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THE EFFECT OF LOW DISCHARGE RATES ON MAYFLY FAUNA

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Abstract. Ever increasing demands for the amount of water result in decreasing discharge rates in streams and inextending the time of their duration. The effect of low discharge rates on the development of zoobenthos was followed on experimental brooks in which the discharge rates can be controlled. In the first phase the effect of what is called the 355 and the 364 day discharge rates was established in comparison with the average discharge rate in the ratio $Q_A : Q_{355\ d} : Q_{364\ d} = 100 : 14.3 : 8.3 = 30.0 : 4.3 : 2.5\ l.s^{-1}$. Low discharge rates lasting for several months strongly decimate the torrentile elements of the bottom fauna. In mayfly larvae it was 60 % of the annual average in the brook $Q_{355\ d}$ and 88 % in the brook $Q_{364\ d}$. Lowering the discharge rate to $Q_{364\ d}$ results in a considerable decrease in the amount of mayfly larvae already in the course of a few days, in lowering to $Q_{355\ d}$ major degradations can be observed after 2 weeks. The shorter time of the reduced discharge rate, the more quickly the regeneration sets on. After a week's duration of the lowest discharge rate one can calculate with complete regeneration within a fortnight. This time space is, however, also influenced to some extent by season of the year. Experiments have demonstrated that prolonged low discharge rates strongly degrade mayfly fauna. In streams up to metarhithron they are discharge rates corresponding to $Q_{355\ d}$, i.e. about 15 % of a long-term average, in further zones the discharge rate will do less harm. Unqualified canalizations deteriorate the situation.

Biocenoses, production, biomass.

Ever increasing demands for the amount of water result in decreasing discharge rates in streams and in extending the time of their duration. The effect of these levels is of course

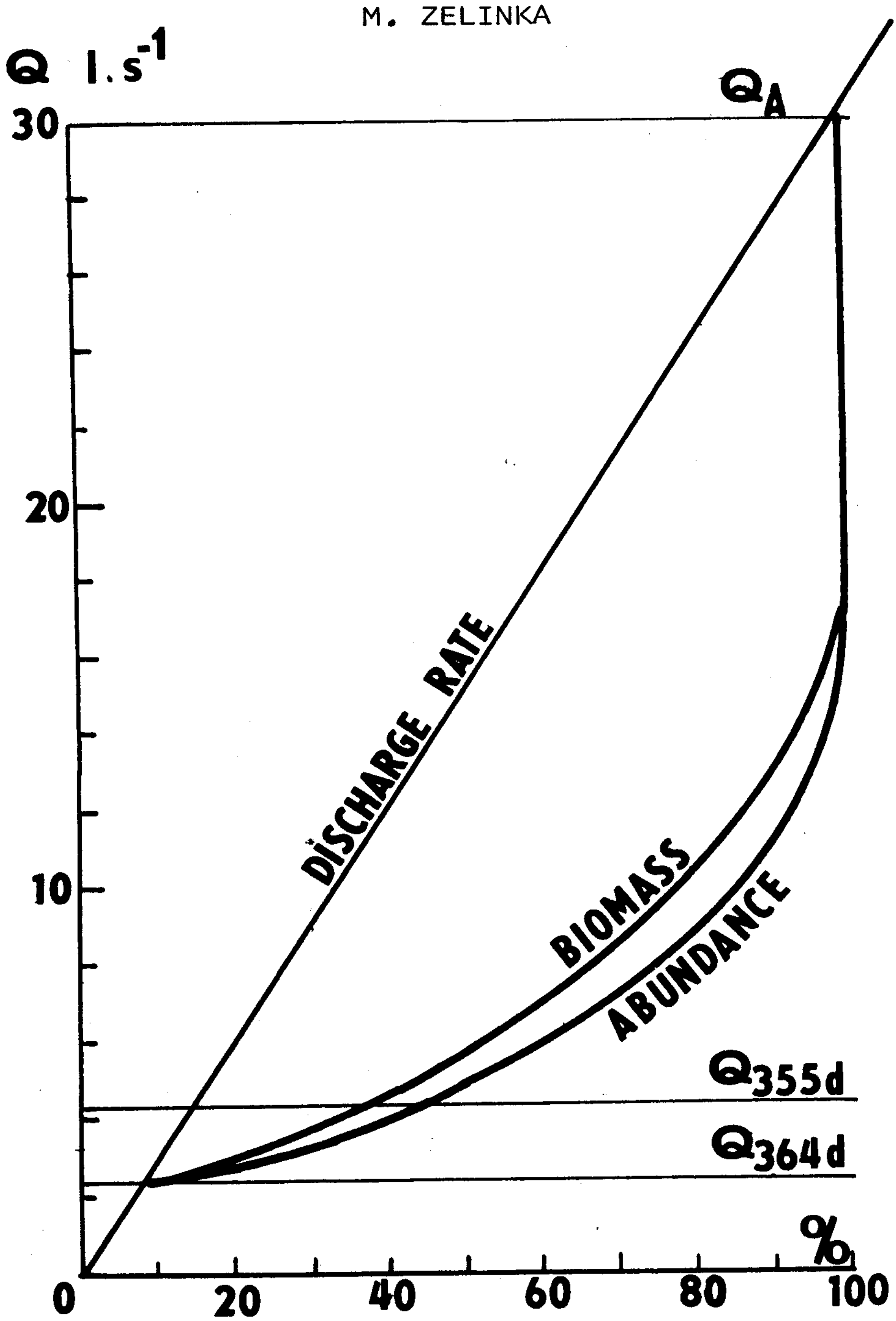

Fig. 1: The effect of low discharge rates on mayfly fauna.

reflected in the biocenoses and biological processes that play the main role in practical problems of production and water saprobity. For economic practice it is important to establish the minimum discharge rate that guarantees such qualitative and quantitative patterns of the living community as corresponds to natural conditions of the stream or a stretch of it. Its determination must therefore start from biological information. The effort at obtaining the most objective basic data has made us build experimental brooks in which it is possible to control the discharge rate according to need.

The object can be found in the metarhithron of the river

Table 1.

Brook	Discharge rate		Mean water velocity	Time of passing through	Water depth in cm	
	$1 . s^{-1}$	% Q_A	$m . s^{-1}$	s	min.-max.	Ø
Q_A	30	100	1.00	16	4 - 20	12
$Q_{355\ d}$	4.3	14.3	0.34	50	2 - 8	5
$Q_{364\ d}$	2.5	8.3	0.24	70	1 - 6	3

Table 2.

Abundance $n . m^{-2}$ Brook	Q_A	$Q_{355\ d}$	$Q_{364\ d}$
Epeorus sylvicola /Pict./	17.3	2.3	0.9
Rhithrogena semicolorata /Curt./	240.9	100.0	27.7
Ecdyonurus 3 spp.	75.5	58.6	16.4
Heptagenia sulphurea /Müll./	3.6	3.2	0
Baetis buceratus Etn.	22.7	30.9	10.0
Baetis rhodani /Pict./	1517.3	713.6	246.4
Baetis fuscatus /L./	50.0	27.3	12.7
Baetis muticus /L./	32.7	10.5	4.5
Baetis vernus Curt.	9.1	0	0.9
Baetis lutheri Müll.-Liebenau	16.4	15.5	5.5
Habroleptoides modesta /Hag./	11.8	6.8	0
Habrophlebia lauta Etn.	1.8	2.7	0
Paraleptophlebia submarginata /St./	0	3.6	2.7
Ephemerella ignita /Poda/	162.7	47.7	11.4
Ephemerella mucronata Bgtss.	1.8	0	0
Torleya major Klap.	0	0.9	0
Caenis 2 spp.	0.9	0.9	4.5
S	2165	1025	344

Svratka (the basin of the river Morava), at the height above sea level of 300 m. In the two years of operation water temperatures did not exceed 18° C, the average water composition in the main indices being as follows: pH 7.4, B.O.D.$_5$ 1.7 $mg.l^{-1}$ O_2, O_2 11.4 $mg.l^{-1}$, $N\text{-}NO_3$ 2.90 $mg.l^{-1}$, $P\text{-}PO_4$ 187 $\mu g.l^{-1}$. The saprobity index of the community is 1.4, which means the worse of oligosaprobity. Three brooks were built of useful length of 20 m, 0.6 m wide, average gradient of 3 ‰. Their bottoms were covered with material from the adjacent stretch of the river.

We investigated the effect of hydrologically characteristic lowes natural discharge rates in comparison with the average discharge rate, which is 30 $l.s^{-1}$ and which was permanent in one of the brooks (± 10%). In the second brook the discharge rate

Table 3.

Biomass mg . m^{-2} Brook	Q_A	$Q_{355\ d}$	$Q_{364\ d}$
Epeorus sylvicola	195.7	15.3	2.0
Rhithrogena semicolorata	1057.8	407.7	78.5
Ecdyonurus 3 spp.	357.5	292.1	96.2
Heptagenia sulphurea	17.1	15.2	0
Baetis buceratus	30.0	22.0	6.6
Baetis rhodani	2584.7	1012.9	341.1
Baetis fuscatus	66.5	11.2	6.9
Baetis muticus	56.5	5.8	11.6
Baetis vernus	13.8	0	1.4
Baetis lutheri	6.5	4.9	1.8
Habroleptoides modesta	31.5	23.1	0
Habrophlebia lauta	3.2	1.6	0
Paraleptophlebia submarginata	0	14.4	12.2
Ephemerella ignita	655.5	230.5	64.7
Ephemerella mucronata	19.2	0	0
Torleya major	0	0.5	0
Caenis 2 spp.	0.4	0.8	3.2
S	5096	2058	626

Table 4.

	Brook	Q_A	$Q_{355\ d}$	$Q_{364\ d}$
	Discharge rate 1 . s^{-1}	30	4.5	2.5
	Percentage of mean discharge rate	100	15.6	9.0
abundance ind. m^{-2}	Total mayfly larvae - %	2165-100	1025-47.3	344-15.9
	Baetis rhodani - %	1517-100	714-47.0	246-16.2
	Rhithrogena semicolorata - %	241-100	100-41.5	28-11.6
biomass mg. m^{-2}	Total mayfly larvae - %	5096-100	2058-40.4	626-12.3
	Baetis rhodani - %	2585-100	1013-39.2	341-13.2
	Rhithrogena semicolorata - %	1058-100	408-38.6	78- 7.4
	Number of species found in two years	20	18	14

was adjusted to be $Q_{355\ d}$ = 4.3 l.s^{-1} and in the third $Q_{364\ d}$ = 2.5 l.s^{-1} (see Tab. 1). In the reduced discharge rate changes of biocenoses occurred relatively quickly and after 3 months we started following regularly the physico-chemical situation and biological relations. Here I evaluate the results concerning mayfly larvae. Samples of macrozoobenthos were taken once a month with a triangular benthometer with the area of 500 cm^2 (Helan et al. 1973). It was not advisable to interfere with the bottoms of small brooks by taking large area samples; we are

Table 5.

Brook		$Q_{364\ d}$	$Q_{355\ d}$
Discharge rate $1 . s^{-1}$		2.0	4.0
% of mean discharge rate		11	23
Abundance $n . m^{-2}$	Initial state - %	2387-100	2387-100
	After 6 days of action - %	980- 41	-
	After 9 days of action - %	-	1640- 69
	Initial state - %	1900-100	1900-100
	After 11 days of action - %	1360- 71	-
	After 39 days of action - %	-	560- 29
Biomass $mg . m^{-2}$	Initial state - %	4649-100	4649-100
	After 6 days of action - %	2940- 63	-
	After 9 days of action - %	-	4793-103
	Initial state - %	2395-100	2395-100
	After 11 days of action - %	962- 40	-
	After 39 days of action - %	-	935- 39

aware of the errors made in sparsely represented species. However, by making averages for the two years of investigation the errors are decreased and for practical utilisation rarely occurring species are not of major importance.

The main results of the long-term operation follow from Tab. 2 - 4. Altogether 20 mayfly species were found, also occurring in the adjacent stretch of the river Svratka and common in this type of stream. In experimental brooks a selective biocenose was not formed. The major part of species was represented in isolated finds. More than 80% of total abundance is represented by two species: *Baetis rhodani* - 71%, *Rhithrogena semicolorata* 10%. Frequent were also *Ephemerella* (*E.*) *ignita* - 6%, and *Ecdyonurus* sp. (3 species) - 5%. There were, however, significan differences between brooks with different discharge rates. In the brook $Q_{355\ d}$ the average number of individuals dropped by 53%, a more pronounced decrease being exhibited in explicitly torrentile species (*R. semicolorata*) than in species living in the bank zone. In the brook $Q_{364\ d}$ the decrease was as much as 84%.

In the biomass (and thus also in the production) the decreases at low discharge rates were even higher, since bigger larvae were affected. At the discharge rate $Q_{355\ d}$ the drop in total biomass of mayfly larvae was 60%, at $Q_{354\ d}$ almost 88% (Fig. 1).

We also followed effects of short-term effects of the above low discharge rates. The results are summarized in Tab. 5. The first series of experiments was only affected by the onset of the species E. (E.) ignita in the period from the reduction of the discharge rates up to the checking after 6 and 9 days of action, which was particularly reflected in the biomass (a quick growth of larvae). The decrease in the number of larvae was, however, significant and increased with the number of days of the duration of low discharge rates (Tab. 5).

From the experiments performed it follows clearly that low discharge rates have an unfavourable effect on mayfly fauna. In trout and grayling streams considerable degradation is evoked by discharge rates corresponding to $Q_{355\ d}$, i.e. about 15% of the long-term average discharge rate. The effects are shown already after a few days of the duration of the low discharge rate and increase gradually. The shorter duration of the low discharge rate, the quicker the regeneration. After a week's duration of the lowest discharge rate studied complete regeneration occurred within a fortnight. This period of time is, however, affected by the season of the year as well.

The main cause of degradation are not slightly increased temperatures or slightly reduced oxygen content (the minimum found was 8.6 $mg.l^{-1}$), but, as for mayfly larvae, chiefly a considerably reduced speed of the stream and covering the bottom with mud. Stones are covered with fine inorganic detritus and living conditions for torrentile larvae are on the whole deteriorated.

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