Growth of *Leptophlebia vespertina* L., *Cloëon dipterum* L. and *Ephemera vulgata* L. (Ephemeroptera) in a Small Woodland Lake

By GÖSTA KJELLBERG

Institute of Limnology, University of Uppsala, Sweden

Abstract

KJELLBERG, G. Growth of *Leptophlebia vespertina* L., *Cloëon dipterum* L. and *Ephemera vulgata* L. (Ephemeroptera) in a small woodland lake. — Ent. Tidskr. 94: 8—14, 1973.

The yearly cycle of changes in length and biomass of the ephemerids *Leptophlebia vespertina, Cloëon dipterum* and *Ephemera vulgata* was followed in a woodland tarn in Sweden. These species are all herbivores and show the same general pattern of growth. The best growth occurred under conditions of abundant food and high temperatures.

The life cycles of *Cloëon dipterum* and *Leptophlebia vespertina* take one year to complete while that of *Ephemera vulgata* takes two years. During 1970, *Cloëon dipterum* had two generations in the same year as a result of an extremely rapid growing summer generation.

Introduction

In most Swedish woodland lakes, the ephemerids are an important food organism for several species of fish. In the smaller lakes and tarns, *Leptophlebia vespertina* L., *Cloëon dipterum* L., and *Ephemera vulgata* L. are particularly important.

Little is known about the autecology and the distribution of the ephemerids found in Swedish lakes and tarns. In Sweden as in the rest of Europe, most of the studies have been carried out on the ephemerids of running water.

During a study of the biology of the fish of a small woodland tarn in Hälsingland, central Sweden (Map 1), ephemerids were collected (1966—1970). These collections included, in addition to the species named above, *Leptophlebia marginata* L., *Caënis horaria* L., and *Heptagenia fuscogrisea* Retz. Unfortunately, there were not enough specimens of these last three species to carry out growth studies.

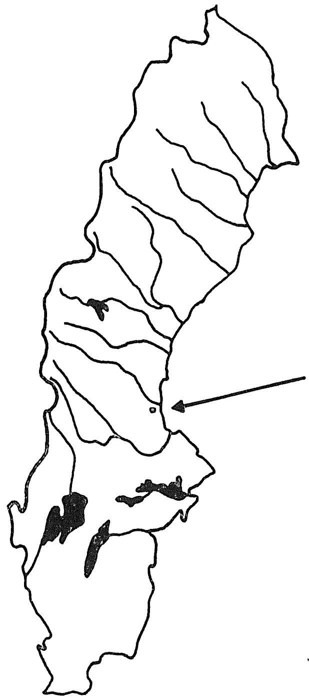
The Lake

The tarn, which lies in a moraine, can be described as oligohumic. It has an area of 5.3 ha and is divided into two basins, one 5 and one 7 m deep. The temperature can rise as high as 25°C at the surface, which is considerably higher than larger lakes in the area. The conductivity (20°) is about 30—40, the colour varies between 20 and 40 mg Pt/liter and the pH lies between 6 and 7. Because of the sheltered location and the rapid warming of the upper layers in the spring, the tarn appears to have no spring circulation at all. The reduced levels of oxygen that began to form under the ice are thus continued into the summer stratification. By the end of August the entire hypolimnion is anaerobic. During October the entire tarn circulates and the oxygen is restored to saturation.

It is surrounded by a coniferous forest dominated by *Pinus silvestris* but also containing some birch (*Betula odorata*) and alder (*Alnus glutinosa*). Very close to the shore of the tarn there is a dense belt of *Ledum palustre* and *Myrica gale*. The *Ledum* is absent in the southeast part of the tarn where the shore consists of a *Sphagnum* bog.

The aquatic vegetation is spread in a sparse belt along the shore. Nearest the shore this belt consists of *Equisetum fluviatile* and *Scirpus lacustris*. Farther out *Nuphar lutea* is found along with a few groups of *Potamogeton natans*. Except for a few clumps of water moss (*Drepanocladus* sp.), there is no submerge vegetation.

There is very little littoral zone as the water is 1 m deep very close to the shore. Near to the shore the bottom consists of allochthonous detritus such as large particles of leaves, needles, bark, small branches, etc. The edge of the shore is also covered with fallen trees and large branches. As the water becomes deeper the material becomes much finer and eventually can be called dy.



Map 1, showing the situation of the tarn.

Methods

Leptophlebia vespertina and *Cloëon dipterum* were collected along the edge of the shore with a hand net having a mesh size of 200 μ. *Ephemera vulgata* was collected in the same way along the shore but was also taken from deeper water with an Ekman grab.

The ephemerid nymphs that were used to construct the growth curves were all collected from the same year's class. One hundred nymphs of both *Leptophlebia vespertina* and *Cloëon dipterum* were measured every sampling time. However, because less material was collected of *Ephemera vulgata* the number of nymphs measured varied from 30 to 50 each sampling time. The nymphs were preserved with formalin and measured with a stereo microscope equipped with a measuring scale in the eyepiece.

The length was measured from the front of the headcapsule to the end of the last segment. It was found that the nymphs contracted somewhat when preserved in the formalin and lost about 10 % of their length. Before weighing, the preserved nymphs were dried with blotting paper to remove the surface water. The sartorius balance that was used for the weighing could be read to 0.1 mg.

In the figures, the curves have been drawn through the average of the values for the sampling date.

Results

Cloëon dipterum. This species completes its life cycle in one year and is viviparous as the eggs hatch in the oviducts. The newly hatched nymphs are released during June

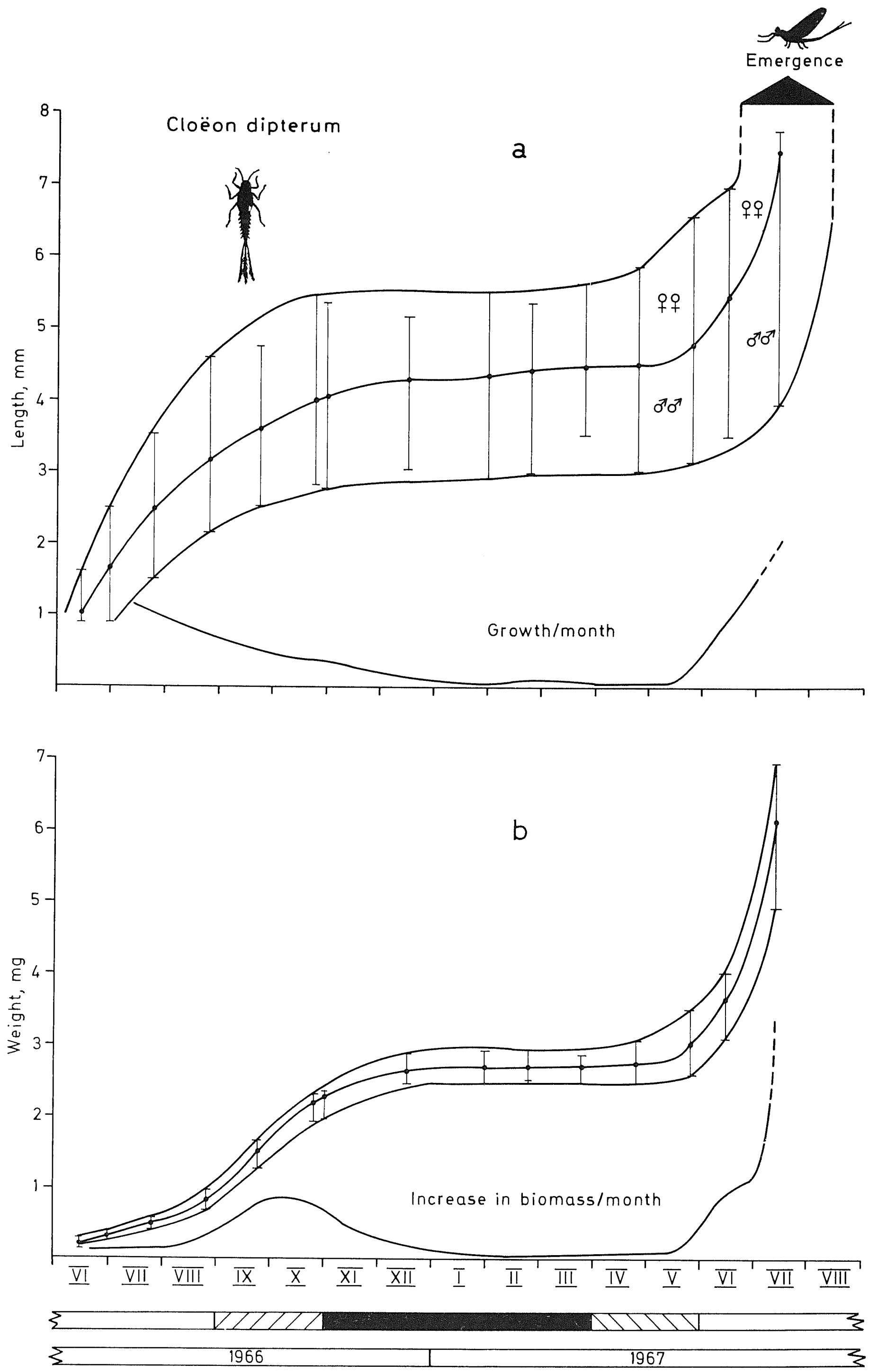


Fig. 1. The growth curve for length (a) and increase in biomass (b) for *Cloëon dipterum.*

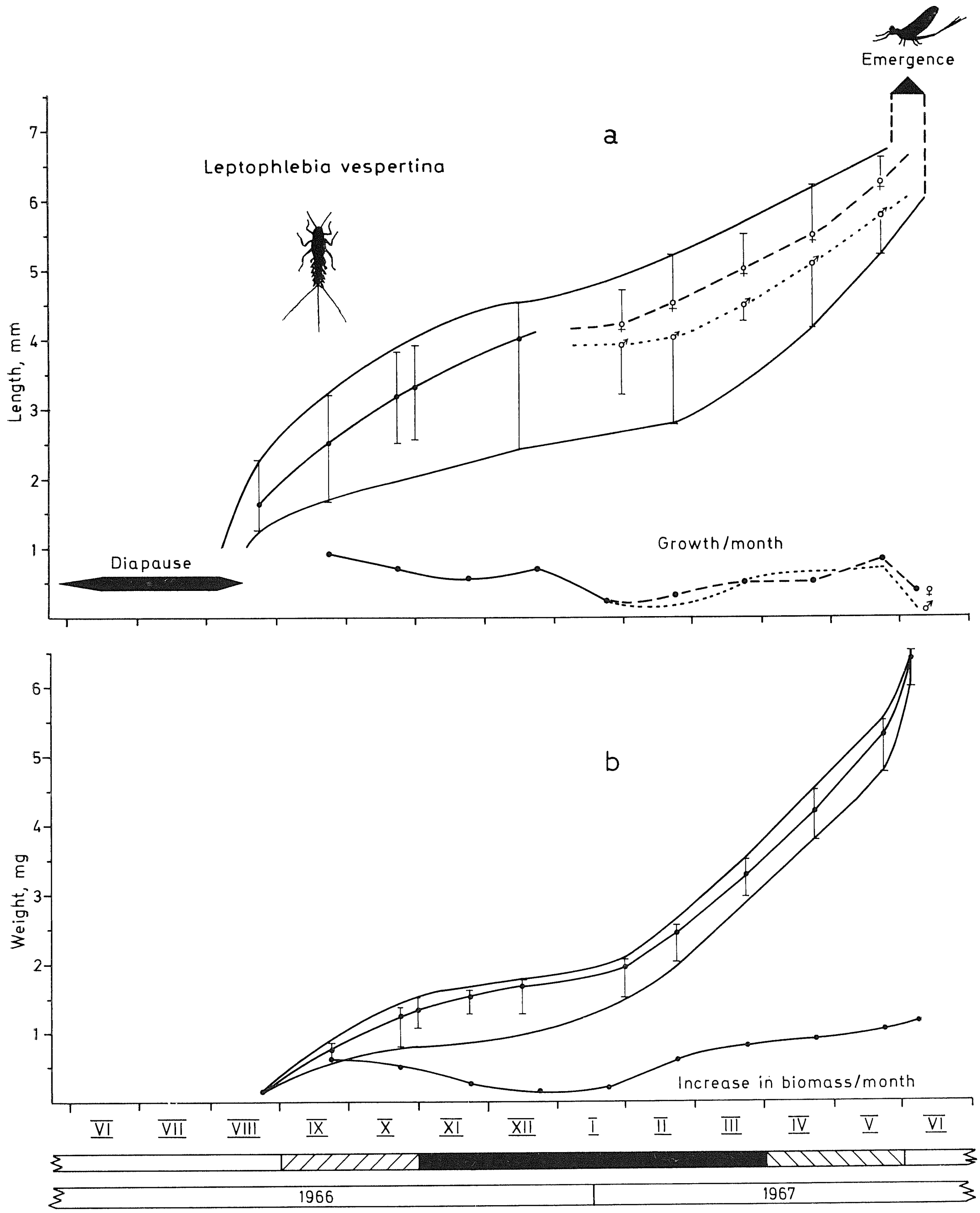


Fig. 2. The growth curve for length (a) and increase in biomass (b) for *Leptophlebia vespertina.*

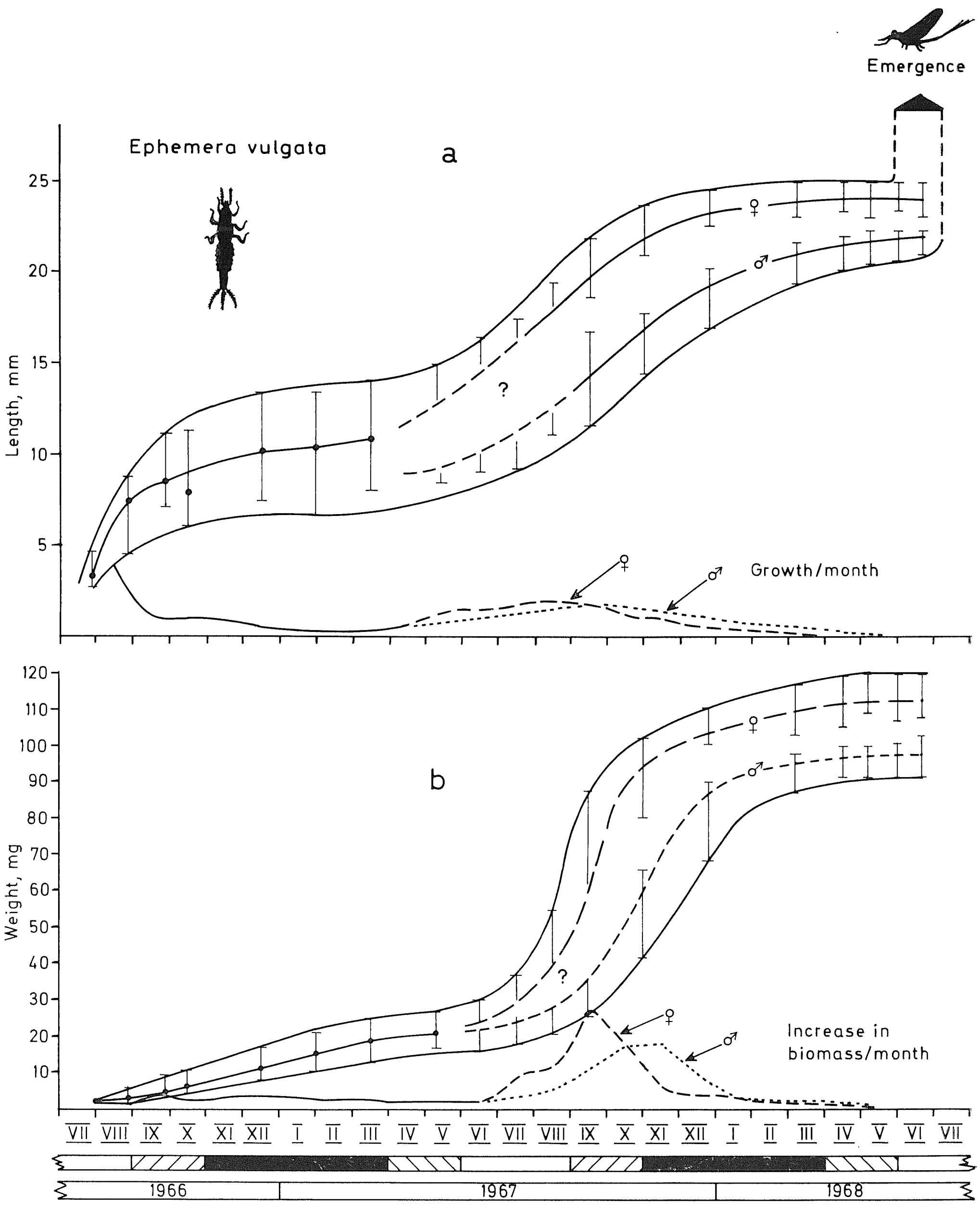


Fig. 3. The growth curve for length (a) and increase in biomass (b) for *Ephemera vulgata*.

and July. The nymphs grew rapidly for a while at the end of the summer, slowly during the fall months, but not at all during the winter (Fig. 1 a). The growth becomes rapid again the next spring (May and the beginning of June). During this period the females grow faster than the males and are somewhat bigger by the time of emergence during June and July.

The curve for the increase in biomass follows closely the curve for length (Fig. 1 b). The nymphs weigh about 0.1 mg after hatching and 6 mg just before emergence.

Leptophlebia vespertina. The life cycle of this species is completed in one year as can be seen by the changes in length (Fig. 2 a). The eggs are laid at the end of May and the beginning of June and hatch, after a short diapause, in the last half of August. The growth is good in late summer and fall, decreases drastically during the winter, and increases again in the spring. In the last half of the growing period, the females grow somewhat faster than the males. Finally, the emergence occurs during a few days at the end of May and the beginning of June. The largest changes in biomass take place during the spring (Fig. 2 b). The curve for the increases in biomass closely follows that for length. At emergence, the nymphs weigh about 6 mg.

Ephemera vulgata. This species differs from the other two in that the life cycle is two years long (Fig. 3 a). During this time there are two periods of marked growth, one during the late summer and fall after hatching and the second during the ice-free period the next year. In the same way as described for the other two species, the growth almost disappears during the winter, and the females grow more rapidly than the males (in the last year). The emergence occurs from the end of May until the beginning of July. In this species, the nymphs that live in the deeper parts of the tarn emerge later than those that live in the shallower parts.

The greatest increase in biomass occurred during the last months of the second summer (Fig. 3 b). Immediately after hatching the nymphs weigh about 1 mg and grow to 90—120 mg before emerging.

Discussion

These three species, all of them herbivores, show in general the same growth cycle with the best growth during periods of high water temperature and abundant food. This food is likely made up for the most part of epiphytic algae (especially diatoms). The diapause that was found in *Leptophlebia vespertina* L. during the period of most abundant food is probably a result of the combination of high water temperature and low oxygen concentrations.

The growth curves for *Cloëon dipterum* L. and *Leptophlebia vespertina* L. resemble closely those given by Macan (1961) for the same species. However, the curves for *Leptophlebia vespertina* L. from Windermere (Moon 1939) are quite different as the growth here was fastest during the winter and the nymph stage lasted almost four months less than in the tarn. This difference may be a result of the different temperature regimes in these two bodies of water. In fact, Macan (1961) points out that even in neighbouring lakes the same species may have quite different growth rates because of differences in food and temperature.

During 1970, two generations of *Cloëon dipterum* were noted in the tarn. One generation emerged early in the summer. The nymphs that arose from this generation grew rapidly during the summer and emerged during September. This second generation in turn gave rise to nymphs in early fall but these grew slowly and emerged the next year

Macan (1961) also noted that two generations of this species were found during the same year in a trout pond. The factors that might give rise to these two generations in the same year are difficult to discover. One possible reason is the lack of competition from other species (for example *Leptophlebia vespertina*). Another might be a combination of abundant food and especially favourable temperature conditions.

It appears that temperature is the most important factor controlling the rate of growth and the duration of the various nymphal stages. In the mountains of Sweden, for instance, *Leptophlebia vespertina* has a two year life cycle. Although *Ephemera vulgata* is not found in extremely cold water, it is likely that this species will have a three-year life cycle at the limit of its temperature range.

Acknowledgements

I wish to express my sincere thanks to Professor U. Grimås, Fil. lic. G. Sandberg and Dr. J. Hobbie for important help in connection with the preparation of this paper.

References

MACAN, T. T. 1961. A key to the nymphs of the British species of Ephemeroptera. Freshwater Biological Association No. 20.

MOON, H. P. 1939. The growth of *Caënis horaria, Leptophlebia vespertina* and L. *marginata* (Ephemeroptera). — Proc. zool. Soc. Lond. 108.