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STUDIES ON EPHEMERELLA IGNITA (PODA) IN A CHALK STREAM IN SOUTHERN ENGLAND

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Abstract

The nymphs of *Ephemerella ignita* occurred in all months except October in the Bere Stream at Bere Heath, a small chalk stream in Southern England. Peak densities of 1,498 m^{-2} and 753 m^{-2} were recorded in May by two sampling methods used simultaneously. The seasonal patterns of growth and abundance are compared with the findings of other authors. A maximum biomass of 0.82 g m^{-2} preserved dry weight is compared with figures for two of the most common invertebrate groups present; the Simuliidae and Oligochaeta.

Introduction

During preliminary studies on the invertebrate community of a South Dorset chalk stream at Bere Heath (Grid. Ref. SY 857925), nymphs of *Ephemerella ignita* (Poda) appeared to represent an important constituent of the fauna. The purpose of the present work was to assess this importance, and attempt to explain the seasonal changes in population structure.

E. ignita has been recorded from many counties of the British Isles (Macan, 1970). The adults generally emerge in the summer but have been observed on the wing in all months of the year in Southern England (Kite, 1962). Previous ecological work on the juvenile stage of *E. ignita* indicates a short, compact, single generation in northern parts of its range in Britain, (Macan, 1957; Maitland, 1965; Egglishaw & Mackay, 1967) and a less discrete life cycle further south and on the continent (Crisp & Gledhill, 1966; Langford, 1971; Thibault, 1971).

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Methods

The study area is a 200 m length of the Bere Stream at Bere Heath, averaging 10 m in width and 0.3-0.7 m in depth. The water is 'hard' (Calcium 90-100 mg l^{-1}) with an annual temperature range of 4-23°C. Full descriptions of the site were given by Ladle *et al* (1972) and Westlake *et al* (1972). Two sampling regimes were used, a programme of weekly quasi-quantitative samples covering the period December 1967-June 1970, and a quantitative sampling programme of variable frequency from February 1969-May 1970. Both series involved the collection of samples of the dominant submerged macrophyte *Ranunculus penicillatus* var. *calcareus* (R. W. Butcher) C. D. K. Cook.

Each weekly sample consisted of randomly chosen shoots of *Ranunculus* with a dry weight of about 5 g (Dried for 24 hours at 105°C). Animals were sorted by hand and preserved in 70% ethanol.

The quantitative sampling apparatus consisted of a metal plate which was placed under the *Ranunculus* and an open-ended box which cut down through the *Ranunculus* to the plate. It has been fully described by Ladle *et al* (1972). Weed fragments were lifted by hand from the box and the water and dislodged animals were pumped into a 0.125 mm sieve. The material retained on the sieve was then added to the weed fragments to complete the sample. Five pairs of samples each of 0.05 m^2 area were taken at 40 m intervals along the reach.

Mapping of the stream-bed at 5 m intervals enabled the dry weight of submerged *Ranunculus* on the study reach to be calculated each time the quantitative samples were taken. Where *Ranunculus* grew to the water surface, with consequent reductions of flow, conspicuous growths of diatoms occurred during early summer. Samples were

not taken from these areas, which were defined when mapping took place.

The body length of nymphs (excluding cerci), and in some cases head capsule widths and preserved dry weights (24 hours at 105°C), were determined.

Results

Population size

The population density of the nymphs on submerged *Ranunculus* throughout the period of quantitative sampling is shown in Fig. 1A, the maximum population density (11,400 m^{-2}) on *Ranunculus* was recorded in late May 1969. At this time 13.6% of the reach area was covered by submerged *Ranunculus*. Discounting larvae present on other substrata, this gave an overall mean density of 1,498 m^{-2} for the 200 m reach (area 1,840 m^2).

The weekly quasi-quantitative results are expressed as numbers of larvae per 10 g of dry weed in figure 1B, they also showed a maximum density during May. This was equivalent to 753 m^{-2} for the reach, when related to the calculated dry weight of submerged *Ranunculus*. This is half the density of nymphs obtained from the quantitative results, but the latter were based on a mean of 10 larger samples.

The stream bed area in May 1969 consisted of 61% gravel and 39% sand and mud, the latter often associated with areas of *Ranunculus*. No samples were taken from the gravel but examination of fine sediment cores, taken during a quantitative study on fine sediment and its associated fauna (Ladle, unpublished data), gave a total Ephemeroptera density of 340 m^{-2} on fine sediment alone.

An annual production figure for *E. ignita* could not be calculated because of the absence of newly hatched nymphs from samples. Egg masses found in the gravel bed of the stream were incubated for 2 to 3 days at 10°C (January, 1972). Hatched nymphs of 0.7 to 0.9 mm indicated that a period of growth must take place in the gravel before the larvae migrate to the *Ranunculus*, where few of less than 1 mm were obtained.

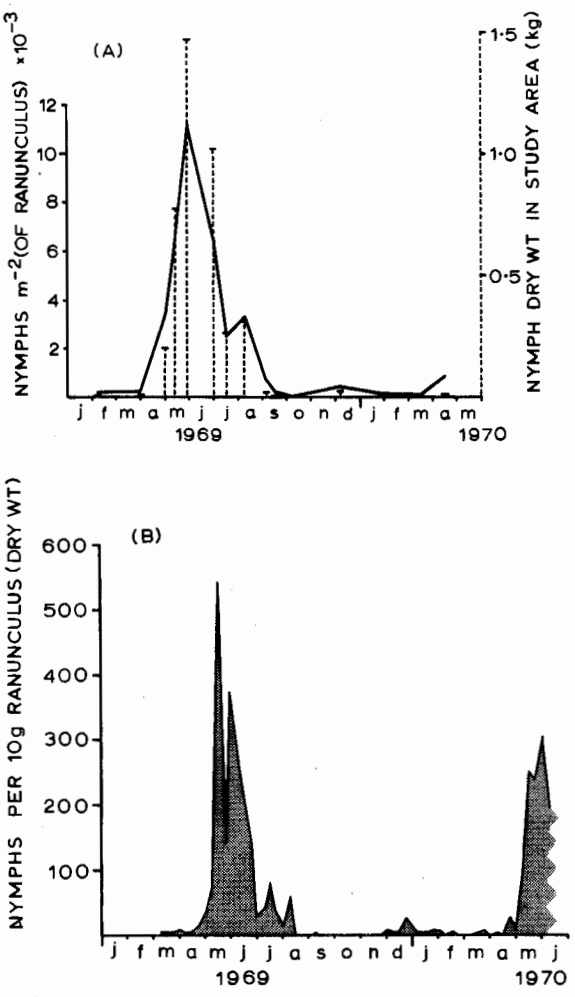

Fig. 1. 'A' Bere Heath. Density of *E. ignita* nymphs on submerged *Ranunculus* (Quantitative Samples) and standing biomass of nymphs in the study area (Preserved dry weight).
'B' Numbers of E. *ignita* nymphs per 10 g of *Ranunculus* (Weekly quasi-quantitative samples).

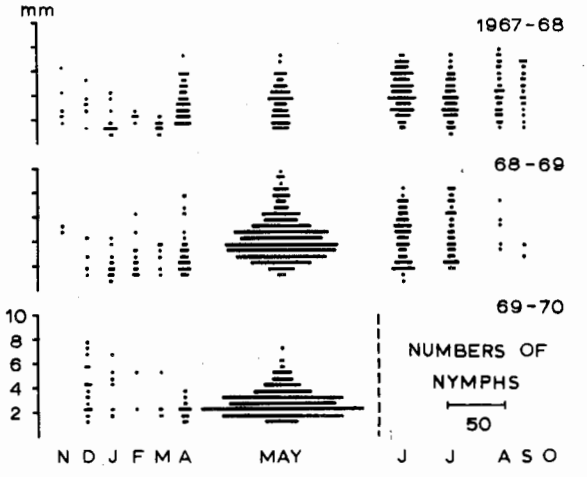

Fig. 2. Size distribution of *E. ignita* nymphs. Monthly data derived from combined weekly Quasi-quantitative samples.

Growth

Nymphs from the weekly quasi-quantitative samples collected from November 1967 to May 1970 were counted and measured. As numbers were frequently small during autumn and winter, monthly totals of nymphs and their respective size distributions were made. These are presented in graphical form in figure 2. It can be seen that from the beginning of December to mid-April, the small numbers of larvae measured were generally less than 4 mm in length, whereas from mid-April to August, the complete size range was present in samples. Later in the summer the proportion of larger nymphs increased and in October nymphs were absent from all samples.

Preserved dry weight was closely correlated with body length (Fig. 3A). The relationship between body length and head capsule width (Fig. 3B) remained more or less constant over all size groups. Weights could thus be accurately predicted from either, when larvae had become fragmented during sorting.

The mean preserved dry weight of each size group of *E. ignita* nymphs, together with their density and size distribution on each date of quantitative sampling, was used to calculate a standing biomass figure for the 200 m reach, taking into account the percentage area of submerged *Ranunculus* (Fig. 1A). This did not include nymphs present on other substrates. The maximum biomass (equivalent to 0.82 g m^{-2} dry weight) for the reach coincided with the peak density in May 1969. The trend of biomass figures closely followed the numerical density of nymphs, with a comparatively higher value in early July 1969, when the proportion of larger nymphs was at its greatest (Fig. 2).

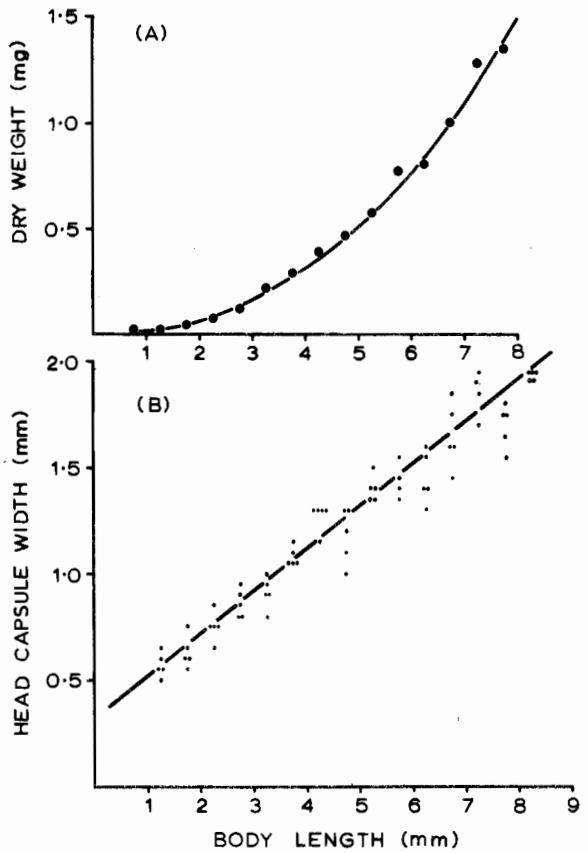

Fig. 3. 'A' Bere Heath. Length-weight relationship of *E. ignita* nymphs. ($y = \frac{\alpha\ 2.21}{67.61}$ $r = 0.99$)

'B' Body length-head capsule width relationship of *E. ignita* nymphs. ($y = 0.2\ \alpha + 0.32$ $r = 0.98$)

Discussion

The pattern of the population of *E. ignita* nymphs at Bere Heath, shown by both sampling methods, indicates a sudden increase to peak numbers in May. Rapid growth, clearly demonstrated during April to May, either does not occur later in the year, or is obscured by the presence of a complete range of sizes. This is probably caused by recruitment of newly hatched larvae. These results contrast with observations on *E. ignita* made by Macan (1957) and Maitland (1965).

In Scotland Maitland (1965) found nymphs present from April to September only, in the R. Endrick and a tributary, the Altquhur Burn. Newly hatched nymphs occurred from April to July. This corresponds to work by Macan (1957) indicating that a Lake District (England) population of *E. ignita* spent at least eight to nine months of the year in the egg stage.

Thibault (1971 & Pers. com.) has conducted experiments on embryonic development at different water temperatures, in conjunction with larval growth studies, on *E. ignita* from the R. Lissuraga in South-west France. Bohle (1972) also describes how temperature effects embryogenesis, in a German population of *E. ignita,* studied in the laboratory and in the natural environment.

Thibault's results suggest that most eggs hatch at temperatures between 10°C and 15°C, with no hatching occurring below 8°C or above 20°C. The shortest incubation time he found was 25 days (at 17.5°C) and the longest 310 days (at 10°C). Staggered hatching in individual egg masses was observed and considerable variation in the

initial hatching time occurred between egg masses at the same temperature.

Bohle (1972) found that a diapause during egg development was obligatory with few exceptions and that it was essential for temperatures less than 13.3°C to persist for a minimum period. He assumes there is no photoperiodic effect on the diapause and suggests successive egg 'stages' have different optimal temperatures for continued development, but that other populations may react differently to their respective temperature regimes.

The mean water temperature on the R. Endrick (Drumtian) in 1960 rose above 8°C between mid-April and mid-October (Maitland, 1966), whereas at Bere Heath in 1969 the mean water temperature remained above 8°C from March to December fluctuating above and below 8°C for the remainder of the year (Fig. 4). On the basis of Thibault's results, hatching would be possible at Bere Heath for most of the year but would be resticted to the period mid-April to mid-October in the R. Endrick. Nymphs of 1-2 mm were found in all months except October and November at Bere Heath. Imagos have been recorded in small numbers in early June (Gledhill – Pers. com.) and eggs laid at this time when the mean water temperature is 14°C to 16°C may hatch and swell the numbers of small nymphs appearing in July and August. The absence of nymphs in October when temperatures were still suitable for hatching could be explained by an obligatory diapause in the egg stage (Bohle, 1972). In this case the summer recruitment of small nymphs would be derived from late hatching eggs of the previous year.

In the R. Lissuraga where mean water temperatures are above 10°C almost continously (Fig. 4) Thibault suggests that 'Eggs laid in the spring and summer develop rapidly or not at all.' Here the nymphs began to appear in November and recruitment continued until June, peak numbers were found in April and May. A short interruption of hatching was followed by a smaller hatch in July and August. Thibault suggests that this may be derived from a fraction of the spring-laid eggs which develop quickly giving a second generation. He concludes that temperature alone does not control the embryonic development but that the day length or photoperiod is possibly involved.

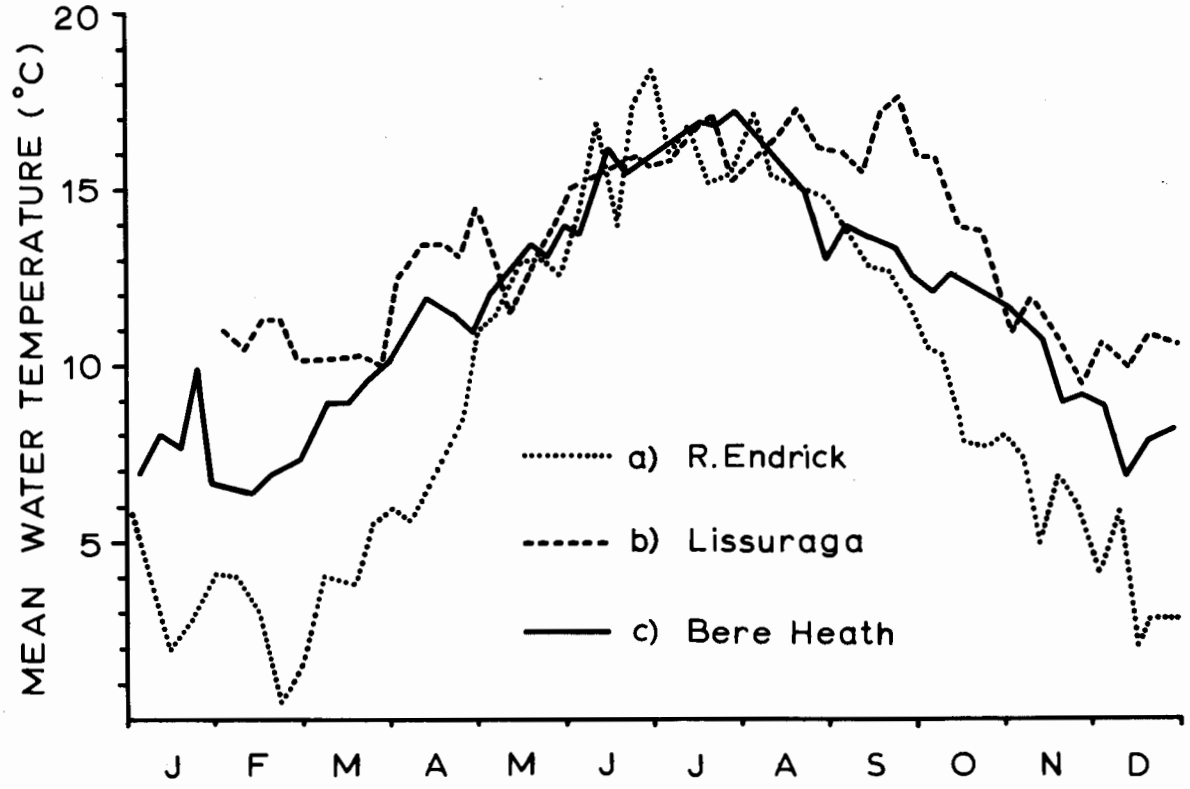

Fig. 4. Water temperature regimes a) R. Endrick; Drumtian, 1960; Maitland, 1966. b) Lissuraga; 1200 m from the source, 1966; Thibault, 1971. c) Bere Heath, 1969; Ladle *et al,* 1972.

The restriction of both sampling regimes at Bere Heath to the areas of submerged *Ranunculus,* gave rise to an underestimate of the overall density of nymphs for the study area. The periods when this would be most significant occurred when newly hatched nymphs were present in the gravel, also in late May and early June when large nymphs were observed on the gravel. However, previous work on streams with submerged macrophytes (Whitehead, 1935; Harrod, 1964) suggest the nymphs occur most frequently on this substrate.

At Bere Heath the maximum biomass of 0.82 g m^{-2} (preserved dry weight) can be compared with similar measurements for other important invertebrates present. During 1969 two species of *Simulium; S. ornatum* and *S. equinum* were found to attain a combined maximum biomass in July of 5.4 g m^{-2}. Oligochaetes, mainly tubificids, present in sand and fine sediment, had a maximum biomass of 4.8 g m^{-2} in April (Ladle, Pers. com.).

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