LIFE CYCLE AND PRODUCTION OF *Ephoron virgo* (EPHEMEROPTERA: POLYMITARCIDAE) IN THE LOWER RIVER EBRO (NE Spain)

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ABSTRACT

Life cycle, production and emergence data are presented for an univoltine population of *Ephoron virgo* from the lower River Ebro (NE Spain). Nymph density ranged from 300 ind/m^2 in May to zero as the population completed emergence in beginning of September. Size of nymphs ranged from 2 to 22 mm, and nymphs weighed from 0.06 to 8 mg. Production estimates (using preserved nymphs) ranged from 226 to 267 mg/m^2 using the instantaneous-growth and the removal sumation methods, respectively.

INTRODUCTION

The ecology of mayflies in Spain is still poorly known despite the recent advances in taxonomy. Many studies are devoted to distribution and relationships with physicochemical river characteristics, but the importance of these factors in population biology has been scarcely investigated. On the other hand the biology of *Ephoron virgo* populations in Europe is known from old studies (see references in Marten, 1986), but recent studies are difficult to find. The species has disappeared from many large European rivers due to pollution although in some rivers the restoration activities of recent years have resulted in the return of some individuals to rivers from which they have been absent for the last 40 years (Marten, 1986). A study of the ecology of the lower 60 Km of the River Ebro has provided the opportunity to investigate the population dynamics of a species which has exhibited annual mass emergences.

SITE DESCRIPTION

The mayfly population studied was located close of the city of Tortosa, 40 Km from the river mouth (station 2 in the Fig. 1). At this point the river is 200 m wide and its maximum depth varied from 1 m in summer to 2,5 m. in spring. Larvae were most common in the centre of the river avoiding the shallow marginal river zones. Water velocity near the bottom was close to 1 m/s. Water depth can also change whitin the day as a result of regulation of discharge from upstream dams. This is more obvious during high spring waters when discharge can be trebled whitin few hours. The substratum is composed mainly of sand, with small boulders. In addition to *Ephoron virgo*, the benthic community is composed of other mayflies (*Caenis luctuosa*, *C. pusilla*) trichopterans (*Hydropsyche exocellata*), triclads (*Dugesia sicula*), snails (*Theodoxus fluviatilis*, *Melanopsis* sp.) and many species of chironomids. *Cladophora* grows on the boulders during summer when light can penetrate to the river bottom. Potamoplankton is abundant (28 mg/l of chlorophyll a in summer) and is mainly composed of diatoms. More details on physicochemical and biological river characteristics are provided in Muñoz and Prat (1989).

MATERIAL AND METHODS

Samples were taken during 1986 and 1987. The life cycle was investigated in 1987. Sampling of the river bottom with a Surber was only possible during summer when discharge was less than 100 m^3/sec. Colonizing experiments with artificial substrates in 1986 indicated that eclosion from the egg occurred at the beginning of May. Sampling the bed of the river at this time was impossible using a Surber, therefore the 1987 sampling began in June. At this time the depth at the sampling area was close to 1'5 m and strong current prevented the use of grabs or a Surber, thus sampling was done with a kicking method: A triangular net (25 cm, side length) of 250 µm mesh was introduced in the river against the current. Aproximately 10 m. of the upstream substratum was disturbed and the mayfly nymphs disturbed by the current were collected in the net.

In July and August, when river depth was close to 1 m, a Surber sample (50 x 50 cm) with a net mesh of 250 µm was used to sample the benthos of the river. In the beginning of July, kick samples with the triangular net were also collected in order to calibrate the density estimates obtained with the net and the Surber, thus larval densities in June can be compared with those obtained in July and August. A transect sampled in July (10 samples across the river) showed some changes in the mayflies density among samples, with highest densities in the deeper zone. Thus samples were taken whenever possible in this zone.

Larvae collected were fixed in the field in 70% ethanol. In the laboratory after sorting, the total length (excluding cerci) was measured. Groups of larvae of the same size were dried at 80ºC for 24 h. This dry-weigh was used in the secondary production calculations.

Emergence was investigated during July and August. The start and end of the daily emergence period was noted on 5 different days during these months. Sex ratio was calculated from adults atracted to a white car lamp close to the river. Adults were collect every 10 minutes from the beginning of emergence until the time that few individuals were attracted to the lights.

RESULTS

Larval density:

Larval densities of *Ephoron* vary from 300 ind/m^2 in May and June until the lower densities in the beginning of September when all larvae had emerged from the river (Fig. 2). Larval density declines quickly during July; in mid-August it remains close to 15 ind/m^2(Fig. 2) and by September all the larvae had emerged.

Larval growth:

There was little growth until mid-July, although large differences exist between individuals as is indicated by the standard deviation (Fig. 3). When larval densities were low, in August, growth was faster (Fig. 3).

Emergence:

Emergence of adults in 1987 began at the mid of July, but mass emergence did not take place until mid August. Mass emergence occurs each year, but according to press reports and data provided by fishermen its importance and the dates of maximum emergences vary from year to year

The time of the start of daily emergence varies with time (Table I). At the end of July began at 19.45' h (solar time) and in later August at 19.25' h. Emergence was continuous until 21.00 h and 20.30' h in late July and late August respectively. Daily differences in sex ratio also exist (Table I). Generally more males than females were collected at the lights except on one date, which was a day with bad weather conditions. Males were always the first to emerge and the last to disappear even when weather conditions were unfavourable. The subimago moult of males took an average of 46 seconds (n = 21, s = 6'4).

Production:

Mean densities and mean growth on each sampling date were used to estimate production. Two methods were used: the removal summation method and the instantaneous growth method (Rigler and Downing, 1984). Both methods have been used in production studies of Ephemeroptera (Waters and Crawford, 1973; Rader and Ward, 1987) and both gave closely related results. In the case of *Ephoron virgo* of the lower Ebro, the removal summation methods gives a higher production estimate (267 mg/m^2) than the instantaneous-growth method (226 mg/m^2) both gave a very similar turnover ratio (P/B) close to 3.5.

DISCUSSION

Due to the sampling problems, larval densities just after the eclosion from eggs (beginning of May until the first days of June) were underestimated, both because of the sampling method used (kicking) and the loss of the smaller larvae through the mesh. Sample accuracy has not been fully investigated, therefore the mean densities in each sampling data are only an estimation of the population density in the river reach studied (200 x 100 m). This densities are similar to those recorded from other rivers in which mass emergence has been noted (Qninba, 1986). Preliminary data from other areas of the lower course of the Ebro River suggest even higher larval densities, explaining the big mass emergences of the population from mid August to beginning of September.

From our data it seems clear that *Ephoron virgo* is univoltine in the River Ebro with a rapid life cycle completed in 5 months. This life cycle is very similar to those known from others parts of Europe (Sowa, 1975; Usseglia-Polatera, 1985; Dodelec, 1986) and Morocco (Qninba, 1986). In this latter case the size of the larvae and the life cycle are very close to our data except for the eclosion of larvae and the emergence period which started and finished earlier in North Africa (March and July) than in Ebro River or in the rest of Europe. As the river in North-Africa could dry-up in some years, the earlier the life cycle can be viewed as a response to the hydrologic characteristics. Also the temperature in Morocco never drops below 15ºC, while in the Ebro temperature in winter is close to 10 ºC. Differences in thermal regime may explain the differences in egg hatching time and emergence period. The growth curve of nymphs are very similar from those of Nord Africa.

Differences in sex ratio of adult *Ephoron album* were also noted in other studies (Kraft *et. al.* 1978). Although no records exist in recent literature on moulting time or male and female behaviour, the characteristics of the Ebro population seem to be very similar to other populations investigated thourough Europe and North-Africa. We have found individuals transported by the wind as far as 50 Km away from the river in days without strong winds. Thus the dispersive power of this species seem to be much greater than in most other mayflies. For example Flanagan and Flanagan (1984) suggested that the lack of species in Manitoba was because adults could not bridge the relatively short gap between the Red and Missouri River Systems. Although the behaviour, morphology and ecology of all populations in Europe seem to be very similar, a study of population genetics would be very interesting. If the dispersive power can really produce a genetic flow between populations, genetic differences should be scarce. However large populations of *Ephoron virgo* are relatively far (more than 100 Km) and for this reason some differences can be expected despite the similarities of the life cycle.

As far as we known secondary production estimations for this species are not existent. Estimations made by two different methods in the River Ebro give close but lower values compared with some data from mountain streams where densities of three Ephemeroptera species were higher in spite of the fact that the mean weights of nymphs were lower (Rader and Ward, 1987). As the nymphs collected in the river were preserved before weighted, an underestimation of production can be expected from our data. According to the literature (Leuven *et. al.*, 1985) and some experiments made with our material, an increase of 25% can be estimated to allow for losses due to alcohol preservation. Therefore the production of *Ephoron virgo* in the Ebro could be close to 300 mg dry weight/m^2. This value is still low compared with other Ephemeroptera studies. In some other parts of the river densities seem to be higher, consequently higher production could be expected.

However, *Ephoron* was never the dominant species in the river bed, chironomids and trichoptera accounted for the most of 5000 ind/m^2, thus the total invertebrate production of the River Ebro in the lower reofilic part may not be lower than in other river systems.

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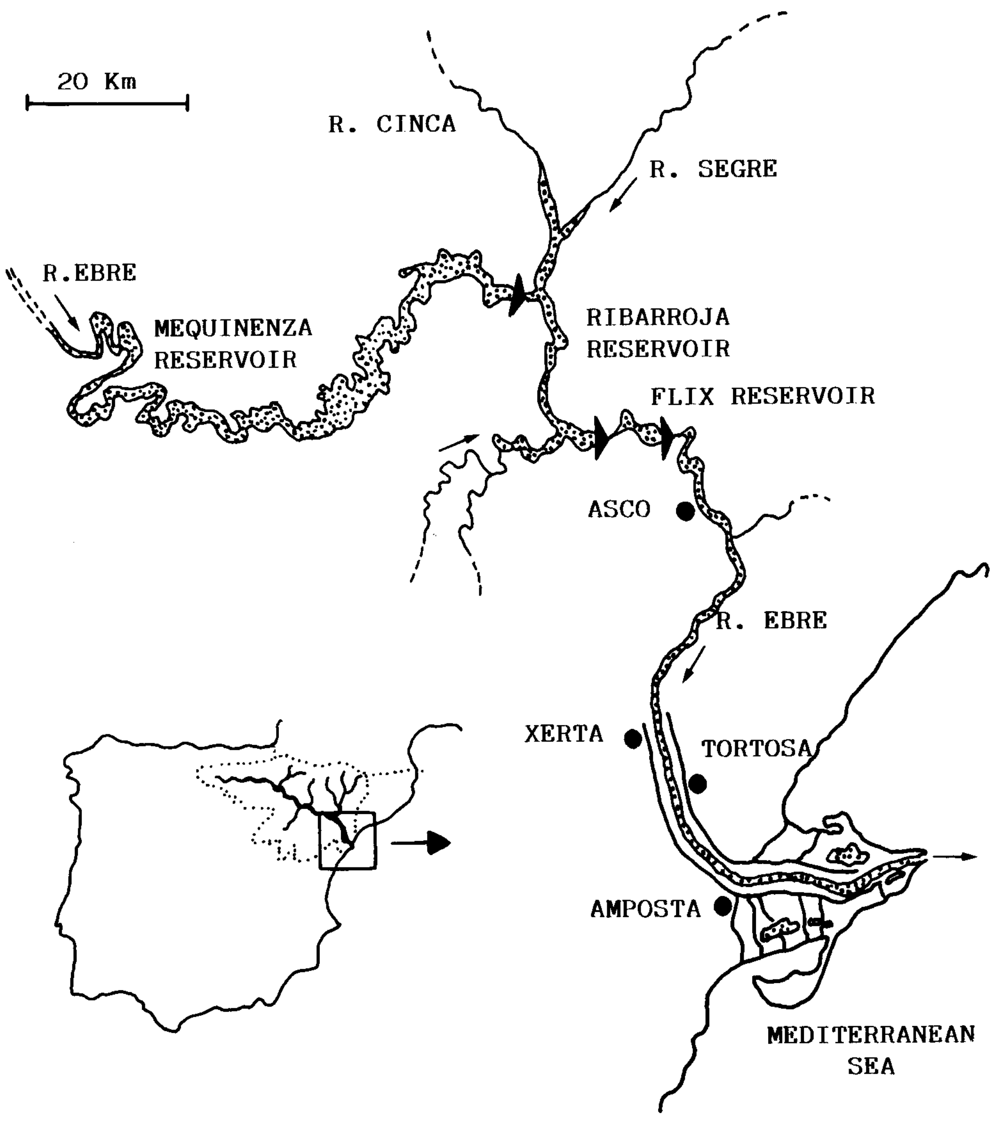

Fig. 1. Location of the sampling site. The studied population of *Ephoron virgo* was located in station 2, close to the city of Tortosa but mass emergences can be observed from Mequinenza to Amposta.

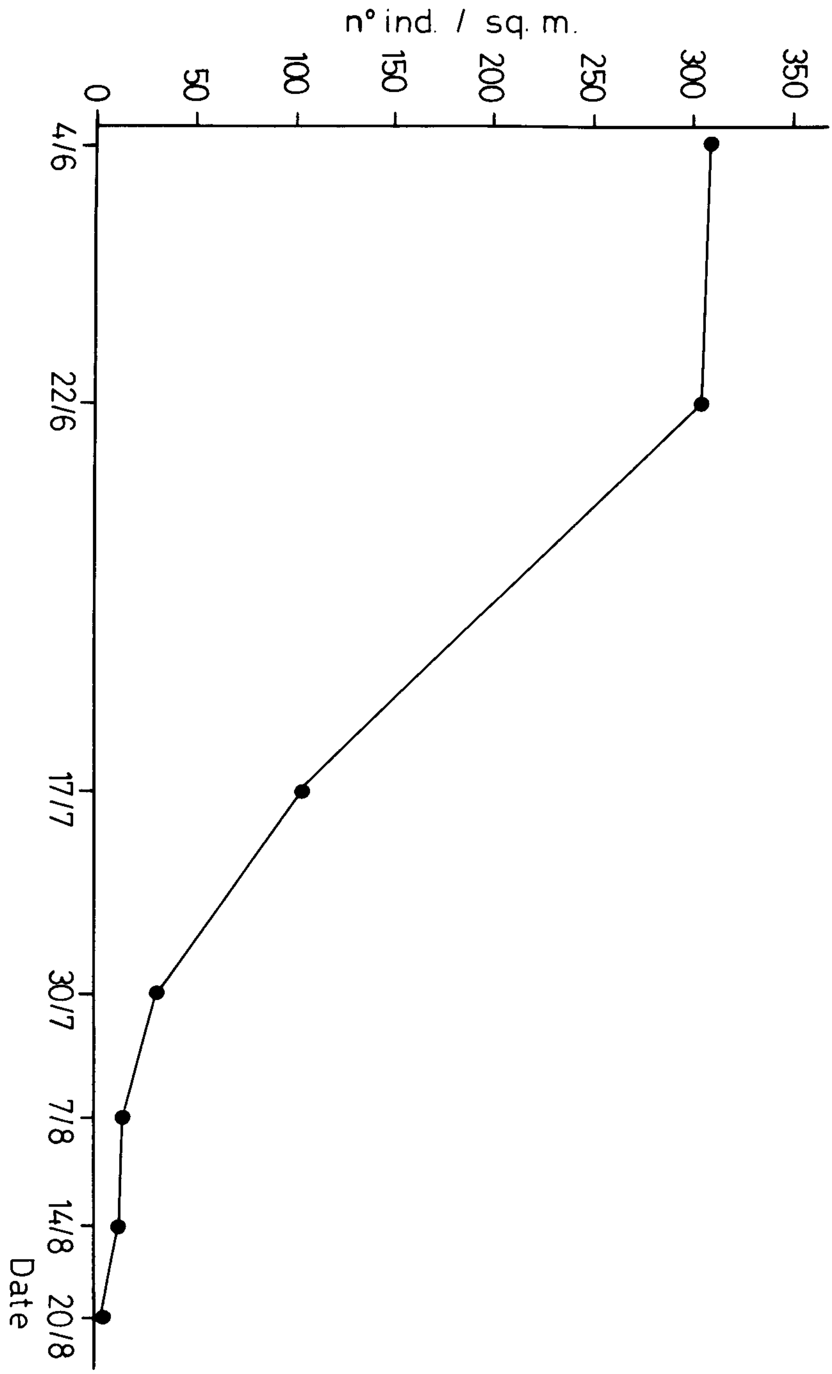

Fig. 2. Changes of mean density of *Ephoron* nymphs with time in station 2.

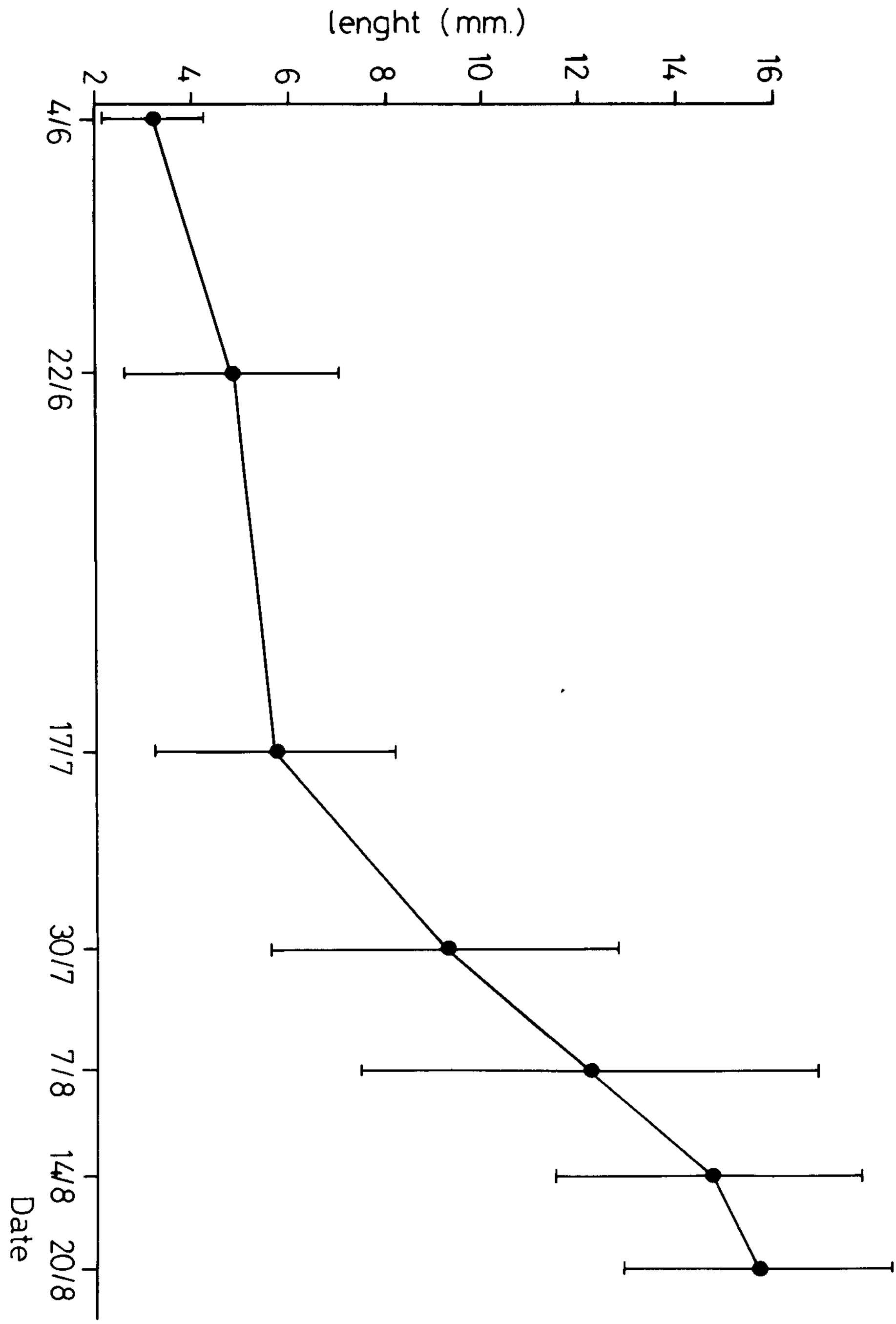

Fig. 3. Growth curve of *Ephoron* nymphs near Tortosa in 1987. Mean size and standard deviation of larvae at each sampling date are show.

Table I. Emergences near Tortosa of *Ephoron virgo* on 5 different dates . Male and female emergences are shown at five or ten minutes intervals. Sex ratio is also indicated.

DATE	SOLAR TIME	MALES	FEMALES	SEX RATIO (M:F)
7 - 8 - 87	20:00 - 20:10	500	338	1.5 : 1
	20:10 - 20:20	40	500	1 : 12.5
	20:20 - 20:30	0	500	-
	Total	540	1338	1 : 2.5
10 - 8 - 87	20:00 - 20:05	342	24	14 : 1
	20:05 - 20:10	537	21	25 : 1
	20:10 - 20:15	298	63	5 : 1
	Total	1177	108	11 : 1
12 - 8 - 87	20:00 - 20:05	431	65	6.5: 1
	20:05 - 20:10	386	77	5 : 1
	20:10 - 20:15	339	64	5 : 1
	Total	1156	206	5.5: 1
13 - 8 - 87	19:55 - 20:05	428	116	4 : 1
	20:05 - 20:15	395	243	1.5: 1
	20:15 - 20:25	217	0	-
	Total	1040	359	3 : 1
20 - 8 - 87	19:30 - 19:40	75	13	6 : 1
	19:40 - 19:50	82	152	1 : 2
	19:50 - 20:00	178	208	1 : 1.2
	20:00 - 20:10	336	20	17 : 1
	20:10 - 20:20	196	1	196 : 1
	20:20 - 20:30	224	1	224 : 1
	Total	1091	395	3 : 1
	TOTAL COLLECTED	5004	2406	2 : 1