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Development of the mayfly *Siphlonurus armatus* in two Southern English rivers (Siphlonuridae: Ephemeroptera)

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Introduction

In a review of developmental patterns of mayflies in Central Europe, Landa (1968) included data on 4 species of *Siphlonurus*, among them *S. armatus* Eaton. Despite the large size and conspicuousness of mature nymphs of this species, little has been recorded of its biology. In fact, Landa's account is almost the only published information on the biology of a species, whose occurrence in Britain was described by Macan (1979) as "inexplicably sporadic".

S. armatus Eaton is known to have a wide distribution from Ireland across the northern and central European lowlands into western Russia (Puthz, 1978). Published records, however, are scanty. In describing the discovery of nymphs in the river Antrift in Hessen, Puthz (1973) could only cite two other records from Germany. Malzacher (1981) added a further record from Austria. Its presence in the Netherlands was recently noted by Mol (1985). Landa and Soldán (1985) reported the species as widespread but scarce in Czechoslovakia. The same could be said about the British Isles. Originally described by Eaton (1870) from Killarney and from Highgate ponds in London (!), it then went unrecorded until Percival and Whitehead (1927) reported it from Yorkshire. Macan (1951) noted its presence in the River Winster, Cumbria and Broxbourne Woods, Herts. Harris (1952) spoke of it as very local in the west of Ireland.

In Sussex, routine sampling by the Southern Water Authority revealed that *S. armatus* was present in several local rivers. A closer look at some of these sites encouraged me to make a study of the life history of this species under British conditions.

Sampling sites

Routine sampling was carried out at single sites on the lower reaches of two rivers. The most productive site was on the river Ouse at Barcombe Mills (site 1, Fig. 2) along an approximately 300m stretch of bank immediately above a weir. This impoundment served as an anti-flooding device and water only flowed over it at rare intervals. The lower end of the sampling site was in effect a sidearm of the river, 14-45m wide, up to 4.5m deep and with a substrate of silt deposited on a clay bed. The presence of the weir and the control exercised by the Water Authority combined to keep variation in water level down to a minimum. With the exception of a few short-lived surges of 40-50cm, levels remained within 20-30cm of the mean throughout the period of the study. The fact that the bank formed part of a privately owned garden meant that there was little disturbance of the marginal vegetation, adding to the stability of the site.

Recordings of water temperature were also kindly supplied by Southern Water Authority. They were taken as spot recordings on 34 occasions during this period. They show that from May to early October temperatures were always above 10°C. The highest recordings were of 17°C and 18°C.in July, although observations in July of the following year showed that this could rise to 22°C at a depth of 50cm. In a severe winter such as that of 1986, temperatures in February fell to 1°C while the water above the weir remained frozen for several weeks.

The second main sampling site was on the River Cuckmere at Chilversbridge (site 3, Fig. 2), just below the reservoir at Arlington. Where the road bridge crosses the river, which formed the upper end of the sampling area, the width was 13-14m, the depth during periods of low water 38-48cm. The river bed was clay with a shallow layer of silt. Conditions were much less stable than on the Ouse. Water levels after periods of heavy rain rose by as much as 2m, and the vegetation along the margins was cut back at least once during the summer. On the other hand, during dry spells the river was shallow enough for it to be possible to wade right across so that sampling did not always need to be confined to the margins. In addition, a slowly flowing sidestream was used for sampling in the winter and spring. However, in summer it was almost completely choked with vegetation and sweeping with a net became impossible.

Sampling

Routine sampling was carried out once a fortnight during the months of March to June and on a monthly basis during the rest of the year. Exceptions to this routine occurred in January on the Cuckmere and, owing to the thickness of the ice, in February on the Ouse. Additional material was collected at Barcombe Mills from the opposite bank of the river during the main season of larval growth in 1986.

The catch of *S. armatus* was sorted by sex and body length to the nearest 0.1mm, measured from the head to the base of the tails. Small nymphs were measured under the binocular microscope but with the larger specimens it was found more convenient to use a wide-field lens.

Results

A total of 526 nymphs was collected and measured in the course of this study. The sex ratio of specimens larger than 8mm was male:female, 1:1.46. The results of the two sampling sites combined are displayed as size-classes in Fig. 1. No nymphs of *S. armatus* were caught throughout 8 months of regular sampling. The last specimen in 1985 was collected on June the 12th while the first in 1986 was obtained after prolonged sweeping of the partly frozen Cuckmere on February 16th. In the second season the last specimen came from the Ouse on June 30th. Once the first nymphs appeared, rapid growth ensued from March to May, culminating in May and early June in the presence of nymphs up to 20mm long with dark wing pads. By the middle of June emergence of adults was virtually complete. In both seasons a small proportion of nymphs tended to lag behind the rest of the population, but there was no evidence to suggest that any of them survived beyond the beginning of summer. Attempts to locate adults on the wing during the emergence season were unsuccessful.

As a check on the validity of the results of the sampling programme, the rate of growth was

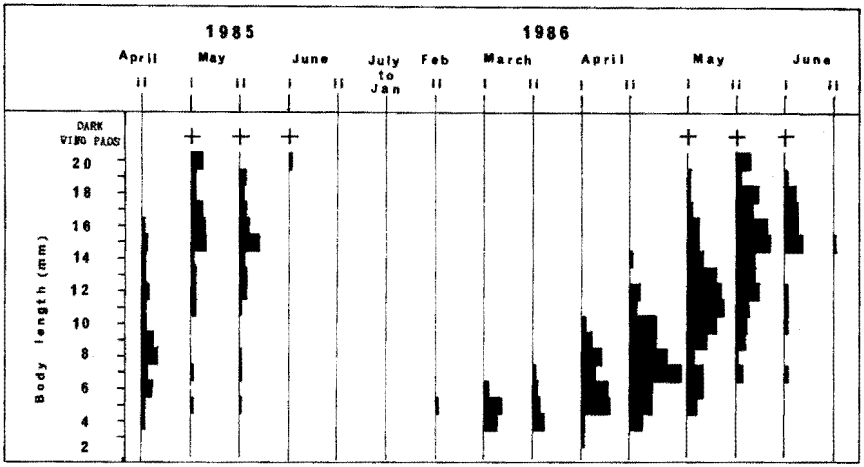

Fig.1. Distribution of size-classes in half-monthly samples of *Siphlonurus armatus* nymphs from the rivers Ouse and Cuckmere, Sussex.

also assessed by the use of 15 × 5cm floating cages tethered to the bank in a backwater of the Ouse. Eight freshly caught nymphs were measured to the nearest 0.5mm and placed in the cages together with a small amount of silt and detritus. The containers were temporarily removed and the surviving nymphs measured and returned to the cages at 3 successive intervals of 2 weeks. At the time of capture on 22nd April mean body length was 6.5mm (8 specimens), on 7th May 10.7mm (4), on 19th May 14.3mm (3), and on 2nd June 16.2mm (3, comprising 1 with dark wing pads, 1 already hatched and 1 died while emerging). These examples serve to illustrate the extremely rapid rate of growth of individual nymphs in the river, even when prevented from selecting optimal conditions.

The question must be raised as to what reliance can be placed on our persistent failure to collect nymphs of *S. armatus* throughout the summer, autumn and much of the winter. The smallest nymph collected was 2.7mm long. No specimens smaller than this of the rather similar nymphs of *Cloeon dipterum* L. were captured either. Nymphs below this size were evidently not being sampled. However, specimens of the latter species of 3mm and upwards were present in the catches throughout the year, often in abundance. Had *S. armatus* been present during other seasons, it would seem that it should have been found also. Moreover, in October 1985 the River Cuckmere was low enough to enable wading and sampling with nets across the whole width of the river. Again, no *S. armatus* were caught, although specimens of *Ephemera vulgata* L., a species normally inaccessible to hand-netting, were obtained. It is concluded that the picture presented above is essentially valid.

Ecology and distribution

As recorded by other workers, *S. armatus* is a species of slow-moving rivers and the margins

of lakes. In the small, eutrophic rivers of Sussex it seems to occur almost exclusively in marginal vegetation, particularly in the slack water upstream from weirs and in other reaches where the flow is sluggish. Such sites provided the bulk of the material collected in the present study. On rare occasions nymphs were found in the middle zone of the river where the flow is fast enough for erosion of the banks to be taking place. In these exceptional sites nymphs were only found in backwaters where pockets with reversed current formed along the river banks.

Distribution records for the county of Sussex have been plotted in Fig. 2, from which it will be seen that it was found in the 3 small river-systems of the Adur, Ouse and Cuckmere.

Discussion

In his classification of the developmental cycles of Central European mayflies, Landa (1968) included *S. armatus* in category A2, that he called "summer" species. He recorded the presence of nymphs from April to June and suggested that, in members of this category, the eggs or early instar nymphs remain in diapause throughout the autumn and winter. The present study shows that, in the milder climate of southern Britain, development of nymphs is already under way by late winter, and emergence of adults takes place in May and early June. In this region, it seems, *S. armatus* does not clearly fit into either of Landa's categories A1 and A2, his "winter" and "summer" species. In fact, it has more in common with *Leptophlebia marginata* (L.) which, despite the head-start it has by early winter – in the Ouse, small nymphs were already present in early December – only completes development a week or two before the first *S. armatus* are ready to emerge.

S. armatus achieves this by the remarkably rapid rate of growth, involving a 4-6 fold increase in body length in the course of 2½ cool months. Rapid growth rates are a characteristic of other members of Landa's group A2. Nevertheless, the rate at which individual specimens, maintained and measured in floating cages, moved from one size-class to another is matched by few British mayflies.

In Welsh streams, Hynes (1961) showed that *S. lacustris* Eaton develops in a similar way, but with the difference that egg-hatch was spread over much of the year. On the other hand, in the cooler climate of Norway, Saettem and Brittain (1985) showed that *S. lacustris* and *S. aestivalis* Eaton emerged throughout the summer, nymphs being present from late August or September onwards. This difference from *S. armatus* is emphasised by the findings of Bretchko (in press), who found that *S. aestivalis* emerged throughout the summer from an unstable mountain tarn in Austria. This was achieved by delayed hatching of eggs and variable growth rates. Such flexibility contrasts with the situation faced by *S. armatus* in southern England, where the habitat is highly stable.

As we have seen, *S. armatus* is not an uncommon mayfly in this part of lowland Britain. Human influences have been important here through the construction of weirs and the creation of long stretches with little current. The scarcity of records of the species in the country as a whole could stem from two factors. First, nymphs are only likely to be large enough to be collected in sweep-nets in rivers during the period from March to June. Second, many surveys of running waters are based on systematic sampling of the bottom fauna. Once into the depositing zone, the problem of sampling deep silted river-beds calls for special techniques. As a result,

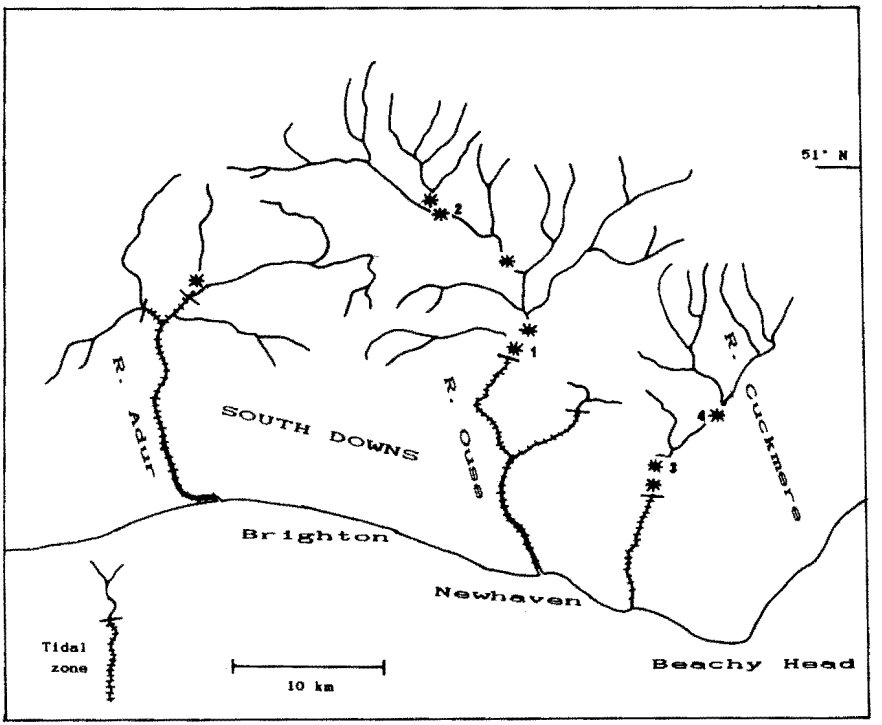

Fig.2. Distribution of *Siphlonurus armatus* in three Sussex rivers. Numbers refer to sites mentioned in the text.

less attention gets paid to them. An example of this is provided by the synoptic surveys of British running waters reported by Maitland (1980). Among the species apparently unrecorded in this large scale operation was *Ephemera vulgata* L. despite the fact that it is a widespread and locally abundant mayfly of lowland Britain. Dr Keith Wilson *(in litt.)* tells me that on May 25th, 1984, he witnessed a mass emergence (estimated at more than a million) of *E. vulgata* from upstream of the weir on the River Thames at Pangbourne. Such was their abundance that adults were even settling on the windscreens of passing cars.

If that was the case for a common species, how much more likely is it that a scarce species of the same river zone, such as *S. armatus*, would escape detection also.

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Summary

1. *Siphlonurus armatus* Eaton, a seldom recorded mayfly of slow rivers and lakes, has a wide distribution across the lowlands of northern and central Europe. Information on its seasonal occurrence has been published for Czechoslovakia, but elsewhere it has received little attention.

2. Surveys of rivers in Sussex showed that the species was not uncommon at certain sites. Regular sweep-net samples were taken at the same sites on two rivers over a period of 15 months.

3. Over the 8-month period from mid June to mid February all catches were negative. From March to May growth was very rapid, and mature nymphs in the 15-20mm size classes were present throughout May and the first week of June. It is concluded that this species is univoltine, and it appears that diapause in either the eggs or early instars is followed by slow development in the winter and emergence before summer conditions in the river prevail.

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