Using Rainforest Research

If shrimps could fly - genetic flow and dispersal of aquatic insects in separated river systems

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Tens of millions of insects and small crustaceans inhabit rainforest streams and rivers. It seems obvious that many of these creatures disperse widely since they are found over extensive areas. This is supported by the rapid recovery of stream communities following disturbances of natural or human origin. However, studies that adequately investigate how insect communities would respond to a large-scale disturbance have rarely been undertaken. Recovery at this scale may be much slower than is currently assumed from small-scale studies.

Ways in which stream insects disperse include downstream drift and flight by the adult forms. Measuring dispersal of stream insects by direct methods such as marking and recapturing is difficult because of their size and the numbers involved. An alternative approach is to determine the genetic structure of populations. Where there is a high level of dispersal, there will be little in the way of genetic differences, whereas isolation causes large genetic differences in populations over time.

Recent research in the Conondale Range of southeast Queensland on a range of stream creatures illustrates how analysing the genetic structure of populations can be used to answer questions about dispersal in streams. These studies have also provided surprising evidence that insect larvae in particular pools are the result of only a few matings rather than being representative of all potential males and females in the population. This could be because in these areas, unlike in more temperate environments, adults do not appear to emerge in big swarms. Emergence times seem to be spread throughout the year with only small numbers flying around at any one time.

What is the study area like?

The Conondale Range divides the Brisbane and Mary Rivers of southeast Queensland. The climate is subtropical with hot wet summers and cool dry winters. Rainforest is widely distributed in upland areas and along rivers at lower altitudes. The streams and tributaries that join together and flow into a river make up that river's 'drainage'. For this study, Rainforest CRC researchers Jane Hughes and Stuart Bunn collected aquatic insects and crustaceans from sites within the Brisbane and Mary River drainages. Within each of these drainages there are two subcatchments. Most samples were collected from 12 sites which encompassed three streams in each subcatchment. The sampling sites were chosen so that each would be geographically closer to sites on the opposite side of the Range rather than sites within the same drainage. This enabled researchers to distinguish between stream dispersal and dispersal by land or air.

Top: Glass shrimp (Paratya australiensis) Atyid shrimps like these are a common and conspicuous inhabitants of rainforest streams
Bottom: Mayfly nymph (Jappa sp.)
Photographs: J Marshall

Which stream dwellers were studied?

A range of species with differing life cycles and abilities to disperse were collected including a small shrimp, a mayfly, a caddis fly and a water strider. The glass shrimp, is the most conspicuous and abundant small crustacean in the pools of streams in the study. Its life cycle is entirely aquatic with a planktonic larval stage which should enable a reasonable amount of dispersal to occur within the stream systems. The water strider collected is also thought to have an entirely aquatic life cycle, and is common on the surface of stream pools.

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

Mayflies are one of the most common grazers of algae in pools. They are thought to have a short-lived winged adult stage and highly mobile larvae while caddisflies have a longer-lived winged adult stage. Jane and Stuart collected the larvae of an undescribed species of mayfly and one of five species of sand-cased caddis flies whose larvae are fairly slow moving and form dense groups on cobbles and boulder surfaces.

Where possible, at least 100 individuals were collected from each study site, sealed in plastic bags and frozen in liquid nitrogen for transport and storage. Genetic techniques were used to distinguish differences between populations, and to enable them to formulate descriptions of population structure.

How did stream populations differ?

The small shrimp showed huge differences in genetic structure not only between populations from different subcatchments, but also within subcatchments. This implies that there is little movement between streams despite the planktonic larval stage.

In contrast, the pattern of genetic differences among the populations of aquatic insects was very different. The differences were very small at the catchment and subcatchment scales indicating high levels of dispersal, as would be expected for species with a winged adult phase. Initially, researchers expected the results for the water strider to differ from the insects with winged phases. What they actually found was that the levels of dispersal were similar, and it has subsequently come to light that many species of water strider occasionally produce winged adults!

When Jane and Stuart looked at the results from *within* streams, they were surprised to find that the genetic differentiation was greater than *between* subcatchments and catchments. This occurred with all three of the insects in this study. They concluded that this unusual pattern could be explained if the insects sampled from a population were the offspring of only a few matings and movement in-stream was limited.

Since there is little difference in the genetic structure of insect populations over larger scales, it is most likely that adult flight provides the means of dispersal for stream insects in the Conondale Range. In contrast, large genetic differences between populations within streams seem to be partly the result of limited in-stream movement of larvae and partly due to the fact that each pool contains only a subset of possible offspring. Within a whole stream most combinations are likely to be represented, which explains why genetic differences between streams and between subcatchments are negligible.

What is the significance of these findings?

Rainforests are subject to disturbances that are natural or caused by human activities. The rate of recovery of populations will partly be determined by how well they can disperse. Studies such as this enable more informed conservation management decisions to be taken, and for us to predict the probability of recolonisation after local extinctions. For fully aquatic species, such as the glass shrimp, recolonisation after extinction in a whole stream is unlikely. On the other hand, for most of the aquatic insects, it appears that recolonisation is very probable for extinctions at the pool, stream or even subcatchment scale.

Jane and Stuart are now examining the role that intervening habitat has on dispersal between catchments. The Conondale work concentrated on a continuous area of rainforest. In their work with the CRC, they are examining rivers separated by dry sclerophyll forest to assess insect dispersal across such areas of non-preferred habitat. Preliminary results, at least for some species, suggests that these areas may be partial barriers to dispersal. Any further rainforest fragmentation may restrict their dispersal further.

For more information:

Jane Hughes or Stuart Bunn
School of Environmental Studies
Griffith University, Nathan Qld 4111
Australia. Fax: 07 3875 6717
Ph: 07 3875 7376 or 07 3875 7407

PHOTOS: PETER LIK, WETROPICS