Beech scale insects turn ecosystem upside-down

By Laura Sessions

Beech honeydew is a sugary liquid that is formed by the sooty beech scale insect. This insect lives almost exclusively on southern beech (*Nothofagus* species) and is very common in the northern South Island. The beech scale insect feeds by sucking out the beech tree's sap and then excretes in the form of honeydew what it can't use.

The honeydew forms small, sweet droplets at the end of the insects' thread-like anal tubes and these drops are harvested by a number of other organisms in the forest. Native birds and invertebrates, honey bees, wasps, fungi and soil micro-organisms all rely on honeydew for food.

To make this supply of honeydew, which is important to so many other organisms, scale insects may remove more than 30% of the total energy that a beech tree produces through photosynthesis. This is a huge energy loss, yet beech trees do not appear to be damaged by the scale insects at all. How can the beech trees survive this drain?

Associate Professor Dave Kelly and Dr Matthew Turnbull, of the Department of Plant and Microbial Sciences, have started a new project to test their hypothesis that the scale insects do not harm the trees. Instead, they think the extra demand imposed by the insects stimulates the trees to increase the amount of energy they produce. In other words, the energy that is captured in honeydew might not have existed at all—even in the tree's tissues—if it weren't for the scale insects.

Previous studies have shown that photosynthesis can be slowed when sugars build up in a plant's leaves and so insects feeding on those leaves might actually increase the plant's rate of photosynthesis. However, this compensatory increase in photosynthesis has been shown most often where insects actually eat the leaves, whereas scale insects suck sugars directly from the tree's sap.

The other major difference between previous studies and the honeydew system is the potentially huge scale effect of this insect. Honeydew is abundant throughout more than one million hectares of New Zealand forest and is produced year round. Scientists have studied other scale insect species in the Northern Hemisphere, but they are only seasonal feeders and so do not have as great an impact.

A continuous boost in the photosynthesis of each infected beech tree across one million hectares of forest would result in a massive increase in the ecosystem's overall productivity. This would mean that not only is the scale insect converting beech sugars into a form that other animals can use it, is also enabling a whole range of organisms to survive by inducing a new energy source. If so, these tiny insects have altered an entire ecosystem on a huge scale.

If Professor Kelly and Dr Turnbull's hypothesis is true, it also has important repercussions on the way ecologists think about ecosystems. Ecologists have debated for many years whether plants regulate herbivores (for example, the abundance of many herbivores is limited by the food available) or vice versa (plant growth is often limited by the herbivores that feed on them). If the beech scale insect causes an increase in tree productivity, it represents an example of top-down ecosystem regulation. The insects are not limited by the amount of sugary sap that trees have, because their feeding actually induces the trees to make more.

Last year, Professor Kelly and Dr Turnbull received funding from the Marsden Fund of the Royal Society of New Zealand to test their ideas about beech scale insects and their honeydew production. With the help of MSc student Yvonne Chew and Postdoctoral Fellow Roger Dungan they are investigating how beech tree photosynthesis might be regulated with and without scale insects.

At the most detailed level, their goal is to understand the specific physiological mechanisms that control photosynthesis in individual leaves and stems. At the tree level, they will test whether photosynthesis is greater on trees with scale insects than on trees without them.

The research team is also conducting experiments to understand why scale insects occur only on certain trees. If the insects do not harm trees, there should be no disadvantage for trees to host them. However, the scale insects do appear to have a patchy distribution and this patchiness seems to be constant across seasons and years.

This pattern in itself hints that the insects do not harm trees much because, if they did, trees without insects would be more competitive than trees with insects, until eventually all trees would have defences that prevented insect infestations. Since this has not happened, the researchers are investigating the role of insect dispersal, tree growth rates and tree chemicals that might influence insect abundance.

Contact:

Associate Professor Dave Kelly

Phone: +64 3 364 2782

email: dave.kelly@canterbury.ac.nz

Dr Matthew Turnbull

Phone: +64 3 364 2987 ext. 7040

email: matthew.turnbull@canterbury.ac.nz

Department of Plant and Microbial Sciences