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Emergence behaviour of some mayflies and stoneflies (Insecta: Ephemeroptera and Plecoptera)

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With 5 figures in the text

Introduction

A very important but also very dangerous step in the life of mayflies and stoneflies is the change from the stage of the aquatic larvae to that of the terrestrial adult. There are three different points, which might lead to casualties:

(1) an unsuccessful hatching,
(2) predators as fish or birds,
(3) unfavourable weather conditions as cold, heat or rain.

As I observed during my studies, the first two points together will reduce the emerging population not more than 10—20 %. So they are not a vital danger for the surviving of the species. But unfavourable weather conditions as frosty nights, heat or heavy rain could probably damage or even extinguish the population of the imagines present at this moment.

In this work the influence of different parameters as light intensity, water temperature and weather conditions on emergence was studied for answering the question, whether aquatic nymphs are able to choose the best moment for emergence, so that the adults will find most favourable conditions for surviving.

It is known from literature (MUELLER 1970, 1973 and others), that ephemeropteran larvae are night-active. We wanted to know, whether emerging nymphs follow a similar rhythm or whether and how they change it.

Method and site of study

This problem was studied in the river Toess, a subalpine river in the eastern part of Switzerland. The altitude is 480 m above sea level and the total width is 20 m. The normal discharge is about $1\ m^3 \cdot s^{-1}$. In times of flooding this value rises up to $150\ m^3 \cdot s^{-1}$.

Following the proposals of MACAN (1964) and MUNDIE (1964) six pyramidal traps with an area of $1\ m^2$ each were used. Floats on two sides kept the traps on the surface of the water. The traps were anchored to keep position. The animals caught in these traps were collected once every two hours.

Results

All ephemeropteran nymphs emerged in all observation periods only during the day between sunrise and sunset.

The period shown as an example in Fig. 1 started after some very sunny days with high water temperature. The rate of emerging mayflies was rather high. But as soon as the solar radiation and the water temperature decrease, also the rather high emergence rate of e. g. *Baetis rhodani* decreases significantly.

In Fig. 2 the contrary effect is shown. After two preceding days with rainfall and low solar radiation the rate of emerging nymphs was very low. On the first day with improv-

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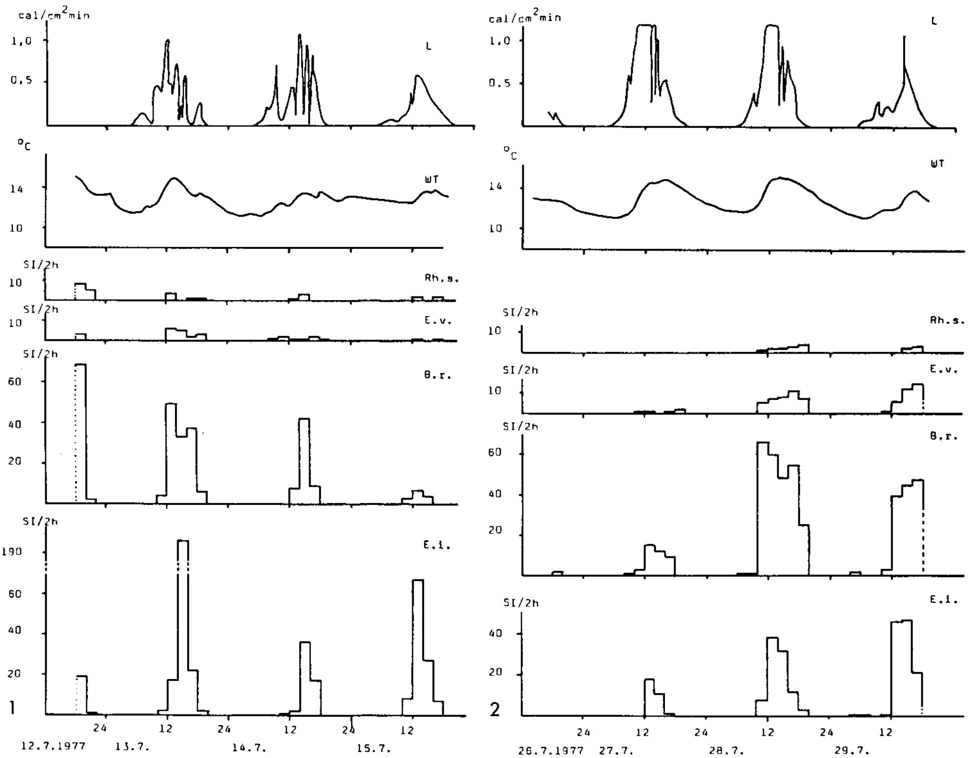

Fig. 1 and 2. Emergence activity in relation to light intensity (L) and water temperature (WT) of *Rhithrogena semicolorata* (Rh. s.), *Ecdyonurus venosus* (E. v.), *Baetis rhodani* (B. rh.) and *Ephemerella ignita* (E. i.).

ing weather conditions the rate of emergence did not change. It lasted till the second sunny and warm day before the rate of emergence increased very much. Other ephemeropteran species showed similar patterns.

Comparing the total of all emerged ephemeropteran subimagines with the total solar radiation shows no significant correlation (Fig. 3 a), but regarding only the days with low radiation, there exists a significant correlation. In Fig. 3 b the emergence rate shows a highly significant correlation with the solar radiation of the preceding day. This correlation was also confirmed for three of four studied mayfly species.

So the solar radiation of the preceding day, which characterizes the weather conditions and the water temperature, can therefore influence the rate of emerging nymphs in some ephemeropteran species. It can also be shown, that the radiation of the preceding day influences the beginning of the emergence, the time of the maximum of emergence and the duration of emergence (Riederer 1981).

These results led us to the diagramm in Fig. 4, in which possible ways of decisions until emergence can happen or not are combined (see also Elliott & Humpesch (1983).

In our study we could also observe three species of *Leuctra: L. albida* Kmp., *L. moselyi* Morton, *L. fusca* L. All three species had the same behaviour, they emerged only at night. Emergence began about two hours after sunset and ended between 4 and 6 a. m.

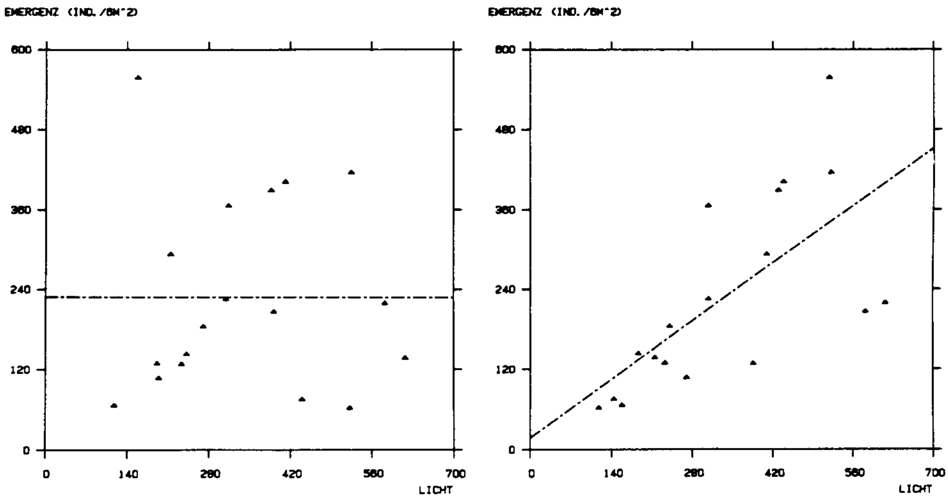

Fig. 3. Total emergence of Ephemeroptera in relation to the solar radiation of the actual day (left) and the preceding day (right) in cal · cm^{-2} · day^{-1}.

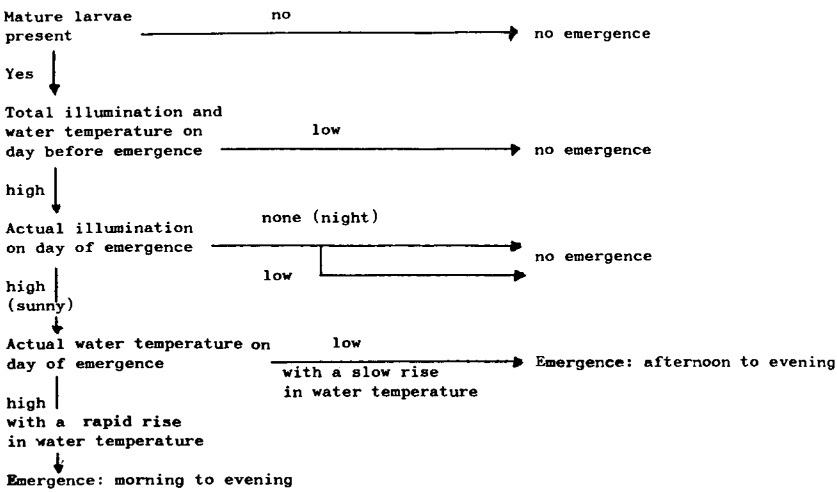

Fig. 4. Diagram for the emergence of ephemeropteran nymphs.

(Fig. 5). These stoneflies showed too a distinct reaction on the water temperature of the preceding day. At higher temperatures the maximum of emergence was before midnight, at lower temperatures it was retarded until the second half of the night.

Several species of Plecoptera, which emerge in spring, could be observed emerging and hatching during the day as for example *Amphinemura sulcicollis* Steph., *Protonemura intricata* Ris, *Isoperla grammatica* Poda and *Siphonoperla torrentium* Pictet.

What is now the reason for the different time for the emergence in spring and in summer?

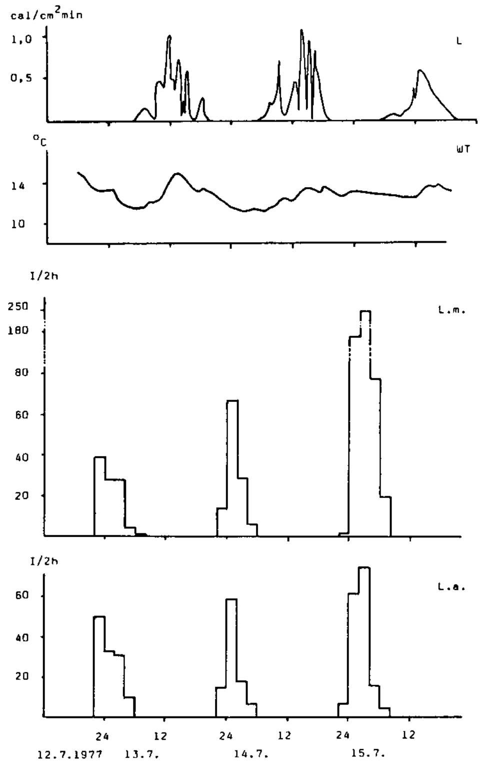

Fig. 5. Emergence activity in relation to light intensity (L) and water temperature (WT) of *Leuctra moselyi* (L. m.) and *Leuctra albida* (L. a.).

In spring air temperatures were low during the day and humidity was high, whereas at night it was very cold or even frosty. The conditions for a successful emergence were therefore better during the day. In summer air temperatures raised during the day very high and humidity decreased. In the night conditions are therefore much better for these insects, which need at least ½—1 hour from leaving the water for hatching and until their new cuticula has hardened enough for building up a sufficient protection against drying up (see also Brinck 1949).

On the contrary, ephemeropteran nymphs are able to emerge and hatch within seconds or at most in few minutes and to fly immediately to the riparian vegetation to find cover. From this reason they are able to emerge even in summer during the day at higher temperatures.

In answering the questions, asked in the beginning, we can conclude, that these animals are capable to choose the time of emergence according to the environmental conditions in the way, that the adults have a good chance to mate and deposit their eggs successfully.

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