

## THE LIFE CYCLE OF *ARGIA VIVIDA* HAGEN IN THE NORTHERN PART OF ITS RANGE (ZYGOPTERA: COENAGRIONIDAE)

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*A. vivida* ranges at least from Mexico to southern Alberta, and larvae live in both warm and cold streams. In warm (geothermally heated) sites in Alberta, Oregon and Idaho, the life cycle is generally univoltine and larval growth is regulated by a short-day induced diapause in the penultimate larval instar. In sites with naturally fluctuating temperature regimes, however, the life cycle appears to be generally semivoltine. The role of diapause in this 2-year life cycle is presently unknown.

### INTRODUCTION

*Argia* is predominantly a neotropical genus, the greater number of species being found in South and Central America (WALKER, 1953). The distribution of *Argia vivida* Hagen ranges at least from Mexico to southern Alberta, and adults have been collected widely in the western United States. Larvae were first described from a cold, spring-fed stream in Washington by KENNEDY (1915), and have subsequently been recorded from sites with naturally fluctuating temperatures (e.g. NIMZ, 1978), as well as from thermal springs with higher, more stable temperatures (PRITCHARD, 1971; PROVONSHA & McCAFFERTY, 1977; NIMZ, 1978). Other members of the genus also occur in thermal springs (NEEDHAM & COCKERELL, 1903; BRUES, 1932; LA RIVERS, 1940; ROBINSON & TURNER, 1975; PRITCHARD, unpublished). In this paper I shall compare life-history data for *A. vivida* in cold and warm streams in Alberta, Idaho, and Oregon.

Year-round data from thermal pools at Banff, Alberta have been published by PRITCHARD & PELCHAT (1977). There, the life cycle appears to be basically univoltine. Adults are found from May through August and young

larvae (instars 3 and 4) occur in September. Growth occurs in the autumn, slows or stops from December to February, and proceeds again in the spring, with most larvae entering the final stage during April. Virtually all individuals collected during May to August were in the final instar, whereas from September through December very few final instar larvae were collected. A short-day induced diapause in the penultimate (F-1) instar as well as slower growth rates in the F-2 and F-3 instars under short-day conditions leads to synchronization of adult emergence at a favorable time of year (PRITCHARD & PELCHAT, 1977; PRITCHARD, unpublished).

COMPARATIVE OBSERVATIONS FROM WARM AND COLD SITES

Figure 1 shows the distribution of instars in a number of sites in April of several years. The major difference between sites is between the Quartzville site and the rest. This site is a cold stream, whereas all of the others are thermal streams. At Quartzville, larvae were exclusively in the final instar, whilst there was a wide range of instars present in the other sites. It was at first supposed that differences in food availability might be responsible, since the warm sites appear to have a lower diversity and lower abundance of prey but because of higher respiration rates *A. vivida* larvae would need to consume more in order to grow at the same rate. However, dissection of larvae from Foley Springs did not indicate that food was in short supply at this site at this time of year.

The two Banff samples were taken in rather different ways. The 1974 sample was taken from warm water in the center of the stream, while the 1971 sample was taken from soil blocks cut from the cooler edges of the stream. Samples taken in the latter manner in May and

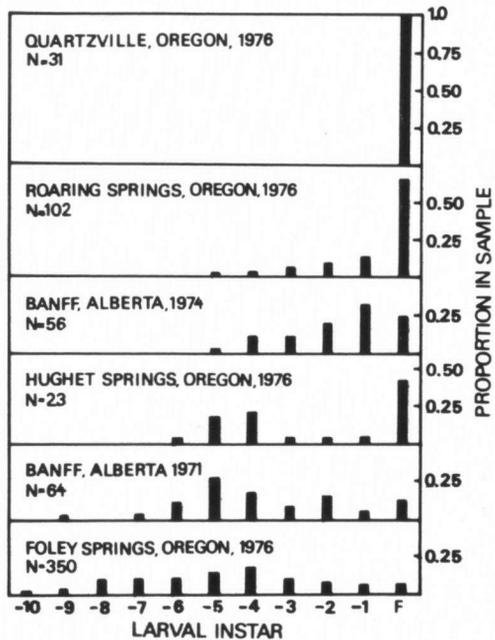


Fig. 1. The size distribution of larvae of *Argia vivida* in samples collected in April from sites in Alberta and Oregon.

June of 1971 also differed considerably from samples taken in the same months in 1974; only final instar larvae were present in the 1974 warm water samples, whereas 10 instars were present in 1971 (PRITCHARD & PELCHAT, 1977). It appears that the life cycle differs in thermal water from that in sites with naturally fluctuating temperature regimes.

In Figure 2 I have collected together information on larvae that have been collected from cold streams in Alberta, Washington and Oregon. With the exception of the Oregon sample of 8 April 1976 (the Quartzville sample), the samples are very small and most were collected rather haphazardly. It is to be expected, therefore, that small larvae would have been missed. There are two principal differences between these data and those from thermal streams. First, final instar larvae occur in late summer and in autumn; and second, several stages short of the final stage occur during the summer. Also, since growth in *Argia vivida* is temperature-dependent (PRITCHARD & PELCHAT, 1977; PRITCHARD, unpublished), it is very unlikely that the larvae at the Quartzville site could have developed in less than 1 year. The conclusion appears to be emerging, therefore, that *A. vivida* in cold streams takes 2 years to complete the life cycle.

A computer-based approach to the elucidation of dragonfly life histories was advocated by NIMZ (1978), who used LAWTON's (1971) work on *Pyrhosoma nymphula* as a data-base for a computer program to predict growth rates of *Argia vivida* in both warm and cold sites in Idaho. The prediction for the warm site gave a very poor fit to the field data, with larvae reaching full size in November, several months ahead of larvae in the field. Clearly, a missing factor in the model is the short-day induced

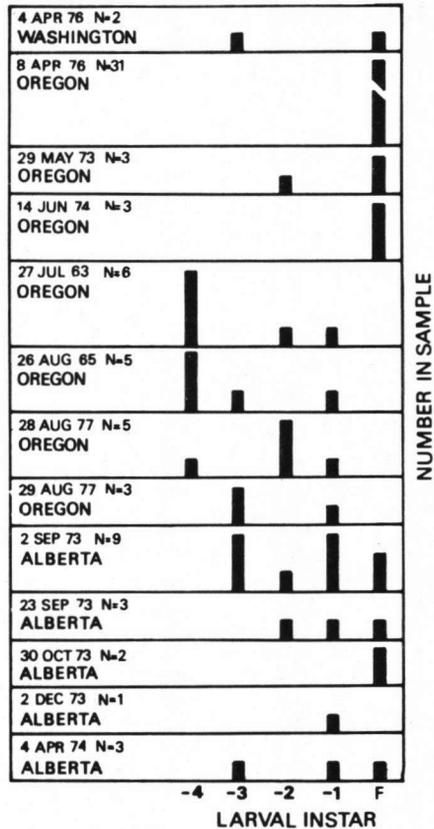


Fig. 2. The size distribution of larvae of *Argia vivida* in samples collected from sites with naturally fluctuating temperature regimes.

diapause in the penultimate larval instar. Of more interest here, however, are the data from the cold site which NIMZ (1978) presented as mean lengths of larvae grouped from several years. These field data matched the predictions of the model well. Furthermore, the prediction was for a 1 year life cycle!

However, there are two difficulties with the treatment of the data. First, in order for the model to correctly predict the 2-year life cycle of the species (*P. nymphula*) on which it was based, production and consumption were reduced arbitrarily when mean daily field temperature fell below 7°C; otherwise the

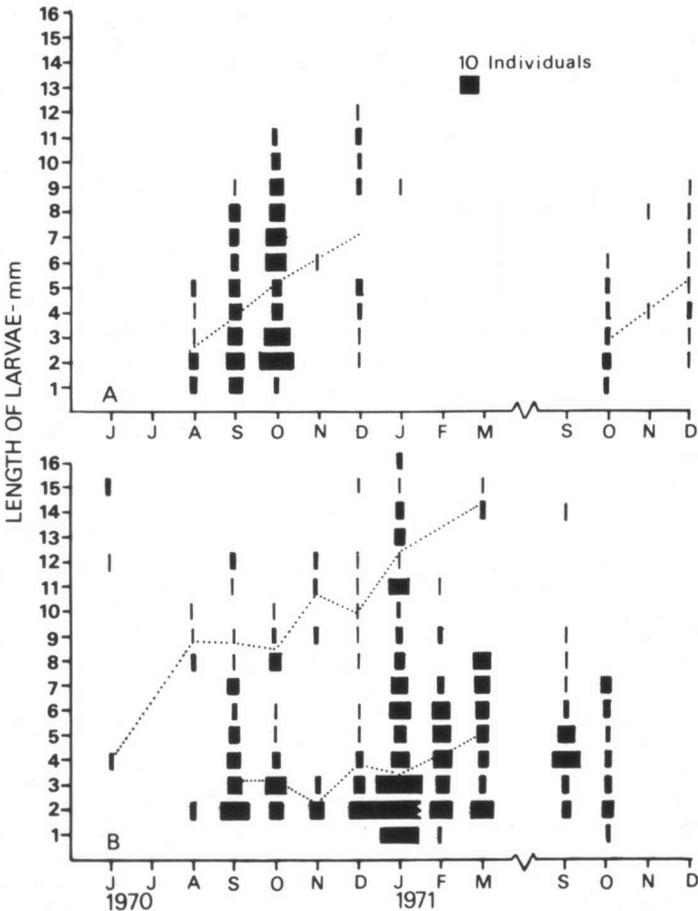


Fig. 3. The size distribution of larvae of *Argia vivida* in samples collected from a warm site (A) and a cold site (B) on Deep Creek, Idaho. (Data kindly provided by Mr. C. Nimz). The dotted lines connect the means for the proposed generations.

life cycle was completed too rapidly. However, no such reduction was made when the *Argia* life cycle was predicted, and yet *A. vivida* probably has a higher temperature threshold for growth than does *P. nymphula* (PRITCHARD, unpublished).

The second problem is that by combining data from several years into a single mean value, one loses information on age structure within the population. Mr. Nimz has very kindly provided me with his unpublished raw data from both the cold and the warm sites and these data are presented in Figure 3. It is quite clear that the age structures in the two sites are different. Although data are missing from critical periods and sample sizes are not large, *A. vivida* appears to have a 2-year life cycle in the cold site, while in the warm site the life cycle appears to be similar to that at Banff and univoltine.

### CONCLUSIONS

I conclude that *Argia vivida* in the northern part of its range generally has a 1-year life cycle in thermal sites but a 2-year life cycle in sites with naturally fluctuating temperatures. However, temperature variation within thermal sites as well as a long oviposition period, can lead to a considerable spread in the age structure of a population such that not all individuals in a warm site will necessarily be univoltine. Some synchronization is achieved by a photoperiodically-induced diapause in the penultimate larval stage. Whether a similar regulating factor is necessary in cold streams is not known at the present time.

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