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Seasonal and diel patterns of mayfly (Ephemeroptera) drift in Korge stream, Latvia

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A complex set of biotic and abiotic factors affects a drift. Mayfly drift has been extensively studied worldwide, but the manner in which the environmental factors interact is not completely clear. The aim of the present study was to characterise mayfly seasonal and diel drift patterns in relation to abiotic factors in a medium-sized lowland stream in Latvia. Drift samples were collected at three-hour intervals in a riffle section in May, August and September 2007. Distinct seasonal and diel patterns of the mayfly drift were observed in the Korge stream. These were not directly infuenced by primary hydraulic factors e.g. current velocity and discharge, but depended on the active growth period of the mayfly species.

Keywords: mayflies; drift; abiotic factors; lowland stream

Introduction

Mayfly drift has been extensively studied worldwide in many aspects from the 1950s to the present day (e.g. Waters 1972; Brittain and Eikeland 1988). Drift is affected by a complex set of biotic and abiotic factors (Brittain and Eikeland 1988) over large and small spatial scales (Hansen and Closs 2007), but the manner in which the factors interact is poorly understood (Wilzbach 1990). Temporal patterns of macroinvertebrate drift are better documented than spatial ones (Boyero and Bosch 2002). Abiotic factors are often considered to give rise to catastrophic drift, while biotic factors e.g. life cycle stages (Waters 1972) are important for behavioural drift. The most important overall factor that influences the benthic fauna is stream hydraulics (Statzner and Higler 1986). The diel periodicity of the mayfly larval drift, especially in baetids, has been widely described (Brittain and Eikeland 1988), but causative mechanisms are still not entirely clear.

Changes in the hydrological regime of Latvian running waters have been predicted as a result of climate change and different scenarios are for the near future available (Bethers and Sennikovs 2007). Assessment of the long-term trends in the discharge of the River Salaca shows an increase in water discharge in the winter and a decrease in the summer (Druvietis et al. 2007). Changes in hydrological regime will clearly influence the macroinvertebrate communities in small stream ecosystems, but

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it must be taken into account that the hydrological regime is an integrative descriptor of numerous selective forces and habitat conditions, and cannot easily be viewed in isolation (Poff et al. 1997). It is expected that warm water fish species will replace cold water species (Regier and Meisner 1990). Baetids are an important food recource of salmonids, and according to Ruginis (2008), larvae of *Baetis* spp. were detected in 66% of 0^+ brown trout guts during August in Lithuania's lowland streams, and were the most frequent aquatic prey of brown trout.

Our investigation was a preliminary study with the aim to characterize mayfly seasonal and diel drift patterns in relation to basic abiotic factors in medium-sized lowland stream in Latvia.

Materials and methods

Study site

The Korge stream is situated in the northern part of Latvia in the North Vidzeme's Biosphere Reserve of the Eastern Baltic. The stream is a tributary of the River Salaca, which is an important river for the natural salmon stocks for the whole Baltic region and it also has a rich lamprey population.

Korge stream is a second-order, fast flowing (mean current velocity ~ 0.4 m/s) and well oxygenated silicious stream with brownish water. Different sized lithal substrates cover the investigated stream reach, and the mean depth is 0.14 m. The catchment's area at the sampling site (24°27′28″ E; 57°45′43″ N) is 126.63 km^2, and is covered with deciduous forests (60%), open grass/bushlands (10%), arable lands (20%) and pastures (10%).

Sampling method

Samples were taken by using a drift net (frame size of 0.25 × 0.25 m^2; mesh size of 0.5 mm) in a riffle section on 18/19 May 2007, 7/8 August 2007 and 29/30 September 2007, for a 30 minute period at 03.00, 06.00, 09.00, 12.00, 15.00, 18.00, 21.00 and 24.00 hour local time. Water temperature (°C) and the light intensity (lux) (lux meter YK-2000 PLX) were measured, as well as the current velocity ("Mini" current meter, model "1205") in front of the drift net.

Seasonal peculiarities

High water conditions were characteristic of May. On 15 May, before sampling, 13.7 mm precipitation was recorded at 6 a.m. and 0.8 mm at 6 p.m. Diatoms, which form gelatinous layers on stone surfaces, dominated in drift samples. Red filamentous algae *Batrachospermum* sp. and *Lemanea fluviatilis* filaments were frequently observed. Low water conditions were present and the riffle was almoust dried up in August. Some filamentous algae (e.g. *Cladophora* sp.) and water moss *Fontinalis* sp. fragments were observed in drift samples. The water level was not significantly above average in September, but there were large amounts of recently fallen tree leaves in the drift samples.

Sample processing

Drift samples were rinsed and placed into 100 ml containers, preserved in 4% formaldehyde and transported to the laboratory, where the laboratory samples were sorted using a stereomicroscope (magnification 7x). Species were identified using following keys: Elliott et al. (1988), Engblom (1996) and Jacob (2003).

Results

Abiotic factors

Mean current velocity at sampling site was 0.37 m/s (SD 0.08) on 18/19 May. The current velocity at the sampling site at riffle was not measured on 7/8 August because of the low water level, but was estimated to be <0.01 m/s. Mean current velocity was 0.46 m/s (SD 0.05) on 29/30 September. Slight fluctuations in current velocity were observed diurnally (Figure 1).

The highest diel fluctuations in water temperature were observed in August (SD 1.10°C) and May (SD 0.99°C) and water temperatures were relatively stable in September (SD 0.35°C) (Figure 2).

Light intensity changed diurnally and seasonally. The highest light intensity (lux) and the longest photoperiod were observed in August. The shortest photoperiod was at the end of September (Figure 3).

Composition of the drift

Larvae of Baetidae, Leptophlebiidae, Heptageniidae and Ephemeridae, belonging to 11 species, were found in the drift samples. Larvae of *Baetis rhodani* (Pictet, 1843) were the most abundant species in the investigated stream reach, but *Baetis fuscatus* (Linnaeus, 1761); *Baetis niger* (Linnaeus, 1761); *Baetis vernus* Curtis, 1834; *Cloeon dipterum* (Linnaeus, 1761); *Centroptilum luteolum* (Müller, 1776); and *Procloeon bifidum* (Bengtsson, 1912) were present in lower numbers. *Habrophlebia lauta* Eaton, 1884 was the second most abundant species, followed by *Habrophlebia fusca* (Curtis, 1834). A few specimens of *Ephemera danica* Müller, 1764 and *Heptagenia sulphurea* (Müller, 1776) were assumed not to be a typical drift component.

Seasonal variations

Several seasonal differences in the mayfly drift were noticed. The last instar *H. lauta* and *H. fusca* larvae were typical in higher number in May than Baetidae species (Table 1). In contrast only individuals of the family Baetidae were collected in

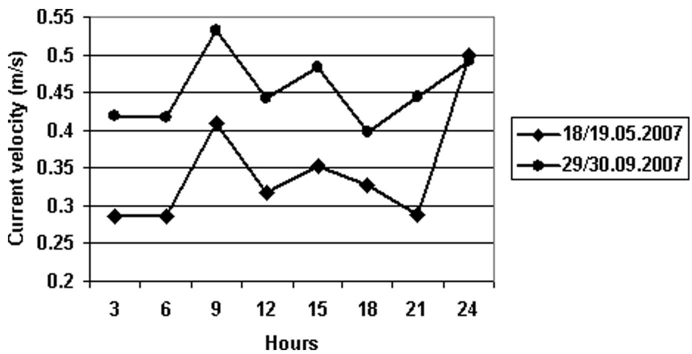

Figure 1. Diel fluctuations in current velocity (m/s) in the sampling site of Korge stream on 18/19 May 2007 and 29/30 September 2007.

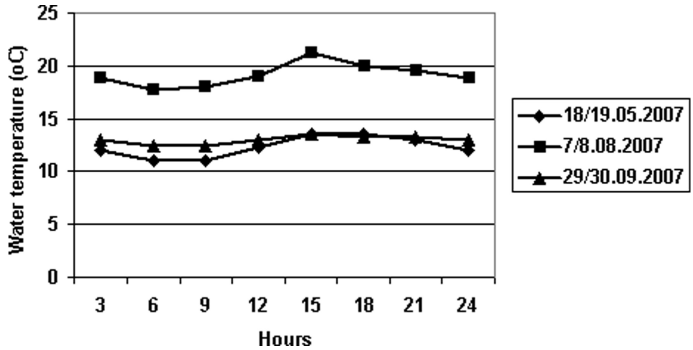

Figure 2. Diel fluctuations in water temperature (°C) in the sampling site of Korge stream on 18/19 May 2007, 7/8 August 2007 and 29/30 September 2007.

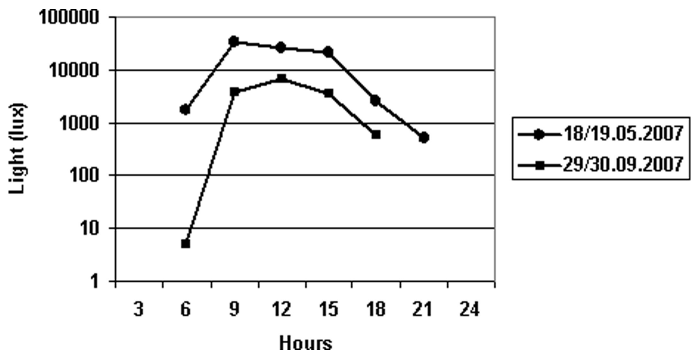

Figure 3. Diel fluctuations in light intensity (lux) in the sampling site of Korge stream on 18/19 May 2007 and 29/30 September 2007.

Table 1. Species composition and total number of individuals collected during the sampling periods on 18/19 May 2007, 7/8 August 2007 and 29/30 September 2007 in the Korge stream.

Taxon name	18/19.05.2007	07/08.08.2007	29/30.09.2007
Baetis sp. juv.	4	130	4
Baetis fuscatus (Linnaeus, 1761)	0	7	2
Baetis niger (Linnaeus, 1761)	0	6	0
Baetis rhodani (Pictet, 1843)	0	110	20
Baetis vernus Curtis, 1834	0	3	0
Centroptilum luteolum (Müller, 1776)	1	0	0
Cloeon dipterum (Linnaeus, 1761)	0	0	1
Ephemera danica Müller, 1764	0	0	3
Habrophlebia fusca (Curtis, 1834)	8	0	7
Habrophlebia lauta Eaton, 1884	18	0	2
Heptagenia sulphurea (Müller, 1776)	0	0	1
Leptophlebiidae Gen. sp. juv.	2	0	0
Procloeon bifidum (Bengtsson, 1912)	0	7	0

August. *B. rhodani* and young instars of *Baetis* spp. dominated (Table 1). The highest species diversity was recorded in September when *B. rhodani* was the most numerous, followed by *H. fusca* and other baetids (Table 1).

Diel variations

Considering the low mayfly drift rates in Korge stream in May and September (Figure 4), insignificant diel variations were observed, with the maximum occurring during the darkest time of the day. Drift rate of mayflies was significantly higher in August with a clear maximum during the darkest time of the day (Figure 4).

Discussion

Abiotic factors

Drift rates did not increase with the increase in discharge, which indicated the dominance of the seasonal mayfly drift pattern. Under natural flow conditions some mayfly species can actively respond to changes in the environmental factors and control their entry into the drift (Cereghino et al. 2004). According to Bis et al. (2000), lowland stream discharge significantly affects food availability, retention and transport of benthic particulate organic matter and the amount of chlorophyll *a*. The amounts of chlorophyll *a* and fine particulate organic matter correlate significantly with the collectors-scrapers functional feeding group (e.g. Ephemerellidae, Caenidae and Baetidae).

Composition of the drift

The diversity of mayfly species in the drift samples was low, considering that 53 mayfly species have been found in Latvia (Poppels 2005). Typical running water species were found on all sampling dates. According to Elliott et al. (1988) Baetidae are basically swimmers or swimmers-climbers, but *Habrophlebia* sp. larvae are sprawlers and climbers. The majority of the species recorded are scrapers and collectors-gatherers.

Seasonal variations

Seasonal peculiarities were mainly determined by individual life cycles of the mayfly species. Considering the high abundance of *Baetis* spp. and *B. rhodani* larvae in

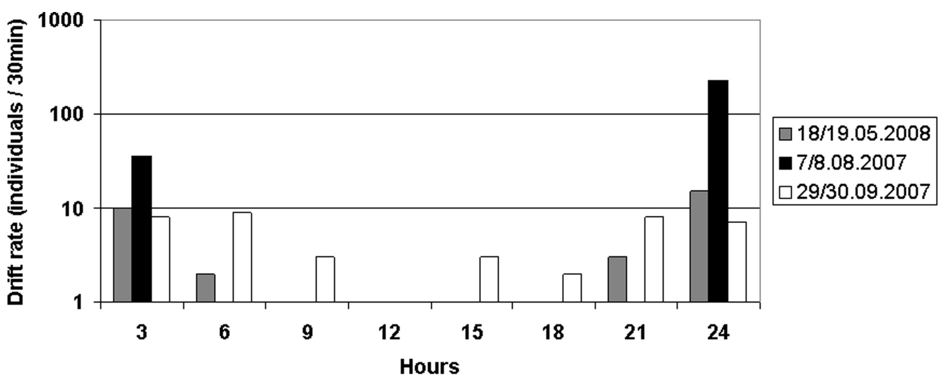

Figure 4. Diel and seasonal patterns of the drift rate on 18/19 May 2007, 7/8 August 2007 and 29/30 September 2007 in the Korge stream.

August, when the last and the first instar larvae were found in the drift samples, this month could be the period of active growth of baetids (Lehmkuhl and Anderson 1972). Thus, the drift pattern could be connected with foraging activities as well as emergence. High baetid densities at low water levels have been observed previously in other studies (Elliott et al. 1988).

Diel variations

We detected only a single baetid drift rate peak in August before the first darkness had set in, but, as was mentioned in other studies, the majority of *Baetis* species have two peaks during the 24 hour observation period (e.g. Allan 1995). These differences can be explained by the different sampling frequency; we sampled every three hours, not hourly.

According to Elliott et al. (1988), feeding on periphyton at night on the top of the stones is characteristic for baetids; some laboratory experiments confirm this hypothesis (Kohler 1985). On the contrary, according to Wilzbach's (1990) field observations, the hypothesis that *Baetis* drift at night because they are searching for food has not been supported. Gut fullness data supported the conclusion that *Baetis* feed continuously and no relationship between diel patterns in epibenthic density and drift was evident for the field enclosures in Wilzbach's (1990) study. The other explanation of the nocturnal increase in baetid drift rate is the avoidance of predation by drift-feeding fish (Mcintosh et al. 2002) and some mayfly species increase their drift rate at the end of their larval life stage and in the presence of predation (Poff and Ward 1991).

Conclusions

Definite seasonal and diel patterns in the mayfly drift were observed in the Korge stream in 2007. It was shown that it was not directly infuenced by primary hydraulic factors e.g. current velocity and discharge, but depended on the active growth period of the mayfly species.

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