Oikos 20: 553–557. Copenhagen 1969

Upstream movements of insects in a South Swedish small stream

LENNART HULTIN, BO SVENSSON and STAFFAN ULFSTRAND
Department of Animal Ecology, University of Lund

1. Introduction

A number of amphibiotic insect species inhabiting lotic biotopes have been shown to perform a "colonization cycle" (Müller 1954), consisting of downstream transport in the juvenile stages (drift) and upstream movements in the aerial adult stages (Roos 1957, Elliott 1969). In organisms lacking an aerial life stage, such as Turbellaria (Steinmann 1913), Amphipoda (Minckley 1964, Lehmann 1967, Hultin 1968) and Isopoda (Thomas 1969), both upstream and downstream movements under the water have been recorded. Only recently was it realized that also in certain amphibiotic stream inhabitants, upstream movements are carried out under the water, i.e. during the juvenile stages of the species (Bishop and Hynes 1969, Schuhmacher 1969).

2. Study area

The present work has been carried out in a small stream about 30 km SE of Lund in South Sweden (approx. 55°35′N, 13°30′E). The stream runs from hilly country with much agriculture through some woodland areas (Fig. 1). The average flow volume is 0.1 m^3/sec., but the flow is rapidly and strongly fluctuating (Fig. 2 A). Because of the small quantity of water, diel and daily changes in water temperature are also large, but as a whole the stream may be regarded as relatively cool, receiving a great deal of ground water (Fig. 2 B). Temporarily the water has been polluted, leading to considerable losses in some animal populations, but nevertheless the stream is known to harbour a comparatively rich animal community. In terms of numbers, the dominating species is the amphipod *Rivulogammarus pulex* L.

3. Methods

One of us (L.H.) has been conducting an investigation of the population of *Rivulogammarus pulex* inhabiting the stream. For this purpose a trap was installed to collect the upstream moving amphipods making use of their tendency to move into small trickles entering the main stream. The trap is described and illustrated in Hultin (1968) where some preliminary figures of the number of amphipods obtained indicate the efficiency of the apparatus. The trap is combined with Müller's (1965) automatic stream drift sampler permitting a division of each diel's catch into 2-hr. portions. The trap was slightly heated in winter to prevent freezing. Still the temperature of the water running through the trap was the same as that of the stream water. The trap is covered with a shelter of transparent PVC. Animals cannot enter the trap otherwise than moving up the entrance.

Besides amphipods a large number of insects have been obtained in this trap. These are the subject of this report.

The nomenclature follows Limnofauna Europaea (Illies 1967) except for the genus *Potamophylax*, for which a revision by Neboiss

Manuscript accepted August 1969.

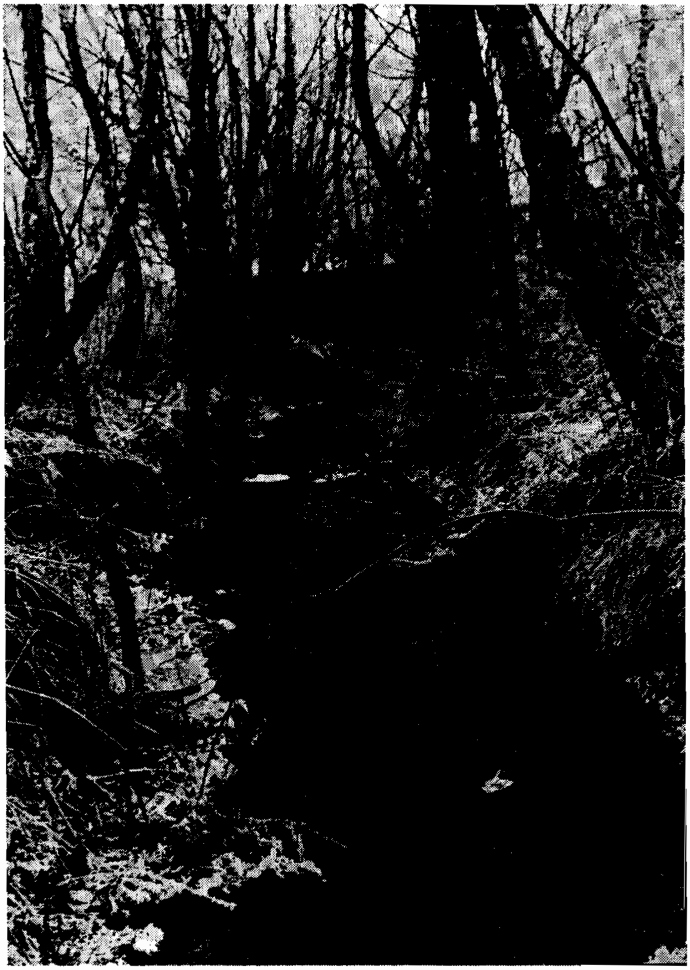

Fig. 1. View of the stream in which the trap was installed. December 1968. Photo B. Svensson.

(1963; cf. Tobias 1969) has necessitated certain changes.

4. Results

In Fig. 3 the numbers of insects obtained in the trap are shown for each month from March 1968 to May 1969. The graph is based on a total of 4205 specimens.

All the species involved display distinct seasonal fluctuations in upstream movement activity, as reflected in the quantities taken in the trap.

Nemoura flexuosa Aub. (Plecoptera) shows a winter peak and is absent from the trap for some months following its vernal flight period (Brinck 1949). *Baetis rhodani* Pict. (Ephemeroptera) on the other hand was trapped in largest numbers in summer and was scarce or absent during the winter months. In July to September large numbers of very small nymphs were taken; they were not counted and are not included in the graph. These small nymphs may be hatched from newly laid eggs, but considering the protracted hatching period demonstrated for *Baetis* by Illies (1959) this is not certain. Half-grown or larger nymphs

Fig. 1. View of the stream in which the trap was installed. December 1968. Photo B. Svensson.

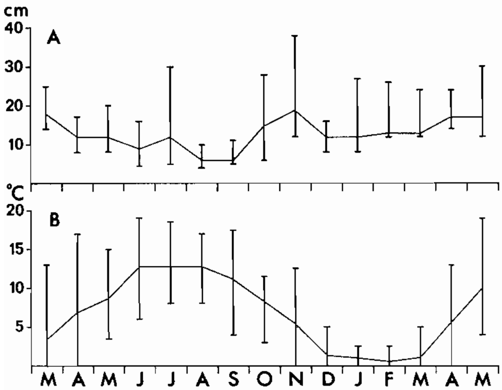

Fig. 2. A. Monthly values of water level near trapping point. B. Monthly values of water temperature near trapping point. In both cases, mean, maximum and minimum are entered.

are present in the stream throughout the year but were trapped almost exclusively in the period during which the species has its flight period.

Overwintered adults of *Velia caprai* Tam. (Heteroptera Veliidae) were taken from March, and the new generation appeared in the catch from May. The young animals grew rapidly and were classified as adults from September. In winter, and particularly when the stream was frozen, no specimens were trapped.

The large larvae of *Potamophylax cingulatus* Steph. (Trichoptera) were taken chiefly in May through July. Its flight period at this locality is concentrated mainly to September (Ulfstrand 1969). Thus the upstream movements were carried out mainly by individuals shortly before most of them were to pupate. Some larvae overshoot the normal period of pupation and emergence, so that large larvae are present all through the year; still very few were obtained in the trap during winter. A few speciments of *Potamophylax nigricornis* Pict. and *Halesus radiatus* Curt. are here included.

The material of *Rhyacophila fasciata* Hag. (Trichoptera) is too small to permit detailed discussion. About one third of the specimens were obtained in August. This species has a very long flight period at this locality, without any marked culmination (Ulfstrand op. cit.).

Larvae of *Elodes minuta* L. (Coleoptera Elodidae) were taken in March to June, with

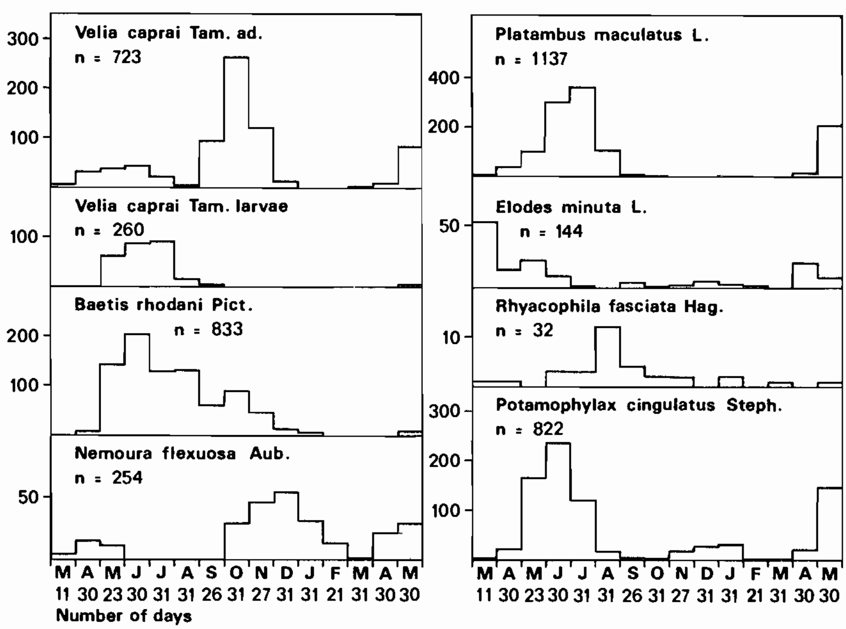

Fig. 3. Monthly numbers of insects obtained in the trap.

many more in 1968 than in 1969. In *Platambus maculatus* L. (Coleoptera Dytiscidae), only adults were obtained, chiefly in May to August.

In addition to the animals included in Fig. 3, small numbers were taken also of the following species:

Plecoptera: *Taeniopteryx nebulosa* L.;

Coleoptera: *Hydroporus discretus* Fairm., *H. memnonius* Nic., *Agabus bipustulatus* L., *A. chalconotus* Panz., *A. guttatus* Payk., *A. paludosus* F., *Ilybius fuliginosus* F. (Dytiscidae); *Hydraena gracilis* Germ. (Hydraenidae); *Anacaena globulus* Payk., *A. limbata* F. (Hydrophilidae); *Elmis aenea* P. Müll., *Limnius volckmari* Panz. (Elminthidae).

5. Discussion

The present results affirm the conclusion reached by Bishop and Hynes (1969) that upstream movements under the water are a significant component of the dynamics also in such amphibiotic insects that, during their aerial life stages, are capable of flying upstream.

The data also agree with the results by e.g. Müller (1966) and Ulfstrand (1968) that in many species the movements are concentrated to a short period within their life cycle. Frequently this is the period shortly before pupation or emergence.

The ecological significance of downstream and upstream movements is certainly different for different lotic populations and biotopes (cf. Elliott 1967, 1968, Ulfstrand 1968). Positive rheotactic behaviour seems to be very common among lotic species, but this does not necessarily lead to large-scale and long-range upstream movements. The more frequently a species takes part in downstream drift, the more important is the development of a reaction pattern involving compensatory upstream movements. This is true whether the downstream movements are a reaction to certain environmental factors (abiotic or biotic), i.e. are "active", or they are due to the temporary inability of the animals to resist the force of the current, i.e. are "passive". In point of fact evidence is accumulating for the existence of both phenomena. Dimond (1967) and Elliott (1967) both agree with Müller (1966) that population density is important for the release of drift, while Elliott (1969) provided examples of "catastrophic" drift in connexion with heavy spates.

Movements up and down the stream may, in extreme cases, take the shape of the "colonization cycle" sensu Müller (1954). The upstream movements are then performed by egg-bearing females, so that, on average, the new generation starts its development higher up in the stream system than the zone where their parents concluded their juvenile life stage. True colonization cycles are, thus, restricted to amphibiotic species. This pattern would be of particularly great importance in large and rapid water-courses.

However, for a more detailed analysis of the whole problem of the movements of lotic species fuller data for a wider selection of species are required.

A trap such as ours cannot be expected to yield a complete picture of the upstream movements. As pointed out by Bishop and Hynes (op. cit.) the position of the trap in the stream has a strong influence on the catch. Our trap was placed near the stream bank where the upstream moving *Rivulogammarus pulex* are most abundant. Judging from field observations, the larvae of *Potamophylax cingulatus* also prefer the zone near the banks. It is possible, however, that certain animals avoid the special conditions prevailing at the trap entrance and refrain from entering. A great deal of effort is required on the part of the animals to ascend the trap entrance, so that the active element in the movement pattern is demonstrated in a very cogent way.

6. Abstract

In a trap designed to collect upstream moving amphipods a large number of insects were obtained, both juvenile and adult stages. Also in amphibiotic insects under-water movements in upstream direction are important. The significance of such movements within the general pattern of population dynamics in lotic species is discussed. The upstream movements of each species were restricted to a limited part of the year.

7. Acknowledgements

We are grateful to Professor Per Brinck for stimulating discussions, to Dr. h. c. Ruben Rausing for giving us access to various facilities on his property, to Mr. Hans Olsson and Mr. Kjell Svensson for practical assistance and to Mrs. Astrid Ulfstrand for preparing the graphs.

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Fil. mag. L. Hultin, fil. kand. B. Svensson and Dr. S. Ulfstrand
Zoological Institute
Helgonavägen 3
S-223 62 Lund
Sweden