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Upstream movement by some Ephemeroptera species

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With 7 figures in the text

Abstract

By an adhesive transparent trap suspended across a Danish lowland river valley swarming subimagines and imagines of the Ephemeroptera *Caenis rivulorum, Baetis* spp., and *Ephemerella ignita* were caught. The number trapped on the upstream and downstream facing side respectively have been interpreted as a reflection of the number flying downstream and upstream the river respectively. The imagines showed a very pronounced upstream movement, while the subimagines moved more or less in both directions.

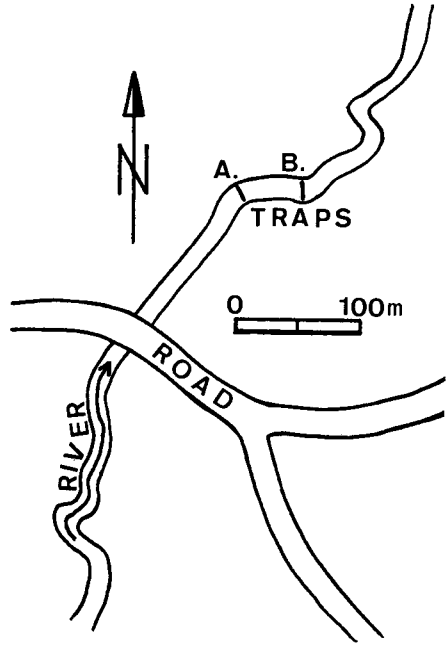

Fig. 1. Outline of the part of stream, Sønderup å, where the traps A and B were placed.

Introduction

The upstream movement of eggbearing females of stream dwelling insects is often considered as a compensation of the downstream drift of the younger stages (MÜLLER, 1953). Direct and indirect evidence for this view are summarized in WATERS (1972). Recently, a complete colonization cycle for the Plecopteran Brachyptera risi has been demonstrated (MADSEN & BUTZ, 1976; MADSEN, 1976).

In the present paper, we shall describe some results from an investigation of the movement of some Ephemeroptera species in a Danish river (fig. 1). A short summary of the results has been published in MADSEN et al. (1973).

Methods

Transparent, adhesive traps of the type described in MADSEN et al. (1973) were suspended across the river (fig. 2) at station B in June, and station A in July, August, and September 1972. Trapped individuals of *Baetis* and *Ephemerella ignita* were removed from the traps over the nine sampling periods given in fig. 3. Individuals of *Caenis* were, except for a few hundred, not removed but counted on the trap which was taken to the laboratory. The lower edge of the trap was 80 cm above the waterlevel, the height of the adhesive part of the trap was 60 cm and the width about 400 cm except in September when the width was 75 cm. The catches were not corrected for differences in trap size or for differences in the lengths of the sampling period, except in the histograms of fig. 3.

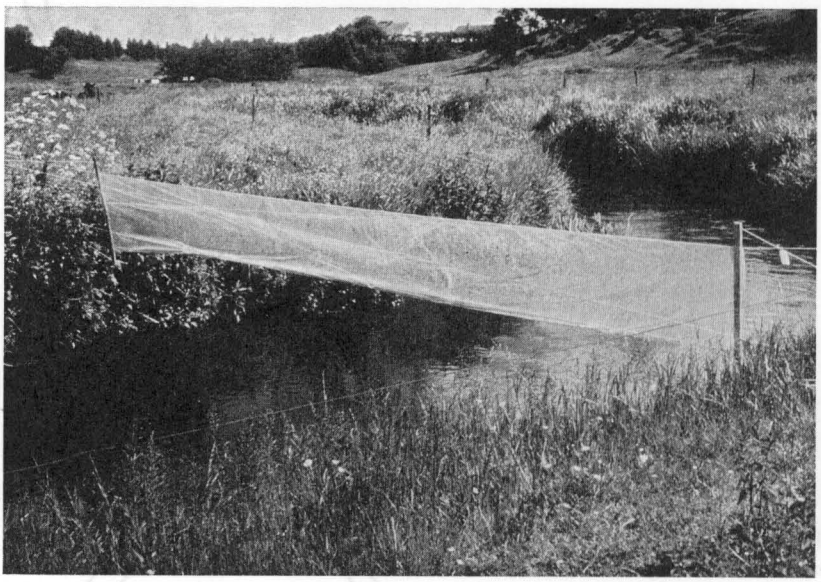

Fig. 2. A trap suspended across the stream.

For each sampling period, information of the wind direction was obtained from observations made by the Danish Meteorological Institute (fig. 4). The distribution of catches across the stream was investigated by dividing the trap into vertical strips, each 25 cm wide, and counting the Ephemeroptera in each strip. A non-parametric Mann-Whitney U-test was used to analyze differences in numbers and proportions on the downstream and the upstream-facing sides of the trap. Spearman Rank test was used in the correlation analysis, and the significance level in all tests was $P \leq 0.05$.

The locality

The investigations were made in the summer of 1972 at Sønderup å, a stream in the eastern part of Jutland, in the province of Himmerland. At the locality where the trap was located, the stream is about 5 m from bank to bank and meanders across a wide meadow. The current is fast, the bottom consists of sand and gravel, and the water depth is 20 to 25 cm. The uniform surroundings were important for selecting that part of the stream, and there are no woods, steep banks or other irregularities.

Results

The species

As adults of *Caenis* are so delicate, it was almost impossible and very time consuming to remove them undamaged from the traps. For a closer determination, a total of 229 were carefully removed so that they could be determined to species, sex, and egg status. They were all *C. rivulorum*,

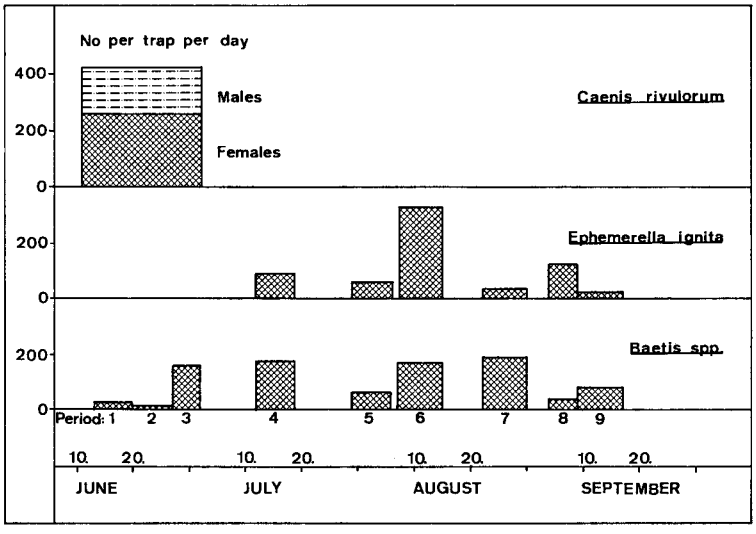

Fig. 3. Number of individuals per trap per day in the 9 sampling periods.

a species typical of Danish rivers and with a very restricted flying season (JENSEN, 1956). All individuals of *Caenis* trapped in the beginning of the season were assumed to be that species. Later in the season, some individuals of other *Caenis* spp., which are typical of standing water, were trapped. Of the 229 individuals examined, 60 % were females, all with eggs, and this proportion was assumed to be representative of the total number of 9356 individuals trapped.

A total of 6925 imagines and 818 subimagines of the genus *Baetis* were trapped. They were not determined to species but at least 3 were present: *B. rhodani, B. vernus*, and *B. macani*. Of the subimagines in the catches 44.7 % were females and 97.1 % of the imagines were females with 97.2 % of these bearing eggs. All the males caught were heavily parasitized by Nematodes!

A total of 4815 imagines and 550 subimagines of *Ephemerella ignitta* were trapped, and 67.3 % of the subimagines were females whilst 99.7 % of the imagines were females. No egg status was recorded because the females easily lost their egg packet.

The temporal distribution of females in the catches is shown in fig. 3. All values are given as number of individuals trapped per day. *C. rivulorum* was restricted to a short period and was succeeded by *E. ignita*. This species occurred until the end of the investigation with its main peak in the beginning of August. The *Baetis* species were trapped throughout the study. It is probable that there is a succession of species, but no effort was made to make a closer determination of the material. Most of the individuals were so damaged that a species determination would be uncertain. The occurrence of male imagines and of male and female subimagines of *Baetis* sp. and *E. ignita* coincided with the occurrence of females.

Upstream — downstream distribution of the catches

75.8 % of *C. rivulorum* were caught on the downstream facing side of the trap.

73 % of all the egg bearing females of *Baetis* were caught on the downstream-facing side of the trap. The proportion of the egg bearing females on the downstream-facing side of the trap for each sampling pereiod is given in fig. 4. The median value for the samples from the downstream-facing side was significantly larger than that for the samples from the upstream-facing side (MANN-WHITNEY U test, $p < 0.001$). Of the 818 subimagines in the catch, 40.7 % were from the downstream-facing side. The proportion of the catches between the two sides varied throughout the season, but the median value for the catches on the downstream-facing side was significantly smaller than that for catches on the other side ($0.01 < p < 0.05$). In the catches of female subimagines, there was no

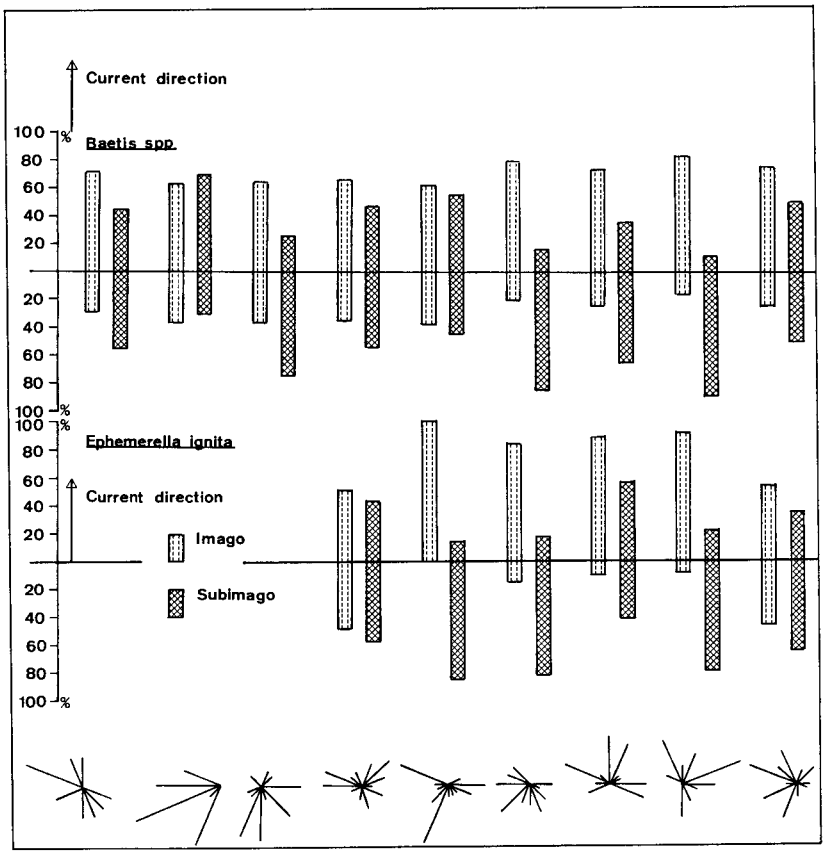

Fig. 4. The distribution of the catches of *Ephemerella ignita* and *Baetis* spp. on the two sides of the traps during the sampling periods 1—9. Wind condition given in the diagrams at the bottom, where each line represents the relative distribution of wind direction.

significant difference between median values for catches from the two sides ($p < 0.05$).

80.3 % of all the trapped females of *E. ignita* were caught on the downstream-facing side of the trap. This pattern applies to all samples.

The largest proportion of the subimagines was trapped on the upstream-facing side of the trap, but when the catches of female subimagines were taken separately there was no significant difference between median values for the two sides ($p > 0.05$). The relative proportions of the two catches on either side of the trap varied during the sampling season. There was a tendency to a positive correlation between the relative proportions of the catches of *E. ignita* and *Baetis* on the downstream-facing side of the trap (fig. 5). This applied to female imagines as well as to female

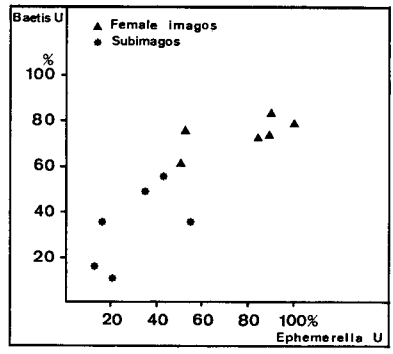

Fig. 5. Correlation between the proportions of *Baetis* spp. and *Ephemerella ignita* caught on that side of the traps catching individuals having upstream directed movement. U = upstream moving individuals.

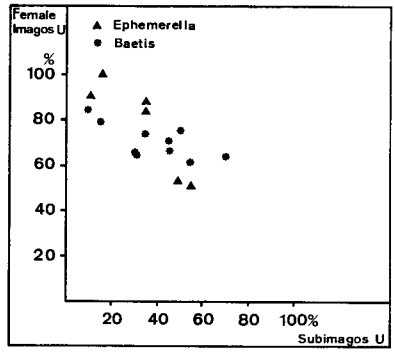

Fig. 6. Correlation between proportions of female imagines and subimagines of *Ephemerella ignita* and *Baetis* spp. on that side of the trap catching individuals having upstream directed movement. U = upstream moving individuals.

subimagines. The number of samples common to the two species were too small to give a significant correlation. There was a negative correlation ($r_S = 0.67$, $p < 0.05$) between the proportion of females and subimagines of *Baetis* spp. trapped on the two sides of the sheet (fig. 6). The same tendency was seen in *E. ignita* but the number of samples were too small to give a significant correlation coefficient.

Distribution of catches across the trap

The distribution across the trap of the number of the total catch of *C. rivulorum* and one catch of *Baetis* spp. is shown in fig. 7. The maximum number of *Baetis* on the downstream-facing side of the trap was in the centre. For *C. rivulorum*, it is seen that by far the largest part of the catch was on the left side of the trap when seen in the upstream direction.

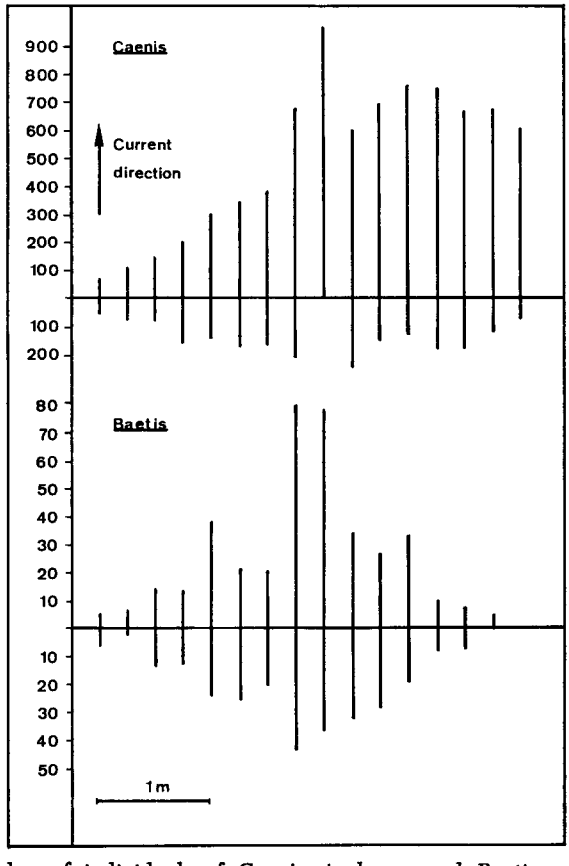

Fig. 7. Number of individuals of *Caenis rivulorum* and *Baetis* spp. caught in each 25 cm vertical strip of the trap.

Discussion

The size and composition of the catches from the traps reflected the activity of the different types of the flying stages of the Ephemeroptera species. If the large number of adults of *C. rivulorum* had the same sex distribution as the small sample, then there was a striking difference between the behaviour of this species and the other two species. In *C. rivulorum*, both males and females swarm, while in the other species it is almost exclusively the females which swarm. The catches of imagines flying upstream were significantly higher than those of imagines flying downstream. These observations are in agreement with several visual observations made at several occasions at many streams in Jutland. *C. rivulorum* has been seen in dense swarms flying upstream, but occasionally weak winds push a swarm backwards. *Baetis* and *E. ignita* are very often seen flying upstream, but never in swarms as dense as those

of *C. rivulorum*. *E. ignita* is normally seen flying upstream, carrying its heavy egg load, near sunset in calm weather. The observations are in accordance with those described by JENSEN (1956).

The catches on the two sides of the trap can be composed by individuals having a directional flight upstream or downstream, individuals swarming in random directions in relation to the stream direction, and individuals blown in by the wind. Information on the prevailing wind directions is given in fig. 4, but is of limited use since it is not known at which wind direction the swarming has occurred. What can be seen is that the wind is highly variable, and that there is no prevailing wind in an upstream or downstream direction. The influence of the wind as a factor influencing the flight direction of the Ephemeroptera and other stream dwelling insects has been discussed several times.

Ross (1957) assumed that a weak downstream wind, caused by the shape of the river valley, guides the insects upstream. ELLIOTT (1967) has observed that the flight direction of Ephemeroptera from an upper moorland stream is the same as the direction of the wind. SÖDERGREN (1971) has observed that *E. ignita* flies against the wind.

The observations of the present study show that there is a net upstream movement of the female imagines of Ephemeroptera in Sønderup å, and when the highly variable wind directions are taken into consideration, it seems highly improbable that the wind direction could have a major influence on the flight direction. However, it must be emphasized that there was no detailed analysis of the relationship between wind direction and the number of inviduals caught on the trap. Wind observations, as well as the catches on the trap, are pooled for each sampling period.

It appears from fig. 5 and 6 that there is a correlation between the catch sizes of *Baetis* spp. and *E. ignita* from the same side of the trap. Even if this correlation is not statistical significant, it may indicate that there is an external factor, e.g. wind having an influence on the size of the catches of the different species.

The subimagines of *Baetis* spp. and *E. ignita* have a behaviour quite different from the imagines. The catches of subimagines were much smaller than those of imagines, indicating a low flight activity. A much larger proportion of the subimagines are males, and the proportions caught on the two sides are highly variable. They show a distribution opposite to that of the female imagines, and the female subimagines occur in similar proportions on the two sides. It is probable that the numbers of subimagines on the two sides of the trap just reflect the number of individuals caught during random swarming and blown in by the wind.

The negative correlation between size of the catches of female imagines and subimagines on the same side of the trap can be interpreted

as support for the idea that a downstream wind has a positive influence on the upstream movement of the female imagines.

The importance of the observation that all the trapped male imagines of Baetis were parasitized is uncertain.

Conclusion

From this study is concluded that male and female imagines of *C. rivulorum*, and female imagines of several *Baetis* species and *E. ignita* have a net movement which is in the upstream direction.

Zusammenfassung

Durch ein adhäsiv wirkendes, durchsichtiges Fangnetz, das über den dänischen Flachlandsbach Sønderup Å gespannt war, wurden die schwärmenden Subimagines und Imagines der Ephemeropteren *Caenis rivulorum, Baetis* spp. und *Ephemerella ignita* gefangen. Die in Richtung stromaufwärts bzw. stromabwärts auf dem Netz gefangenen Tiere wurden jeweils als repräsentativ für die in den gleichen Richtungen geflogenen Individuen angesehen. Die Imagines zeigten eine sehr ausgesprochene Bewegung bachaufwärts, während die Subimagines sich mehr oder weniger in beiden Richtungen bewegten.

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