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EVIDENCE OF UPSTREAM MIGRATION BY FEMALE ADULTS OF BAETIS ALPINUS PICT. (EPHEMEROPTERA) AT HIGH ALTITUDE IN THE PYRENEES

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In a high mountain stream, *Baetis alpinus* at emergence is significantly smaller downstream than upstream. These size differences are used to demonstrate migration of adults upstream : downstream, the size of adult females caught after oviposition corresponds with the size of subimagines which have emerged there ; upstream, the size of adult females corresponds with the size of subimagines which have emerged both up and downstream. The migration is clearly an upstream movement.

Migration vers l'amont des imagos femelles de Baetis alpinus Pict (Ephemeroptera) dans un vallon pyrénéen de haute montagne.

Dans un torrent de haute montagne, la taille de *Baetis alpinus* à l'émergence est significativement plus petite en aval qu'en amont. Ces différences de taille permettent de mettre en évidence une migration vers l'amont des adultes : en aval, la taille des adultes femelles capturées après leur ponte correspond à celle des subimagos qui ont émergé sur place ; en amont, la taille des adultes correspond à celle des subimagos issus de l'ensemble du cours. La migration est nettement orientée vers l'amont.

Introduction

Since the hypothesis put forward by Muller (1954) of a colonization cycle where adult females fly upstream to lay their eggs and the larvae drift gradually downstream, many field observations and laboratory experiments have attempted to demonstrate the phenomenon by clarifying aerial movements (Roos 1957, Lehmann 1970, Elliott 1971, Muller 1973, Russev 1973, Madsen et al. 1973, Svensson 1974). In this study, variations in size shown by imagines and subimagines at different sites are used to demonstrate upstream movements of female adults of *Baetis alpinus*, a common species of Ephemeroptera in high mountain streams.

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Study area and methods

A detailed description of the stream system, Estaragne, has been given elsewhere (Lavandier 1974). The main stream rises as a spring at 2 380 m and flows for 2,75 km before entering lake Oredon (1 850 m). Two zones can be separated on either side of a glacial rise (2 100-1 950 m). In the upper part the drainage basin is rocky, barren of much vegetation and enclosed by peaks. In the lower part the basin is more open towards the eastern side and is partially wooded. The stream is covered with snow for 4-8 months of the year according to altitude. Under the snow, temperatures are closed to 0 °C ; they can reach 13 °C at the lower end of the stream in summer.

Five sites were studied (*fig.* 1) : station 1, near the mouth at 1 850 m and station 2, just below the glacial rise at 1 920 m, represent the lower zone ; station 3, just above the glacial rise at 2 150 m, station 4 at 2 190 m and station 5 near the source at 2 370 m, represent the upper zone.

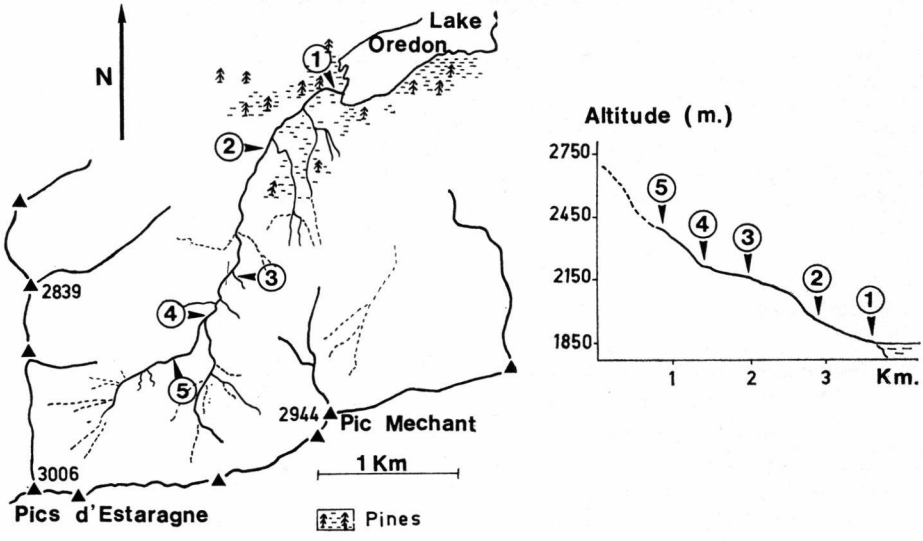

FIG. 1. — Map and profile of the river Estaragne. Location of the stations.

The fauna was studied from 1971 to 1973 during the periods when the stream was accessible (june-november below 1 950 m ; july-november above 2 100 m).

More than 2 000 imagines and subimagines were caught using nets, emergence traps and drift nets. These latter, used weekly, allowed a large number of emerging subimagines and adult females carried down by the current after oviposition to be collected.

Results

Many subimagines were collected in the whole of the stream system except near the source where only 1 or 2 individuals were caught every year. The size of the subimagines, which depends on the characteristics of development (Lavandier 1979) increases from mouth to source (*fig.* 2). The differences between mean sizes are very highly significant

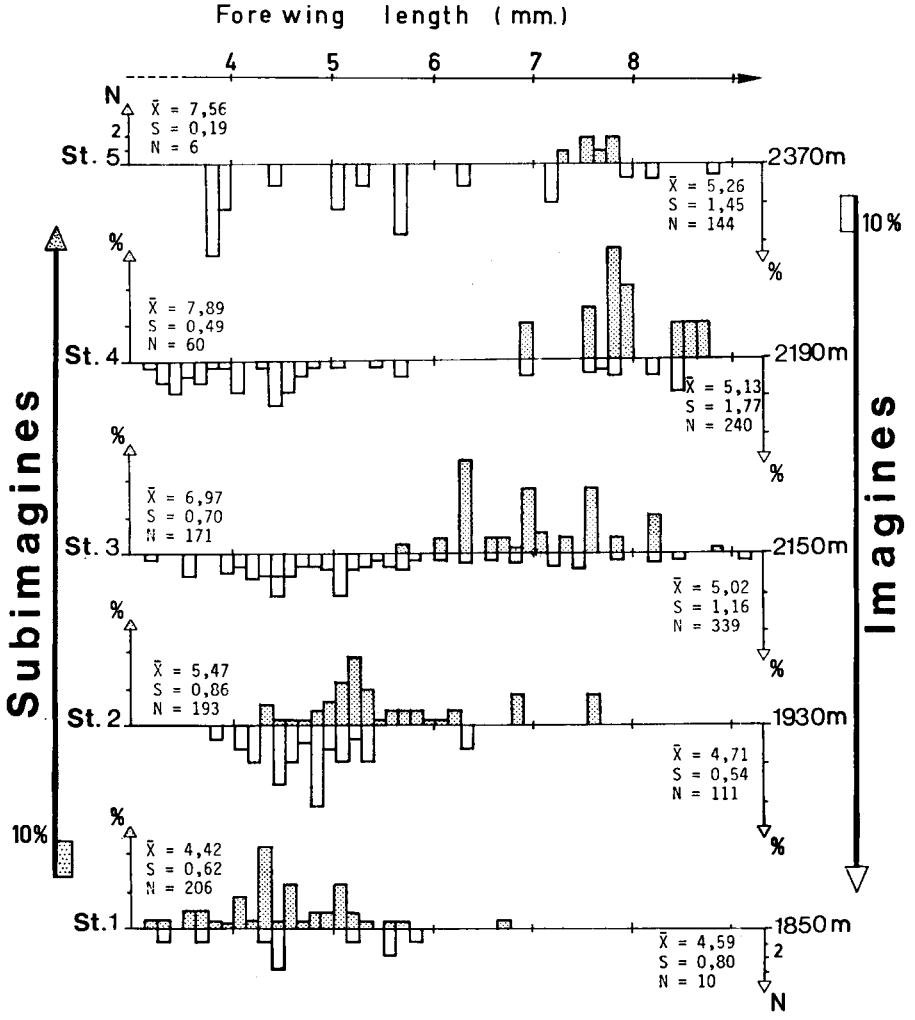

FIG 2. — Size frequency distribution of female imagines (white) and subimagines (grey) caught at the five sites studied along the stream. Size = forewing length in mm.

Mean size ($\bar{X}$) standard deviation (S) and number of individuals (N) are shown for each histogram.

(t-test) and, more specially, two groups of emerging subimagines can be distinguish on either side of the glacial rise : subimagines are smaller below 1 950 m than above 2 100 m.

The size of adult females, collected in a drift net after oviposition, shows the same changes according to altitude. Adult females are small in the lower part of the stream ; mean size is larger in the upper part, where size range is larger. The variances of the populations collected upstream and downstream are significantly different (F-test, $P = 0{,}01$).

Aerial movements may be deduced by comparing the size of subimagines at the localities where they emerge (starting place of the migration) with the size of imagines at the localities where they lay their eggs (end of the migration) (*fig.* 2). At the lower sites, below 1 950 m, the size of adult females corresponds with the size of subimagines which have emerged there. Above 2 100 m, the size range of adults corresponds with the size of the subimagines which have emerged both up- and downstream. This demonstrates an aerial movement upstream which seems important in the Estaragne system. The migration is clearly upstream : • the small adults which come from the lower part of the system are the most numerous at all the altitudes ; thus, at every station, the mean size of the imagines is significantly smaller ($P = 0{,}001$) than that of the emerging subimagines ; • although few subimagines have emerged near the source, many adults have been caught ; although many subimagines have emerged near lake Oredon, few adults only have been caught ; • again, no large adult emerging above 2 100 m, has been caught in the lower part of the river.

Conclusion

Adult females of *Baetis alpinus* clearly show an aerial movement upstream, followed by oviposition. Such a behaviour, developed to a considerable extent in the Estaragne system, explains the presence of adults and nymphs in habitats where no or only few individuals are able to complete their life cycle. This contributes further evidence to the importance sometimes attributed to adult migration in the ecology of certain streams and mountain torrents (Roos 1957, Dorris et Copeland 1962, Ulfstrand 1968, Hynes 1970, Schwarz 1970, Pearson and Kramer 1972, Madsen et all. 1973, Thomas 1975, Lavandier 1979) and supports the colonization-cycle hypothesis of Muller (1954).

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