Acta entomologica bohemoslovaca

MILOŠ ZELINKA

Mayflies (Ephemeroptera) in the drift of trout streams in the Beskydy Mountains

ABSTRACT

This paper is the last of a series of studies bringing the results of a three-year investigation of mayflies in clean trout streams, practically uninfluenced by man. The drift of mayflies was followed both qualitatively and quantitatively in relation to the benthos, to the density of fish stock, and to the flow of water. It was found that practically all species of mayflies colonising brooks were subject to drift, but especially species of the genus *Baetis*. The daily and yearly changes are in accordance with previous information. A considerable increase in the drift density occurs in the first phase of floods. If the total drift is calculated according to the flow a yearly average 25 % of mayfly larvae living in the brook drift into the river; for species of the genus *Bastis* it may be as much as 50 %.

Separatum
Vol. 73, No. 2
20. 5. 1976

Acta ent. bohemoslov., **73** : 94—101, 1976
ISSN 0001—5601

Mayflies (Ephemeroptera) in the drift of trout streams in the Beskydy Mountains*

MILOŠ ZELINKA

Department of the Biology of Animals and Man, J. E. Purkyně University, Brno

Baetis, Ecdynurus

Animals being drifted by a strean of water are a regular phenomenon depending or several varying factors of the environment and its living community (MÜLLER, 1954; SÖDEGREN, 1971; LEVANIDOVA & LEVANIDOV, 1965). This phenomenon is a link of the populating circle of flowing water and is denoted by the term drift. Drift was also studied in the complex biological investigation of the trout streams or brooks of the Beskydy Mountains which was carried out from 1966 to 1969 (ZELINKA, 1969; HELAN et al., 1973).

MATERIAL AND METHODS

For sampling the drift we used the tubes described in the papers by KUBÍČEK & ZELINKA (1966) and KUBÍČEK (1966), the water being strained by means of a strainer of mesh 0.4 mm. The drift was sampled every mounth in the Lušová and Brodská streams. The sampling was carried out either by a single action for at least 2 hours or at intervals throughout 24 hours. Besides the water strained the total flow or distarge of water was measured. A long-term average flow in the Lušová is 145 l/sec and in the Brodská 176 l/sec. During the period of investigation the average flow was somewhat lower (dry years). The samples were taken at various flow rates, including floods, mostly, however, at medium to low rates. On average, about one-twentieth of the actual flow of water was strained. The average daily flow rate in the period of investigations was about 9,500 m^3 in the Lušová and 12.500 m^3 in the Brodská. On the days when samples of the drift were taken 2 to 150 m^3 of water were strained, depending on the flow of the stream and the time of straining. Mostly the quantity was about 20 m^3, which is about 1/550 of the average daily flow. We think that the number of samplings and the quantity of water strained are sufficient to give us a relatively good picture of the drift of mayflies in the trout streams of the Beskydy Mountains.

The total drift was processed by Dr. Frant. Kubíček (in litt.), from whom I have taken over the basic data concerning the mayflies.

RESULTS

The qualitative composition of the drift of mayflies. In both streams 19 species of mayflies were found during the three years of investigation (ZELINKA, 1969, 1974). As evident from Table 1, most of the species were found in the drift as well. If we take the five species of the genus *Baetis* as one taxon (the determination of small drifting individuals is not always reliable), then only 4 species were not found in the drift. The representation of those 4 species in the benthos, however, does not even reach 1 % of the total number of mayflies. They are the species: *Paraleptophlebia submarginata*, *Centroptilum luteolum*, *Centrophilum pennulatum*, *Chitonophora*

* Part IV of the study of mayflies in the trout streams of the Beskydy Mountains.

TABLE 1

Proportional representation of mayfly larvae in the benthos and in the drift.

Taxon	Proportional representation in % in the benthos	in the drift
Ephemera danica MÜHL.	0.66	1.50
Ecdyonurus sp. div.	15.31	1.35
Heptagenia lateralis CURT.	1.55	0.45
Rhithrogena semicolorata CURT.	16.60	11.86
Epeorus assimilis ETN.	2.46	0.90
Habrophlebia lauta ETN.	4.08	5.86
Habroleptoides modesta HAG.	9.32	0.90
Paraleptophlebia submarginata ST.	0.51	0
Baetis rhodani PICT.	+	+
Baetis bioculatus L.	+	
Baetis alpinus PICT.	+39.6	+64.86
Baetis pumilus BURM.	+	+
Baetis niger L.	+	
Centroptilum luteolum MÜHL.	0.96	0
Centroptilum pennulatum ETN.	0.16	0
Ephemerella ignita PODA	2.06	5.86
Chitonophora krieghoffi ULM.	0.30	0
Torleya maior KLP.	5.19	4.51
Caenis macrura STEPH.	1.24	1.95

Average values from each stream for the whole period of investigation.

krieghoffi. The two most frequent species in the benthos — *Baetis rhodani* and *Rhithrogena semicolorata* — were the most frequent in the drift as well. The genus *Baetis* which, in the benthos, represented 40 % of the total abundance of mayfly larvae, reached as much as 65 % of all drifting larvae. The representatives of this genus also live in algal periphyton. On the other hand larvae of the genus *Ecdyonurus*, living only under stones and, represented in the benthos by 15 %, were rare in the drift, little more than 1 %. A similar situation was found in *Habroleptoides modesta* (9%, in the drift 0.9%). In the other species the percentage representation in the drift corresponded, on the whole, to the situation in the benthos. Frequently exuviae of mayfly larvae were sampled.

Quantitative relations of mayfly drift. Most papers dealing with mayfly drift operate with the quantity per volume unit of water, usually per m^3. In our case this quantity was in the Lušová 0.54 and in the Brodská 0.33 larvae per 1 m^3 of water (average of all samplings). There was a difference between the two streams in the ratio of the drifting representatives of the genus *Baetis* and the larvae of the other species of mayflies, even though the larvae of the genus *Baetis* were always the most frequent: In the Lušová the ratio was 1 : 0.18 — in the Brodská 1 : 0.87.

In studying the total dynamics of biological processes in a stream the most important factor is the total number of mayflies washed away from a certain part or from the whole stream. According to the total flow at the time of drift sampling we calculated the total drift for each day, and from the monthly and or yearly average rates the total drift. As the main samplings were carried out near the places where the streams empty into the river Bečva, we can calculate the total drift from the brook and compare it with

TABLE 2a

The quantity of the drift of mayfly larvae.

Name of stream	Average drift in 1 m³ of water — Number of individuals *Baetis*	other mayfly larvae	S	Average flow in the period of investigation l/sec	Total average drift of mayfly larvae per year — Number of individuals *Baetis*	other mayfly larvae	S
Lušová	0.457	0.082	0.539	110	1 585,315	284,455	1 869,770
rBodská	0.177	0.154	0.331	169	943,336	820,756	1 764,092

Average values for the investigation lasting three years. S=total.

TABLE 2b

Quantity of mayfly larvae in the benthos.

Name of stream	Average number of individuals in the benthos per 1 m² *Baetis*	other mayfly larvae	S	Number of mayfly larvae in the whole brook; average number of individuals per year *Baetis*	other mayfly larvae	S	Total drift per year in relation to benthos % *Baetis*	other mayfly larvae	S
Lušová	291	400	691	2 894,286	3 978,400	6 872,686	54.8	7.1	27.2
Brodská	215	456	671	2 349,305	4 982,712	7 332,017	40.2	16.5	24.1

Average values for the investigation lasting three years. S=total.

the quantity of mayfly larvae in the benthos. The results of these calculations, given in Table 2, are the average values of the investigation over a period of three years in the two streams.

From those calculations it follows that from the trout streams of the Beskydy Mountains a yearly average of about 25 % of all mayfly larvae living on the bottom of the whole brook is drifted away. (Note: in the drift individuals smaller than 0.5 mm were not calculated; however, they were not collected in the quantitative processing of the benthos either, cf. ZELINKA, 1969). In the representatives of the genus *Baetis* this constitutes on the average as much as 50 %. The ratio mentioned shows a great and systematic recolonisation ability in mayflies, without which this fauna could not survive in the mountain streams.

Periodicity of mayfly drift. The irregularity of the number of drifting mayfly larvae has been proved several times. This concerns both the daily and the yearly cycles. Also sudden increases of the flow influence it.

The 24 hour cycle was particularly followed every month from January to September, 1968. This showed clearly that the greatest drift takes place at night, the course of the peak being shifted from the first half of the night in

TABLE 3

Differences in the drift of mayflies throught the year.

Stream / Season	Average drift per 1 m³ *Baetis*	Average drift per 1 m³ other mayfly larvae	Average drift per 1 m³ S	Aver. flow in the period of investig. l/sec	Average yearly flow m³	Total average daily drift individuals *Baetis*	Total average daily drift individuals other mayfly larvae	Total average daily drift individuals S	Average total yearly drift individuals *Baetis*	Average total yearly drift individuals other mayfly larvae	Average total yearly drift individuals S	Drift in % *Baetis*	Drift in % other mayfly larvae	Drift in % S
Lušová														
year	0.457	0.082	0.539	110	3 468,960	4,343	779	5,122	1 585,315	284,455	1 869.770	100	100	100
spring	0.695	0.150	0.845	141	1 123,872	8,467	1,827	10,294	781,091	168,580	949,671	49.3	59.3	50.8
summer	0.518	0.048	0.566	80	635,459	3,580	332	3,912	328,882	30,550	359,432	20.7	10.7	19.2
autumn	0.433	0.088	0.521	78	613,249	2,918	593	3,511	265,933	53,700	319,633	16.8	18.9	17.1
winter	0.191	0.029	0.220	141	1 096,380	2,327	353	2,680	209,409	31,625	241,034	13.2	11.1	12.9
Brodská														
year	0.177	0.154	0.331	169	5 329,584	2,584	2,249	4,833	943,336	820,756	1 764,092	100	100	100
spring	0.221	0.209	0.430	329	2 611,677	6,287	5,934	12,221	578,409	545,908	1 124,317	61.3	66.5	63.7
summer	0.162	0.076	0.238	116	918,584	1,620	758	2,378	149,005	69,708	218,713	15.8	8.5	12.5
autumn	0,157	0.115	0.272	116	908,560	1,572	1,148	2,720	143,001	104,484	247,485	15.2	12.7	14.0
winter	0.082	0.113	0.195	115	890,763	811	1,118	1,929	72,921	100,656	173,577	7.7	12.3	9.8

Average values for the period of investigation lasting three years. S=total.

TABLE 4

Drift of mayfly larvae in a sudden flood. Lušová, 17 July, 1967

Datum		Before torrent	beginning	During flood peak	subsiding
Time (hrs.)		12,00	14,00	14,45	15,45
Flow l/sec		55	200	273	170
	%	100	364	496	309
Drift n/m³					
Baetis rhodani		5	6	8	3
Habrophlebia lauta		1	16	30	1
Caenis macrura		0	4	0	0
S of drift		6	26	38	4
	%	100	433	633	67
Drift n/sec		0.330	5.200	10.374	0.680
	%	100	1,576	3,144	206

the cold period of the year to the second half of the night and/or to the early morning hours in the warm period of the year. On the average the number of larvae in the drift at night was 100 % higher than in the day.

The differences found in the course of the year can be seen from Table 3, in which, besides the number of drifting larvae in 1 m³ of water, the calculation related to the total quantity of water discharged in the corresponding season is given. These show that the greatest drift takes place in the three spring months, constituting more than 50 % of the total yearly drift. Least drift takes place in the winter months, about 10 % of the total yearly drift. In spring the increased flow has its effects, but it is mainly the spring activity of mayfly larvae (the distribution of juvenile stages) which account for the increase. In winter the activity of larvae is small.

The relation of drift to the total flow. Data in the literature is usually on the abundance of the drift in 1 m³ of water. Often the data on the total flow are missing altogether or it is subjectively estimated as "low, increased, etc." Some authors arrive at the conclusion that with an increased flow the quantity of the drift decreases. From the results obtained in the Beskydy streams it is evident that the flow is one of the factors (even if not always the most important one) influencing the total drift.

An important increase in the drift — and mayfly larvae above all — occurs at the beginning of sudden spate of floods. Very quickly (in the course of several minutes), however, the density of the drift drops and from the peak of the flood, and particularly whem receding, there is little drift. The total drift, in relation to the increased flow, is usually great. We had an opportunity of carrying out one observation a sudden flood or spate. The increase of the density of the drift and of the total quantity of drifting mayfly larvae per time unit was quite evident (Table 4). In the receding phase of a short term spate the absolute density of drift was lover than before it occurred, but the total number of specimens drifting through the stream was still higher. This illustrates a quick defensive reaction of mayfly larvae to floods. In increased flows of different origins (such as snow thawing, long lasting rains) the drop in the drift density of mayflies can be expected before the peak of the flood.

On the basis of the measurements carried out we tried to find the relation between the discharge quantity or flow and the drift of mayfly larvae. We

TABLE 5

Relation of flow to total drift of mayfly larvae per day

Flow l/sec	Total drift per day individuals	Flow l/sec	Total drift per day individuals
22	323	70	1 390
30	2 463	70	1 814
32	608	87	205
34	1 176	95	2 216
34	205	99	5 132
34	998	105	5 443
35	876	123	20 191
38	3 283	130	5 505
48	0	132	15 967
50	0	150	0
50	216	150	258
53	2 289	160	1 244
53	916	180	6 843
53	6 868	184	6 359
53	0	184	15 898
54	933	186	0
56	967	190	0
56	968	200	5 184
60	0	204	29 964
60	1 452	220	950
60	0	250	0
63	0	265	687
63	0	318	13 729
65	1 685	360	3 110
66	1 710	699	30 197
66	4 562	1 026	212 750

did not find any dependence when comparing the discharge measured at the time of sampling with the density of drift in 1 m^3 of water. There is another picture when compare the flow with the total daily drift (Table 5). This is in connection with the relation between drift density and the total daily drift. Statistical analysis confirmed in this case the conclusive evidence of the regression coefficient (T = 9.90). An even closer relationship was confirmed between the logarithms of the values of both variables. A great dispersion, however, must be taken into consideration.

The influence of fish stock on the drift of mayfly larvae. In the period from January 1968 to April 1969 we followed every month the drift in a zone of the Brodská stream with a high fish stock (*Salmo trutta* m. *fario* 186 %, *Cottus poecillopus* 135 %), and also in a zone which was practically devoid of trout (*Cottus* 70 %) and in a zone with the original natural stock of fish (for details cf. ZELINKA, 1974). It is interesting to note than in the zone without fish stock the number of drifting mayfly larvae (the genus *Baetis* and the others) was reduced by almost a half when compared with the zone with a high fish stock. It would be necessary to obtain more results to find out the real reason. We noted that in the zone of the stream without fish the speed of the stream was somewhat lower than average. The density of mayfly larvae in the benthos was, however higher in the zone with high fish stock: 344 *Baetis* larvae and 491 other larvae per 1 m^2 as against 211

Baetis larvae and 381 other larvae in the zone without fish (cf. ZELINKA, 1974).

DISCUSSION

A three-year investigation of the drift of mayfly larvae in the trout streams of the Beskydy Mountains has shown that practically all species represented in the benthos are subject to drift, the proportional representation of the individual species in the benthos corresponding, on the whole, to their proportional representation in the drift. An exception are the larvae of the genus *Ecdyonurus* which drift very little. On the other hand, the larvae of the genus *Baetis* were more numerous in the drift than in the benthos, which corresponds to the information obtained from a number of other streams (ELLIOT, 1967, 1968; MÜLLER, 1954, 1963, 1973; WATTERS, 1962, 1968).

An average quantity of drifting larvae was about 0.5 specimens per 1 m^3 of water. Well-known differences between day and night were verified (ELLIOT, 1965; MÜLLER, 1963, 1966; TANAKA, 1960). More than 50 % of the total yearly drift took place in the three spring months. A great increase of the drift of mayfly larvae (tens of larvae in 1 m^3) occurs in the first phase of sudden floods. This drift is described as catastrophic and I think that the reincorporation of larvae into the benthos takes in those cases much more time than in the normal drift and/or in the drift artificially producent in balanced low discharges. An artificially produced drift due to e.g., works in the stream bed (cf. e.g., MÜLLER, 1970) cannot be completely identified with catastrophic drift due to flood, the difference consisting in the reincorporation of the drifting specimens into the benthos.

A relationship between the absolute density of drift and the flow quantity was not confirmed. There is, however, a relation between the flow and the total drift of mayfly larvae per certain time unit. There are, however, exceptions even here, and more observations are needed.

Even though most of the drifting larvae incorporate themselves in the benthos comparatively soon, in the long-term average we found practically the same quantity of mayfly drift at several points of the longitudinal section of the trout stream, and also just before it empties into the river. If we calculate from the average flow the total yearly drift of mayfly larvae we find that this quantity reaches as much as 25 % of all mayflies living in the stream on the yearly average. In the representatives of the genus *Baetis* this number is as high as 50 %. The recolonisation must, therefore, be very great.

CONCLUSION

As drift is an important part of the colonising circle of flowing waters, it was followed in the complex biological investigation of the trout streams of the Beskydy Mountains. The evaluation of the results in mayfly larvae has revealed a number of interesting facts:

1. Practically all mayfly species represented in the benthos are subject to drift, especially species of the genus *Baetis*.
2. The average number of drifting larvae was 0.5 individuals per 1 m^3 of water, there being daily as well as seasonal differences.
3. The drift is increased in the first phase of sudden spates.
4. The relationship between the density of the drift of mayfly larvae and the flow at that moment was not mathematically confirmed. There is, how-

ever, a relation between the total flow and the drift per certain time unit.

5. The influence of the density of fish stock on the drift of mayfly larvae needs to be verified by further investigation.

6. From the whole trout stream about 25 % of mayfly larvae (in the genus *Baetis* as many as 50 %) living in the stream on the yearly average were washed away into the river.

REFERENCES

ELLIOT J. M., 1965: Daily fluctuations of drift invertebrates in a Dartmoor stream. *Nature*, **205** : 1127—1129.

ELLIOT J. M., 1967: The life histories and drifting of the Plecoptera and Ephemeroptera in a Dartmoor stream. *J. Anim. Ecol.*, **35** : 343—362.

ELLIOT J. M., 1968: The daily activity patterns of mayfly nymphs (Ephemeroptera). *J. Zool.*, **155** : 201—221.

HELAN J. et al., 1973: Production conditions in the trout brooks of the Beskydy Mountains. *Folia Fac. Sci. Nat. Univ. Purkynianae Brunensis, Biol.* XIV, **4** : 1—105.

KUBÍČEK F., 1966: Eine neue Methode der quantitativen Entnahmen der organischen Drift. *Zool. listy*, **3** : 284—285.

KUBÍČEK F. & ZELINKA M., 1966: Nová metoda kvantitativního odběru organismů z tekoucí vody. (New methods of quantitative sampling of organisms in running waters.) *Vodní hospodářství*, **6** : 241—242 (in Czech).

LEVANIDOVA I. M. & LEVANIDOV V. J., 1965: Sutochnyje migraciji donnych lichinok nasekomych v rechnoj struje. 1. Migracii lichinok podenok v reke Chor. (Diurnal migration of the bottom insect larvae in the streamline. 1. The migration of mayfly larvae in the River Chor.) *Zool. zh.*, **44** : 373—385 (in Russian).

MÜLLER K., 1954: Investigations on the Organic Drift in North-Swedish streams. *Rept. Inst. Freshw. Res. Drottningholm*, **35** : 133—149.

MÜLLER K., 1963: Tag-Nachtrhythmus von Baetidenlarven in der organischen Drift. *Naturwissenschaften*, **50** : 161.

MÜLLER K., 1966: Die Tagesperiodik von Fliesswasserorganismen. *Z. Morph. Ökol. Tiere*, **56** : 93—142.

MÜLLER K., 1970: Tages- und Jahresperiodik der Drift in Fliessgewässern in verschiedenen geographischen Breiten. *Oikos*, Suppl., **13** : 21—44.

MÜLLER K., 1973: Die Phasenlage von Evertebraten in der Drift. *Ökol. Stn. Messaure, Ber.*, **28** : 1—11.

SÖDERGREN S., 1971: Undersökningar över drift av Ephemeroptera, Plecoptera och Trichoptera i Rickleau. *Rapp. Ricklea*, **18** : 1—68.

TANAKA H., 1960: On the daily change of drifting of bentic animals in stream, especially on the types of daily change observed in taxonomic groups of insects. *Bull. Freshw. Fish. Res. Lab. Tokyo*, **9** : 13—24.

WATTERS T. F., 1962: Diurnal periodicity in the drift of stream invertebrates. *Ecology*, **43** : 316 to 320.

WATTERS T. F., 1968: Diurnal periodicity in the drift of a day-active stream invertebrate. *Ecology*, **49** : 152—153.

ZELINKA M., 1969: Die Eintagsfliegen (Ephemeroptera) in Forellenbächen der Beskiden. I. Abundanz und Biomasse. *Fac. Sci. Nat. Univ. Purkynianae Brunensis*, **10**, Biol. **25** : 155 to 166.

ZELINKA M., 1974: Die Eintagsfliegen (Ephemeroptera) in Forellenbächen der Beskiden. III. Der Einfluss des verschiedenen Fischbestandes. *Věstník Čs. spol. zool.*, **38** : 76—80.

Received November 22, 1974; accepted June 24, 1975.

Author's address: RNDr. M. Zelinka, CSc., Katedra biologie živočichů a člověka University J. E. Purkyně, Kotlářská 2, 611 37 Brno, Czechoslovakia.