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Comparison of the Life Cycles of Two Mayfly Species Between Upper and Lower Parts of the Same Stream

by

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R. BAN & T. KAWAI: Comparison of the Life Cycles of Two Mayfly Species Between Upper and Lower Parts of the Same Stream.
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The life cycles of the burrowing mayflies, *Ephemera strigata* Eaton and *E. japonica* McLachlan were studied comparatively between upper part and lower part of a small tributary of the Yoshino River. *E. strigata* was more common than *E. japonica* in the studies areas. *E. japonica* was found only in the upper part and in tiny tributaries of the stream. *E. strigata* was univoltine in the lower and in the upper parts of the stream. However, the population falls into two groups, one of which emerges in early May and the other in summer. Water temperature seems to be one of the factors affecting the variable life cycle of *E. strigata*. *E. japonica* is univoltine. Emergence of this species was observed from June to August.

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INTRODUCTION

Sand burrowing genus *Ephemera* is the dominant mayfly type in the pool communities of streams. Three species, *E. strigata* Eaton, *E. japonica* McLachlan and *E. orientalis* McLachlan, are widely distributed in Japan.

It is reported that *E. japonica* occurs in upper parts, *E. strigata* in middle and lower reaches and *E. orientalis* in lower parts of rivers. *E. japonica* also occurs in tributaries which flow rapidly (Kuwata, 1958).

It has been reported that *E. strigata* has one generation per year in the Niu River and one generation per two years in the Umamigasaki River, where water temperature is low (Gose, 1970). Its emergence period is from May to middle June in the Niu River and June in the Umamigasaki River.

E. japonica has one generation per year and the emergence period is from May to late June at Ikadaba, upper part of the Yoshino River (Gose, 1970).

In general, the life cycle of insects is different between upper and lower parts in the same stream (Gose, 1970). Some authors have suggested that those variations may be due to the effects of water temperature on egg development and larval growth (Brittain, 1977; Humpesch, 1979).

In this study, the life cycle of two *Ephemera* species was studied comparatively between the upper and lower parts of a small tributary.

STUDY AREA AND METHODS

This study was performed in the Takami and the Shigo Rivers, tributaries of the Yoshino River (Fig. 1). The Yoshino River, 134 km in length, runs off the Odaigahara which is one of the highest ridges of the Kii Mountains and 1965 m above sea level. The Takami and Shigo Rivers have not been dammed or subjected to other artificial alterations. Most of the stream basin is a wooded sector of *Cryptomeria* plantation. Precipitation is concentrated in the summer, especially in June and July.

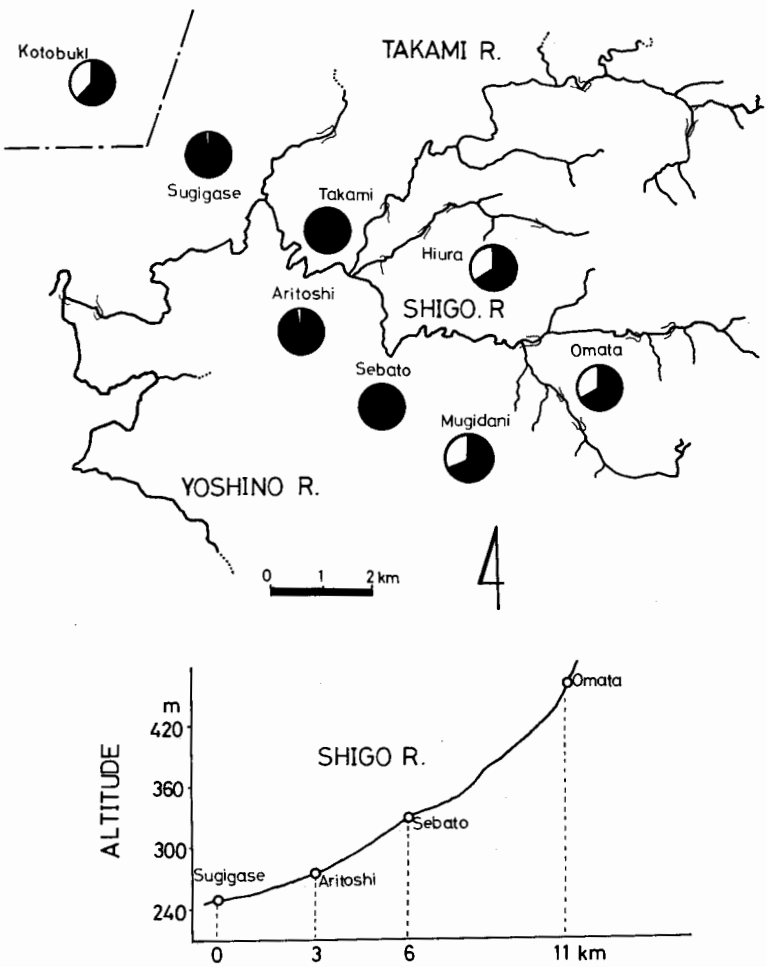

Fig. 1: The elevation of the investigated area and dominance of *E.strigata* (black) and *E. japonica* (white) expressed as the relative number of individuals at eight stations.

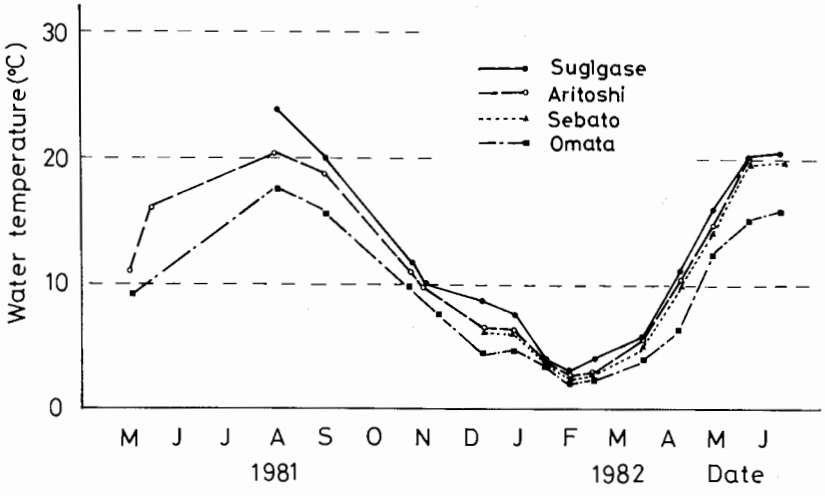

Fig. 2: Seasonal changes of water temperature (°C) at the four study points, Omata, Sebato, Aritoshi and Sugigase.

The water temperature was measured every month at four stations, Omata, Sebato, Aritoshi and Sugigase, early in the afternoon (12:00 – 14:00) (Fig. 2).

Temperatures in the winter were 2 – 4°C at all stations, but they varied widely in other seasons, especially in summer. It should be noted that the water temperature at Omata was lower than at the other stations (Fig. 2).

The width of stream varied from 4 m at Omata to about 20 m at Sugigase. Collections were made at the margins of the pools in depths of 5 cm to 60 cm. On 6th September 1981 only a small number of larvae were collected in the usual habitat at Sugigase.

We collected larvae of *E. strigata* and *E. japonica*, monthly from June 1981 to April 1982 at Omata and Sugigase, from October 1981 to April 1982 at Sebato and Aritoshi and measured them in the laboratory. The body length of the larvae was measured from the front of the head to the base of the terminal filament with an accuracy of 1 mm and the colour of wing pads was recorded.

Until November 1981, sandy substrates were removed with a steel hand net with a mesh of about 1 mm and the larvae were picked out in the field. After November 1981, about 1 kg bottom sand was carried away in a bucket and the larvae were picked up in the laboratory.

On 27th October 1981, the distribution of *Ephemera* species along the Yoshino River was checked by collecting larvae by the same method.

Laboratory experiments were performed to determine the effect of water temperature on the hatching period of eggs. The eggs were obtained from females which emerged at Omata and Aritoshi at beginning of May, 1982. Each egg mass was divided into four and incubated at 4, 15, 20 and 25°C.

RESULTS

E. strigata was more dominant everywhere in the study area, especially in the lower parts of the stream, at Sebato, Aritoshi, Sugigase and Takami. It made up more than 95% of numbers of *Ephemera* collected throughout the year. *E. japonica* occurred only in small tributaries, for example the Hiura and Kotobuki, and in the upper part of the stream, at Omata and Mugidani (Fig. 1). But at Omata, the proportion of the larvae was not constant. The percentage of *E. strigata* varied from 80% in autumn to 25% in spring probably because of the emergence of adults and drift of the larvae. The distributions of the two species agree with a previous study (Kuwata, 1958).

In a lower station, Sugigase, the growth of the larvae of *E. strigata* was very rapid during summer, autumn and early winter. Little growth occurred during the winter period prior to emergence. Final instars of *E. strigata* were found mainly in April 1982 (Fig. 3). In 1982, adults of *E. strigata* emerged in late April and early May at the four stations, Omata, Sebato, Aritoshi and Sugigase. The life cycle of *E. strigata* at Sugigase was one generation per year.

In an upper station, Omata (Fig. 4), the larvae of *E. strigata* were very small, and their body length was only about 5 mm in September 1981. They grew rapidly until November when the body length became about 10 mm, and they then ceased growing until spring. But another group of small sized individuals appeared in November. The existence of two groups became clear in the spring. Both groups did not grow during the winter, but they began to grow rapidly in April. After the emergence of the first group in spring, another group was expected to mature during summer, but we were not able to confirm that emergence occurred in summer. It is certain though that the life cycle and growth pattern of *E. strigata* at Omata were different from those at Sugigase. The life cycle of *E. strigata* at Sebato and Aritoshi was similar to that at Sugigase (Fig. 5). In summer and autumn, there were only small larvae at all four stations. But in winter and spring, two groups, a large sized group and a small sized group were recognized at Omata, although there was only a large sized group in the other three stations.

E. japonica was studied at Omata. Small larvae began to appear in September and grew rapidly until November. Growth was very little in winter, but considerable again in spring. Final instar larvae occurred from June to August in 1981 and in May 1982. The presumed emergence period of this species therefore is three months of summer. So *E. japonica* has only one generation per year at Omata (Fig. 6).

DISCUSSION

Some authors have suggested that the principal factors affecting the life cycle are food supply and water temperature. *Ephemera danica* (Müller) changes its

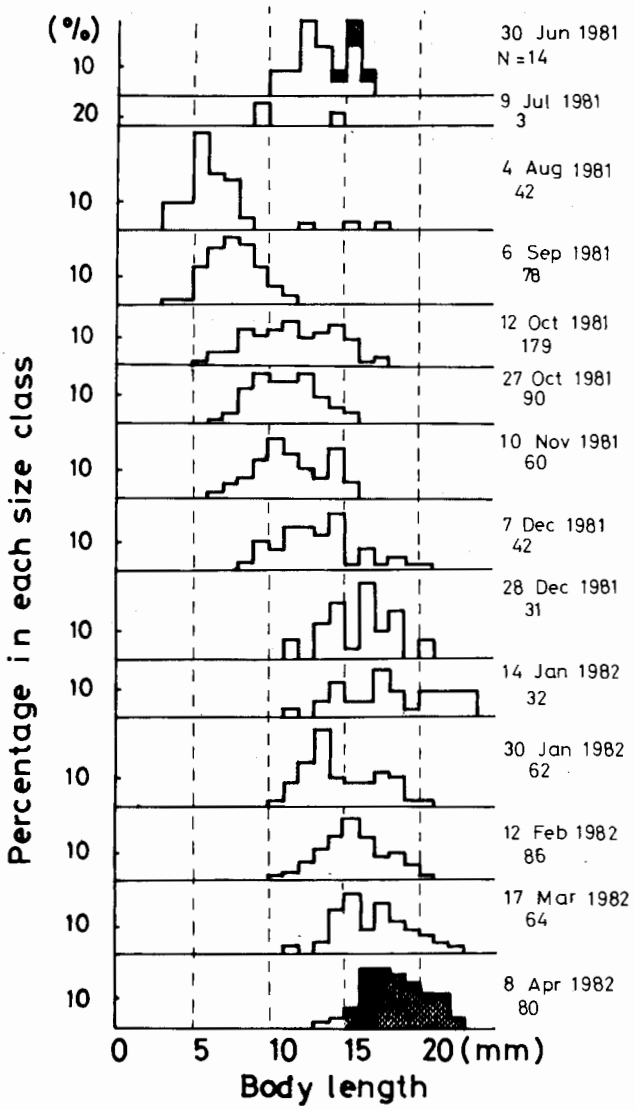

Fig. 3: Seasonal change of body length frequency of *E. strigata* larvae at Sugigase. Frequencies are expressed as percentage. Shaded area shows mature larvae.

life cycle from one generation per two years to one generation per year where food is abundant and habitat conditions are ideal (Whelan, 1981). *Stenopsyche griseipennis* McLachlan (Trichoptera) changes the life cycle from two generations per year to two generations per three years or one generation per year according to water temperature (Gose, 1970). In *Epeorus latifolium* Uéno

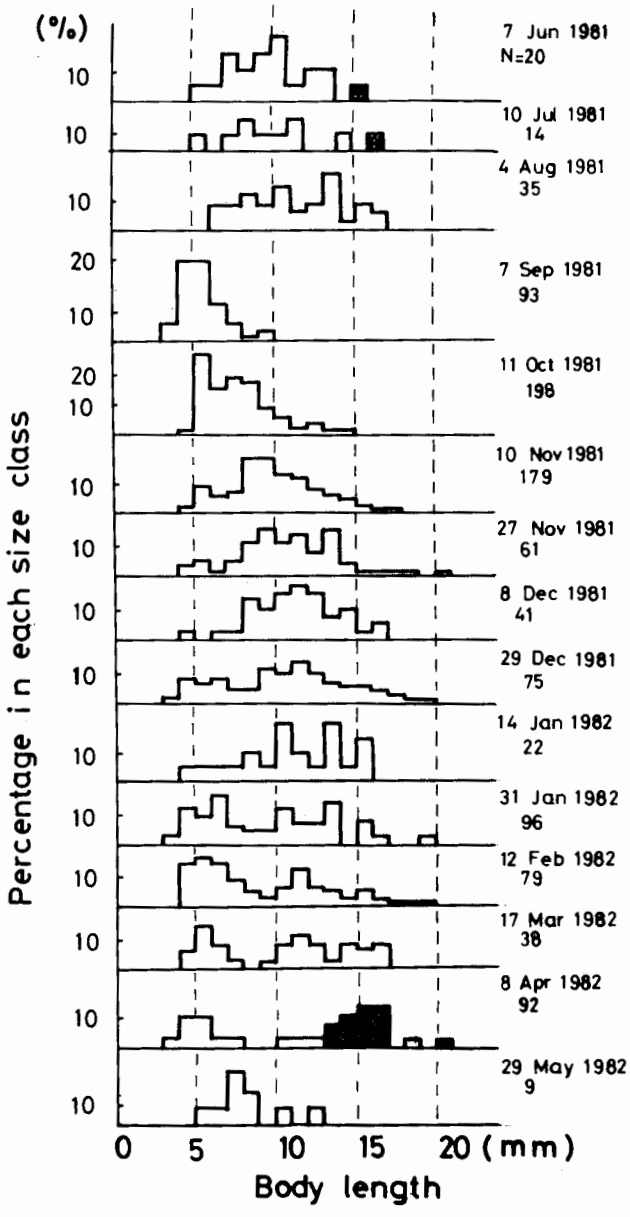

Fig. 4: Seasonal change of body length frequency of *E. strigata* larvae at Omata. Frequencies are expressed as percentage. Shaded area shows mature larvae.

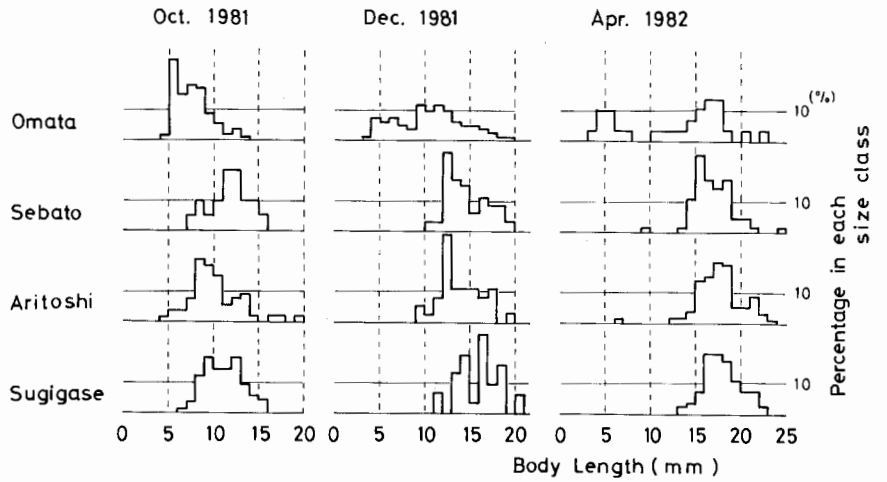

Fig. 5: Comparison of body length of *E. strigata* larvae from four collection points in October and December 1981 and April 1982. Sample sizes are 35-98 individuals.

(Ephemeroptera), the population is divided into two groups, which emerge separately, probably because of differences in water temperature (Gose, 1970).

That section of the population of *E. strigata* at Omata which remains in the stream after the early emergence in spring has three possible fates.

1. It emerges in the summer. If this is so, and we did just not observe it, there are two groups each with one generation per year.
2. It emerges in the next summer, with this group having one generation every two years.
3. It dies during the summer. The existence of this group would then best be explained by delayed hatching of eggs. However, we found no evidence of egg diapause, almost 100% of the eggs hatched synchronously at all temperature conditions (Fig. 7).

We must conclude that our data are insufficient to reach firm conclusions about *E. strigata* in the upper reaches, where there may be two groups, one emerging in early May and another in summer.

In the lower part of the stream *E. strigata* has a characteristic life cycle of one generation per year, all individuals of this species emerge together in May and belong to only one population.

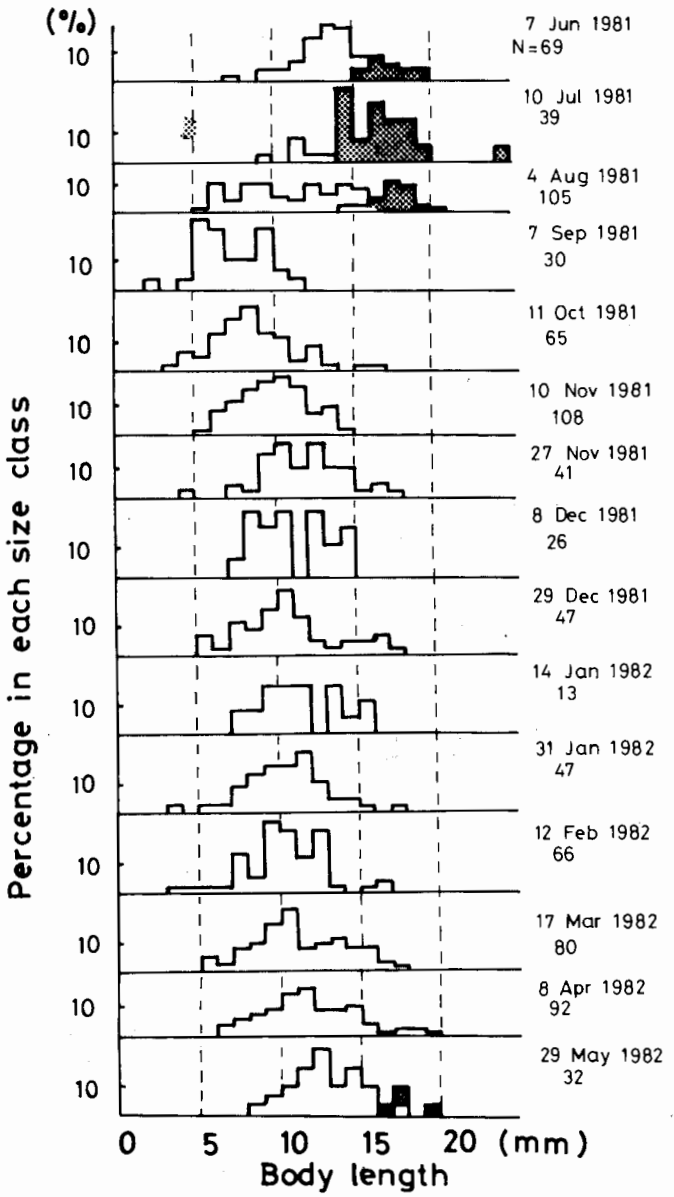

Fig. 6: Seasonal change of body length frequency of *E. japonica* larvae at Omata. Frequencies are expressed as percentage. Shaded area shows mature larvae.

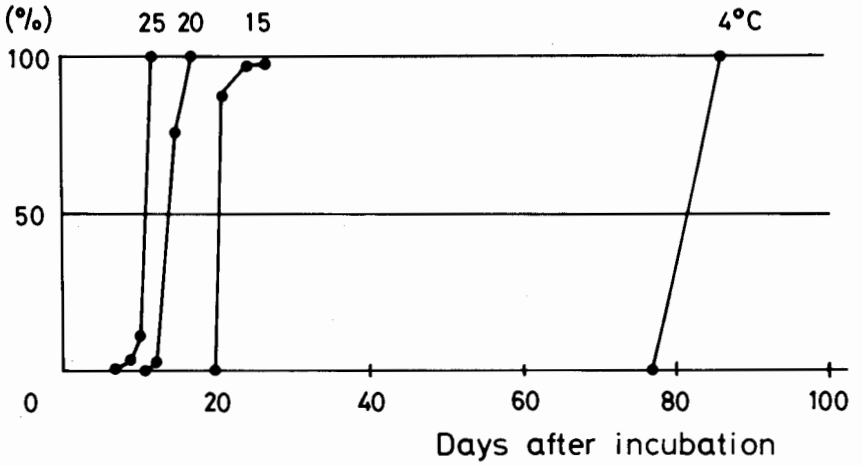

Fig. 7: Hatching curves of eggs of *E. strigata* under four different water temperatures, 25°C, 20°C, 15°C and 4°C.

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