method carried out in situ yield relatively more exact results about immediate productivity than indirect methods. This method is, however, biassed by an error, as the metabolism of rheophilic periphyton is influenced by the absence of the streaming of water in enclosures (WHITFORD, Schumacher 1961).

The results obtained by this method in several measurements in the brook Brodská (see Tab. 2) are somewhat higher than the values measured by other authors. MCCONNELL and SIGLER (1959) found out the values of 0.5 to 0.7 mg O_2 per 1 mg of chlorophyll-a per hour in measuring the productivity rate of periphyton on stones. For the calculation the authors used the value of 1.5 mg per 1 mg of chlorophyll-a per hour. The average value of the assimilation number of periphyton on artificial substrata in the brook Brodská (7.6 mg O_2 per 1 mg of chlorphyll-a per hour) is also higher than that stated by KOBAYASI (1961 b — 2.1 mg O_2 per 1 mg of chlorophyll-a per hour in winter and 4.9 mg O_2 in summer under light saturation). The lower determined values of assimilation numbers of the authors mentioned can be explained by a higher quantity of chlorophyll-a per unit area, as the assimilation number (mg O_2 per 1 mg of chlorophyll-a per hour) drops with the increasing quantity of chlorophyll-a.

BOMBÓWNA (1972) gives the limits of productivity for diatom communities of the River Raba as 0.5 to 3.0 mg O_2 per 1 g of dry weight per hour; for *Cladophora* 3.0 to 7.0 mg O_2 per 1 g of dry weight per hour. These data correspond to our results (average value 3.8 mg O_2 per 1 g of dry weight per hour). If we recalculate the results obtained by BACKHAUS (1967) who used C^{14} method for measuring the productivity of periphyton on the foils to the production of oxygen, we obtain the values of 0.8 to 10.0 mg O_2/m^2.hr, i.e. lower values than those in the present paper.

4. Zoobenthos

In the following chapters we give a survey of the composition of the individual groups of the zoobenthos, its distribution on the bottoms of the brooks and qualitative as well as quantitative changes in the course of the year. Notes on the influence of fish on the zoobenthos are attached.

4.1 Vermes

4.1.1 Turbellaria

The most frequent representatives of worms in the trout brooks are the planarians, above all the species *Dugèsia gonocephala* (Dugès). They occurred frequently under stones in all stations under investigation, both in the current and near the banks.

The differences in the abundance of planarians between the upper and lower stations are not significant, and due to scanty material collected in the years 1966/67 it is impossible to evaluate quantitative relations of planarians reliably. In the Lušová we did not find any planarian in the upper stretch in the current, while under the stones near the banks there lived about 30 to 36 specimens per sq.m. In the Brodská planarians occurred in the stream less in the upper stretch than in the lower one, the stones in the current being less populated than those near the banks (Tab. 4).

Tab. 4. **Average annual abundance of Dugésia gonocephala in the Lušová and Brodská**

Trout brook		Lušová		Brodská			
Station		L2	L1	B2	B1	B1b	B1c
Current	1966/67	0	30.2	13.8	32.7	—	—
	1967/68	—	42.8	—	30.2	27.2	28.1
	1968/69	—	22.8	—	4.8	11.1	4.9
Bank	1966/67	36.0	30.1	31.2	89.4	—	—
	1967/68	—	50.1	—	76.3	72.9	95.8
	1968/69	—	33.5	—	35.2	26.1	60.6

Substantial differences in the distribution of planarians were noticed between the current and stagnant water near the banks. From Tab. 4 it is evident that the values of the average annual abundance of planarians are in all cases higher near the banks than in the current; they are multiples of the values of occurrence in the current. Also the difference in the density of population of the stones of the two brooks is evident. While in the current there lived more planarians in the Lušová than in the Brodská, there occurred more planarians near the banks in the Brodská than in the Lušová. This difference in the distribution corresponds to the outer character of the brook Brodská.

In the annual cycle planarians show the highest development in May to August (Fig. 15); in the remaining period of the year they occurred less frequently. The maximum densities do not fall into the same time; there are differences between the situation of the maxima in the course of the year as well as in the quantity reached. Maximum abundance of planarians reached the values of 100 to 290 specimens per 1 sq.m, which corresponds to the biomass of 2.1 to 6.2 g per 1 sq.m.

The biomass of planarians was calculated from the average weight of 1 specimen: 21.48 mg. That is why the changes in the biomass correspond to the changes in the abundance in the individual stations (Fig. 15).

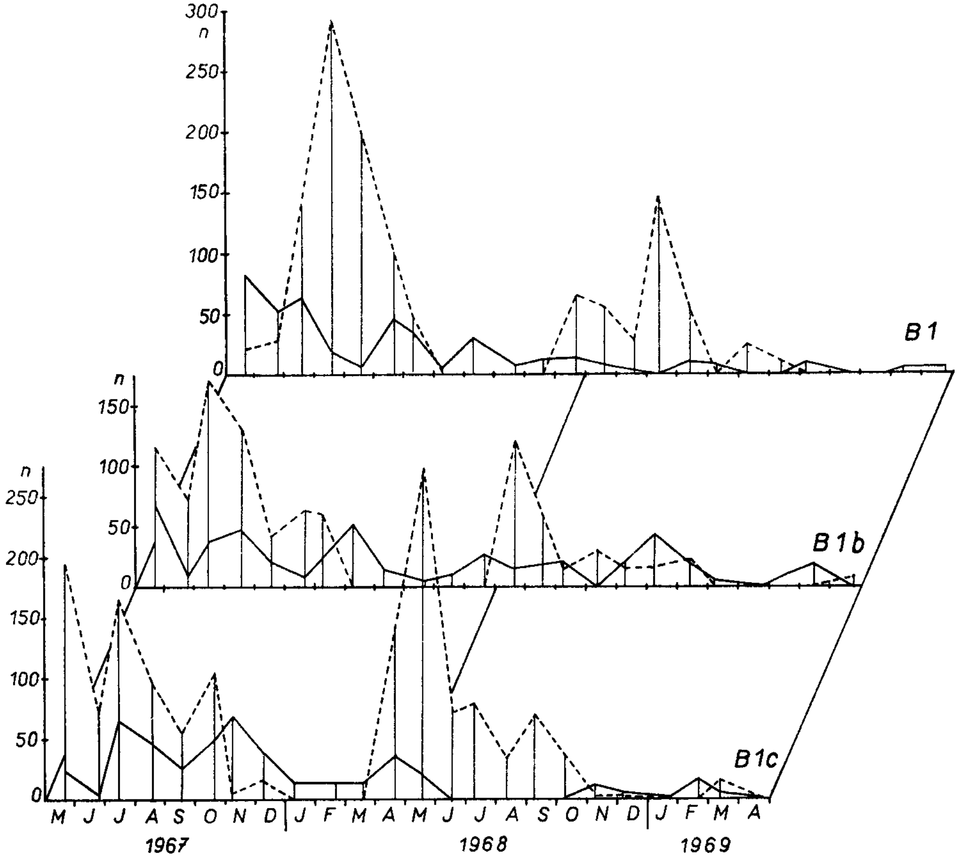

Fig. 15. Space and time distribution of *Dugèsia gonocephala* in the lower stations of the Brodská.

We did not find out any correlation between the abundance and or the biomass of planarians and the density of population of the yellow trout in the Brodská. Even though there are certain differences in the abundance of planarians between the stretches with a different population of the yellow trout, these differences are not significant. The importance of planarians as food of yellow trout or sculpin is, after all, insignificant; in the digestive organs of both species no planarians were ever found (ORSÁG and ZELINKA, in print).

The production of planarians was not specifically stated.

4.1.2 Oligochaeta

The time and space distribution of *Oligochaeta* was irregular in both brooks. There occurred unspecified species of *Tubificidae* and *Lumbriculidae*. The quantitative part of both families in the total zoobenthos is negligible in both brooks. Due to scanty material collected in the period of the whole research it is impossible to evaluate the differences between the two brooks, the individual stations and biotopes.

As can be seen from Tab. 5, *Oligochaeta* were mostly not found at all. As far as they occurred, their abundance was insignificant. The average annual abundance of both families varied between 0.7 to 18.3 specimens per 1 sq.m. Relatively highest were its values in the current in the lower stretch of the Lušová and lowest in stagnant water near the banks in the Lušová and the Brodská in the lower stations.

Tab. 5. Average annual abundance of Tubificidae and Lumbriculidae in the Lušová and Brodská

Trout brook		Lušová		Brodská			
Station		L2	L1	B2	B1	B1b	B1c
Current	1966/67	0	0	0	0	—	—
	1967/68	—	18.3	—	1.7	0.9	1.7
	1968/69	—	14.4	—	10.4	8.6	5.6
Bank	1966/67	1.2	0	0	0.7	—	—
	1967/68	—	1.4	—	6.2	1.2	1.8
	1968/69	—	2.4	—	4.4	5.5	7.3

Owing to insufficient material neither the biomass nor the production were separately specified.

4.1.3 Hirudinea

The trophic importance of leeches is small and they are insignificant as food component of the yellow trout and the sculpin. Therefore, *Hirudinea* were followed only separately and were not included in the total calculation of the zoobenthos. All leeches found belonged to the genus *Herpobdella*.

From quantitative indices we only found out abundance in *Hirudinea*. Its values were for the most part very low and both in the time. In the space and time distributions there was a great irregularity. *Hirudinea* were missing in the upper stations of both brooks and in the lower station of the Lušová. Isolated occurrences come from the lower stations of the brook Brodská, where they occurred most frequently in the lowest stretch (B 1c), which was without fish. We found them under stones both in the current and near the banks. Their relatively more frequent occurrence in the lower stretch of the Brodská is probably due to certain slight organic pollution. The average abundance reached 1.2 to 2 specimens per 1 sq.m.

4.2 Mollusca

Mollusca were represented in the brooks by one slug, *Ancylus fluviatilis* Müller; from *Lamellibranchia* we only found 4 specimens belonging to the genus *Pisidium* for the whole time of the investigation in the lower station of the Brodská. Within the framework of the whole phylum we shall therefore evaluate only the production ecology of *Ancylus fluviatilis*.

In the first year of the investigation, 1966/67, it did not for the most part occular in the upper stations with the exception of the current in the Lušová. But also in the lower stations its representation was mostly very weak. In the following two years its population was much more numerous, especially on the stones near the banks.

While in the brook Lušová the density of population in both biotopes was, on the whole, well-balanced, there was a substantial difference in the population of the bank and the torrential zones in the Brodská. This is clearly evident from the percentual shares in the total number of the specimens collected throughout the whole investigation in the Brodská: current—28.9 %, bank—71.1 %.

Tab. 6. **Average annual abundance of Ancylus fluviatilis in the Lušová and the Brodská**

Trout brook		Lušová		Brodská			
Station		L2	L1	B2	B1	B1b	B1c
Current	1966/67	0.6	1.0	0	4.9	—	—
	1967/68	—	18.3	—	15.7	10.3	13.2
	1968/69	—	0.8	—	2.6	2.6	5.2
Bank	1966/67	0	6.2	0	14.0	—	—
	1967/68	—	0.9	—	43.1	19.7	40.9
	1968/69	—	1.6	—	24.1	11.6	25.3

Analogical differences also occurred in the values of the average annual abundance (Tab. 6); they are again particularly conspicuous in the Brodská.

We found out the differences between the individual stretches of the Brodská with different yellow trout population. The middle stretch with increased fishstock has relatively the lowest abundance of *Ancylus fluviatilis*.

The biomass was determined from the average weight of 1 specimen, viz. 2.6 mg. The changes in the biomass therefore correspond to the changes in the abundance. Production rates were not separately calculated.

4.3 Amphipoda

In the Beskydy brooks *Amphipoda* are represented by the only species—*Rivulogammarus fossarum* (Koch). The population of this species and its importance in the ecosystem of streaming waters have been little studied in this country. The papers by Straškraba (1966) on the analysis of populations and their distribution in the streams Lucina and Morávka and their relations to the fishstock, as well as that by *Obrdlík* (1972) about the same species from a small wood brook without fish in the surroundings of Brno have so far been the only ones.

The material from both Beskydy brooks contained more than 12,600 specimens and the analysis of that population will be contained in another paper. In this chapter we deal mainly with quantitative indices and estimated production rate.

In the first year of investigation, 1966/67, samples were taken in the upper and lower stretches of either brook. In the further stage the upper stations were left out of the study.

The upper stretches of the brooks had a population with the average annual biomass of 2.192 g and abundance of 212 n/sq.m. (Lušová) and 1.965 g and 146 n/sqm. (Brodská). The annual production of those stretches corresponded to about a quadrupole of the average biomass.

4.3.1 Annual cycle

In the lower stretches of both brooks under investigation the annual cycle proceeded in similar ways. Adult specimens which had survived the winter gave rise to a new generation which matured and in turn founded a new generation. That generation survived the winter and matured early in spring. That is why there are 3 main depressions in the course of the changes of the abundance, viz. in summer (June, July, or August), in autumn (September or October), and in winter (January, February, or March) according to hydrological and thermal conditions (Fig. 16). The summer and autumn depressions of the abundace are

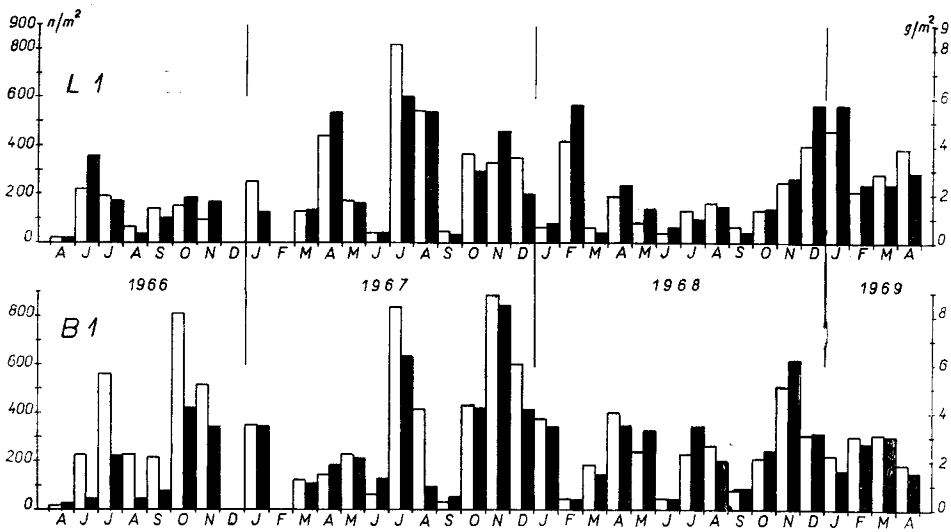

Fig. 16. Abudance and biomass (black columns) of *Rivulogammarus* in the lower parts of the Lušová and the Brodská (L1, B1).

probably due to the mortality of the wintering specimens and juvenile specimens of the following generation. The winter depression is influenced by increased mortality under adverse conditions, especially in the bank zone. Nor the influence of fish predation can be excluded (see Chapter 5, 6).

This cycle corresponds to the diagram as described by Hynes (1955) and as observed also by Lehmann (1967). Similar fluctuations in the course of the abundance in *Rivulogammarus* can also be read from the data by Obrdlík (1972) on the example of the small wood brook.

The course of the changes in the density of population in individual stations of the Beskydy brooks does not tally exactly, as it depends on a number of biotic and abiotic factors of the environment, particularly on the change of torrential and fluviatile stretches divided often by weirs and on different fishstock, as was pointed out before by Straškraba (1966).

4.3.2 Differences in the density of population between the torrentile and the bank zones

We take into consideration the fact that the share of the bank zone is about 20 %, the torrentile zone about 80 %. In most of the samples taken the number of specimens was higher in the bank zone than it was in the torrentile zone. The differences varied and were dependent mainly on hydrological and thermal conditions in the course of the year. The relative representation of the population of *Rivulogammarus* in the bank zone and in the current of the stations under investigation was as follows:

Station/year		bank : current
Lušová — lower (L 1)		3.0 : 1
	1966/67	
	1967/68	2.0 : 1
	1968/69	2.2 : 1
Brodská — lower (B 1)		
	1966/67	1.7 : 1
	1967/68	1.3 : 1
	1968/69	1.9 : 1
(B 1b)		
	1967/68	1.5 : 1
	1968/69	1.5 : 1
(B 1c)		
	1967/68	0.8 : 1
	1968/69	1.6 : 1

The instantaneous stages of population in the evaluated zones (bank, current) were sometimes also opposite or the same (1 : 1), particularly at higher discharge rates, when the current speed from bank to bank was higher than 15 cm/sec., or, on the other hand, at low water level (totally lower current) or in winter, when a major part of the bank zone froze down to the bottom. Such changes being more frequent in the brook Brodská than in the Lušová, the density of population in the bank zone of the Brodská was, on the average, lower than that in the Lušová. These changes also concerned the biomass which, however, always remained higher in the bank zone than in the current (min. 1.2 : 1, max. 3.6 : 1).

4.3.3 Size composition of the population

A preliminary analysis of the population of *Rivulogammarus* in the Beskydy brooks showed that, in the ration of both sexes (♀♀ : ♂♂) the males prevailed, only in some samples from the spring months the share of females was slightly increased. The situation in the share of sex groups in the individual stations was as follows:

Lušová—lower		♀♀ : ♂♂			adult : juvenile	
	bank	current	total	bank	current	total
1966/67	0.8 : 1	0.6 : 1	0.7 : 1	1.7 : 1	1.1 : 1	1.5 : 1
1967/68	0.7 : 1	0.7 : 1	0.7 : 1	1.2 : 1	1.6 : 1	1.4 : 1
1968/69	0.4 : 1	0.4 : 1	0.4 : 1	1.09 : 1	1.1 : 1	1.08 : 1
Brodská—lower						
B 1 1966/67	0.7 : 1	0.7 : 1	0.7 : 1	1.4 : 1	1.1 : 1	1.3 : 1
1967/68	0.7 : 1	0.6 : 1	0.7 : 1	1.9 : 1	1.2 : 1	1.4 : 1
1968/69	0.6 : 1	0.7 : 1	0.6 : 1	1.4 : 1	1.4 : 1	1.4 : 1
B 1b 1967/68	0.8 : 1	0.7 : 1	0.7 : 1	0.8 : 1	1.02 : 1	0.9 : 1
1968/69	0.5 : 1	0.3 : 1	0.4 : 1	0.4 : 1	0.7 : 1	1.06 : 1
B 1c 1967/68	0.7 : 1	0.9 : 1	0.8 : 1	0.9 : 1	1.3 : 1	1.05 : 1
1968/69	0.6 : 1	0.5 : 1	0.6 : 1	1.8 : 1	0.7 : 1	1.2 : 1

For juvenile were taken specimens up to the length of 4 mm incl. (see Obrdlík 1972). Specimens up to 2 mm incl. were frequent particularly in the summer and autumn months, the sizes from 2 to 4 mm were frequent towards the end of summer and autumn and in winter. Adult specimens exceptionally reached the lengths of 13 to 14 mm, more frequent were sizes of 10 to 11 mm. Obrdlík (1972), who measured these populations, states the average size of males as 8.2 mm and of females 7.7 mm.

The most continuous distribution of size groups was found in the Lušová (Fig. 17, L 1). The specimens of the Brodská population of the size above 8 mm were irregularly frequented, particularly in the stretch with excessive fishstock and in the stretch without fish (Fig. 17, B 1b, B 1c).

4.3.4 Abundance and biomass

The course of the abundance and of the biomass throughout the year are given in Fig. 16 and 18 and the mean values of those indices in Tab. 7. The variation of the values in the course of the year shows regular decrease and an increase in some summer, autumn, and winter months in all stations according to the course of the annual cycle of population.

Tab. 7. **Average abundance (A), biomass (Bi) and production (P) of the Rivulogammarus in the stations under investigation**

Station			1966/1967	1967/1968	1968/1969	$\bar{x}$	P in g/m² per year
Lušová lower		A Bi	183 2.012	210 2.740	220 3.323	201 n 2.527 g/m²	10.6227
Brodská lower	Bl	A Bi	319 1.831	376 3.075	244 2.567	313 h 2.726 g/m²	10.4483
	Blb	A Bi	—	347 3.072	288 2.243	318 n 2.657	12.4041
	Blc	A Bi	— —	510 4.689	321 2.860	415 n 3.775 g/m²	14.7400

The minimum values of abundance in the Lušová for the whole period of investigation were 20 n and of biomass 0.200 g/sqm, maximum 819 n and 6.083 g/sqm. The minimum values in the Brodská (B 1) with normal fishstock were 12 n and 0.242 g/sqm, maximum 841 n and 6.362 g/sqm.

In the stretch with excessive fishstock (B 1b), which borders on the preceding one, the values were higher: min. 12 n with biomass 0.420 g/sqm., max. 972 n and 10.710 g/sqm.

In the stretch without fish (B 1c) the values were as follows: min. 45 n and 0.360 g/sqm, max. 1,370 n and 8.609 g/sqm.

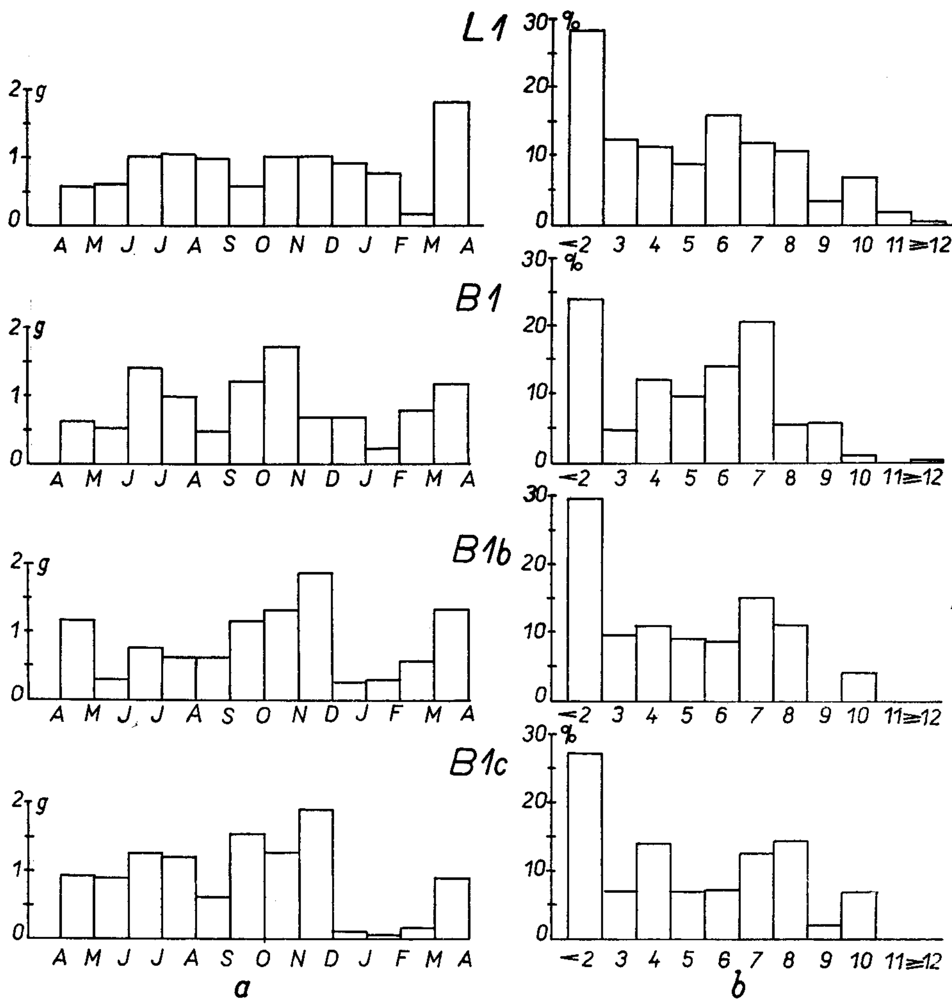

Fig. 17. a — Average monthly increments (of the production rate) of *Rivulogammarus* population in the stations under investigation. L1 and B1 in g/m², B1b and B1c in g/0.7 m². b—Percentual composition of size groups in individual stations. Summarised for the whole period of investigation.

According to average values for two to three years the lowest annual abundance in the brook Lušová was 201 n and the biomass 2.527 g/sqm (Tab. 7). In the three succeeding stretches in the brook Brodská (B 1, B 1b, B 1c) the abundance

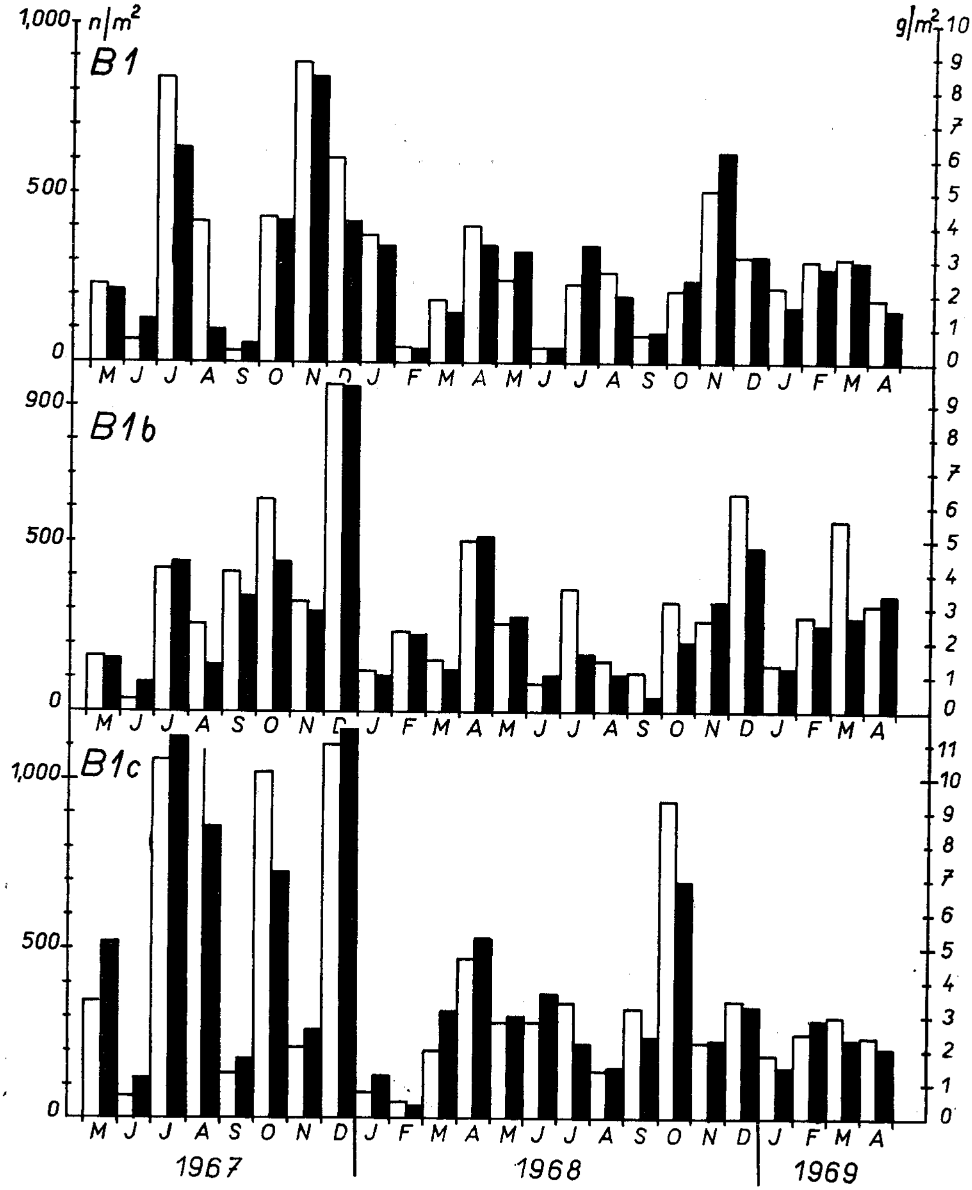

Fig. 18. Abundance (white columns) and biomass (black columns) of *Rivulogammarus* in the lower part of the Brodská. Stretch with normal fishstock (B1), with increased fishstock (B1b) and without fishstock (B1c).

of the first two stretches was the same (313 and 318 n), in the third it was higher by about one-third (415 n). The lowest biomass was however, in the middle stretch (B 1b, with excessive fishstock). The highest biomass was in the stretch without fish (B 1c)—3.775 g/sqm. In that stretch there was also a higher frequency of specimens of 8 and 10 mm (Fig. 17).

4.3.5 Estimated production rate

The calculation of the production rate was done by means of the ZELINKA procedure based on the length-weight curve (Fig. 19) and by determining the monthly increments between the individual size classes. The annual production rate was not calculated in each year of investigation but for the whole period by adding the monthly values to obtain one ideal year. In the brook Brodská the highest increments were obtained towards the end of the year (October to December), the lowest in January or in February. The spring generation had the highest increase in June—July, the summer generation in September—November.

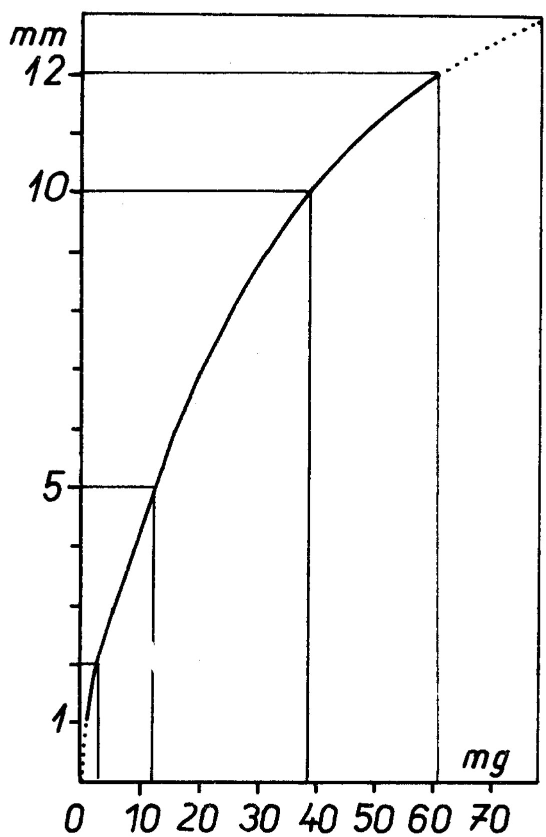

Fig. 19. The length-weight curve of the *Rivulogammarus* population in the Beskydy brooks.

In the Lušová the increments were less outstanding (see Fig. 17).

The average annual production rate of *Rivulogammarus* in the lower part of the Lušová was calculated as being 10.6227 g/sqm and corresponds to more than a quadruple of the average annual biomass (Tab. 7).

In the individual stretches of the lower part of the Brodská production conditions were different. The lowest production rate was in the stretch with natural fishstock (B 1), the highest in the stretch with no fish (B 1c). The production rate of both these stretches was more than 3.5 times higher of the average annual biomass. The production rate in the stretch with excessive fishstock (B 1b) was 12.404 g/sqm per year. This quantity corresponds to more than a quadruple of the average annual biomass.

Considering the mean value of the whole lower part of the Brodská as a part with various fishstock, we can, in the population of *Rivulogammarus* calculate with the production of 12.7962 g/sqm per year. This quantity corresponds to about a quadruple of the average annual biomass. This value is also given in the final results.

4.3.6 The influence of the fishstock on the population of *Rivulogammarus*

A conclusive influence of fish on the *Rivulogammarus* population cannot be supported from our results. From the values of abundance, biomass, and production rate it can be judged that the stretch of the Brodská without fish (B 1c) is highest as for the quantitative indices. Also in the size composition of the population this stretch shows the greatest share of specimens from 8 to 12 mm and more (24 %), where as in the remaining two stretches this share is lower. Both stretches of Brodská with different fishstock show little difference in abundance and biomass. In the production rate the stretch with excessive fishstock is even somewhat more fertile than that with natural fishstock (Tab. 17). Also the qualitative characteristics of the population of those two stretches shows little difference.

The lower stretch of the Lušová (L 1) was without fish (for detail see Chapter 5), but soon after the fish were removed, the *Carpathian sculpin* which is an important consumer of shrimps, multiplied here. We think therefore that even this stretch "without fish" was influenced by fish predation, the same as the stretch of the Brodská with natural fishstock (B 1). Also the conspicuously balanced increments in the *Rivulogammarus* population for the most part of the whole year (Fig. 17, L 1) would point to the influence of the *Carpathian sculpin*.

The trouble with the evaluation of the influence of fish on the density and composition of the population of *Rivulogammarus* consists also in the fact that the shrimps belong to very active migrants (drift) and that their natural distribution in the stream (mainly the colonisation upstream) was made difficult by obstacles (weirs) separating the individual stretches (for the problems see e.g. MEIJERING 1972).

4.4 Hydracarina

The species determination of mites was not done; we therefore evaluate only quantitative relations of the whole group. The differences between the two brooks and between their upper and lower stations are not clear; the stones were populated more or less to the same extent.

Major differences in the density of mites occurred between the torrential and the bank zones. The differences, however, are not so unambiguous as in the *Coleoptera* or *Simuliidae*. In most cases the percentual shares in the total number of mites are higher in the current than near the banks; Brodská: current—58.9 %, bank—40.1 %; Lušová: current 65.9 %, bank—34.1 %. It is the same when comparing the average annual abundance of mites (Tab. 8). *Hydracarina* populated stones in the current much more frequently than stones near the banks.

Tab. 8. **Average annual abundance of Hydracarina in the Lušová and the Brodská**

Trout brook		Lušová		Brodská			
Station		L2	L1	B2	B1	B1b	B1c
Current	1966/67	15.5	8.2	13.3	16.1	—	—
	1967/68	—	42.9	—	47.3	46.0	14.6
	1968/69	—	50.2	—	49.1	38.7	38.8
Bank	1966/67	11.8	9.9	29.5	34.4	—	—
	1967/68	—	28.9	—	59.1	18.1	9.1
	1968/69	—	24,1	—	44.3	19.4	8.6

The main period of their development is the end of spring and the summer. In the maximum the density of mite population reached roughly 100 to 200 specimens per 1 sq.m (sporadically more than 250 specimens per 1 sq.m). The minimum development was noticed in the winter months.

Neither in this group did we find out significant differences between stretches with various population of the yellow trout in the Brodská. From Tab. 8 is evident certain thinning of the population of mites down the stream towards the lowest station (B 1c).

The biomass and production of *Hydracarina* were not separately specified.

4.5 Ephemeroptera

Mayfly larvae are one of the main components of the zoobenthos of the Beskydy brooks under investigation. In abundance they surpass considerably the representation of other animal groups, in the biomass they follow the order *Trichoptera*. Some results of the investigation have been published (Zelinka 1969, Zelinka 1972) and from the publications quoted we repeat here only the basic information, necessary for drawing general conclusions.

4.5.1 Differences in the fauna of mayflies between the two brooks in their upper and lower stretches

In the first year of investigation we carried out the investigation in the upper and lower stretches of the trout sector (epirithron) of the two brooks. From Tab. 9—12 it is evident that the differences in the species composition, abundance, and biomass are comparatively small and for the most part they do not surpass the possible methodological error. The same concerns the differences between the brooks Brodská and Lušová. As we found out by an informative investigation in some other tributaries of the river Bečva, the conditions in the myafly fauna are practically the same in them (in detail see ZELINKA 1969). We found out the total of 19 taxa.

Tab. 9. Representation of the individuals species of mayflies in the current (average number of individuals per 1 m² in the period of 1966/1967)

Taxon Station	Brodská		Lušová	
	upper	lower	upper	lower
Ephemera danica	2	+	3	3
Ecdyonurus sp. div.	39	89	94	80
Heptagenia lateralis	0	1	1	0
Rhithrogena semicolorata	92	109	188	173
Epeorus assimilis	20	29	21	16
Habrophlebia lauta	1	3	7	13
Habroleptoides modesta	32	55	33	52
Baetis rhodani	261	253	315	222
Baetis bioculatus	2	2	4	30
Baetis alpinus	43	43	2	24
Baetis pumilus	22	42	67	24
Ephemerella ignita	11	13	30	5
Chitonophora krieghoffi	5	0	3	3
Torleya maior	10	36	34	18
Caenis macrura	1	2	3	5
Sum total	(541)	677	805	668
Sum of taxa	14	14	15	14

4.5.2 Annual cycle

In the following two years we only followed the lower stations of the two brooks. We can therefore evaluate the average rates of a three-year investigation. The annual cycle of the growth of the larvae and the emergence of the imagines corresponds to the data known from the literature for our territory (e.g. LANDA 1969), with respect to the local temperature conditions. In all three annual cycles all the species found out were always present in the brooks. In the individual years the abundance in some species was changing, which is evaluated lower. The total abundance and biomass, on the other hand, remains practically the

Tab. 10. Representation of the individual species of mayflies near the bank (average number of individuals per 1 m² in the period of 1966/1967)

Taxon / Station	Brodská		Lušová	
	upper	lower	upper	lower
Ephemera danica	6	4	6	7
Ecdyonurus sp. div.	125	115	166	75
Heptagenia lateralis	8	13	33	34
Rhithrogena semicolorata	4	2	10	3
Habrophlebia lauta	50	52	62	65
Habroleptoides modesta	48	38	48	66
Paraleptophlebia submarginata	0	2	29	4
Baetis rhodani	30	12	40	18
Baetis bioculatus	0	3	0	0
Baetis pumilus	4	5	23	0
Baetis niger	0	0	2	0
Centroptilum luteolum	+	0	45	3
Centroptilum pennulatum	0	6	1	1
Ephemerella ignita	10	3	3	+
Chitonophora krieghoffi	2	0	2	2
Torleya maior	24	23	26	14
Caenis macrura	9	3	16	9
Sum total	(320)	281	512	301
Sum of taxa	13	14	16	14

same. Here we should like to draw the attention to the fact that the time of the emergence of the imagos of most species is comparatively long, so that the emergence in species with two generations per year overlaps and in the collections we then find larvae of the most different sizes. This makes the following of the growth as well as the estimated production rates very difficult.

4.5.3 Differences in the occurrence of mayfly larvae in the current and near the bank

Comparing the species composition of mayfly larvae living in the current of the brooks under investigation and those living in the stagnat water near the banks we find out distinct differences. From the Tab. 9—13 it follows that some species live only in the current (*Rhithrogena semicolarata*, *Epeorus assimilis*, most representatives of the genus *Baetis*), while others live only in the calm water near the banks (*Heptagenia lateralis*, *Paraleptophlebia submarginata*, *Centroptilum*). Typical representatives of the species living both in the current and near the banks are the species of the genus *Ecdyonurus*, *Habroleptoides modesta*, *Torleya maior*. Interesting conditions are also in the abundance and biomass, as stated in the following chapter.

Through repeated collections we found out large and quick shifts of mayfly larvae due to the change in the speed of the current. Torrential species shift according to the changes of the speed of the current and within hours they populate even places originally without current or even without water (see e.g. VERRIER 1953). The density of population varying with the width of the current it is necessary to use a conversion factor in the data of quantities of mayflies per area, as it is stated in the methodological part.

4.5.4 Abundance and biomass

On the basis of the first year of investigation we can say that in the abundance and biomass of mayfly larvae there are comparatively small differences between the two brooks on the one hand and between the upper and the lower stretches of each brook on the other hand (Tab. 11 and 12). A higher abundance in the

Tab. 11. **Average abundance of mayfly larvae (number of individuals per 1 m² in the period of 1966/1967)**

Brook	Upper station		Lower station	
	current	bank	current	bank
Brodská	(541)	(320)	677	281
Lušová	805	512	668	301

Tab. 12. **Average biomass of mayfly larvae (weight in g per 1 m² in the period of 1966/1967)**

Brook	Upper station		Lower station	
	current	bank	current	bank
Brodská	1.967	2.378	2.533	2.474
Lušová	3.738	3.272	3.889	2.259

upper stretch of the brook Lušová was due to a higher number of larvae of the species *Centroptilum luteolum* and the genus *Ecdyonurus*. In the former, whose occurrence is otherwise mostly rare, it is not possible to exclude the possibility of a chance collection of a high number of specimens in one place. For technical reasons it was not possible to carry out collections every month, which distorts the resulting averages and therefore we do not use the results of that station in further evaluations. The results given in the tables and graphs are average results of the three-year investigation (sample taking every month) in 4 stations of the brooks under investigation and their validity is very high owing to the length of investigation and the number of samples taken.

The average abundance in the current was 754 larvae per 1 sq.m. (comparative), near the bank 387 larvae per 1 sq.m. The average biomass in the current was 3.046 g per sq.m, near the bank 2.675 g per sq.m. With the ratio of the area of the current to calm water being 80 : 20 this means a total average of 681 larvae weighing 2.972 g per 1 sq.m. of the surface area of the water of the brooks. Calculated per 1 hectare of the water surface of the brooks it means 6,810.000 larvae weighing 29.72 kg on the annual average.

The abundance in the current is thus by 100 per cent higher than near the bank, while the difference in the biomass is small. This is due to the fact that there are few small larvae of the genus *Baetis* living near the bank; on the other hand near the banks occur big larvae of the species *Ephemera danica* and *Heptagenia lateralis* and also big nymphae especially of the genus *Ecdyonurus* shift to the bank zone. The average weight of one specimen in the current is substantially higher (Fig. 22).

In the course of the year the abundance and biomass varies in accordance with the well-known course of individual species (Fig. 20 and 21). In the May maximum there are represented mainly the species *Rhithrogena semicolorata* the end phase of the first and the beginning phase of the second generation of *Baetis rhodani* as well as individuals hatching after a diapause. The emergence of a number of species occurs simultaneously in June, the summer rise in the abundance is mainly due to the second generation of *Baetis rhodani*. The biomass

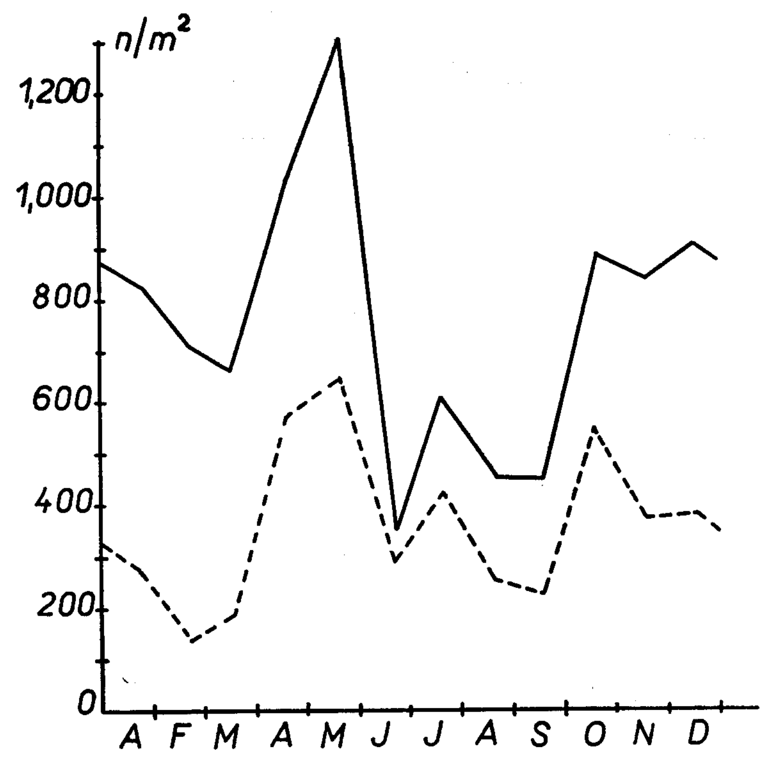

Fig. 20. Abundance of mayfly larvae in individual months (averages from 4 stations in 3 years); ——— current, - - - - bank.

does not increase and there is a drop in it until the end of September. Up to the arrival of frosty days both abundance and biomass increase, in the course of the unfavourable winter reason the number of individuals drops (the same occurs in floods and after the snow thaw) and the increments in most species are small (cf. also production). An abrupt rise comes in spring. From the course of the total abundance curve and particularly the abundance of individual species it follows that in many cases the eggs hatch successively or that the larvulae stay

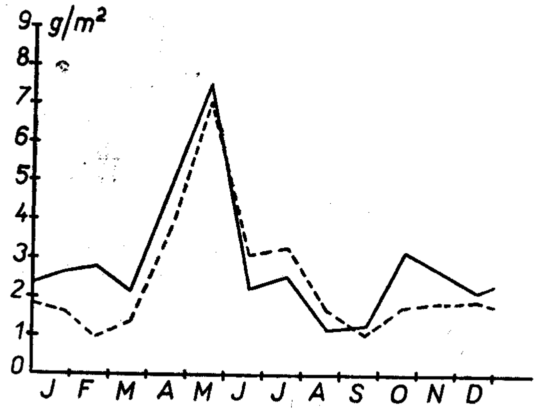

Fig. 21. Biomass of mayfly larvae individual months (averages from 4 stations in 3 years); ——— current, – – – – bank.

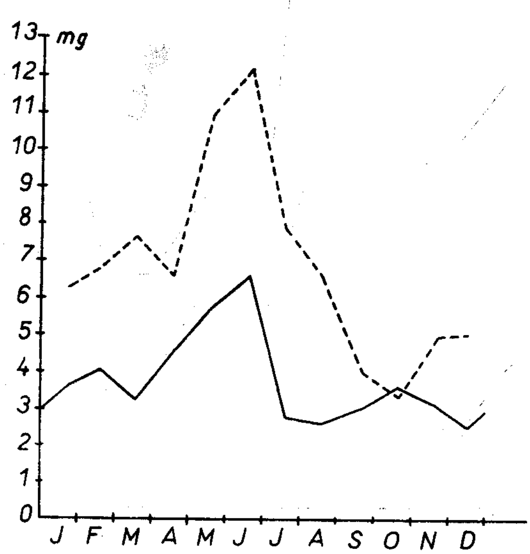

Fig. 22. Average weight of 1 specimen in individual months (averages from 4 stations in 3 years); ——— current, – – – – bank.

for a long time in the interstitial and are not caught by current collections of zoobenthos.

The total abundance and biomass of mayfly larvae were well-balanced in the current, in the course of the three years of investigation. This, however, cannot be said about the conditions near the banks where, in the period of 1967/68 there was an abrupt increase (Tab. 13). Species with the smallest ability of resisting

Tab. 13. **Representation of individual mayfly species (annual averages from all stations)**

Taxon	Current			Bank		
	1966/67	1967/68	1968/69	1966/67	1967/68	1968/69
Baetis rhodani	263	132	254	—	—	—
Rhithrogena semicolorata	157	110	149	—	—	—
Ecdyonurus sp. div.	88	84	88	119	120	56
Habroleptoides modesta	47	45	95	51	85	40
Torleya maior	29	109	98	21	74	40
Habrophlebia lauta	8	21	53	60	130	82
Baetis alpinus	23	88	62	—	—	—
Baetis pumilus	44	44	39	—	—	—
Epeorus assimilis	22	18	8	—	—	—
Heptagenia lateralis	—	—	—	27	40	13
Ephemera danica	—	—	—	6	13	9
Caenis sp.	—	—	—	9	9	10
Centroptilum sp. div.	—	—	—	18	16	8
Other species	36	22	25	60	28	18
Sum total	717	673	871	371	515	276

the current increased in their numbers: *Habrophlebia lauta*, *Torleya maior* and *Heptagenia lateralis*. In the following year their abundance dropped again. In our opinion the reason of the rise of their number were well-balanced discharge rates without major spates. Differences were found out also in the abundance of some species (Tab. 13). Striking was the drop in *Baetis rhodani* in the period of 1967/68 and, on the other hand, the increase of the species *Torleya maior* in the same period. Minor changes were found out in some further species; in others the representation was well-balanced all the time (*Rhitrogena semicolorata*, *Habroleptoides modesta*, the genus *Ecdyonorus*). These changes are most probably due to unfavourable or favourable conditions in the critical development stages of individual species.

4.5.5 Production

Having considered all circumstances connected with the calculation of the production of the zoobenthos of streaming waters we decided to follow the abundance and the growth of individual size groups in the course of the whole year.

Out of 19 taxa represented the most frequent are three, forming 75 per cent of the total biomass: *Baetis rhodani*, *Rhitrogena semicolorata* and the genus

Ecdyonurus. In these taxa there were always collected a sufficient number of individuals for following the growth in the course of the whole year. Examples of calculations were published in the papers by ZELINKA (1972), KUBÍČEK and al.

Tab. 14. **Estimated production rate for Baetis rhodani (average based on collections for the period of 1966/1967 in 3 stations**

Date of sampling	n/m^2	mg/m^2	Average weight of one individual in mg	Increment in mg		
				per month		per day
16—17 May	262	1,297.0	4.95		—	—
20—22 Jun.	446	624.8	1.40	Jun.	810.02	27.0
18—19 Jul.	361	851.3	2.36	Jul.	691.5	22.3
15—16 Aug.	280	384.5	1.37	Aug.	523.8	16.9
12—13 Sep.	340	752.4	2.21	Sep.	455.4	15.2
10—11 Oct.	305	249.9	0.82	Oct.	247.4	7.9
14—15 Nov.	222	189.2	0.85	Nov.	101.1	3.4
				Dec.	56.8	1.8
25—26 Jan.	140	180.3	1.29	Jan.	72.5	2.3
				Feb.	131.6	4.7
1—2 Mar.	191	198.9	1.04	Mar.	354.6	11.4
12—14 Apr.	248	668.5	2.70	Apr.	772.9	25.8
24 May	394	1,892.7	4.80	May	1,097.8	35.4
Sum	3,189	7,289.5	23.79		5,317.0	174.1
$\bar{x}$	290	662.7	2.29			14.57

Tab. 15. **Estimated production rate for Rhithrogena semicolorata (average based on collections for the period of 1966/67 in 3 stations)**

Date of sampling	n/m^2	mg/m^2	Average weight of one individual in mg	Increment in mg		
				per month		per day
16—17 May	116	1,712.3	14.76		—	—
20—22 Jun.	87	1,255.3	16.42	Jun.	634.3	21.1
18—19 Jul.	17	225.8	13.28	Jul.	255.3	8.2
15—16 Aug.	3	61.8	20.6	Aug.	40.1	1.3
12—13 Sep.	23	33.3	1.45	Sep.	192.0	6.4
10—11 Oct.	209	303.6	1.45	Oct.	397.4	12.8
14—15 Nov.	193	371.1	1.92	Nov.	351.9	11.7
				Dec.	296.6	9.6
15—26 Jan.	172	601.4	3.50	Jan.	408.9	13.2
				Feb.	846.5	30.2
1—2 Mar.	281	841.1	2.99	Mar.	1,831.5	59.1
12—14 Apr.	458	3,019.2	6.59	Apr.	3,407.9	113.6
24—25 May	994	7,088.9	7.13	May	3,815.9	123.1
Sum	2,553	15,514.0	90.09		12,478.0	410.3
$\bar{x}$	232	1,411.0	6.08			34.19

(1972). We can only repeat here that we did not follow the individual instars, as for finding out the production it is substantial to express the length increment which is not always the same in the instars.

Tab. 16. **Estimated production rate for the genus Ecdyonurus (average based on collections for the period of 1966/67 in 6 stations**

Date of samling	n/m²	mg/m²	Average weight of one individual in mg	Increment in mg		
				per month		per day
16—17 May	40	743.0	18.6		—	—
20—22 Jun.	74	1,243.7	16.8	Jun.	824.7	27.5
18—19 Jul.	53	1,095.3	20.7	Jul.	827.4	26.7
15—16 Aug.	26	608.3	23.4	Aug.	507.7	16.4
12—13 Sep.	66	337.5	5.1	Sép.	709.5	23.7
10—11 Oct.	211	971.3	4.6	Oct.	1,019.0	32.9
14—15 Nov.	147	1,469.9	10.0	Nov.	740.8	24.7
				Dec.	511.5	16.5
25—26 Jan.	104	1,313.0	12.6	Jan.	541.3	17.5
				Feb.	627.2	22.4
1—2 Mar.	95	599.6	6.3	Mar.	630.4	20.3
12—14 Apr.	112	1,144.6	10.2	Apr.	707.9	23.6
24—25 May	111	1,758.3	15.8	May	822.4	26.5
Sum	1,039	11,285.0	144.1		8,470.0	278.7
x	94.5	1,025.9	10.86			23.21

In Tab. 14—16 are given all the results of calculations for the three most frequent species. From Fig. 23—25 follows the course of growth of individual species and the production throughout the year. The estimated production rate in *Baetis rhodani* is 5.317 g per 1 sq.m of the current per year. As the current takes up 80 per cent of the brooks under investigation and as this species lives practically only in the current, it means 4.234 g per 1 sq.m of the surface area of the brook per year. Similarly, after reducing the species *Rhithrogena semicolorata* by 20 per cent, the production makes up 9.982 g per 1 sq.m per year. The production of the genus *Ecdyonurus* was calculated according to the increment of larvae irrespective of the species in question. In our calculations we used the ratio 80 (current): 20 (near the bank), as these larvae are found all over the area of the brooks. The estimated annual production rate in these larvae is 8.470 per 1 sq.m.

It is interesting to notice that in all three cases there is approximately the same ratio between the annual production and the average annual biomass, viz 1 : 8.02 in *Baetis rhodani* 1 : 8.84 in *Rhitrogena semicolorata* and 1 : 8.25 in *Ecdyonurus*. We are, therefore, of the opinion that we can count on the average ratio between the biomass and production (i.e. 1 : 8.37) in all species of the brooks under investigation. If we multiply the average biomass of mayfly larvae, found out by the three-year investigation (see above), then the estimated production rate per year is 24.875 g per 1 sq.m. From Table 17 it is possible to calculate the production rates for the individual stretches. The variation of

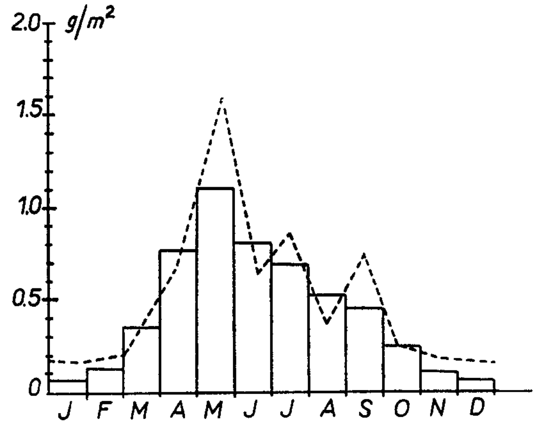

Fig. 23. Average monthly biomass and production rate of the species *Baetis rhodani* per 1 m² of the torrential zone (averages from 3 stations in the period of 1966 to 1967); columns—production, – – – – biomass.

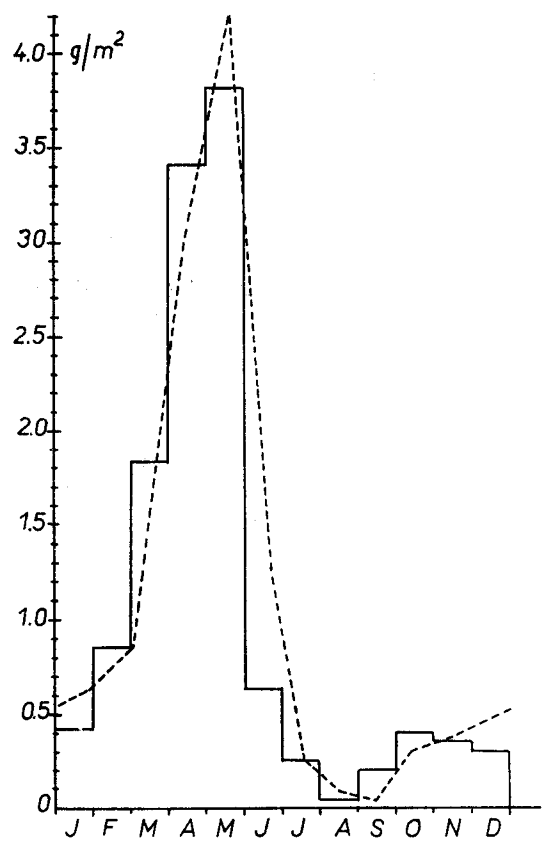

Fig. 24. Average monthly biomass and production rate of the species *Rhithrogena semicolorata* per 1 m² of the torrential zone (averages from 3 stations in the period of 1966 to 1967); columns—production, – – – – biomass.

the total production rate in the individual years of investigation was comparatively small (see Tab. 18). The variations near the bank are in connection with the variation of the biomass, as mentioned above. It is interesting to note

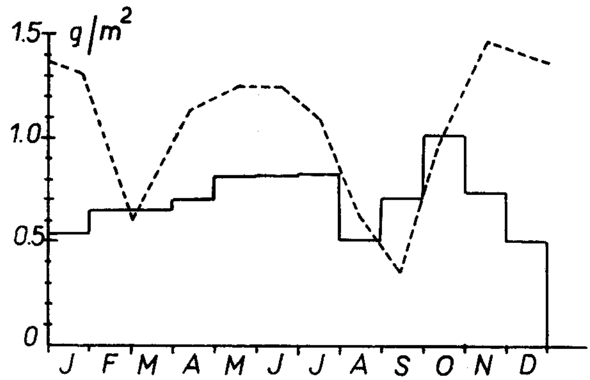

Fig. 25. Average monthly biomass and production rate of the genus *Ecdyonurus per* 1 m² of the area of the whole brook (averages from 3 stations in the period of 1966 to 1967); columns— production, – – – – biomass.

that the drop at the bank was accompanied by the increase in the current and vice versa.

Tab. 17. **Biomass and abundance of mayfly larvae (annual averages from 4 stations)**

Biomass in g/m²	1966/1967	1967/1968	1968/1969	Average
Bank (20%)	2.668	3.642	1.716	2.675
Current (80 %)	3.387	2.721	3.029	3.046
Sum total (100 %)	3.244	2.905	2.766	2.972

Abundance in n/m²	1966/1967	1967/1968	1968/1969	Average
Bank (20 %)	371	515	276	387
Current (80 %)	717	673	871	754
Sum total (100 %)	648	642	752	681

The production rate of mayfly larvae per 1 hectare of the trout brooks in the Beskydy can, according to our calculations, be estimated to be 246.9 kg per year. With respect to the procedure used we think that this estimate correspond to a great extent to reality.

Tab. 18. **Production of mayflies in g/m² (averages from 4 stations)**

Period	1966/1967	1967/1968	1968/1969	Average
Production in the whole brook	27.152	24.316	23.152	24.875
Production in the current	28.349	22.775	25.352	25.494
Production near the bank	22.332	30.484	14.363	22.396

4.5.6 The influence of the changed fishstock

An investigation lasting two years in stretches with the changed fishstock was carried out in the brook Brodská (see the methodological part). The results showed that a difference of almost ± 100 per cent in the density of population in the yeallow trout and almost ± 50 per cent in the density of population of the sculpin did not show demonstrable differences in the biomass of mayfly larvae (Tab. 19). There was, however, a difference in abundance (Tab. 20), when in a stretch with a high fishstock there increased the numbre of mayfly larvae in the current by almost 50 per cent. At the same time the average weight of 1 specimen decreased (Tab. 21). This leads to an assumption that the fish con-

Tab. 19. **Biomass of mayfly larvae in stretches on the Brodská with changed fishstock (annual averages in g/m²)**

Stretch Period	Current			Bank		
	1967/68	1968/69	Average	1967/68	1968/69	Average
B1 natural fishstock	2.696	2.105	2.401	3.879	1.661	2.770
B1b increased fishstock	2.994	2.535	2.765	3.321	1.408	2.365
B1c without fish	2.180	2.545	2.363	3.415	1.676	2.546

Tab. 20. **Abundance of mayfly larvae in stretches of the Brodská with changed stock (annual averages of individuals per 1 m²)**

Stretch	Current			Bank		
	1967/68	1968/69	Average	1967/68	1968/69	Average
B1 natural fishstock	651	581	616	490	285	387
B1b increased fishstock	809	862	835	494	226	360
B1c without fish	442	742	592	482	223	353

Tab. 21. **Average weights of mayfly larvae in stretches of the Brodská with changed fishstock**

Stretch	Individual average weights in mg (two years)	
	current	bank
B1 natural fishstock	3.898	7.158
B1b increased fishstock	3.311	6.569
B1c without fish	3.992	7.213

sumed more major larvae and in the smaller competition more smaller larvae could resist. Further research, will however, be necessary to confirm this assumption.

Mayflies are one of the main components of the food of the yellow trout and an important component of the food of the bullhead, as was confirmed for the brooks of the Beskydy (Zelinka and Orság, in print). They become prey to the trout chiefly in hatching as subimagines and further larvae of the species living in the periphyton. In the food there are greatly represented those species in which the emergence of the subimagines from the surface takes a long time, such as the genera *Baetis*, *Ephemerella*, *Rhithrogena.* In the periphyton of the brooks there is mainly *Baetis rhodani*, which is also mostly represented in the drift. The sculpin looks for the food under the stones and is by no means

Tab. 22. **Species composition of mayfly larvae in stretches of the Brodská with changed fishstock**

Taxon	B 1 natural fishstock	B 1b increased fishstock		B 1c without fish	
	average n/m^2 1967 to 1969	average n/m^2 1967 to 1969	% A = 100	average n/m^2 1967 to 1969	% A = 100
Beatis rhodani	119	118	158	151	127
Baetis alpinus	70	115	164	29	41
Baetis pumilus	30	41	137	31	103
Rhithrogena semicolorata	114	135	118	115	101
Ecdyonurus sp. div.	77	82	106	73	95
Habroleptoides modesta	43	63	146	58	135
Torleya maior	116	130	112	64	55
Habrophlebia lauta	24	33	137	47	196
Epeorus assimilis	7	20	286	12	171
Other species	16	28	175	12	75
Sum	616	835	135	592	96

Note: Near the bank without major differences in the representation of individual species.

fastidious. If we relate these ascertainments to the abundance of individual species in the followed stretches of the brook Brodská, then the most influenced by fish predation should be larvae of the genus *Baetis* and *Rhithrogena semicolorata*. From Tab. 22, however, it follows that in the stretches with highly increased fishstock all species were always more frequent, most frequent of them being the species *Baetis rhodani*. Whenever there was a change in the abundance of some species in the course of the investigation, then this change occurred uniformly in all the followed stretches irrespective of the density of the fishstock.

As for mayfly larvae as fish food in the trout brooks, it can be said that they are no limiting factor for the increase of the population of the yellow trout to the numbers stated in Tab. 51.

4.6 Plecoptera

An important group of the zoobenthos of the brooks in the Beskydy mountains are the *Plecoptera*. In rich material we have found out a total of 21 species (see Tab. 23). The taxon stated in the tables as *Leuctra sp.* juv. are juvenile, not exactly specified larvae which very probably belong to some of the stated species

Tab. 23. **The abundance of stone-fly larvae in the current and near the bank (the average number of specimens per 1 m² in the period 1966/1967)**

Taxon	Current				Bank			
	Brodská		Lušová		Brodská		Lušová	
	upper	lower	upper	lower	upper	lower	upper	lower
Dinocras cephalotes	0	0	0	0	0	0	0	0
Perla burmeisteriana	0	0	0	0	0	0	0	0
Perla marginata	22	23	18	15	0	1	3	2
Perlodes microcephala	1	1	2	0	0	0	1	0
Isoperla oxylepis	21	30	25	24	0	0	0	1
Protonemura meyeri	1	1	9	1	0	0	0	0
Protonemura nitida	12	12	13	4	0	0	0	1
Protonemura intricata	4	1	5	5	0	0	0	0
Protonemura praecox	0	0	0	0	0	0	0	0
Nemoura fulviceps	1	1	1	0	1	1	0	1
Nemoura cambrica	13	8	22	9	11	12	30	28
Amphinemura sulcicollis	19	20	13	12	0	0	0	2
Leuctra hippopus	0	0	0	12	1	10	4	13
Leuctra albida	0	13	0	23	19	16	8	14
Leuctra prima	1	0	0	0	0	0	1	0
Leuctra autumnalis	0	0	0	1	1	0	0	1
Leuctra inermis	3	3	5	0	0	0	0	0
Leuctra aurita	0	0	0	0	0	0	0	0
Leuctra sp.juv.	18	12	27	21	15	14	3	2
Chloroperlidae div.sp.	0	1	0	1	0	0	0	0
Sum of specimens	116	126	140	128	48	54	50	65
Sum of taxa	12	13	11	11	6	6	7	10

of this genus. The taxon *Chloroperlidae sp.* div. includes the species: *Chloroperla tripunctata* (Scop.), *Siphonoperla torrentium* (Pict.), and *Siphonoperla neglecta* (Rosstock), which were not distinguished in processing the material.

4.6.1 Differences in the fauna of stone-flies between the two brooks and their upper and lower stretches

On the basis of a three-year research we can say that, as for the species composition of stone-flies, both brooks are practically the same. Only some quite sporadically occurring species that could not always be found in quantitative samples were missing in some samples in one of the brooks (Tab. 23).

Minor differences exist between the upper an the lower stretches of the brooks and evidently follow from clear-cut requirements of stone-fly larvae for temperature conditions (Tab. 23). In the upper part of the brook Lušová e.g. *Leuctra hippopus* and *Leuctra albida* were missing, whereas *Perlodes microcephala* was missing in the lower part. In the Brodská, which has smaller temperature difference, the differences are not so marked. All the differences are, however, so small that they are of no practical importance for the evaluation of the total biomass.

4.6.2 Annual cycle

From the Fig. 26 it is evident that most stone-fly larvae occur in the brooks in the cold season of the year. The emergence of a number of species occurs mostly in April and in May (from the frequent ones e.g. *Leuctra hippopus* in March and even February, *Nemoura cambrica* in April, *Isoperla oxylepis* from April to June, *Amphinemura sulcicollis* in April to May). In summer only *Leuctra albida* and *Leuctra autumnalis* are most frequently represented and, of course, species with a development of several years, i.e. *Perla marginata*; but even this species showed a clear drop in abundance in May. In autumn the number of larvae of most species grows quickly again. This course corresponds to hitherto information.

4.6.3 Differences in the occurrence of stone-fly larvae in the current and near the bank

Stone-fly larvae live mostly solely in streaming water. Also in our case the number of species and the total abundance are substantially lower near the bank than in the current (see Tab. 23, 25). Only the species *Nemoura cambrica, Leuctra albida*, and *Leuctra hippopus* were regularly found in higher numbers in stagnating water near the banks. Also nymphae before emerging shift towards the banks and that is why a high number of representatives of some species, otherwise living in the current, sometimes occurs in the individual takings near the bank. Total averages are, however, only slightly influenced by this fact.

4.6.4 Abundance and biomass

The course of abundance and biomass of stone-fly larvae for the whole period of investigation has been comparatively well-balanced (see Tab. 24, 25, 26). Nor in this respect did we find out any substantial differences between the two brooks or between their upper and lower stretches. Unlike mayflies, however, the average abundance near the bank makes up below 24 per cent and the biomass only 16 per cent as compared with the current. It follows from what has been said above and, on top of it, the big larvae of the genus *Perla* live for the most part

Fig. 26. The abundance of stone-fly larvae in the individual months (averages from 4 stations in 3 years); ——— current, - - - - bank.

Fig. 27. The biomass of stone-fly larvae in the individual months (averages from 4 stations in 3 years); ——— current, - - - - bank.

in the current, so that the average weight of an individual in the current was 19.39 mg, whereas near the bank it was 8.20 mg. Like in mayflies there was a certain growth of both abundance and biomass near the bank in the period 1967/68 (chiefly *Leuctra albida*), which again clearly indicates well-balanced discharge conditions in that period. Otherwise we have not found out conclusive differences.

The average abundance found out on the basis of all samples in the course of three years was 61 specimens near the bank and 144 specimens in the current (per 1 sq.m); the biomass near the bank was 0.464 and in the current 2.843 g/sq.m (calculated for an average sq.m in the current). For the surface area of the whole

Tab. 24. **The biomass of stone-fly larvae (yearly averages in lg/m²)**

Station		Period	Current		Bank	
			Biomass of Plecoptera	Biomass of Perla	Biomass of Plecoptera	Biomass of Perla
Lušová upper		1966/67	2.640	2.255	0.568	0.427
Lušová lower		1966/67 1967/68 1968/69	2.551 2.368 2.426	2.246 1.873 1.890	0.540 0.405 0.358	0.207 0.149 0.131
Brodská upper		1966/67	3.107	2.861	0.251	0.020
Brodská lower	B 1	1966/67 1967/68 1968/69	3.389 2.746 2.575	3.001 2.318 1.926	0.135 0.918 0.204	0.035 0.687 0.060
	B 1b	1967/68 1968/69	3.521 2.788	3.080 2.116	0.555 0.239	0.370 0.020
	B 1c	1967/68 1968/69	3.050 2.959	2.720 2.221	1.081 0.310	0.736 0.124

Tab. 25. **The abundance of stone-fly larvae in the individual years (yearly averages from 4 stations)**

Taxon	Current			Bank		
	1966/67	1967/68	1968/69	1966/67	1967/68	1968/69
Dinocras cephalotes	0	1	1	0	1	0
Perla burmeisteriana	0	1	0	0	0	0
Perla marginata	20	24	24	1	4	2
Perlodes microcephala	1	1	1	1	1	0
Isoperla oxylepis	25	28	32	1	2	1
Protonemura meyeri	3	3	3	0	0	1
Protonemura nitida	10	2	1	1	0	0
Protonemura intricata	3	0	4	0	1	1
Protonemura praecox	0	1	1	0	0	0
Nemoura fulviceps	1	1	0	1	1	2
Nemoura cambrica	13	5	9	20	8	15
Amphinemura sulcicollis	16	23	32	1	5	4
Leuctra hippopus	3	4	23	6	4	7
Leuctra albida	9	20	4	13	24	9
Leuctra prima	1	1	1	1	0	1
Leuctra autumnalis	1	1	1	1	1	0
Leuctra inermis	2	5	2	0	0	4
Leuctra aurita	0	0	1	0	0	1
Leuctra sp.div.juv.	19	19	18	8	19	6
Chloroperlidae div.sp.	1	5	2	0	1	1
Sum of specimens in n/m²	128	145	160	55	72	55

Tab. 26. **Total abundance and biomass of stone-fly larvae (yearly averages from 4 stations)**

Biomass in g/m²	1966/1967	1967/1968	1968/1969	Average
near the bank in the current	0.374 2.992	0.740 2.921	0.278 2.687	0.464 2.843
in the whole brook	2.412	2.485	2.205	2.367
Abundance in n/m²	1966/1967	1967/1968	1968/1969	Average
near the bank in the current	55 128	72 145	55 160	61 144
in the whole brook	113	130	139	127

brook it means 127 specimens weighing 2.367 g/m² (Tab. 26). Calculated for 1 hectare it means 1,270.000 specimens weighing 23.67 kg in the average of the whole year.

There are 5 main taxons constituting the abundance:

Perla marginata	14.7 %
Isoperla oxylepis	17.9 %
Nemoura cambrica	7.9 %
Amphinemura sulcicollis	15.4 %
Leuctra sp. div. (chiefly *L. albida*)	33.7 %
other species	10.4 %

In the biomass it is, however, the genus *Perla* (practically *P. marginata*) constituting 84 % of the total biomass of stone-fly larvae in the current and 82.4 % in the whole brooks. That is why the curve marking the course of the biomass is not well-balanced (Fig. 27) and is influenced by catching major larvae of the genus *Perla* in quantitatively taken samples.

4.6.5 Production

As follows from the evaluation of the biomass, the level of production of stone-fly larvae in the brooks under investigation will be determined by the production of the species *Perla marginata*. We have, however, not acquired sufficient material in this species to proceed in the same way as in the calculation of production of mayfly larvae, as the density of larvae is comparatively low and it would have been necessary to take samples from a considerably larger area of the bottom. We could not carry out special takings aimed at the genus *Perla* and in the estimate of the production rate of stone-flies we tend to coefficient 8.1, by which the average yearly biomass is multiplied. Coefficient 8 or near this number has been stated in a number of representatives of the zoobenthos of these brooks and we suppose that it will not be much different in the larvae of the stone-flies. According to this the estimated production rate of stone-flies is 18.972 g/sq.m per year, i.e. 189.72 kg per 1 hectare of the brook surface per year.

4.6.6 Influence of the changed fish stock

The results of the investigation of the total abundance, the abundance of the individual species and the biomass of stone-fly larvae are stated in Tab. 27 and 28. It follows quite clearly that neither the incresaed nor the decreased fishstock

Tab. 27. **The biomass and abundance of stone-fly larvae in the stretches of the Brodská with changed fishstock (averages for the whole year)**

Stretch	Biomass in g/m²					
	Current			Bank		
	1967/1968	1968/1969	Average	1967/1968	1968/1969	Average
B1 natural fishstock	2.746	2.575	2.661	0.918	0.204	0.561
B1b increased fishstock	3.521	2.788	3.154	0.555	0.239	0.397
B1c without fish	3.050	2.959	3.004	1.081	0.310	0.695
	Abundance in n/m²					
B1 natural fishstock	149	159	154	74	49	62
B1b increased fishstock	152	170	161	75	64	69
B1c without fish	131	150	141	87	56	71

of the yellow trout and the sculpin had any influence on the occurrence of the stone-fly larvae. On the whole, it corresponds to the representation of these larvae in the food of the two species of fish. From the evaluation of hitherto results of the investigation into the food of yellow trout (Zelinka 1971) it is evident that stone-flies are represented in the food of yellow trout by about 5 % (mostly small species), which can by no means influence their occurrence. In the sculpin (Orság and Zelinka, in print) it is also about 5 % (without a choice of species) and on top of it, the stock of the sculpin could be changed only partly.

4.7 Trichoptera

Caddis flies are an important component of the fauna in the Beskydy brooks under investigation. Their larvae constitute a substantial part of the abundance of the rheobenthos and, as for the weight, they belong to the components with the highest biomass. The share of caddis fly larvae in fish food is by no means negligible. The qualitative composition of the caddis fly fauna corresponds to the character of the brooks under investigation. In the brook stretches under investigation there occured species current in and typical of those biotopes,

Tab. 28. **The species composition of stone-fly larvae in the stretches of the Brodská with the changed fishstock**

Taxon	B1 natural fishstock	B1b increased fishstock		B1c without fish	
	Average n/m² 1967 to 1969	Average n/m² 1967 to 1969	% A = 100	Average n/m² 1967 to 1969	% A = 100
Dinocras cephalotes	0	1	0	1	0
Perla burmeisteriana	0	0	0	0	0
Perla marginata	26	30	115	33	127
Perlodes microcephala	2	1	0	1	0
Isoperla oxylepis	33	29	88	26	79
Protonemura meyeri	2	4	0	4	0
Protonemura nitida	2	3	0	4	0
Protenomura intricata	1	2	0	0	0
Protenomura praecox	2	3	0	0	0
Nemoura fulviceps	0	0	0	0	0
Nemoura cambrica	6	5	0	4	0
Amphinemura sulcicollis	41	45	110	30	73
Leuctra hippopus	5	8		13	
Leuctra albida	7	2		3	
Leuctra prima	0	1		1	
Leuctra autumnalis	1	0	95	1	87
Leuctra inermis	1	3		1	
Leuctra aurita	0	1		0	
Leuctra sp.div.juv.	24	21		14	
Cloroperlidae div.sp.	1	2	0	5	0
Sum of specimens	154	161	105	141	92

Note: Near the bank without major differences in the representation of individual species

as also follows from Tab. 29 and 32. It is possible to draw the attention to less known specie *Rhyacophila mocsaryi* KLAP. and *Beraeamyia hraběi* MAYER. On the whole more than 34 taxa were determined. Most data are based on the finds of adults specimens or mature pupae.

4.7.1 Differences in the fauna of caddis flies between the two brooks and their upper and lower parts

The two brooks do not differ a great deal in their population of caddis fly larvae. The qualitative composition of the groups important for the production (families *Rhyacophilidae*, *Hydropsychidae*, *Limnephilidae* and *Sericostomatidae*) is very similar in both brooks (Tab. 29). Slight differences in the population between the individual corresponding stations of the two streams were probably due to differences in the methods. (Expressive differences in the occurence of larvae found out between the torrential and the bank zones correspond to the nature of the streams.)

As for the quantitative aspect, both streams are very similarly populated by caddis fly larvae (Tab. 30, 31). Certain differences in abundance and biomass

Tab. 29. **Abundance of the individual species of Trichoptera in the current and in the bank zone of the brooks. Average number of specimens per 1 sqm in the period 1966 to 1967. (P — only pupae were found)**

Biotope	Current				Bank			
Station	B2	L2	B1	L1	B2	L2	B1	L1
Rhyacophila fasciata (*P*)		1.3						
Rhyacophila moscaryi (P)		0.4				1.1		
Rhyacophila nubila	4.8	6.3	14.6	6.8		3.6		
Rhyacophila obliterata (P)	0.2		1.0				1.5	
Rhyacophila tristis			1.3					
Rhyacophila sp.div.	8.5	14.6	9.3	2.9	2.7	1.5		0.5
Rhyacophila total	13.5	22.6	26.2	9.7	2.7	6.2	1.5	0.5
Glossosoma boltoni	3.0							
Agapetus sp.juv.	0.5							
Hydroptila sp.						1.0		
Philopotamus sp.			2.4					
Hydropsyche instabilis		8.5	6.4	18.4		1.3	1.0	
Hydropsyche pellucidula				1.5				0,7
Hydropsyche saxonica	7.1	4.1	9.2	8.8				
Hydropsyche sp.div.juv.	9.3	10.3	21.1	25.0	1.5		1.0	0.7
Hydropsyche total	16.4	22.9	36.7	53.7	1.5	1.3	2.0	1.4
Plectrocnemia conspersa	0.1			0.4		2.8		1.3
Polycentropus flavomaculatus		0.7	1.3	1.2		0.6	14.3	8.2
Tinodes waeneri	0.2	1.6						
Micrasema sp.				0.4				
Drusus annulatus			1.8				5.1	
Ecclisopteryx guttulata	1.5	3.8		5.6	1.5	1.0		5.0
Potamophylax latipennis						1.8		
Potamophylax nigricornis	0.7	0.7			32.5			0.6
Potamophylax sp.div.		0.7		8.0		3.3	1.0	
Halesus radiatus					3.5		13.5	
Halesus sp.	4.4	0.6	0.5	4.6				4.1
Stenophylacini g.sp.juv.							5.3	16.3
Chaetopterygini g.sp.	1.1			1.7	7.0		2.8	39.7
Limnephilinae g.sp.juv.	1.8	3.0	1.1	1.9	12.0	47.3	2.5	19.0
Limnephilinae total	8.0	5.0	1.6	9.0	55.0	52.4	25.1	79.7
Silo pallipes	1.4	1.3	0.5	2.5		3.5		2.1
Silo piceus				0.4				
Silo sp.juv.		1.8	0.2	0.7		1.0		3.0
Seicostomatidae g.sp.	2.7	6.5	10.3	14.6	7.7	1.6	20.5	26..3
Beraea pullata				0.4				
Beraeamyia hraběi		1.0				1.0		
Odontocerum albicorne	0.2				11.2	1.1	2.8	
Trichoptera juv.div.	6.6	9.3	43.1	10.2	10.4	13.0	8.3	6.5

between the two brooks are not conclusive enough to make it possible to speak about a different character and production abilities of the two brooks. These differences, as seen from Tab. 30 and 31 were much less conspicuous in the

Tab. 30. **Abundance of Trichoptera (n/m^2). Average values for the period 1966 to 1967**

	Upper parts		$\bar{x}$	Lower parts		$\bar{x}$	Total average
	Current	Bank		Current	Bank		
Brodská	54.1	90.0	72.0	124.1	79.6	101.8	86.9
Lušová	76.5	86.5	81.5	108.8	134.0	121.4	101.4

Tab. 31. **Biomass of Trichoptera (g/m^2). Average values for the period 1966 to 1967**

	Upper parts		$\bar{x}$	Lower parts		$\bar{x}$	Total average
	Current	Bank		Current	Bank		
Brodská	1.48	3.23	2.35	2.35	4.56	3.45	2.90
Lušová	2.15	2.74	2.44	3.03	8.46	5.74	4.09

following year (1967 to 1968). Quantitative data for the two years are, therefore, more balanced: The total average abundance and biomass of larvae in the Brodská (166 n/m^2, 4.02 g/m^2) does not differ much from the values obtained in the Lušová (174 n/m^2, 4.05 g/m^2). There are also well-ballanced values in the lower stretches of the brooks: Brodská (286 n/m^2, 5.69 g/m^2), Lušová (267 n/m^2, 5.71 g/m^2). Nor were there found significant differences in the abundance and biomass of larvae in the current and in the bank zone: Brodská-current: 202 n/m^2, 3.99 g/m^2, bank: 131 n/m^2, 4.06 g/m^2. Lušová-current: 224 n/m^2, 4.38 g/m^2, bank: 124 n/m^2, 3.72 g/m^2.

Clear quantitative differences were found out in either brook when comparing the upper and the lower parts. These differences were due to different nature of the upper and the lower parts.

4.7.2 Annual cycle

The investigation of the annual cycle of the individual species of caddis flies is very difficult on the basis of the material collected. Often it is impossible to differentiate and determine the species of individual larvae. Reliable determination is mostly possible on the basis of mature pupae of adult specimens. As far as determination features of larvae are known, they often hold for the larvae of the last instars, whereas the younger stages are indeterminable as to the species. The one-month intervals of sample taking seem to be too long for following the life cycles, particularly in spring. One of the determining factors of the length of the life cycle will be the curve of water temperature at the station throughout the year and/or the length of the period with the optimum temperature. Thus e.g. for the species *Hydropsyche instabilis* CURT. it is usual to state the length of development as 1 year in stations with favourable water temperature (HYNES 1961, MARINKOVIĆ-GOSPODNETIĆ 1961), whereas in Central Europe the develop-

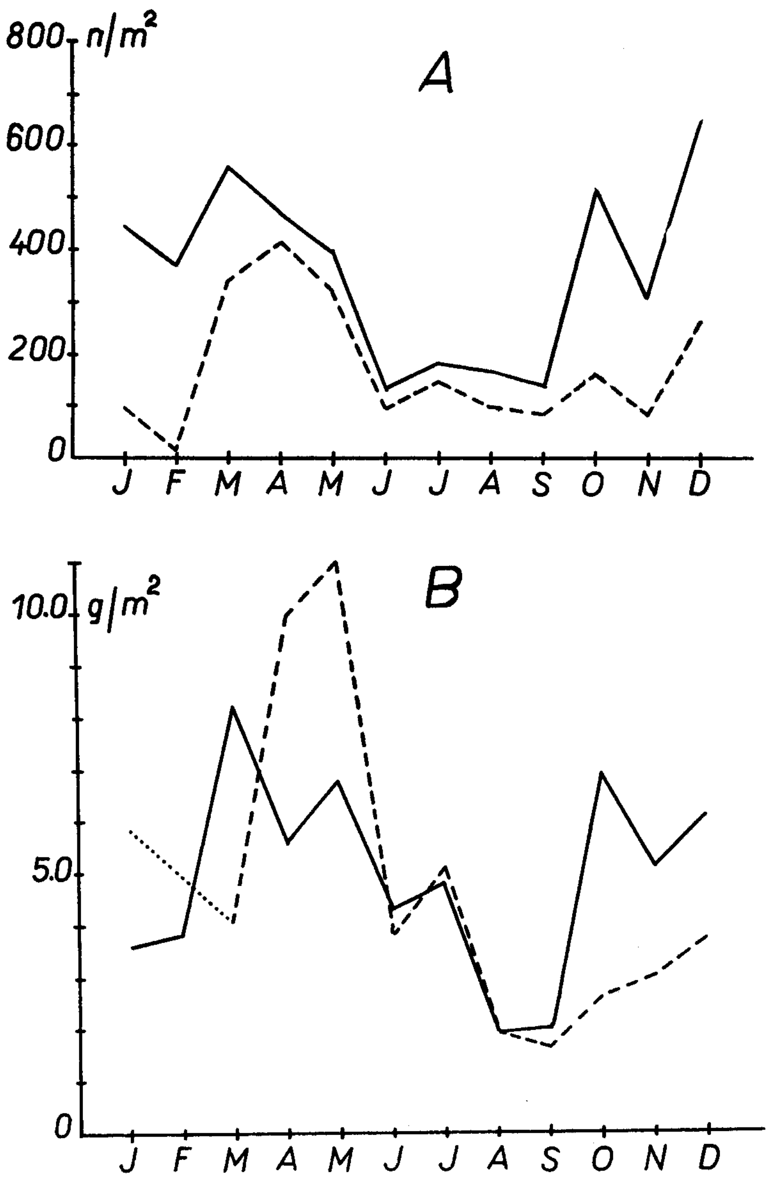

Fig. 28. Average monthly values of *Trichoptera* abundance (A) and biomass (B) in the two brooks for 3 years of investigation; ——— current, – – – – bank.

ment of that species lasts 1.5 to 2 years (DITTMAR 1955). Similar data were found out for *Hydropsyche saxonica* McL. From this family the following species occurred in the Beskydy brooks: *Hydropsyche pellucidula* CURT., *Hydropsyche saxonica* McL., *Hydropsyche instabilis* CURT. Their differentiation is possible only in the last instars (SEDLÁK 1971). The development of those species took two years, the imagines were found in June and in July.

From the family *Rhyacophilidae* larvae of the species *Rhyacophila mocsaryi* KLAP., *Rhyacophila fasciata* HAG., *Rhyacophila obliterata* McL., *Rhyacophila nubila* ZETT., and *Rhyacophila tristis* PICT. occured in the brooks under investigation. The presence of the first three species could be determined reliably only due to the presence of pupae or adults. In the larval stages the species mentioned are not reliably determinable. *Rhyacophila nubila* ZETT. has a life cycle lasting one year and six month with a very long period of the occurence of imagines (from Jun. to Sep.), in *Rhyacophila fasciata* HAG. the development in the Beskydy brooks took probably two years, but in more favourable conditions it can be reduced to 1.5 year (DITTMAR 1955). The species *Rhyacophila mocsaryi* KLAP. and *Rhyacophila obliterata* McL. have a typical life cycle of 2 years.

In the family *Sericostomatidae* it is very difficult to differentiate the two basic genera of the family—*Sericostoma* LATR. and *Notidobia* STEPH. The given differentiating features have been very questionable so far. DITTMAR (1955) considers the development of larvae of the genus *Sericostoma* to take three years. ELLIOTT (1969), on the other hand, found two independent and, from the time point of view, shifted generations with a one-year cycle in the population of *Sericostoma personatum* SPENCE. As it is, for the time being, not clear which species of this family are present in the brooks under investigation, it is not possible to determine the length of their development in detatil. Similar determination trouble occur in the larvae of another group important for the production, the family *Limnephilidae*.

In the graphs of the monthly values of abundance and biomass (Fig. 28) there are clear peaks in the spring and in the autumn months and a drop in the summer season in the time of the emergence of imagines. This course is normal and typical of most groups of larvae of water insects. Irregular drops of the values in the winter months were most probably due to methodical inaccuracies in sample taking (more difficult sample taking at high water level or when the level was frozen etc.).

4.7.3 Differences in the occurence of larvae in the current and near the bank

In following the distribution of larvae in those biotopes no deviations were found from current and well-known data for the type of brooks under investigation. Typically rheobiontic were larvae of the families *Rhyacophilidae*, *Glossosomatidae* and *Hydropsychidae*, calm and shallow bank zones, on the other hand, were rich in larvae of the family *Limnephilidae* (mainly from the tribes *Stenophylacini* and *Chaetopterygini*). Other larva species were more or less indifferent under the given conditions. Typical representatives of this group are larvae of the family *Sericostomatidae* and the species *Polycentropus flavomaculatus* PICT. A substantial part of the population of both basic biotopes was thus constituted by larvae of the groups significant for production. The changes of discharge

Tab. 32. **Abundance of the individual species of Trichoptera in the current and near the bank throughout the period of investigation. Annual average values per 1 sqm from all stations. (P—only pupae vere found, + under 0.1)**

	Current			Bank		
	1966/67	1967/68	1968/69	1966/67	1967/68	1968/69
Rhyacophila fasciata (P)	0.3	0.1			0.3	
Rhyacophila mocsaryi	0.1	0.8	1.4	0.3		
Rhyacophila nubila	8.1	12.3	14.9	0.9	0.3	0.2
Rhyacophila obliterata (P)	0.3	0.1	0.1	0.4	0.2	0.1
Rhyacophila tristis	0.3	1.1	2.1		0.1	0.2
Rhyacophila sp.div.	8.8	10.3	17.1	1.2	0.7	0.8
Rhyacophila total	17.9	24.7	35.6	2.8	1.6	1.3
Glossosoma boltoni	8.0					
Agapetus sp. juv.	0.1					
Hydroptila sp.		0.1	0.2	0.3		0.1
Philopotamus sp.	0.6	+	0.3			0.2
Hydropsyche angustipennis			0.1			
Hydropsyche instabilis	8.3	22.0	24.0	0.6	0.5	1.4
Hydropsyche pellucidula	0.4	1.5	1.3	0.2		
Hydropsyche saxonica	7.3	26.6	20.2		3.0	1.2
Hydropsyche sp.div.juv.	16.4	190.4	212.9	0.8	5.0	3.5
Hydropsyche total	32.4	240.5	258.5	1.6	8.6	6.1
Neureclipsis bimaculata		0.1				
Plectrocnemia conspersa	0.2	+		1.0	1.3	0.1
Polycentropus flavomaculatus	0.8	13.3	4.8	5.8	31.5	14.5
Tinodes waeneri	0.5	2.3	0.6		1.3	1.1
Psychomyia pusilla			0.5			
Micrasema sp.	0.1	0.7	0.3			0.2
Drusus annulatus	0.5			1.3		
Ecclisopteryx guttulata	2.7	11.7	12.2	1.9	5.4	2.1
Potamophylax latipennis (P)		0.1		0.5	0.3	
Potamophylax stellatus					0.8	
Potamophylax nigricornis	0.4			8.3	2.9	1.3
Potamophylax sp.div.	0.4			1.1	0.7	0.2
Halesus radiatus				4.3	4.0	0.6
Halesus sp.	2.5	0.8		1.0	1.9	0.5
Stenophylacini g.sp.juv.				5.4	15.1	9.8
Chaetopteryx villosa (P)						0.1
Chaetopterygini g.sp.juv.	0.7			12.4	9.9	11.3
Limnephilinae g.sp.juv.	2.0	0.9	0.8	20.2	31.6	46.4
Limnephilinae total	6.0	1.8	0.8	53.2	67.2	70.2
Silo pallipes	1.4	0.7	0.1	1.4	2.9	1.7
Silo piceus	0.1				0.5	
Silo sp.juv.	0.7	1.1	0.8	1.0	0.4	
Athripsodes sp.			0.1		0.2	0.5
Sericostomatidae g.sp.	8.5	36.1	73.9	14.0	44.0	53.7
Beraea pullata	0.1					
Beraeamyia hraběi	0.3		0.2	0.3		
Odontocerum albicorne	+	0.2		3.8	0.7	1.4
Trichoptera juv.div.	17.3	82.5	128.0	9.6	43.2	24.5

rates were closely connected with the width of the current zone and thus also with the concentration or thinning of the fauna, the data of the abundance of caddis fly larvae in the current were multiplied by the correction coefficient similarly as with other representatives of the benthos. The data mentioned above are summarised in Tab. 32.

4.7.4 Abundance and biomass

The summary values of biomass and abundance of caddis fly larvae are given in Tab. 33. Lower average values in the first year of investigation were due to sampling in the upper parts of the brooks with generally weaker population (as also follows from Tables 30 and 31). In the following two years the upper stations were dropped from the investigation and the data in Tab. 33 are from four stations of the lower parts (L 1, B 1, B 1b, B 1c).

Tab. 33. **Biomass and abundance of Trichoptera throughout the period of investigation. Annual average values per 1 sqm from all stations**

	1966/67	1966/67 corrected	1967/68	1967/68 corrected	1968/69	1968/69 corrected	Average	Average corrected
g/m^2								
Current	2.25	1.80	5.21	4.16	6.88	5.50	4.78	3.82
Bank	4.74	0.95	4.40	0.88	4.64	0.92	4.59	0.91
Total		2.75		5.04		4.42		4.73
n/m^2								
Current	90.8	72.6	415.9	332.7	516.2	412.9	340.9	272.8
Bank	97.5	19.5	208.2	41.6	177.0	35.4	160.9	32.1
Total		92.1		374.3		448.3		304.9

The total average abundance for the 3 years was 341 n/m^2 in the current and 161 n/m^2 in the bank zone. In the biomass the corresponding values were as follows: 4.78 g/m^2 and 4.59 g/m^2. From the values given it follows that the average weight of larvae from the bank zones is about twice as high as that in the current (see also Tab. 36).

As the current zone constitutes about 80 % of the bottom area (or, more exactly the surface area) and the bank zone 20 % it was necessary, like in other groups of the zoobenthos, to convert the results found out to those proportions. Calculated for the 80 : 20 ratio the values of abundance were 273 n/m^2 in the current and 32 n/m^2 in the bank zone, the total being 305 n/m^2. The values of biomass: current 3.82 g/m^2, bank zone < 1 g/m^2, total 4.73 g/m^2. Calculated for 1 hectare the value of abundance is 3,050,000 larvae with total weight of 47.3 kg.

In caddis larvae there was no significant drop in the abundance and biomass near the bank in 1968 to 1969 as against the preceding rise. In the second and the third years the values were more or less balanced. A probable influence of the changes of the discharge rates on the population of the bank zone was not found in caddis larvae, though it was the case in mayfly and stone-fly larvae.

4.7.5 Production

The production rate of caddis fly larvae was estimated by following the abundance and the increments of individual size groups of larvae. The procedure of the calculation was the same as in estimating the production rates of the other groups of animals. In this way the production rate was found out in larvae of some most significant groups—the genera *Rhyacophila*, *Hydropsyche* and the family *Sericostomatidae*. The population of larvae of the genera *Rhyacophila* and *Hydropsyche* was constituted by several species with differently shifted two-year development and in the family *Sericostomatidae* it was not at all possible to determine the species constituting the population. For checking the procedure another attempt was made at estimating the production rate of the univoltine species *Ecclisopteryx guttulata* PICT. (subfamily *Drusinae*), whose development only takes several months (larvae found out from Sep. to Apr.). The results of the estimate of the production rate are given in Tab. 34.

Tab. 34. **Average annual biomass (B), production rate (P) and the P/B coefficient in some groups of Trichoptera larvae. Average values from 2 stations for 2 years of investigation**

	B mg/m²	P mg/m²	P/B
Rhyacophila	503.6	4,834.2	9.59
Hydropsyche	2,611.5	24,967.9	9.56
Sericostomatidae	1,304.3	12,091.4	9.27
Ecclisopteryx guttulata	171.3	1,673.0	9.76
Average P/B coeff.			9.54

The most significant from the production point of view was the group of larvae of the genus *Hydropsyche* (24.96 g/m² per year), half of the production rate was in larvae of the family *Sericostomatidae* (12.09 g/m² per year). In larvae of the genus *Rhyacophila* the annual production rate was 4.83 g/m² and in the species *Ecclisopteryx guttulata* it was 1.67 g/m² per year. In all these groups of larvae very similar values of the P/B coefficient were found out (P = annual production, B = average annual biomass) varying between 9.27 and 9.76. Thus it was possible to calculate the production rate of the whole caddis fly fauna from the brooks (Tab. 35) by means of the average coefficient of 9.54. Like in the

Tab. 35. **Estimated production rate of Trichoptera larvae. Average annual values from 4 stations**

g/m²	1966/67	corrected	1967/68	corected	1968/69	corrected	Average	Average corrected
Current	21.46	17.17	49.60	39.68	65.58	52.47	45.55	36.44
Bank	45.30	9.06	41.95	8.39	43.85	8.77	43.70	8.74
Total		26.23		48.07		61.24		45.18

determination of abundance and biomass the production rate of larvae was calculated proportionally for 1 m² of the bottom. Like in Tab. 33 the total average is reduced due to values of the first year of investigation. The average annual production rate in three years from 4 stations of the brooks is thus 45.18 g/m² per year, i.e. 451.8 kg/ha per year.

4.7.6 Influence of changed fishstock

In the second and in the third years of investigation the fishstock in the lower part of the Brodská was artificially changed. This gave rise to three stretches: the B 1—without influencing, natural state, B 1b—stretch with excessive fishstock (the population of the trout increased by 100 %, the population of sculpin by about 50 %, B 1c—stretch almost without fish (sculpin—about 50 % of the original population). Concrete data about this artificial interference are given in Chapter 5.

This interference with the fishstock was partly reflected in the fauna of caddis fly larvae. The weight of the larvae in the stretch with excessive fishstock was partly lowered, by about 2 mg of the average weight of 1 specimen (Tab. 36). Reduced weight can also be explained by partial predation of big larvae by fish. Further investigation would, however, be necessary to confirm and specify this phenomenon.

The changed fishstock resulted in a partial change in the species composition of the caddis fly fauna. The population of the current remaind almost without

Tab. 36. Average weight of one Trichoptera larva (mg) in the stretches of the Brodská with changed fishstock. Average values for 2 years of investigation.

	Current	Bank
Bl — natural state	12.6	23.4
Blb — increased fishstock	10.4	20.4
Blc — without fish	12.2	20.6

Tab. 37. Changes in the abundance (n/m²) of some groups of Trichoptera larvae in the stretches of the Brodská with changed fishstock. Average values from the bank zone for 2 years

Stretch	Bl	Blb	Blc
Stenophylacini	24.8	15.5	8.3
Chaetopterygini	11.0	8.8	9.8
Limnephilinae juv.	39.9	27.7	42.8
Limnephilinae total	75.7	52.0	60.9
Polycentropus	25.3	21.1	26.5
Sericostomatidae	50.1	46.2	48.4
Total	151.1	119.2	135.8

change, whereas in the bank zone there was a reduction of some groups of larvae (see Tab. 37). The low values of abundance in the B 1c stretch (without fish) can be due to partial pollution.

Summary data on the change of abundance and biomass of larvae due to excessive fishstock are given in Tab. 38 and 39. From the tables it follows that

Tab. 38. **Abundance of Trichoptera (n/m^2) in the stretches of the Brodská with changed fishstock. Annual average values.**

	Current			Bank		
	1967/68	1968/69	x̄	1967/68	1968/69	x̄
B1 — natural state	562.1	469.5	515.8	218.1	186.1	202.1
B1b — increased fishstock	428.3	561.5	494.9	182.8	122.1	152.4
B1c — without fish	286.8	451.5	369.1	183.1	203.4	193.2

Tab. 39 Biomass of Trichoptera (g/m^2) in the stretches of the Brodská with changed fishstock. Annual average values.

	Current			Bank		
	1967/68	1968/69	x̄	1967/68	1968/69	x̄
B1 — natural state	7.57	5.43	6.50	5.44	4.55	4.99
B1b — increased fishstock	4.38	5.96	5.17	3.62	2.59	3.10
B1c — without fish	3.03	5.98	4.50	2.53	5.43	3.98

the excessive fishstock resulted in the decrease of population in the bank zone by about 50 specimens per 1 sqm, which makes about 1.9 g/m^2 of the biomass. In the larvae from the current the excessive fishstock did not have such significant influence. The decrease of the values in the stretch B 1c, probably due to pollution, is more significant in larvae of the more sensitive species living in the current than in larvae from the bank zone.

The above statements about the influence of the increased fishstock are identical with generally known information on the food of the trout (Tuša 1968, Blahák 1972) and on the influence of excessive fishstock (mainly the population of the yellow trout) on the composition of the rheobenthos (Sedlák 1969). The yellow trout consumed chiefly easily accessible larvae, mostly freely creeping or taken by the current and occuring mostly in calm sectors of the bank zone (the families *Limnephilidae*, *Sericostomatidae*).

4.8 Megaloptera

From *Megaloptera* larvae of the only species *Sialis fuliginosa* PICT. (see VAŇHARA 1970) occured in both trout brooks. From the total number of larvae collected in the course of the whole investigation period, 37.8 % occurred in the Brodská and 62.2 % in the Lušová. From the ecological point of view the Lušová seems to be more favourable for the occurrence of *Sialis* larvae by its more suitable hydrological conditions.

In both brooks stones near the banks were more populated. Thus in the Brodská we found 82.9 % in stagnant water near the banks and only 17.1 % lived in the current. Similarly in the Lušová 80.2 % lived near the banks and 19.8 % in the current (percentual shares were calculated out of the total number of larvae found in the individual brooks).

The upper stations of both brooks were more frequently populated than the lower ones; the two brooks, however, differed from each other qualitatively. While the ratio of abundance in the upper and in the lower Lušová is 53 : 3, in the Broská it is substantially lower, viz. 6 : 0.

The abundance of larvae in the course of the year is very low, it varied from 0 to 24 specimens per 1 sq.m; the distribution and occurrence of larvae are also irregular. The average abundance of *Sialis* larvae was <1 specimens per 1 sq.m in the current and 2.7 specimens per 1 sq.m near the banks.

Due to low occurrence it is not possible to evaluate quantitative conditions of *Sialis fuliginosa* in stretches with different population of the yellow trout in the Brodská. The values are more or less balanced.

Neither the biomass nor the production was separately stated.

4.9 Diptera

The quantitative share of *Diptera* larvae in the zoobenthos of the two brooks is quite significant, particularly as far as the numbers are concerned. The representation of species and genera of the individual families is evident from Tab. 40. The values stated therein express an average abundance of larvae per 1 sq.m, calculated for the whole investigation period, 1966 to 1969. The share of the families in the composition of *Diptera* is different.

4.9.1 *Tipulidae* occurred mostly near the banks. Sapro-phytofagous larvae of both species found out were mostly found near the banks, chiefly in the Brodská. On the other hand, in the Lušová there occurred only several larvae in the current under the stones.

4.9.2 Most species and/or genera of the family *Limoniidae* occurred irregularly and sporadically. They are mostly predatory larvae, currently occurring in clear and well-oxidated brooks. The most frequent of the *Limoniidae* larvae were larvae of the genus *Dicranota* not specified in detail, which showed a clear preference for the current in the distribution. The abundance in the current is in some cases a multiple of that near the bank. In most samples the larvae occurred in quantities of 6 to 20 specimens per 1 sq.m (only exceptionally 70 and 88 specimens per 1 sq.m in two samples in March and in May in the Lušová).

In the larvae of the genus *Dicranota* we did not find any relation between their quantity and a different population of the yellow trout in the Brodská. From the values quoted below there follows more or less a depression of the number of larvae downstream, which may be due to certain organic pollution of the lower stations and elimination of oligosaprobic and steno-oxybiotic species. The relatively highest density of larvae throughout the whole investigation was noticed in the current of the Lušová; it was 105 specimens per 1 sq.m.

Average abundance of *Dicranota* larvae (n/m²), was following:

Station	Current	Bank
Lušová L 1	105	3
Brodská B 1	80.3	22.1
B 1b	33.3	17.7
B 1c	27.7	2.7

The next relatively most numerous species of *Limoniidae* is *Antocha vitripennis*. Its larvae occur regularly in rapid brooks and are evidently sapro-phytofagous and detritovorous. In the distribution of larvae there occurred a slight preference for calmer water near the banks.

The occurrence of the other species *Limoniidae* was irregular and sporadic.

4.9.3 The family *Dixidae* was represented by two species (Tab. 40) whose detritovorous larvae show a slight preference for the bank zones of the brooks. They were much more numerous in the Brodská. The occurrence of both species is, however, irregular and sporadic.

4.9.4 Chironomidae

Chironomidae larvae consitute one of the frequently occurring groups of zoobenthos in both trout brooks, even though their percentual share on the total biomass and/or production of the whole zoobenthos will be indisputably small. In the present paper we have evaluated all the material of *Chironomidae* larvae collected throughout the whole period of investigation (1966 to 1969) with regard to partial results published before in the papers by Kubíček and al. (1972) and Losos (1972). For the reasons of complexity of the whole study we have to sum up some of the results published before.

4.9.4.1 Differences in the populations of the upper and the lower stations of the two brooks

In the first year of investigation (1966 to 1967) we followed the brooks Lušová and Brodská in two stations each to find out whether there were any differences in the population of stones by midge larvae in the upper and the lower parts of the two brooks. From the results published (Kubíček and al. 1972) it is evident that the density of larvae in both stations was different (see Tab. VI, p. 867, in l.c.). Apparent differences were noted mainly in the Lušová, where the average

Tab. 40. **Average annual abundance of Diptera and the representation of individual taxons in the Lušová and the Brodská**

Taxon	Lušová		Brodská	
	Current	Bank	Current	Bank
Tipulidae				
Tipula (Yamatotipula) lateralis Meig.	0.3	—	—	0.6
Tipula maxima Poda	—	—	—	0.3
Limoniidae				
Limonia (Dicranomyia) didyma Meig.	—	—	—	0.3
Antocha vitripennis (Meig.)	0.4	0.6	0.7	0.1
Pedicia rivosa (L.)	—	—	—	0.1
Pedicia sp.	—	—	0.2	0.3
Dicranota sp.	9.0	0.3	7.3	0.7
Limnophila (Brachylimnophila) nemoralis Meig.	—	—	0.2	—
Limnophila (Eleophila) sp.	0.3	0.6	0.1	0.1
Molophilus sp.	—	—	0.2	—
Dixidae				
Dixa nebulosa Meig.	—	1.3	0.2	0.6
Dixa puberula Loew.	—	—	—	0.5
Chironomidae	296.8	166.5	264.7	160.5
Ceratopogonidae	1.9	0.6	1.7	0.5
Simuliidae	38.5	0.9	32.1	0.0
Psychodidae				
Pericoma stammeri Jung	0.4	—	—	—
Pericoma unispinosa Tonn.	0.9	—	—	—
Pericoma sp.	—	—	—	0.3
Stratiomyidae				
Oplodontha viridula (Fabr.)	—	—	—	0.3
Tabanidae				
Hybomitra sp.	0.6	—	—	0.1
Tabanus maculicornis Zetterstedt	0.3	0.2	—	—
Rhagionidae				
Atherix marginata (Fabr.)	14.8	6.0	29.2	12.3
Empididae				
Chelifera sp.	—	—	0.1	0.7
Wiedemannia sp.	1.2	—	0.1	0.7

annual abundance of larvae in the lower station was higher by 47.2 % than in the upper one. In the Brodská, however, this difference was not so conspicuous, it being only 8.4 %. It was shown that stones both in the current and near the banks in the lower stations were more populated than those in the upper ones. The results are, however, not quite conclusive, as they are results of only one year's investigation.

The species composition of *Chironomidae* larvae was roughly the same with the exception of the bank zones in the Brodská, where we found 50 % fewer taxa. To the dominant species belonged above all *Potthastia gaedii* (MG.). In this species it is interesting to note that its larvae appeared in the brooks in considerably lower numbers in the following two years. In the first year of investigation *Potthastia gaedii* larvae constituted on the average as much as a 50 % representetion of all *Chironomidae* collected in the course of that year in both stations and both biotopes. From the spring species larvae of *Euorthocladius rivulorum* (K.) were also quite frequent (19 %); we collected its larvae on stones only in the current. Near the banks, larvae of *Prodiamesa olivacea* (MG.) were typical (11 %). The occurrence of other taxa was practically the same both in the upper and in the lower stations of both brooks.

4.9.4.2 Species composition and annual cycles

The species composition of *Chironomidae* fauna was determined only by the occurring larvae and/or pupae isolated from quantitative samples. The imagines were not followed. A partial survey of the species composition and quantitative conditions of *Chironomidae* in the upper and the lower stations of both brooks in 1966 to 1967 was reported by Losos (in KUBÍČEK and al. 1972) and in the lower stations of both brooks throughout the whole investigation by Losos (1972). To have complete data we shall again give some of the results.

For the whole period of investigation we found 28 taxa according to the larvae. The main share is formed by the *Diamesinae* larvae: *Diamesa insignipes* K., *Diamesa thienemanni* K., and partly *Potthastia gaedii* (MG.). Their percentual share in the lower stations was—in the course of the whole investigation—higher in the current than near the banks:

	Current	Bank
Lušová	43.7 %	35.4 %
Brodská	44.4 %	19.7 %

Another group, quantitatively less important, is constituted by rheobiotic larvae of *Euorthocladius rivulorum* (K.), constituting a 9.8 % representation of all larvae in the current, and partly also by larvae of *Eukiefferiella discoloripes* G. (current—9.8 %, bank—only 2 %). On stones near the banks there occurred larvae of another group, *Ablabesmyia lentiginosa* (near the banks—22.3 %, in the current only 6 %). And the last group of quantitative importance were larvae not determined in detail, belonging to the *Rheorthocladius-Trichocladius* *group*, represented to the same extent in both biotopes (current—10.4 %, near the banks—10.2 %). A more detailed survey of the species composition of *Chironomidae* is given in Tab. 1 and 2 in Losos (1972).

Since we did not follow the adult stages, it was impossible for us to find out annual cycles of development in a number of taxa and/or the number of generations. A predominant part of *Chironomidae* larvae belongs to univoltine species which are also of the greatest quantitative importance.

4.9.4.3 Differences in the occurrence of larvae between the two brooks and biotopes

Differences in the species composition of *Chironomidae* in the Lušová and in the Brodská are negligible. They were found out in several rare species such as *Cladotanytarsus atridorsum* K., *Eukiefferiella minor* Edw., *Macropelopia nebulosa* (Mg.), *Neozavrelia luteola* Goetgh., and the genus *Eudactylocladius*, not determined in detail. The species basis of *Chironomidae* fauna is the same in both brooks. The same goes for the individual stations.

Certain major differences concerned the population of stones in the current and those near the banks. This, however, concerns a few species and, above all, the space distribution of torrential and lenitic species. They are mainly explicitly rheobiotic larvae of *Euorthocladius rivulorum* (K.), practically not found near the banks, and partly also larvae of both species of the genus *Diamesa* and *Eukiefferiella discoloripes*, in which a greater preference for the current is shown. From the lenitic species they are mainly larvae of the *Ablabesmyia lentiginosa* group which, on the other hand, were more frequently found near the banks. In the remaining taxa the space distribution in both brooks was approximately the same and possible differences in the population of both biotopes are negligible.

4.9.4.4 Abundance and biomass

As has been stated before, the species composition of *Chironomidae* was practically the same in the upper stations as in the lower ones, but the abundance of larvae was lower in the former. Due to the fact that the results of a one-year investigation are not sufficiently conclusive, we abandoned further evaluation of quantitative data in the upper stations.

The lower stations in the two brooks were followed for 3 years (1966 to 1969). The results obtained give a sufficiently clear picture of the quantitative conditions of *Chironomidae* in both trout brooks. From the results of quantitative analyses we found out that there were substantial differences in the values of abundance and biomass of *Chironomidae* above all between the individual years of investigation. This is particularly conspicuous in the first year of investigation. Quantitative differences were shown not only in *Chironomidae*, but also in some other, chiefly small representatives of the zoobenthos, such as *Hydracarina*, *Coleoptera*, partly also *Simuliidae* (in the lastmentioned group only in the Brodská).

In Tab. 41 we stated the values of the average annual abundance, calculated for the all brook (80 % from the current and 20 % from the bank zones) for the lower stations of the Brodská and the Lušová. The low density of *Chironomidae* larvae (and/or other groups) in the first year of investigation may have

Tab. 41. **Differences in average annual abundance between individual annual seasons in some groups of minor zoobenthos in the Lušová and the Brodská (abundance calculated per 1 sqm. of the whole brook)**

Trout brook	Lušová			Brodská		
Year period	1966/1967	1967/1968	1968/1969	1966/1967	1967/1968	1968/1969
Chironomidae	63.9	259.3	437.8	54.7	148.2	515.4
Coleoptera	9.6	25.1	184.4	17.3	167.0	134.5
Simuliidae	38.0	34.0	20.6	3.3	22.6	51.2
Hydracarina	8.5	40.1	50.0	19.8	45.0	48.1

been influenced partly by adverse hydrological conditions (higher discharges) but also by methodically incomplete sampling. For those reasons we base our calculations of abundance, biomass, and production rate mainly on the results of the last two years, 1967 to 1968 and 1968 to 1969.

Changes in the abundance of *Chironomidae* larvae in the lower stations of both brooks are expressed in Fig. 29 and 30. In the time distribution of *Chironomidae* there are two peaks of development. The spring peak in both brooks is particularly conspicuous. It lasts from the end of March sometimes up to the middle of May and it is formed predominantly by larvae of *Diamesa insignipes*, *Diamesa thienemanni* and *Euorthocladius rivulorum*. In spring the abundance of larvae in the current varied from 699 to 2,473 n/m² in the Lušová and from 585 to 1,685 in the Brodská. Similar, quantitatively less outstanding, were the conditions near the banks: 303 to 1,240 n/m² in the Brodská and 989 to 1,465 n/m² in the Lušová. In the spring maximum the density of midge larvae in the Lušová was also higher than that in the Brodská.

The summer maximum of *Chironomidae* was no longer so conspicuous, it stretches for a longer period and it is not uniform in all stations under investigation, in the biotopes and in the individual years. The abundance of larvae was

Tab. 42. **Average annual abundance (n/m²) and biomass (mg/m²) of Chironomidae in the lower stations in the Lušová and the Brodská**

Trout brook	Abundance				Biomass			
	Lušová		Brodská		Lušová		Brodská	
Biotope	current	bank	current	bank	current	bank	current	bank
1966/1967	66	56	62	11	85	35	52	36
1967/1968	271	215	140	180	181	122	62	110
1968/1969	494	213	571	294	374	178	325	208
Average values	277	161	258	161	213	111	146	118
Average values for the whole brook	254		238		193		141	

lower in the summer season and varied from 366 to 378 n/m² in the Lušová and from 581 to 752 n/m² in the Brodská. This maximum was formed by small larvae, so that also the biomass of larvae was low, varying from 0.2 to 0.4 g/m².

The values of the average annual abundance are given in Tab. 42. For their calculations we used quantitative data obtained in all lower stations.

The biomass of larvae and pupae of *Chironomidae* was not weighed directly, but it was determined from the curve of length-weight relations. Not following the adult stages it was impossible for use to classify the larvae exactly into individual species. For those reasons we abandoned the following of instars and the total *Chironomidae* material was processed according to the length-frequency analysis.

For the calculation of *Chironomidae* biomass we first of all plotted a curve to represent the average length-weight relations in larvae of all taxa of *Chironomidae* found, irrespective of the individual species. For plotting the curve we took a number of larvae which we classified approximately into several size groups of 50 specimens each. In each group we found out the average length of the body and the weight of the larva. From the data obtained we then plotted the curve of the length-weight relation for all *Chironomidae* larvae occurring in the two

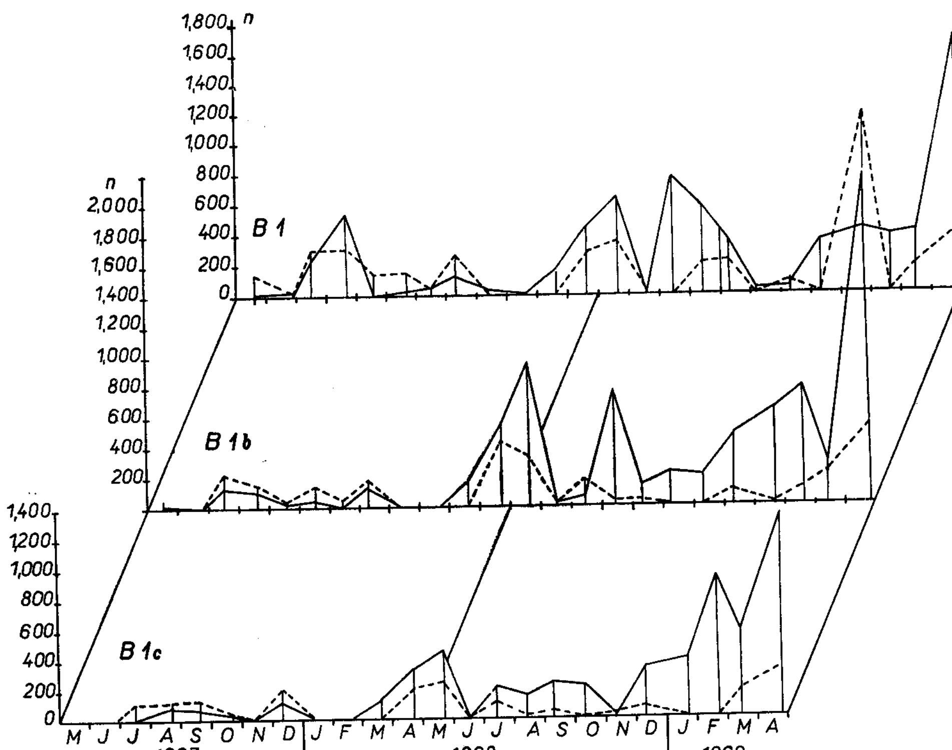

Fig. 29. Changes in abundance of *Chironomidae* in the lower stretches of the Brodská with changed fishstock; ——— current, - - - - bank.

brooks (Fig. 31). From that curve we then calculated the biomasses of *Chironomidae* isolated from the individual zoobenthos samples.

The changes in the biomass of *Chironomidae* more or less correspond to the changes of abundance (Fig. 30, 32). In the period of the spring peak the biomass of *Chironomidae* in the Brodská and the Lušová varied between 405 to 1,748 mg/m² and 1,469 to 2,164 mg/m² respectively. The values stated were taken from all lower stations for the last two years, i.e. 1967 to 1968 and 1968 to 1969. Between the two seasons we found substantial differences both in abundance and in biomass. The ratio of the average biomass from all lower stations between the two years in the spring peak was 791 : 1,606 mg/m². Near

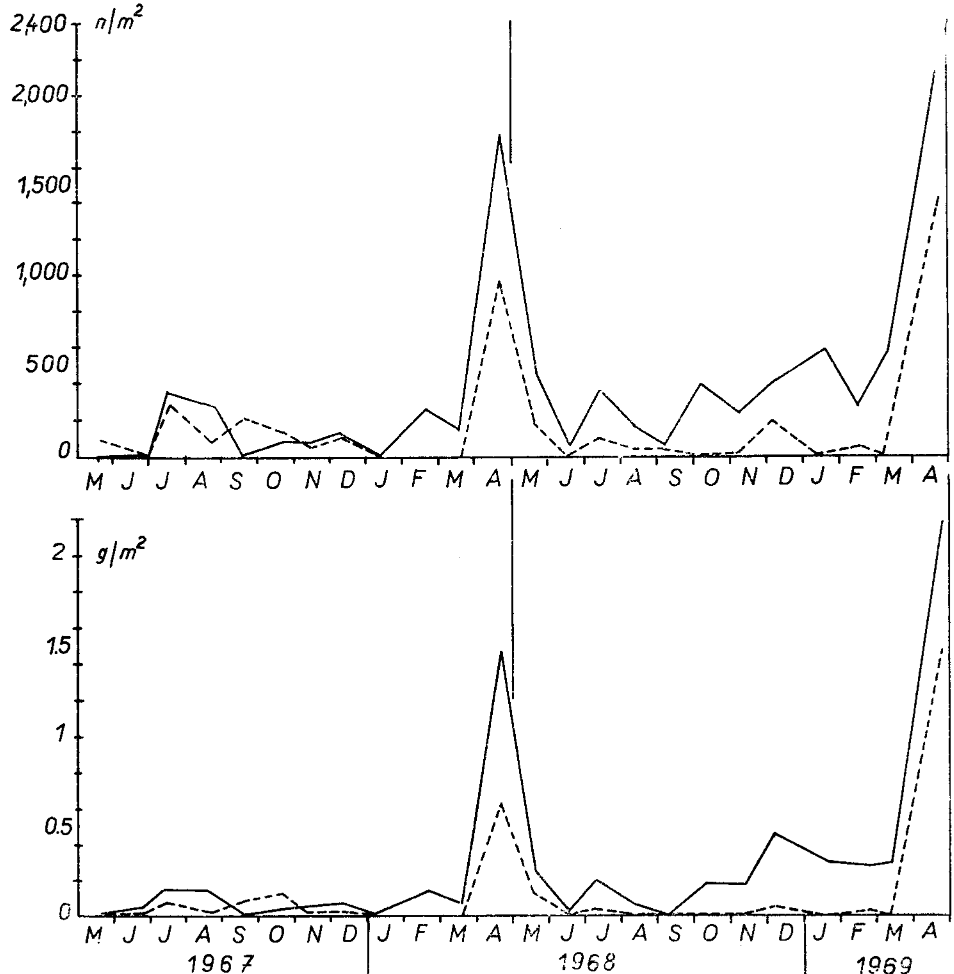

Fig. 30. Changes in abundance and biomass of *Chironomidae* in the lower station of the Lušová; ——— current, - - - - bank. Abundance in n/m², biomass in g/m².

the banks the biomass of *Chironomidae* was lower and, under the same conditions, it varied from 221 to 329 mg/m² in the Brodská and 629 to 1,448 mg/m² in the Lušová. The differences between the last two years of investigation are analogical in the ratio 366 : 662 mg/m².

In Tab. 42 there are the annual average values of abundance and biomass for all lower stations of both brooks, but for all the 3 years of investigation, as well as the values calculated for 1 sqm of the brook (80 % current, 20 % bank zone). From this table great differences between the individual years can be seen. In the first year of investigation both abundance and biomass are particularly low, which has been explained by adverse hydrological conditions on the one hand, but partly it was due to imperfect technique of sampling the material in the field.

From the values of abundance and biomass stated it is further evident that the density of *Chironomidae* larvae is substantially higher in the Lušová than

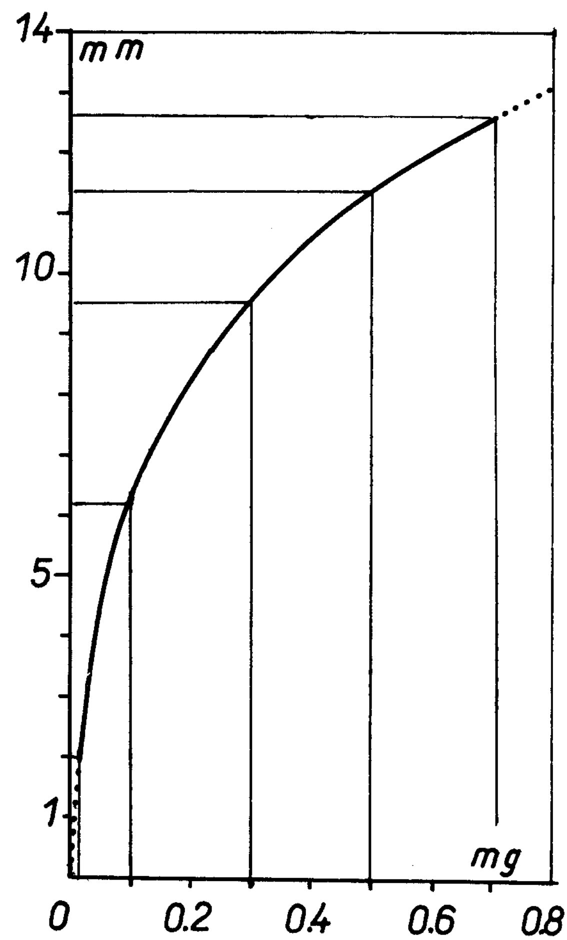

Fig. 31. Length/weight curve of *Chironomidae* larvae.

in the Brodská, both in the current and near the banks. This is due to a more suitable situation of the Lušová, flowing through more open terrain. It has less water and is relatively warmer.

4.9.4.5 Production

The calculations of the production rate of *Chironomidae* was based on the length-frequency analysis of the all populations. Taking samples of the zoobenthos once a montle is too long an interval to follow the development of larvae of individual species in more detail. Thus the development of some univoltine species, such as *Diamesa insignipes* K. and *Diames thienemanni* K., and *Euorthocladius rivulorum* (K.), which have the greatest share in the whole family *Chironomidae* in both brooks, goes quite quickly, so that in April, and sometimes in May, we may get the whole generation of those species in one sample. In the remaining period of the year the larvae do not occur. For the determination of their production rate it would be necessary to take more samples at shorter interval than one month in the period of their occurrence.

For all those reasons we only tried to get a rough estimate of the production rate of *Chironomidae* irrespective of their individual species. We based our calculations on the principles of the methods (see Chapter 2.3).

In Tab. 43 we quoted the values of the production rate calculated for the lower stations of both brooks for the last two years. From the values quoted it follows that the production rate of *Chironomidae* per 1 sqm, similarly as the

Tab. 43. **Production of Chironomidae (in mg/m²) in the last two years in the Lušová and the Brodská**

Trout brook	Lušová		Brodská					
Station	L1		B1		B1b		B1c	
Biotope	Current	Bank	Current	Bank	Current	Bank	Current	Bank
1967/1968	1,913	840	581	851	511	634	313	587
1968/1969	3,349	1,756	3,070	1,653	3,708	1,108	2,303	808
Average production	2,631	1,298	1,826	1,252	2,110	871	1,308	596
Production of the whole brook	2,364		1,711		1,862		1,166	

biomass, is again higher in the Lušová than in the Brodská. The bank zones have a substantially lower production rate of *Chironomidae* than the torrential zones. In the first year of investigation we did not calculate the production rate of *Chironomidae*, since the quantitative data obtained were exceptionally low in that year and they are not sufficiently conclusive.

The production rate of *Chironomidae* in the lower stations was roughly 2.4 g/m² in the Lušová and 1.6 g/m² in the Brodská (the average of 3 stations). Calculated for the area of 1 hectare the estimated production rate would vary from 16 to 24 kg. The average share of *Chironomidae* in the total production of zoobenthos is small and constitutes roughly 1,5 %.

In calculating the production rate of *Chironomidae* we also determined the value of the P/B coefficient. Its values are given in Tab. 44. In 2 cases the P/B coefficient was higher than 8, in one case it was lower than 4. We think that the production rate was overestimated or underestimated by the fact that we did not have data of some winter month at our disposal. In winter the banks were frozen and covered with ice, so that we could not take any samples. The average P/B coefficient for the torrential zones is 5.65, for the bank zones 5.7. These values approach the factor 5, used by MANN (in EDMONSON et WINBERG 1971, p. 162) for production rate estimate.

Tab. 44. **P/B coefficients in Chironomidae in the lower stations of the Lušová and the Brodská**

Biotope	Current		Bank	
Year period	1967/1968	1968/1969	1967/1968	1968/1969
B1	4.1	5.4	4.7	5.6
B1b	5.1	6.6	4.3	8.1
B1c	4.6	5.4	4.3	6.3
L1	7.1	6.8	3.8	8.3
Average values	5.65		5.7	

4.9.4.6 Influence of changed fishstock

The result of the two-year investigation of the lower stations in the Brodská did not show any relation between the density of *Chironomidae* and the density of the yellow trout population. For comparison, in Tab. 45 and 46 we quoted the values of abundance and biomass of *Chironomidae* in all 3 lower stretches of the Brodská together with the values calculated per 1 sq.m of the brook. From the results quoted it is evident that the highest abundance and/or biomass of *Chironomidae* larvae were in the highest stretch with natural density of the

Tab. 45. **Abundance of Chironomidae (in n/m²) in the lower stations of the Brodská with changed fishstock**

Year period	1967/1968			1968/1969		
Biotope	current	bank	brook	current	bank	brook
B1	140	180	148	571	294	515
B1b	100	149	109	565	137	480
B1c	69	90	73	429	127	369

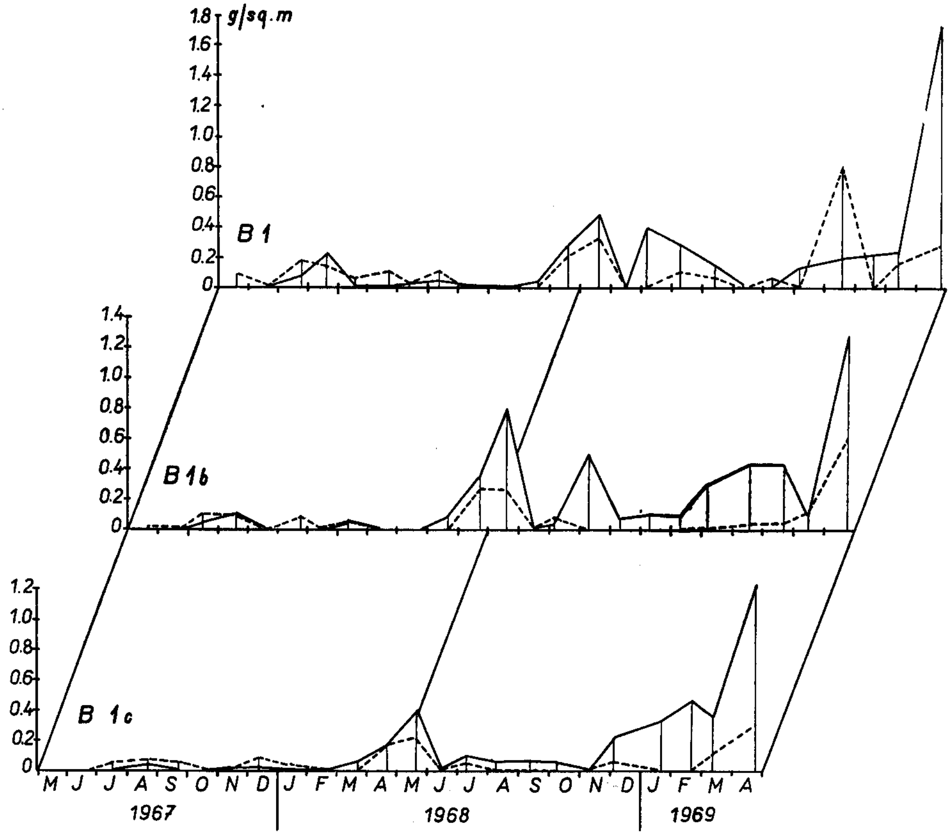

Fig. 32. Changes in biomass of *Chironomidae* in the lower stretches of the Brodská with changed fishstock; ——— crurrent, - - - - bank.

Tab. 46. **Biomass of Chironomidae (in mg/m²) in the lower stations of the Brodská with changed fishstock**

Year period	1967/1968			1968/1969		
Biotope	current	bank	brook	current	bank	brook
B1	62	110	71	325	208	302
B1b	53	75	58	343	103	295
B1c	30	49	34	282	95	244

yellow trout population (B 1), not only in the current, but also near the banks. On the other hand, the lowest values were found out in the lowest stretch without fish (B 1c). The middle stretch with excessive fishstock (B 1b) had the values of abundance and biomass of larvae within the range of the two limits found out.

When comparing the values in all 3 stretches of the Brodská we found out a gradual decrease of the density of population downwards towards the mouth of the brook. This difference was particularly clear in 1967 to 1968 and reached as much as 50 %; in the following year it was smaller. We think that the decrease in the density of midge larvae both in the current and near the banks was due to slight pollution of the brook Brodská. Similar trends were also registered in the Brodská in other groups of the zoobenthos, e.g. *Simuliidae*, *Hydracarina*, *Trichoptera*.

4.9.5 Ceratopogonidae

Larvae and pupae of *Ceratopogonidae* constitute a quantitatively insignificant group of zoobenthos in both brooks. The whole family is characterised by a very irregular space distribution and the occurrence of larvae and/or pupae is also very irregular to sporadic in some places. Larvae occurred in almost all months of the year, the highest number of occurrences being in April and May in the current and in September and October on the stones near the banks. We did not carry out species determination.

Throughout the whole period of investigation we found altogether 283 larvae, fewer pupae. Out of that number 67.5 % (191) lived in the Brodská and 32.5 % (92 specimens) in the Lušová. Thus the Brodská is more populated by them the Lušová, the difference being more than twofold.

The quantitative population of both biotopes is practically the same in the Brodská and in the Lušová. Larvae populate stones in the current more than those near the banks. This follows clearly from the following comparison: Brodská: current—75.8 %; bank zone—23.2 %; Lušová: current—69.5 %; bank zone—30.5 %.

The average monthly abundance of *Ceratopogonidae* larvae is very low and in different stations it varied within the following limits: near the banks 0 to 1.9 n/m^2; current—0 to 5.7 n/m^2.

The biomass and production rate of *Ceratopogonidae* were not separately determined due to scanty material and irregular occurrence.

4.9.6 Simuliidae

Larvae and pupae of *Simuliidae* occurred on stones mainly in the current of all stations under investigation. In stagnant water along the banks they were mostly completely missing; throughout the whole period of investigation 1966 to 1969 they occurred there in only 4 collections chiefly during increased discharge rates, but always in negligible quantities. They were larvae of the following species: *Simulium nigripes*—6 specimens/m^2 (L 2—13 Apr., 1966), *Odagmia ornata*—9 n/m^2 (L 1—21 Aug., 1967), and *Odagmia monticola* in the numbers 7 and 8 n/m^2 (B 1b, 28 Jan. and 25 Feb., 1969).

The share of *Simuliidae* on the whole zoobenthos of both trout brooks was very low.

Simuliidae were represented there by 8 species, common in our country. Larvae of all the species determined occur mostly in streaming cold waters, mostly in nountain and slope brooks and small rivers; only *Simulium nigripes* and *Prosimulium* (*S.*) *tuberosum* descend to the plains. The species composition and percentual representation of the individual species in the current of the two trout brooks is given in next text; the percentage for the whole period of investigation, 1966 to 1969, was calculated separately for either brook:

Species	Brodská	Lušová
Eusimulium brevidens RUBTZOV	0.2 %	—
Eusimulium costatum (FRIEDERICHS)	—	0.3 %
Eusimulium cryophylum RUBTZOV	0.2 %	0.5 %
Eusimulium latipes (MEIGEN)	5.5 %	4.5 %
Odagmia monticola (FRIEDERICHS)	38.5 %	46.5 %
Odagmia ornata (MEIGEN)	2.3 %	6.8 %
Prosimulium nigripes ENDERLEIN	34.5 %	40.6 %
Simulium (*S.*) *tuberosum* (LUNDSTRÖM)	18.8 %	1.3 %

It is evident that out of 8 species the dominant ones were *Odagmia monticola* and *Prosimulium nigripes* and in the brook Brodská partly also *Simulium* (*S.*) *tuberosum*. The percentual composition of *Simuliidae* larvae and pupae is roughly the same in both brooks.

The annual cycle of *Prosimulium nigripes* points to one generation per year; most larvae were found in the winter season up to April with the maxima up to 285 larvae per 1 sq.m. In *Odagmia monticola* there occur 2 generations.

The annual cycle of *Prosimilium nigripes* shows that there lives only one generation in the year in the brooks. Their larvae were mostly found in winter and partly in spring, practically up to April. The maximum abundance of larvae was as high as 285 specimens per 1 sq.m. In *Odagmia monticola* it is possible to estimate two generations per year. The maximum representation of larvae in both brooks was in winter and at the beginning of spring with the maximum of 248 larvae per 1 sq.m.; weaker and not so numerous generations were also found in summer.

Both dominant species influence significantly the abundance of the whole family *Simuliidae*, reaching the maxima in both trout brooks in winter and partly in the summer months in the number of 100 to 450 larvae per 1 sq.m.

Tab. 47. **Average annual abundance of Simuliidae in the Lušová and the Brodská**

Trout brook		Lušová		Brodská			
Station		L2	L1	B2	B1	B1b	B1c
Current	1966/67	13.5	47.5	22.0	4.1	—	—
	1967/68	—	42.3	—	28.3	17.6	13.4
	1968/69	—	25.7	—	64.0	71.5	33.8
Bank	1966/67	0.7	0	0	0	—	—
	1967/68	—	1	—	0	0	0
	1968/69	—	0	—	0	1.3	0

The differences between the brooks, the stations, and/or biotopes in the abundance of *Simuliidae* larvae is evident from Tab. 47, which contains the values of average monthly abundance.

From that table it is clearly evident that *Simuliidae* larvae and/or pupae populate—as it corresponds to their ecology and way of nutrition—exclusively the torrential zones of both brooks and, on the other hand, avoid stagnant water along the banks. Quantitative differences in the population of both brooks and the stations are not significant, more conspicuous are the differences in abundance between individual years, particularly in the Brodská. Neither biomass nor production were separately determined.

4.9.7 Other groups of Diptera

Larvae of the families *Stratiomyidae* *Tabanidae*, and *Empididae* also showed irregular and sporadic occurrence.

An outstanding quantitative share in the composition of Diptera belongs to larvae of *Atherix marginata* from the family *Rhagionidae* (Tab. 40). In all the stations under investigation the larvae showed a clear preference for the torrential zones of the brooks where their average abundance was roughly 2 to 2.5 times higher than that near the banks (Tab. 40). The weakest population of stones was in the Lušová both in the current and near the banks. In the Brodská the values of average abundance were substantially higher, increasing downstream. Distribution of *Atherix marginata* larvae in the current and near the banks of the two brooks:

Station	Current	Bank
Lušová 1	105	52
Brodská 1	248	98.3
Brodská 1	289	181
Brodská 1c	359.5	143.5

The increase of the number of *Atherix marginata* larvae in the lower stations of the Brodská is in accordance with the ecological character of this species which is less particular to cleanliness. As can be seen from the table above there was not found out any correlation between the density of larvae and the density of population of the yellow trout in the brook Brodská.

The biomass and production of the *Diptera* families were not separately calculated.

4.10 Coleoptera

The order *Coleoptera* was not specified into species. Most of the imagines and development stages belonged to the genus *Helmis*. From the quantitative point of view *Coleoptera* formed a numerous group of the zoobenthos of the two brooks, but due to their tiny size their share in the total production of zoobenthos is small. *Coleoptera* formed 4,8 % of the total zoobenthos and occurred on stones both in the current and near the banks.

In the first period of the research in 1966/67 the quantitative differences between the upper and the lower stations of the two brooks were not significant; we might speak about a more or less balanced density of *Coleoptera*. It is, however, interesting to note that in that year in both brooks the occurrence of *Coleoptera* was much lower than in the following two periods, i.e. 1967/68 and 1968/69. This difference roughly formed about 1 order (Tab. 48). It was significant

Tab. 48. **Average annual abundance of Coleoptera in the Lušová and the Brodská**

Trout brook		Lušová		Brodská			
Staton		L2	L1	B2	B1	B1b	B1c
Current	1966/67	13.8	11.5	8.2	19.4	—	—
	1967/68	—	25.2	—	184.7	69.3	51.8
	1968/69	—	218.9	—	155.5	266.8	272.8
Bank	1966/67	7.2	2.0	3.4	0.9	—	—
	1967/68	—	24.6	—	96.2	19.2	18.8
	1968/69	—	46.3	—	50.5	21.5	19.7

particularly in the current; on the other hand, the density of population near the banks in the last two years was well-balanced. The low abundance in the first year of investigation was most probably due to unfavourable hydrological conditions (increased discharges in the brooks), which probably unfavourably influenced the distribution and reproduction of *Coleoptera*. This phenomenon is encountered with in other groups mostly including tiny species such as *Ceratopogonidae Simuliidae* and *Chironomidae*.

The quantity of Coleoptera varies considerably throughout the year, which is probably in connection with different cycles of development in the individual species. In the period of the maximum development of the whole order, mostly falling to summer (partly to the end of spring) *Coleoptera* reached the abundance of 100 to 770 specimens per 1 sq.m. The values of the average annual abundance in individual stations and biotopes are stated in Tab. 48.

From Fig. 33—34 a clear-cut difference in the quantitative population of stones in the current and those near the banks is evident. *Coleoptera* occurred mostly in the current, whereas near the banks their occurrence was lower. These differences are evident also in the average annual abundance (Tab. 48). While in the torrential zones there occurred 84.4 % and 80.2 % in the Brodská and the Lušová respectively (out of the total number of *Coleoptera* found in the individual brooks), on the stones near the banks there lived only 15.6 % in the Brodská and 19.8 % in the Lušová.

The differences in the population of 3 stretches on the Brodská with different yellow trout population are not significant. As evident from Fig. 33—34 all 3 stretches are populated more or less to the same extent.

The biomass and production rate of *Coleoptera* were not separately specified.

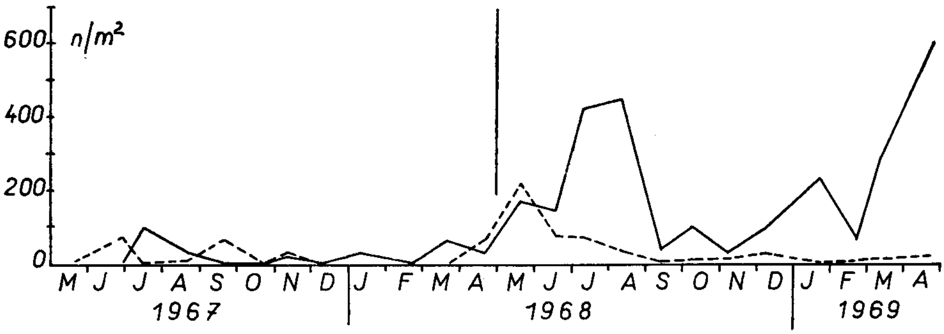

Fig. 33. Space and time distribution of *Coleoptera* in the Lušová; ——— current, - - - - bank.

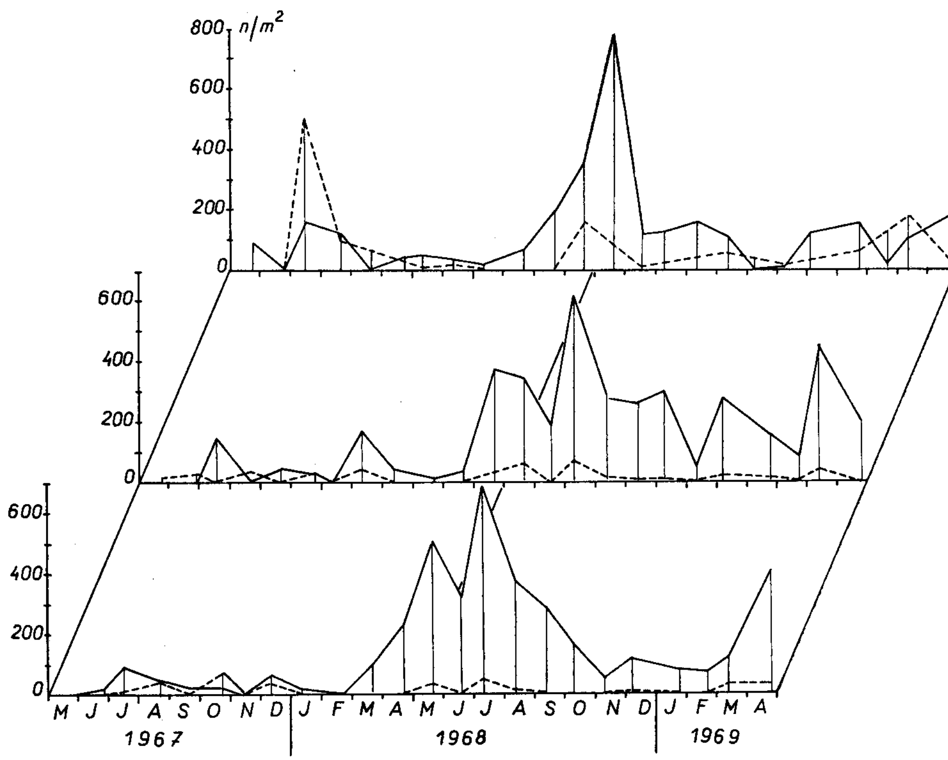

Fig. 34. Space and time distribution of *Coleoptera* in the lower stations of the Brodská; ——— current, - - - - bank.

4.11 Biomass of the group "Varia"

As has been stated in the methods, besides taxonomic groups important from the production point of view, we separated another group, the so-called "*Varia*". That group contained the remaining taxonomic groups which are of little impor-

Tab. 49. **Average annual abundance (n/m^2) and biomass (mg/m^2) of the group "Varia" in the Brodská**

Year	Taxonomic group	Abundance						Biomass					
		B1		B1b		B1c		B1		B1b		B1c	
		current	bank	current	bank	current	bank	current	bank	current	bank	current	bank
1966/1967	*Ceratopogonidae*	0	0	—	—	—	—	207	279	—	—	—	—
	Simuliidae	4.1	0										
	Other Diptera	10.5	4.8										
	Megaloptera	0	2.7										
	Coleoptera	19.4	0.9										
	Hydracarina	16.1	34.4										
	Other Vermes	0	0.7										
1967/1968	*Ceratopogonidae*	1.5	0	0	0.3	0.3	0.8	778	1,058	600	964	470	657
	Simuliidae	28.3	0	17.6	0	13.4	0						
	Other Diptera	17.2	18.0	10.2	24.0	14.2	15.6						
	Megaloptera	0.4	3.1	1.4	0	0	2.7						
	Coleoptera	184.7	96.2	69.2	19.2	51.8	18.0						
	Hydracarina	47.3	59.1	46.0	18.1	14.6	9.1						
	Other Vermes	1.7	6.2	0.9	1.2	2.2	1.8						
1968/1969	*Ceratopogonidae*	3.6	1.5	3.6	1.7	5.3	0.4	1,999	1,116	1,726	755	1,653	1,079
	Simuliidae	64.0	0	71.5	1.3	33.8	0						
	Other Diptera	64.7	22.9	41.7	12.8	54.7	21.1						
	Megaloptera	0	0	0	1.7	0	1.0						
	Coleoptera	155.5	50.5	266.8	21.6	272.8	19.7						
	Hydracarina	49.1	35.2	38.7	19.4	38.8	8.6						
	Other Vermes	10.4	4.4	8.6	12.8	6.2	3.7						

tance for the production or which could not be weighed in the field or for whose determination we had no specialists.

In "*Varia*" we included *Vermes* with the exception of *Dugèsia gonocephala* and *Hirudinea* further *Hydracarina Megaloptera Coleoptera* and the remaining *Diptera*. All those groups were thus weighed together in the field. Later on we isolated *Chironomidae* in which the biomass was determined from the curve of lenth-weight relations. Those values were then substracted from the values of the biomass of "*Varia*". Average weight differences were then put in Tab. 49 and 50 in comparison with the average values of abundance of the individual groups.

Tab. 50. **Average annual abundance (n/m²) and biomass (mg/m²) of the group "Varia" in the Lušová**

Year	Taxonomic group	Abundance		Biomass	
		current	bank	current	bank
1966/67	*Ceratopogonidae*	0	0	485	406
	Simuliidae	47.5	0		
	Other Diptera	11.6	2.9		
	Megaloptera	0.4	0.3		
	Coleoptera	11.5	2.9		
	Hydracarina	8.2	9.9		
	Other Vermes	0	1.2		
1967/1968	*Ceratopogonidae*	0	0	1,757	1,037
	Simuliidae	42.3	1.0		
	Other Diptera	77.0	12.7		
	Megaloptera	2.9	5.7		
	Coleoptera	25.2	24.6		
	Hydracarina	42.9	28.9		
	Other Vermes	18.3	1.4		
1968/1969	*Ceratopogonidae*	5.7	1.9	1,448	818
	Simuliidae	25.7	0		
	Other Diptera	36.7	14.2		
	Megaloptera	0	4.4		
	Coleoptera	218.9	46.3		
	Hydracarina	50.2	24.1		
	Other Vermes	0.8	1.6		

5. Influence of different fishstock on zoobenthos

In the brook Brodská we had the possibility of influencing the density of the fishstock for a long time (2 years) and following the influence of those changes on benthos. Carrying out and keeping the changes was made possible by artificial weirs more than 2 m high, which made the migration of fish difficult (Fig. 35). Besides, the fishstock was checked and controlled four times a year by means of an electric fish shocker (by workers of the Institute for the Investigation of Vertebrates of the Czechoslovak Academy of Sciences). In the stretch above the weirs the original, so to speak natural fishstock was left, between the weirs

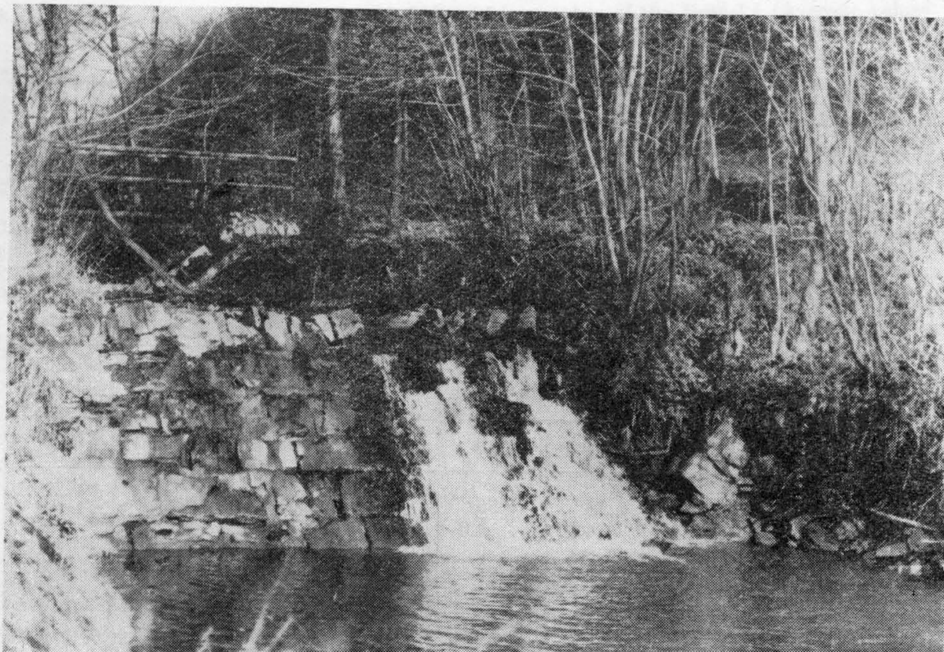

Fig. 35. Brook Brodská: the small rocking dam (weir) in the brook.

(length about 200 m—Fig. 7) the fishstock was increased, below the weirs down to the mouth of the brook into the Bečva (500 m) the stretch was "without fish" (removing the Carpathian sculpin completely did not succede). The data on the number of fish in the individual stretches are given in Tab. 51. Throughout the part under investigation there is no tributary, the average gradient, depth, and nature of the bottom being practically the same.

Tab. 51. Fishstock density in the individual stretches of the Brodská

Species		B1 natural fishstock	B1b increased fishstock	B1c without fish
Salmo trutta m. fario	per 1 m²	0.147	0.273	0.010 only sporadically
	per 1 ha	1,470	2,730	100
Cottus poecillopus	per 1 m²	0.480	0.646	0.350
	per 1 ha	4,800	6,460	3,500

The natural stretch was followed from May, 1966 to April, 1969, the stretch with excessive fishstock and that without fish from May, 1967 to April, 1969. In sample taking and sample processing a uniform working method was used (see the methodological part).

We did not follow the influence on phytobenthos. As follows from the chapter in question, the main influence in this respect is due to light conditions. According to small differences in the zoobenthos (see Tab. 52) it is also impossible to judge for the phytobenthos to be influenced by the change in the abundance of animals.

Tab. 52. **Abundance of the zoobethos in the individual stretches of the Brodská (Average value from 1967 to 1969)**

Taxon in n/m²	B1 natural fishstock		B1b increased fishstock		B1c without fishstock	
	current	bank	current	bank	current	bank
Dugèsia gonocephala	18	56	19	50	17	78
Tubificidae	4.0	4.8	4.7	3.4	3.7	4.5
Hirudinea	0.1	0	0	0	0.2	0.7
Ancylus fluviatilis	9	34	7	16	9	33
Rivulogammarus fossarum	253	487	303	562	382	547
Hydracarina	50	34	42	19	27	9
Plecoptera	154	62	161	69	141	71
Ephemeroptera	616	387	835	360	592	353
Sialis	0.2	1.5	0.7	0.9	0	1.8
Trichoptera	515	202	495	152	369	193
Chironomidae	356	237	333	143	249	109
Ceratopogonidae	2.5	0.8	1.8	0.9	2.8	0.6
Simuliidae	46	0	45	0.6	24	0
Other Diptera	41	20	26	19	35	19
Coleoptera	170	73	168	20	162	19
Sum	2,235	1,599	2,441	1,416	2,014	1,439

The differences in the representation of the individual components of zoobenthos in stretches with different fishstock density are best seen from a Tab. 52 and 53. As long as we take the zoobenthos as a whole, it is impossible to speak about major changes in the current and near the banks. In the current the number of specimens even increased (mainly *Ephemeroptera*, to a smaller extent also *Rivulogammarus*), but the weight of one specimen dropped. Influence by fish predation can be judged at only from the drop of the number of caddis flies of the suborder *Integripalpia*, midges, and/or *Ancylus* near the banks. In detail we should like to refer to the chapters dealing with the individual groups of the zoobenthos.

We can state than an increase of the yellow trout by 86 % and the Carpathian sculpin by 35 % against the original natural stock did not mean any decrease of the total abundance of the zoobenthos. On the contrary, in some groups we found out an increase with a simultaneous decrease of the average weight of 1 specimen. Only near the bank the number of caddis flies of the suborder *Integripalpia* decreased. In the stretch which was practically without trout and

Tab. 53. **Biomass of the zoobenthos in the individual stretches of the Brodská (Average values from 1967 to 1969)**

Taxon in g/m²	natural B1 fishstock		increased B1b fishstock		without B1c fish	
	current	bank	current	bank	current	bank
Dugêsia gonocephala	0.387	1.203	0.408	1.074	0.365	1.675
Ancylus fluviatilis	0.024	0.087	0.018	0.042	0.024	0.086
Rivulogammarus fossarum	2.111	5.633	4.021	7.067	3.612	5.954
Plecoptera	2.661	0.561	3.154	0.397	3.004	0.659
Ephemeroptera	2.401	2.770	2.765	2.365	2.363	2.546
Trichoptera	6.500	4.990	5.170	3.100	4.500	3.980
Chironomidae	0.199	0.159	0.198	0.089	0.156	0.072
Other Diptera + Sialis + + Coleoptera + Hydracarina + + other Vermes	1.389	1.087	1.164	0.860	1.061	0.868
Sum of the zoobenthos	15.672	16.490	16.898	14.994	15.085	15.876

in which the number of the Carpathian sculpin was lower on the average by 27 % we did not find out conclusive differences against the natural stock. Even though this research was carried out for only two years and a longer investigation would be necessary we think that autochtonous food in the brooks is not a limiting factor for the increase of the density of the population of the yellow trout to numbers stated in Tab. 50. (Note: The growth of the trout in the individual stretches will be evaluated in another paper. For the time being, we can, however, say that in the stretch with excessive fishstock there was no deterioration of the growth abilities of fish).

6. Conclusions

In the Beskydy trout brooks we determined more than 167 species of water organisms (see the list of taxa, periphyton 29, zoobenthos 138).

In the composition of the periphyton the prevalining part were diatoms, particularly the genera *Achnanthes*, *Diatoma*, *Gomphonema*, and *Cymbella* all over the bottom, in the torrential and sufficiently light zones of the stream *Cladophora* were frequent in summer. In winter months *Ulothrix zonata* was characteristic.

The species composition of the communities of the natural substratum of the bottom and artificial substrata was the same, formed predominantly by diatoms. Significant correlations were found out between the results of the abundance of algae (annual average 1,620 $\times 10^3$ cells/cm²), the quantity of organic matter (average 21.7 g/m²), and the quantity of chlorphylle-a (average 69.1 mg/m²). The average value of gross primary production of the artificial substratum was 60.3 mg O_2/m² per hour.

The development of periphyton was influenced by high discharge rates of water especially during the spring thaw and by local light conditions. The values of the indices of periphyton and productivity rate correspond to data by other authors from clean quickly running waters. In major eutrophic streams higher values were found out.

The zoobenthos of the Beskydy brooks is formed by more than 138 species, the most frequent of them being the representatives of caddis flies (25 %) and midges (20 %), further stone flies (15 %) and mayflies (14 %). The most important were the species of the genera *Rhyacophila* and *Hydropsyche* and the representatives of the family *Limnephilidae* and *Sericostomatidae*, further *Baetis*, *Rhithrogena* and *Ecdyonurus*, species of the genus *Leuctra*, *Perla marginata* and *Isoperla oxylepis*, *Rivulogammarus fossarum*, *Ablabesmyia lentiginosa*, *Diamesa insignipes*, *Diamesa thienemani*, *Euorthocladius rivulorum* and the group *Rheorthocladius-Trichocladius*.

In the abundance of the zoobenthos (Tab. 54) the greatest share consisted of mayfly larvae (30.3 %), shrimps (15.4 %), caddis fly larvae (13.5 %) and midge larvae (11.4 %), thus making up a substantial part of the bottom community. As for the weight, (Tab. 54) the most important were the groups *Trichoptera* (31.3 %), *Ephemeroptera* (19.7 %), *Amphipoda* (19.6 %), and *Plecoptera* (15.6 %).

From the point of view of the production (Tab. 54) of the Beskydy brooks, *Trichoptera* formed 37.6 %, *Ephemeroptera* 21.1 %, *Plecoptera* 16.1 %, *Amphipoda* 10.8 %, other groups together 14.4 % (Tab. 54).

We determined the production rate in nearly all basic groups of the zoobenthos (*Trichoptera*, *Ephemeroptera*, *Amphipoda*, and *Chironomidae*), in the remaining groups we applied the P/B coefficient 8.1. All the coefficients are in accordance with the data in Borutski and al. (1971 for some species of midges and in Edmonson and Winberg (1971) for some water organismes.

When we used the coefficient 8 to calculate the hitherto known average annual biomass of zoobenthos in trout waters, we obtained very similar results (cf. also in Kubíček and al. 1971, Kubíček 1971):

Stream	Average annual biomass kg/ha	Anunal production kg/ha
Trout brooks of the Beskydy	151.0	1,177
Svratka (near Štěpánov)	163.2	1,305
Loučka (near Blažkov)	128.0	1,024

These streams have also a very similar composition of zoobenthos, both qualitative and quantitative.

The influences of abiotic factors of the environ of the Beskydy brooks, above all the changes in discharge rates, the speed of the streaming, the thermal régime and the changing of pools and torrential zones were reflected in the annual cycle of benthic organisms and their distribution on the bottom of the brooks. Also a regular supply of organic matter in the form of leaves and its gradual reduction has an influence particularly on a high share of detritovorous bottom organisms (see Hynes 1970).

Tab. 54. Average annual abundance, biomass and production of bottom fauna in the trout brooks of the Beskydy Mountains

Taxon	Abundance n/m²			Biomass g/m²		total (corr. m²)	Production g/m² (corr. m²)	P/B coeff.
	current	bank	total (corr. m²)	current	bank			
Trichoptera	341	161	305	4.780	4.590	4.730	45.180	9.2—9.7
Ephemeroptera	754	387	681	3.046	2.675	2.972	24.875	8.0—8.8
Plecoptera	144	61	127	2.843	0.464	2.367	18.972	8.1
Amphipoda	250	560	312	2.261	5.565	2.921	12.796	3.6—4.6
Dugèsia gonocephala	24	57	31	0.526	1.224	0.666	5.394	8.1
Ancylus fluviatilis	8	19	10	0.018	0.048	0.024	0.194	8.1
Chironomidae	267	161	246	0.179	0.114	0.167	1.774	4.1—8.3
"*Varia*":								
Hydracarina	35	25	33					
Sialis fuliginosa	1	3	> 1					
Ceratopogonidae	2	1	> 1	1.112	0.817	1.053	8.529	8.1
Simuliidae	35	< 1	28					
Coleoptera	127	30	108					
Others	351	178	316					
Total	2,339	1,644	2,199	14.765	15.497	14.900	117.714 g/m² = = 1,177 kg/ha	

The changes in the variation of abundance and biomass of the zoobenthos in the course of the year corresponded to the model "of the annual cycle", as elaborated by HYNES (1970) for running waters.

Different relations in the quantitative as well as in the qualitative composition of the zoobenthos in the torrential and in the bank zones were found out. While in the torrential zones of the stream *Trichoptera*, *Emphemeroptera*, and *Chironomidae* larvae and some *Coleoptera* larvae and imagines predominated, in the bank zones it was *Rivulogammarus*, *Dugèsia* and others. The measure of the limiting speed of the torrential and the bank zones was the speed of the stream 15 cm/sec. Our investigation results about the influence of the current on the distribution of the zoobenthos correspond to the data by other authors (e.g. RAUŠER 1956, AMBÜHL 1959, KAMLER 1966, and others).

The influence of different fishstock on the zoobenthos was not proved due to complicated relations in the fishstock (yellow trout, Carpathian sculpin). The two stretches chosen as being without fish (one in the Lušová, the other in the Brodská) were not equivalent, as one of them (the Lušová) had an increased population of the Carpathian sculpin, whose population after removing the other fish (yellow trout) was not controlled. Only some phenomena point to the fact that the benthic fauna may have been influenced in the stretch (Brodská B 1b) where the population of the yellow trout and C. sculpin was increased.

The stretch with the excessive fishstock in the Brodská showed differences in the abundance and the biomass of some groups of the zoobenthos in contrast with the neighbouring stretches (with normal fishstock and without fish). Thus e.g. the abundance of mayfly larvae and amphipods was higher in the stretch with excessive fishstock than in the stretch with normal fishstock. In other groups it was lower (e.g. *Trichoptera*, *Ancylus*), in further ones there were no changes. Conspicuous were, however, the changes in the lower average size and weight of the specimens e.g. in mayflies, caddis flies, and amphipods and in the species composition of caddis flies which, together with mayflies and midges, form the main component of fish food.

An important results is, however, the fact that not even the excessive fishstock did substantially lower the food basis with the determined composition and quantity of the zoobenthos. Such experience had been made before in another trout stream in our country (the Loučka near Blažkov, see SEDLÁK 1969, KUBÍČEK 1971, KUBÍČEK and al. 1971).

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TOMUS XIV BIOLOGIA 38 OPUS 4
1973

LIST OF THE TAXA IN BOTH BESKYDY BROOKS

PHYTOBENTHOS

Cyanophyceae

1 *Hydrococcus sp.*
2 *Phormidium sp.*

Bacillariophyceae

3 *Achnanthes minutissima* Kütz.
4 *Achnanthes lanceolata* Bréb.
5 *Achnanthes amphicephala* Hust.
6 *Cocconeis placentula* Ehr.
7 *Cocconeis pediculus* Ehr.
8 *Cymbella venticosa* Kutz.
9 *Cymbella prostrata* (Berg) Cleve
10 *Cymbella affinis* Kütz.
11 *Diatoma elongatum* Ag.
12 *Diatoma vulgare* Bory
13 *Fragilaria capucina* Desm.
14 *Gomphonema olivaceum* (Lyng.) Kütz.
15 *Gomphonema tergestinum* (Grun.) Fricke
16 *Gomphonema angustatum v. productum* Grun.
17 *Gomphonema intricatum v. pumilum* Grun.
18 *Meridion circulare* Ag.
19 *Navicula gracilis* Ehr.
20 *Navicula cryptocephala* Kütz.
21 *Navicula cryptocephala v. intermedia* Grun.
22 *Nitzschia dissipata* (Nitzsch.) Grun.
23 *Rhoicosphaenia curvata* (Kütz.) Grun.
24 *Surirella ovata* Kűtz.
25 *Synedra ulna* (Nitzsch.) Ehr.
26 *Synedra amphicephala v. austriaca* Grun.
27 *Synedra vaucheriae* Kűtz.

Chlorophyceae

28 *Cladophora glomerata* (L.) Kűtz.
29 *Ulothrix zonata* Kűtz.

Vermes

30 *Dugèsia gonocephala* (DUGÈS)

Oligochaeta

Hirudinea (*Herpobdella*)

Mollusca

31 *Ancylus fluviatilis* MŰLLER
32 *Pisidium sp.*

Crustacea, Amphipoda

33 *Rivulogammarus fossarum* (KOCH)

Hydracarina
Insecta

Ephemeroptera

34 *Ephemera danica* MŰLL.
35 *Ecdyonurus gr. venosus*
36 *Heptagenia lateralis* CURT.
37 *Rhithrogena semicolorata* CURT.
38 *Epeorus assimilis* ETN.
39 *Habrophlebia lauta* ETN.
40 *Habroleptoides modesta* HAG.
41 *Paraleptophlebia submarginata* ST.
42 *Baetis rhodani* PICT.
43 *Baetis bioculatus* L.
44 *Baetis alpinus* PICT.
45 *Baetis pumilus* BURM.
46 *Baetis niger* L.
47 *Centroptilum luteolum* MŰLL.
48 *Centroptilum pennulatum* ETN.
49 *Ephemerella ignita* PODA
50 *Chitonophora krieghoffi* ULM.
51 *Torleya maior* KLP.
52 *Caenis macrura* STEPHN.

Plecoptera

53 *Dinocras cephalotes* (CURTIS)
54 *Perla burmeisteriana* CLAASSEN
55 *Perla marginata* (PANZER)
56 *Perlodes microcephala* (PICTET)
57 *Isoperla oxylepis* (DESPAX)
58 *Protonemura meyeri* (PICTET)
59 *Protonemura nitida* (PICTET)
60 *Protonemura intricata* RIS
61 *Protonemura praecox* (MORTON)
62 *Nemoura fulvipes* KLAPÁLEK
63 *Nemoura cambrica* (STEPHENS)
64 *Amphinemura sulcicollis* STEPHENS

65 *Leuctra hippopus* KEMPNY
66 *Leuctra albida* KEMPNY
67 *Leuctra prima* KEMPNY
68 *Leuctra autumnalis* AUBERT
69 *Leuctra inermis* KEMPNY
70 *Leuctra aurita* NAVÁS
71 *Chloroperla tripunctata* (SCOPOLI)
72 *Siphonoperla torrentium* (PICTET)
73 *Siphonoperla neglecta* (ROSSTOCK)
Chloroperlidae g. sp. div.

Megaloptera

74 *Sialis fuliginosa* PICT.

Trichoptera

75 *Rhyacophila fasciata* HAG.
76 *Rhyacophila mocsaryi* KLAP.
77 *Rhyacophila nubila* ZETT.
78 *Rhyacophila obliterata* MCLACH.
79 *Rhyacophila tristis* PICT.
Rhyacophila sp. div.
80 *Glossosoma boltoni* CURT.
81 *Agapetus sp.*
82 *Hydroptila sp.*
83 *Philopotamus sp.*
84 *Hydropsyche instabilis* CURT.
85 *Hydropsyche angustipennis* CURT.
86 *Hydropsyche pellucidulla* CURT.
87 *Hydropsyche saxonica* MCLACH.
Hydropsyche sp. div. juv.
88 *Neureclipsis bimaculata* L.
89 *Plectrocnemia conspersa* CURT.
90 *Polycentropus flavomaculatus* PICT.
91 *Tinodes waeneri* L.
92 *Psychomyia pusilla* FBR.
93 *Micrasema sp.*
94 *Drusus annulatus* STEPH.
95 *Ecclisopteryx guttulata* PICT.
96 *Potamophylax latipennis* CURT.
97 *Potamophylax stellatus* CURT.
98 *Potamophylax nigricornis* PICT.
Potamophylax sp. div.
99 *Halesus radiatus* CURT.
100 *Halesus sp.*
Stenophylacini g. sp. div.
101 *Chaetopteryx villosa* FBR.
Chaetopterygini g. sp.
Limnephilinae g. sp. div.
102 *Silo pallipes* FBR.
103 *Silo piceus* BRAU.

104 *Silo sp.*
105 *Arthripsodes sp.*
Sericostomatidae g. sp.
106 *Beraea pullata* CURT.
107 *Beraeamyia hraběi* MAYER
108 *Odontocerum albicorne* SCOP.

Diptera, Tipulidae
109 *Tipula (Yamatotipula) lateralis* MEIG.
110 *Tipula maxima* PODA

Diptera, Limoniidae
111 *Limonia (Dicranomyia) didyma* MEIG.
112 *Antocha vitripennis* (MEIG.)
113 *Pedicia rivosa* (L.)
114 *Pedicia sp.*
115 *Dicranota sp.*
116 *Limnophila (Brachylimnophila)nemoralis* MEIG.
117 *Limnophila (Eloeophila) sp.*
118 *Molophilus sp.*

Diptera, Dixidae
119 *Dixa nebulosa* MEIG.
120 *Dixa puberula* LOEW.

Diptera, Chironomidae
121 *Ablabesmyia lentiginosa-Group*
122 *Apsectrotanypus trifascipennis* (ZETT.)
123 *Brillia modesta* MG. (EDW.)
124 *Cladotanypus atridorsum* K.
125 *Corynoneura celeripes* WINN.
126 *Diamesa insignipes* K.
127 *Diamesa thienemanni* K.
128 *Eudactylocladius* TH.
129 *Eukiefferiella discoloripes* G.
130 *Eukiefferiella minor* EDW.
131 *Euorthocladius rivulorum* (K.)
132 *Eutanytarsus gregarius-Group*
133 *Eutanytarsus inermipes-Group*
134 *Macropelopia nebulosa* (MG.)
135 *Microtendipes chloris-Group*
136 *Microtendipes tarsalis-Group*
137 *Neozavrelia luteola* GOETGH.
138 *Paratrissocladius fluviatilis* GOETGH.
139 *Polypedilum convictum-Group*
140 *Polypedilum laetum-Group*
141 *Potthastia gaedii* (MG.)
142 *Potthastia longimana* (K.)
143 *Prodiamesa olivacea* (MG.)
144 *Rheocricotopus brunensis* (G.)
145 *Rheocricotopus effusus* (WALK.)

146 *Rheorthocladius-Trichocladius-Group*
147 *Synorthocladius semivirens* (K.)
148 *Thienemanniella clavicornis* K.

Diptera, Ceratopogonidae

Diptera, Simuliidae
149 *Eusimulium brevidens* RUBTZOV
150 *Eusimulium costatum* (FRIEDERICHS)
151 *Eusimulium cryophylum* RUBTZOV
152 *Eusimulium latipes* (MEIGEN)
153 *Odagmia monticola* (FRIEDERICHS)
154 *Odagmia ornata* (MEIGEN)
155 *Prosimulium nigripes* ENDERLEIN
156 *Simulium (S.) tuberosum* (LUNDSTRÖM)

Diptera, Psychodidae
157 *Pericoma stammeri* JUNG
158 *Pericoma unispinosa* TONN.
159 *Pericoma sp.*

Diptera, Stratiomyidae
160 *Oplodonta viridula* (FABR.)

Diptera, Tabanidae
161 *Hybomitra sp.*
162 *Tabanus maculicornis* ZETTERSTEDT

Diptera, Rhagionidae
163 *Atherix marginata* (FABR.)

Diptera, Empididae
164 *Chelifera sp.*
165 *Wiedemannia sp.*

Coleoptera
166 *Hydroporus sanmarki* SAHL.
167 *Elmis maugei* BEDEL

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TOMUS XIV BIOLOGIA 38 OPUS 4
1973

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ПРОДУКЦИЯ ФОРЕЛЬНЫХ РУЧЬЕВ БЕСКИД

(*ЧССР, Моравия*)

РЕЗУЛЬТАТЫ ИССЛЕДОВАНИЯ ПРОВОДИВШЕГОСЯ В РАМКАХ МБП В 1966—1971 ГГ.

Краткая характеристика обследованных ручьев с разнообразным населением рыб приводилась уже в других работах (см. Кубичек и соавторы 1971, Луск и Здражилек 1969 г.). Температурные и химические отношения приводятся в рис. 9 и таб. 1.

Перифитон изучался на естественных и искусственных субстратах, продуктивность измерялась по кислородному методу светлых и темных бутылок.

Зообентос отбирался количественно с помощью оригинального бентометра (рис. 10) а с помощью круговой сети (у берега) в виде репрезентативных проб.

Исследование проводилось на нескольких участках течения с разным населением рыб или без рыб.

В бескидских форельных ручьях мы определили свыше 167 видов водных организмов (см. список таксонов, перифитон 29, зообентос 138).

В составе перифитона преобладали диатомы, в частности семейства *Achnanthes*, *Diatoma*, *Gomphonema* и *Cymbella* по всему дну, на участках с течением и с достаточным освещением была летом частая *Cladophora*. В зимние месяцы характерна была *Ulothrix zonata*. Видовой состав сообществ естественного субстрата дна был тот же; он составлен преимущественно диатомами. Доказательные корреляции были обнаружены между результатами абунданции водорослей (в среднем 1620×10^3 клеток/см^2 в год), количеством органических веществ (в среднем 21.7 g/m^2) и количеством хлорофилла „a" (в среднем 69.1 mg/m^2). Среднее значение брутто первичной продукции искусственного субстрата составляло 60.3 mg O_2/m^2 в час. На развитие перифитона оказывали влияние высокие расходы воды, в частности при весеннем таянии и местные световые условия. Значения показателей перифитона и продуктивности отвечают данным остальных авторов, полученных из чистых быстротекущих вод. В больших эвторофизированных течениях были обнаружены значения более высокие.

В состав бескидских ручьев входит свыше 138 видов, из них наиболее частыми были представители ручейников (25 %) и хирономиды (20 %), далее веснянки (15 %) и поденки (14 %). Самыми важными являлись виды рода *Rhyacophila* и *Hydropsyche* и представители семейства *Limnephilidae* и *Sericostomatidae*, далее *Baetis*, *Rhithrogena* и *Ecdyonurus*, виды рода *Leuctra*, *Perla marginata* и *Isoperla oxylepis*, *Rivulogammarus fossarum*, *Ablabesmyia lentiginosa*, *Diamesa insignipes*, *Diamesa thienemanni*, *Euorthoclaolius rivulorum* и группа *Rheorthocladius* — *Trichocladius*. В абунданции зообентоса (Таб. 54) наибольшую долю составляли личинки поденок (30.3 %), бокоплавы (15.4 %), личинки ручейников (13.5 %) и хирономид (11.4 %) и образовали таким образом существенную часть сообщества дна. По весу были самыми значительными группы *Trichoptera* (31.3 %), *Ephemeroptera* (19.7 %), *Amphipoda* (19.6 %) и *Plecoptera* (15.6 %).

С точки зрения продукции бескидских ручьев *Trichoptera* составила 37.6 %, *Ephemeroptera* 21.1 %, *Plecoptera* 16.1 %, *Amphipoda* 10.8 %, остальные группы всего 14.4 % (Таб. 54).

Мы определили продукцию почти у всех основных груп зообентоса (*Trichoptera*, *Ephemeroptera*, *Amphipoda* и *Chironomidae*), у остальных групп мы применили П/Б коэффициент 8.1 для исчисления продукции.

Все установленные коэффициенты находятся в соответствии с данными Боруцкого и др. (1971 г.) для некоторых видов тендипедид и с данными Edmonson и Winberga (1971) для некоторых водных беспозвоночных.

Используя коэффициент 8 при пересчете до сих пор у нас для форельных ручьев известных средних годовых биомасс зообентоса, мы получили весьма близкие результаты. (См. также Кубичек и др. 1971, Кубичек 1971):

Течение	средняя годовая биомасса кг/га	годовая продукция кг/га
Форельные ручьи Бескиды	151.0	1 177
Свратка (у Штепанова)	163.2	1 305
Лоучка (у Блажкова)	128.0	1 024

Эти течения имеют очень подобный качественный и количественный состав зообентоса.

Влияния абиотических факторов среды бескидских ручьев, в частности изменения расходов воды, скорость течения, температурный режим и чередование спокойных текущих участков нашли отражение в годовом цикле бентических организмов и в их дистрибуции на дне ручьев. Такая регулярная добавка органической массы в виде листьев и его постепенное уничтожение ее имеет влияние в частности на высокой удельный вес детритоворных типов организмов дна (см. Hynes 1970).

Изменения в колебании абунданции и биомассы зообентоса в течение года отвечали модели ,,of the annual cycle", которую для текущих вод разработал Hynes (1970).

Были обнаружены также разные отношения в количественном и качественном составе зообентоса в части с течением и у берега. В то время как в участках с течением преобладали личинки *Trichoptera*, *Ephemeroptera* и *Chironomidae* и имаго и личинки некоторых *Coleoptera*, в более спокойных участках течения преобладали *Rivulogammarus*, *Dugèsia* и др. Критерием предельной скорости участка с течением и у берега служила скорость течения 15 см/сек. Наши установления о влиянии течения на дистрибуцию зообентоса соответствуют данным других авторов (напр. Raušer 1956, Ambühl 1959, Kamler 1966 и др.).

Влияние рыбьего населения на зообентос не было ввиду сложных отношений в разнообразном рыбьем населении (форель, подкаменщик) доказано. Оба избранных участка без рыб (один — на Лушовой, второй — на Бродской) не были равноценными, так как один из них (Лушова) отличался повышенной популяцией подкаменщика, состояние которых в течение двух лет от отлова остальных рыб (форель) не было регулировано. Лишь некоторые явления показывают, что влияние рубьего населения на фауну дна могло произойти в участке (Бродска В 1b), где большее население форелей и подкаменщиков.

Перенаселенный участок ручья Бродска отличался различиями в абунданции и биомассе некоторых групп зообентоса в отличие от соседних участков (с нормальным населением рыб и без рыб). Напр. абунданция личинок поденок и бокоплавов была в участке с излишним окличеством рыб выше чем в участке с нормальным населением рыб. У остальных групп была ниже (напр. *Trichoptera*, *Ancylus*), у дальнейших не произошли никакие изменения. Однако бросались в глаза изменения в уменшенной средней величине и весе особей, напр. у поденок, ручейников и бокоплавых и в видовом составе ручейников, которые составляют вместе с поденками и тендипедидами основную часть питания для рыб.

Однако важно, что перенаселенный участок при определенном составе и количества зообентоса не обеднил существенно пищевую базу. Этот опыт был уже получен и в другом форельном ручье в ЧССР (Лоучка у Блажкова, см. Седлак 1969, Кубичек 1971, Кубичек и др. 1971).

PRODUKČNÍ POMĚRY VE PSTRUHOVÝCH POTOCÍCH BESKYD.

Souhrn

V beskydských pstruhových potocích jsme determinovali více než 167 druhů vodních organismů (viz seznam taxonů, perifyton 29, zoobentos 138).

Ve složení perifytonu převládaly diatomy zejména rody *Achnanthes*, *Diatoma*, *Gomphonema* a *Cymbella* na celém dně, v proudivých, dostatečně prosvětlených úsecích toku byla v létě hojná *Gladophora*. V zimních měsících byla charakteristická *Ulothrix zonata*. Druhové složení společenstev přirozeného substrátu dna a umělých substrátů bylo stejné, tvořeno převážně rozsivkami. Průkazné korelace byly zjištěny mezi výsledky abundance řas (roční průměr $1\,620 \times 10^3$ buněk/cm²), množstvím organických látek (průměr 21,7 g/m²) a množstvím chlorofylu ,,a"

(průměr 69,1 mg/m²). Průměrná hodnota brutto primární produkce umělého substrátu byla 60.3 mg O_2/m^2 za hodinu.

Rozvoj perifytonu byl ovlivňován vysokými průtoky vody, zejména při jarním tání a místními světelnými podmínkami. Hodnoty ukazatelů perifytonu a produktivity odpovídají údajům jiných autorů z čistých, rychle tekoucích vod. Ve větších, eutrofisovaných tocích byly zjištěny hodnoty vyšší.

Zoobentos beskydských potoků je formován více než 138 druhy, z nichž nejpočetnější byli zástupci chrostíků (25 %), pakomárů (20 %), dále pošvatky (15 %) a jepice (14 %). Nejvýznamnější byly druhy rodů *Rhyacophila* a *Hydropsyche* a zástupci čeledi *Limnephilidae* a *Sericostomatidae*, dále *Baetis*, *Rhithrogena* a *Ecdyonurus*, druhy rodu *Leuctra*, *Perla marginata* a *Isoperla oxylepis*, *Rivulogammarus fossarum*, *Ablabesmyia lentiginosa*, *Diamesa insignipes*, *Diamesa thienemanni*, *Euorthocladius rivulorum* a skupina *Rheorthocladius-Trichocladius*.

V abundanci zoobentosu (Tab. 54) tvořily největší podíl larvy jepic (30,3 %), blešivci (15,4 %), larvy chroustíků (13,5 %) a pakomárů (11,4 %) a vyplňovaly tak podstatnou část společenstva dna.

Váhově byly nejvýznamnější skupiny *Trichoptera* (31,4 %), *Ephemeroptera* (19,7 %), *Amphipoda* (19,6) a *Plecoptera* (15,6 %).

Z hlediska produkce beskydských potoků *Trichoptera* obsáhla 37,6 %, *Ephemeroptera* 21,1 %, *Plecoptera* 16,1 %, *Amphipoda* 10,8 %, ostatní skupiny dohromady 14,4 % (Tab. 54).

Stanovili jsme produkci téměř u všech základních skupin zoobentosu (*Trichoptera*, *Ephemeroptera*, *Amphipoda* a *Chironomidae*), u zbývajících skupin jsme použili koeficientu 8,1 pro výpočet produkce z průměrné roční biomasy. Všechny zjištěné P/B koeficinety (Tab. 54) jsou v souladu s údaji Bnnnnnnnn et al. (1971) pro některé druhy pakomárů a s údaji Edmonsona a Winberga (1971) pro některé vodní bezobratlé.

Když jsme při použití koeficientu 8 přepočetli doposud u nás pro pstruhové potoky známé průměrné roční biomasy zoobentosu, obdrželi jsme velmi shodné výsledky (viz také in Kubíček et al. 1971, Kubíček 1971):

Tok	prům. roční biomasa kg/ha	roční produkce kg/ha
Pstruhové potoky v Beskydech	151,0	1 177
Svratka (u Štěpánova)	163,2	1 305
Loučka (u Blažkova)	128,0	1 024

Tyto toky mají také velmi podobné složení zoobentosu po stránce kvalitativní i kvantitativní.

Vlivy abiotických faktorů prostředí beskydských potoků, zejména změny průtoků, rychlost proudění, teplotní režim a střídání klidných a rychle tekoucích úseků se obrazily v ročním cyklu bentických organismů a v jejich distribuci na dně potoků. Také pravidelný přísun organické hmoty ve formě listí a jeho postupné odbourávání má vliv zejména na vysoký podíl detritovorních typů organismů dna (viz Hynes 1970).

Změny v kolísání abundance a biomasy zoobentosu během roku odpovídaly modelu "of the annual cycle", který v tekoucích vodách propracoval Hynes (1970).

Byly zjištěny také rozdílné vztahy v kvantitativním i kvalitativním složení zoobentosu v proudové a břehové části. Zatímco v proudících úsecích toku převažovaly larvy *Trichoptera*, *Ephemeroptera*, *Chironomidae* a imaga a larvy některých *Coleoptera*, v příbřežních úsecích toku převažoval *Rivulogammarus*, *Dugèsia* aj. Měřítkem hraniční rychlosti proudivého a břehového úseku byla rychlost proudu 15 cm/sec. Naše zjištění o vlivu proudu na distribuci zoobenthosu korespondují s údaji jiných autorů (např. Raušer 1956, Ambühl 1959, Kamler 1966 aj.).

Vliv změněné rybí obsádky na zoobenthos nebyl v možnostech našeho pokusu prokázán. Vranku se zejména na potoce Lušová nepodařilo odlovit a po čase se její populace naopak zvýšila. Pouze některé jevy na pokusných úsecích potoka Brodská naznačují, že k ovlivnění fauny dna rybí obsádkou mohlo dojít v úseku B1b, kde obsádka pstruha i vranky byla zvýšena. Přerybněný úsek potoka Brodská vykazoval určité rozdíly v abundanci a biomase některých skupin zoobenthosu na rozdíl od sousedních úseků s normální rybí obsádkou a bez ryb. Např. abundance larev jepic a blešivců byla v přerybněném úseku vyšší než v úseku s normální rybí obsádkou. U jiných skupin byla nižší (např. *Trichoptera-Intergripalpia*, *Ancylus*), u dalších nedošlo k žádným změnám. Nápadné však byly změny ve zmenšené průměrné velikosti a váze jedinců a larev jepic, chrostíků a blešivců a u chrostíků v poměrném zastoupení jednotlivých druhů. Chrostíci jsou přitom spolu s jepicemi a pakomáry hlavní složkou potravy ryb.

Důležitým výsledkem však je, že ani převýšená obsádka ryb při zjištěném složení a množství zoobenthosu neochudila podstatně potravní základnu. Tyto zkušenosti byly již získány také na jiném pstruhovém toku u nás (Loučka u Blažkova, viz Sedlák 1969, Kubíček 1971, Kubíček and al. 1971).

CONTENTS

Helan J, Kubíček F., Losos B., Sedlák E., Zelinka M.

PRODUCTION CONDITIONS IN THE TROUT BROOKS OF THE BESKYDY MOUTAINS

Vydala Universita J., E. Purkyně v Brně — přírodovědecká fakulta
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