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Factors influencing the life-histories of some stream insects in Alberta

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With 7 figures in the text

Most methods of sampling the bottom fauna of streams are subject to major sources of error. Two of the greatest of these are due to the non-random distribution of animals in the stream, and the failure of most sampling techniques to obtain eggs, very small larvae, or adults.

The first source of error may be minimised by taking larger or more numerous samples, but the second can only be overcome by using more refined sampling techniques. Such methods are often beyond the resources of the fisheries biologist who requires a simple and inexpensive method of estimating the population density of fish food organisms. For this reason I have undertaken a study of the life-histories of some of the predominant Ephemeroptera and Plecoptera in Alberta, since this information may be used to check the reliability of estimates based on simple sampling methods.

The study was carried out in Gorge Creek, a small trout stream on the eastern slopes of the Canadian Rockies in Alberta. The stream was selected because it is fairly typical of the smaller trout streams of the area, because it is conveniently located for easy access during the summer, and because temperature data were available for this stream for some previous years. It was unfortunately difficult or impossible to reach the stream during some of the winter months.

Gorge Creek consists of two main branches each rising at about 1850 m and each about 6½ km long, and a common section of the same length. The last section enters the Sheep River at an altitude of about 1500 m, and all of the samples were taken in a two-hundred-metre stretch immediately above the Sheep River. The rate of flow fluctuates, rising to 300 cm/sec or more when the snow is melting and dropping to 80—100 cm/sec in mid-summer. The depth of the water varies between about 20 and 40 cm, and the bottom of the stream is composed of small boulders and rocks with some patches of gravel.

In addition to the samples of insects which were taken every four weeks, data have been accumulated on some of the physical characteristics of the stream. A thermograph was installed in the summer of 1960 but proved to be unreliable. It was replaced in the spring of 1961 and has been in almost continuous operation since then.

The data obtained (Fig. 1) show that Gorge Creek has a temperature of 0° C for about six months. During this period, from mid-October to mid-April, no sunlight reaches the stream and the layer of ice on the surface grows thicker until by February there is a honeycombed layer of ice two or three feet thick covering the stream. Beneath this layer a flow of water is maintained, and an oxygen determination made in mid-February 1962 revealed that it contained 12 mg/l of oxygen, representing 100% saturation at this altitude.

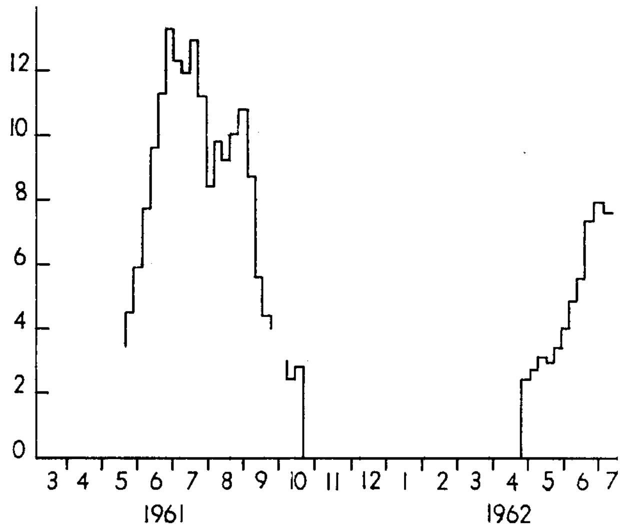

Fig. 1. Mean weekly temperature of Gorge Creek during 1961 and 1962. Abscissa: Months of the year. Ordinate: Temperature in degrees Centigrade.

In mid-April the water temperature began to rise and by the end of July the mean weekly temperature had reached 10° C. It remained at or above this level for seven weeks and then began to decline, dropping to less than 0.5° by the end of October.

Maximum and minimum temperature records for Gorge Creek were available for the summer months of 1950—1955. These show that 1961 and 1962 were typical summers, 1961 warming up slightly earlier than usual, and 1962 being somewhat later than usual. There is only slight variation between years, and the available data suggest that there is less than three weeks difference between the earliest and the latest years.

The data for Gorge Creek contrast strikingly with the records obtained from a small stream in England by Macan (1958). In that stream the mean weekly temperature was above 10° for 24 weeks during the summer of 1954, and was below 5° for 12 weeks in the following winter. In Gorge Creek, comparable data for the summer of 1961 and the following winter show that the temperature was above 10° for 7 weeks and below 5° for 39 weeks. There is a similar difference between the amount of heat available. MACAN found that during the 30 weeks following the beginning of October 1954, his stream accumulated 30 500 degree hours. The comparable figure for Gorge Creek from October 1961 was 1221 degree-hours. The total for the year in Gorge Creek was less than 30 000 degree-hours.

For purposes of sampling, the year was divided into thirteen four-week periods. Samples were taken in every period except on two occasions when it proved impossible to reach the stream. The samples were taken by means of an ordinary pond net, supplemented occasionally by a plankton net. No attempt was made to obtain quantitative samples, and collecting was continued until it was judged that an adequate sample had been obtained. The larvae were preserved in 70% alcohol and their length measured to the nearest 0.5 mm.

Data on the emergence periods of the species studied was obtained by intensive collecting of adults during 1960, 1961 and 1962.

The biggest problem encountered in this study has been the identification of the larvae. In some cases it has not yet been possible to separate larvae of related species, and in others, attempts at rearing the larvae have proved unsuccessful.

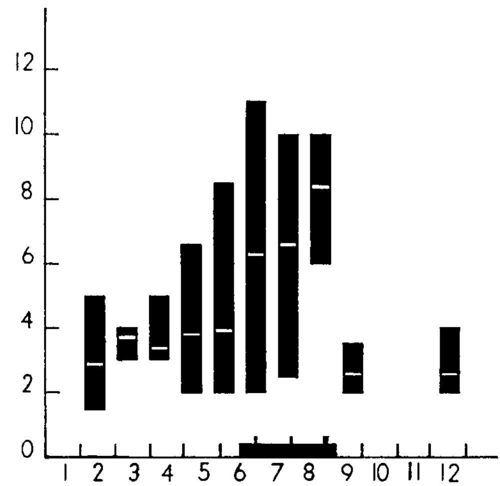

Fig. 2. Growth of *Cynigmula ramaleyi*. The mean size is shown by a short white horizontal line, and the size range by a black rectangle. The black rectangle on the abscissa indicates the known emergence period.
Abscissa: Months of the year. Ordinate: Body length in millimetres.

Despite the rigorous conditions, Gorge Creek has been found to support a diverse fauna of Ephemeroptera and Plecoptera. Many of the species cannot yet be distinguished from one another, and others are present in such small numbers as to make sampling inadequate as a means of working out the life-histories. Amongst these are some which appear to be multivoltine and others which probably take two years to develop.

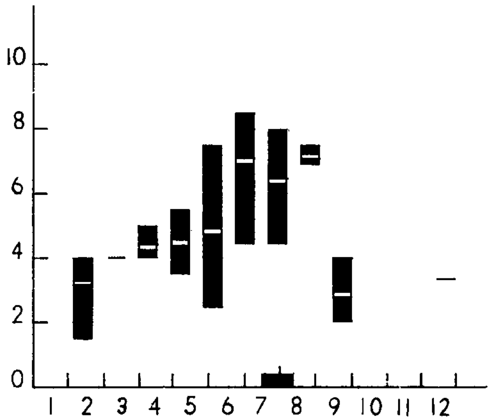

Fig. 3. Growth of *Ephemerella inermis*. For explanation see Fig. 2.

All of the species for which adequate data are available are univoltine, and these fall into three categories according to the stage at which they pass the winter.

In some, such as *Cynigmula ramaleyi* (Fig. 2) and *Ephemerella inermis* (Fig. 3), the eggs are laid during July and August and hatch soon afterwards. The larvae

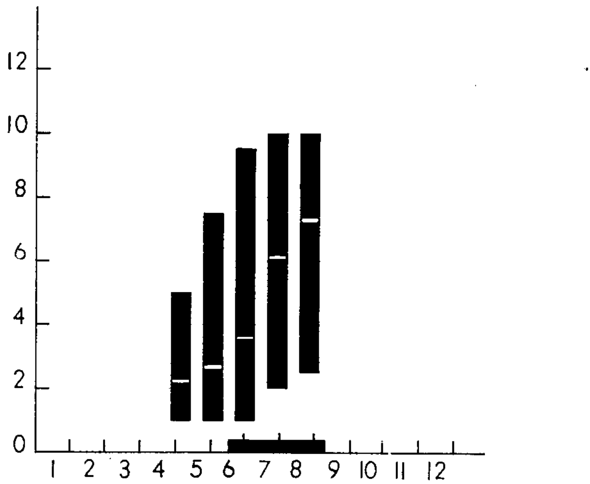

Fig. 4. Growth of *Epeorus longimanus*. For explanation see Fig. 2.

grow to a length of 2—3 mm during the fall and then cease growth during the winter. In the spring growth is resumed and development completed by July or August. In both of these examples it seems probable that the hatching period is long, as Macan (1957) suggested for *Rhithrogena semicolorata*. Some evidence has been obtained that *Rhithrogena virilis* has a similar life-history in Gorge Creek, but since the small larvae cannot be distinguished from those of *R. robusta* and *R. doddsi* some doubt remains in this case.

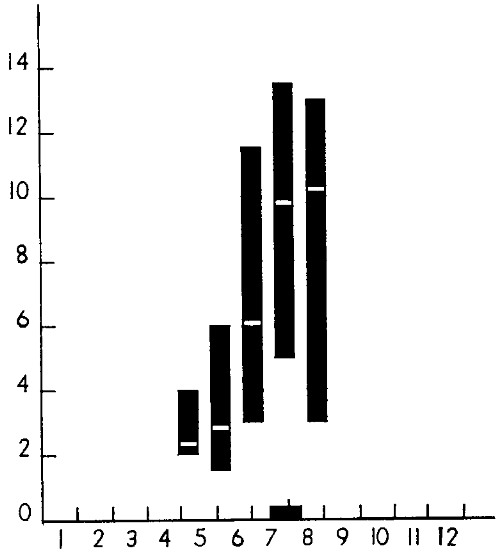

Fig. 5. Growth of *Ephemerella lapidula*. For explanation see Fig. 2.

A second type of life-history is observed in *Epeorus longimanus* (Fig. 4) and a species of *Ephemerella* (Fig. 5). The latter species was incorrectly identified in the abstract of this paper as *Ephemerella grandis*. It is not this species, but may be *E. lapidula*. In these species, the eggs are laid in July and August, but do not

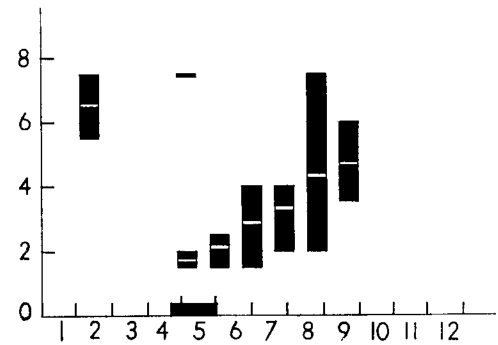

Fig. 6. Growth of *Nemoura columbiana*. For explanation see Fig. 2.

hatch until the following spring. Small larvae appear for the first time in April and grow very rapidly to complete their development by July or August.

The third type of life-history occurs in some, perhaps all, species of *Nemoura* found in Gorge Creek (Fig. 6). Here the eggs are laid in late spring (May and early June) and hatch shortly afterwards. The larvae grow throughout the summer and fall and, more slowly, during the winter. In the spring more rapid growth is resumed and the larvae mature in May and June.

HYNES (1961) has divided species which have a seasonal life-cycle (i. e. those in which there is a seasonally changing size distribution) into two categories, slow and fast, the former being those in which the eggs hatch soon after laying and in which larval growth is slow and steady over a long period, and the latter being those in which there is rapid growth after a long egg-diapause or an intermediate generation. On this basis, *Cynigmula, Ephemerella inermis* and *Nemoura* would all be classified as slow seasonal types, and *Epeorus* and *Ephemerella lapidula (?)* as fast seasonal types. Nevertheless it does appear that in Gorge Creek it is possible to make a valid distinction between those slow seasonal types which overwinter as small larvae which do not grow, and those which overwinter as half-grown larvae which do grow, albeit slowly.

In his paper, HYNES further points out that it is advantageous to the carnivores to have a wide size distribution at any given time, in order that they may exploit the full range of food available. He points out that this is achieved intraspecifically in *Isoperla grammatica* and interspecifically by two species of *Chloroperla*. An exactly similar situation is seen in Gorge Creek in the genus *Alloperla*. Here there are five species present, the adults displaying a sequence of emergence from June to October; in the stream there is consequently a very wide range of sizes of larvae, which I am unfortunately quite unable to distinguish from one another.

When the three types of life-history are examined in relation to the physical environment is becomes evident that temperature is an extremely important factor in influencing the life-histories. In two of the three types, no growth takes place during the period when the stream temperature is 0°, and in the third type, exemplified by *Nemoura*, growth is considerably retarded (Fig. 7).

The importance of temperature is also emphasised by a comparison between the data obtained for Gorge Creek and that obtained for Deadhorse Creek, a small stream which enters Gorge Creek just above the sampling area. The seasonal temperature cycle is very similar to that of Gorge Creek, but in 1961 and 1962 was delayed by about three weeks. A consequence of this is that larvae which hatched in the late summer in Deadhorse Creek had three weeks more warm weather in which to develop before winter. They may therefore be expected to overwinter at a somewhat larger size than those in Gorge Creek. In the spring, however, the earlier warming of Gorge Creek may be expected to permit larvae in this stream to grow more rapidly than those in Deadhorse Creek. This is borne out by the data for Deadhorse Creek for *Cynigmula*. On the other hand, eggs which hatch in the spring may be expected to be delayed in Deadhorse creek, and the larvae therefore smaller; this is supported by the data for *Epeorus*.

Despite the profound influence of temperature on the life-histories of these insects there is little doubt that other factors are also involved. In the genus *Alloperla*, it seems highly probable that the seasonal succession which is observed in the adults is due, in part, to competition between the various species. In other examples the presence or absence of a species from a particular stream may be

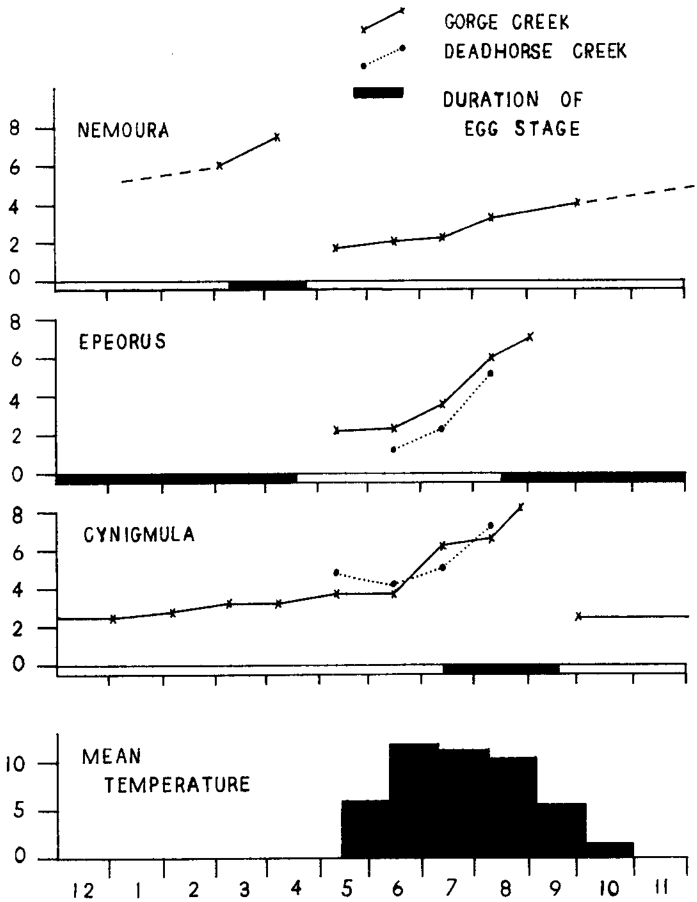

Fig. 7. The life-histories of three genera in relation to the mean monthly temperature of Gorge Creek. Abscissa: Months of the year, commencing in December. Ordinate: Body length in millimetres (top three graphs); temperature in degrees Centigrade (bottom graph). The duration of the egg stage is surmised from the size distribution of the larvae.

due to factors outside the stream itself. This is seen in the genus *Rhithrogena*. In Gorge Creek larvae of three species are found, but in Deadhorse Creek all of these are absent. There appear to be no reasons why the larvae should not survive in Deadhorse Creek and the reason for their absence is almost certainly that eggs are not laid in this stream. This may be because dense vegetation surrounds Deadhorse Creek, while Gorge Creek has some open ground on either side. Certainly oviposition has never been observed in Deadhorse Creek, and larvae are prevented from entering the stream from Gorge Creek by the waterfall at the bottom of Deadhorse Creek.

It is evident from these preliminary results that a great deal of work remains to be done, both in extending the survey to include a wider range of invertebrates, and to cover a wider range of streams and rivers. Nevertheless, there appear to be two conclusions to be drawn. First, there is no doubt that sampling by the usual methods may produce highly erroneous estimates of the bottom fauna density, because important species may be temporarily absent. Second, the life-histories of the species studied do not differ fundamentally from those of related species living under less rigorous conditions. It is hoped that an extension of this survey into the far North will reveal what happens when the winter is even longer and the summer shorter.

Acknowledgements

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Discussion

GAUFIN: What effect did temperature have on the emergence dates of the five species of *Alloperla*?

HARTLAND-ROWE: I have not yet examined the emergence dates in relation to temperature; four of the species overlap in time and the fifth, *Alloperla forcipata*, emerges in October when the temperature has dropped considerably.

HYNES: I think we should be careful not to use the word diapause for resting eggs. One of my students has found that in Plecoptera no diapause in fact occurs, it is merely that development is slow. Also I am doubtful if temperature is the main factor controlling adult emergence. It is certainly true that one can obtain adult stoneflies out of season by manipulating the temperature, but in unusual years the various species emerge at the right time even if the temperature is exceptionally cold. It would seem therefore that, while temperature may control growth, something else, perhaps day-length, may influence emergence.

HARTLAND-ROWE: I agree with Dr. HYNES on both points and plead guilty to using the term diapause.

MORGAN: I would agree with Dr. HYNES that, in the late summer, daylength rather than temperature may regulate the time of emergence of insects. In lakes temperature may be the limiting factor in the spring as insects brought into the laboratory in the early spring and subjected to normal daylength and higher water temperature will emerge up to three weeks earlier than in the field. In other words at the beginning of the emergence period the daylength may be longer than that which limits emergence for the insects tested.

Ricker: Are there any *Pteronarcys* in this stream? Collections I have made seem to show three size groups present in early summer.

Hartland-Rowe: They are very rare in this stream though abundant in the vicinity of Calgary at a lower altitude.