Using Rainforest Research

Keeping cool when the heat's on: aquatic insects in rainforest streams

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Freshwater insects are ectotherms - cold-blooded animals whose temperature balance is regulated by external heat sources. Because of its direct effects on physiological functions like respiration and digestion, temperature has a influence on where and when different species of freshwater insects are found. In Europe and North America, temperature alters predictably with altitude and the seasons, and aquatic insects there can easily optimise thermal responses to fit these predictable patterns. The Australian environment presents more of a problem to freshwater insects though, because stream temperatures fluctuate unpredictably from year to year.

A number of factors contribute to this, the strongest being the frequency of droughts in Australia, when streams may be reduced to little more than a series of shallow pools. Stream temperatures generally rise higher in dry than wet years because smaller volumes of water gain temperature more rapidly. Cyclones and bushfires also contribute as their effects reduce shade over forested streams causing solar heating to intensify until the canopy regrows. To deal with such fluctuation, Australian freshwater insects could logically be expected to evolve more flexible, broad-ranging temperature responses than those from more predictable climates in Europe and North America.

The Chironomidae

Rainforest CRC PhD student Brendan McKie recently studied the distribution of aquatic Chironomidae in 36 streams throughout the Wet Tropics. Known commonly as non-biting midges, Chironomid larvae inhabit freshwater habitats, feeding on organic detritus in the sediment at the bottom in the same way that earthworms do in soil. Adults superficially resemble mosquitos but do not feed on blood.

Brendan also examined how well they tolerate extreme temperatures in the streams of the Wet Tropics and the temperate subalpine streams near Canberra.

Broader tolerance in ancient fauna

Recent discovery in the Wet Tropics of species previously thought to be restricted to cooler regions of southeast Australia suggests these midges have very broad temperature tolerances indeed. Laboratory testing confirms this, although Brendan discovered variation linked to the evolutionary history of midges. Species that evolved 150-90 million years ago when Australia was part of the Gondwanan supercontinent (with Antarctica and South America), and was colder and wetter than now, have narrower tolerances than those that evolved more recently, during drier periods in Australia's history.

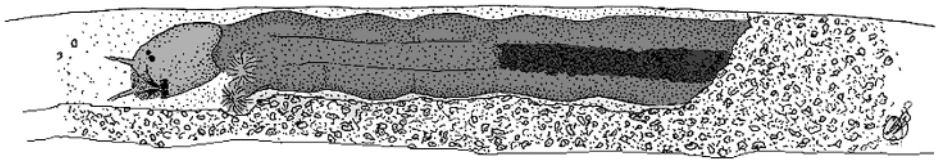
Right: a rainforest stream typical of Chironomid habitats in the Wet Tropics

The Rainforest CRC is a research partnership involving the Commonwealth and Queensland State governments, the Wet Tropics Management Authority, the tourism industry, Aboriginal groups, CSIRO, James Cook University, Griffith University and The University of Queensland

The Gondwanan chironomids however, are still more temperature tolerant than typical species from Europe and North America.

Brendan found no differences in the tolerances of midges from the Canberra streams compared with those from the Wet Tropics. Even though the Canberra streams are substantially cooler, during hot dry summers water temperatures can be similar to those of tropical streams. The environmental fluctuations that characterise Australian streams appears to have maintained broad temperature tolerances among midges Australia-wide, contrasting with the northern hemisphere where insects at different latitudes typically have different temperature tolerances.

This contrast continues in the distribution patterns of species found. In the northern hemisphere, midge species are generally restricted to narrow altitudinal zones, and exhibit marked differences in the type of communities found at high, middle and low altitudes. No such zonation occurs in the Wet Tropics. Although Gondwanan species are more common at high altitudes, they occur in well-shaded, cooler lowland streams also. No zonation was evident with latitude either, with Gondwanan species occuring throughout the entire Wet Tropics bioregion. Similarly, at the continental scale several species range down the entire eastern seaboard, and even in the alpine regions of southeast Australia, there are no unique species above the snowline.



Midge larva, living inside a tube constructed from silk and detrital particles. The mid-grey colour is due to a blood-like chemical, possessed by many chironomids to aid in oxygen uptake. Such species are known to fishermen as "bloodworms" (illustration: Linda Davis).

The trouble with too much tolerance

Australia has fewer chironomid species than comparably sized areas in Europe and North America. Here, between 15 and 50 species are typically found at single stream sites, whereas northern hemisphere sites frequently yield hundreds of species, reflecting relative degrees of specialisation in these animals. Temperature can be regarded as a *resource* since ectotherms *exploit* the heat energy available in their environment to power their daily activities. The predictability of northern hemisphere seasonal temperature cycles enables its chironomids to narrowly optimise their temperature responses. This allows the temperature resource to be more finely divided, an advantage which enhances speciation - or the evolution of new species. In contrast, the unpredictability of the Australian stream temperature cycle has favoured chironomids with broader tolerances, preventing fine-scale niche differentiation and possibly, retarding speciation.

Management Implications

Other Rainforest CRC researchers have discovered similarly high levels of tolerance to both low oxygen concentrations and high sediment loads in the Wet Tropics freshwater fauna. It appears that broad environmental tolerances may be a general feature of Australian aquatic insects. However, the very adaptation of the fauna to hydrological unpredictability makes it peculiarly vulnerable to changes caused by the construction of dams and weirs that impose greater regularity on stream and river flows. Such structures dampen environmental fluctuations and favour introduced northern hemisphere species better adapted to more constant conditions, many of which are pests. With increasing pressure on water supplies from a growing human population in the Wet Tropics region, care is needed to avoid excessive impacts on the rainforest streams. Like the terrestrial forests, these streams support unique animal species found nowhere else in Australia. Among these are some endemic Gondwanan midges that do not occur in warmer north Queensland streams outside the Wet Tropics. Any alteration to stream temperature regimes resulting from dam construction or other disturbances could compromise the existence of this ancient fauna.

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