



CSIRO research results in \$billion dividend

A CSIRO Division could more than pay for its entire research budget from the savings from a single research project.



TINY parasitic worms are saving Australia's pine-wood industry at least \$50 million every year. And the investment? Scientific research that cost less than one per cent of this sum - about half a million dollars.

According to figures prepared by South Australian forestry authorities, Australia will save somewhere between \$1-4 billion every "rotation", i.e. the 30-35 years between planting and harvesting of the Australian pine plantations.

above: Under the microscope, 0.5mm-long juvenile nematodes and (right) one billion of them, ready to store. These nematodes, which occur naturally in the soil, can home in on the fruit-boring moth, burrow inside it, and emit a toxin which kills it. Fruit-boring moth is China's most serious apple orchard pest. In Australia, codling moth could be attacked by nematodes in preparation for pheromone treatment, but funds are not available.



The same work, using different worms, is also used to control insect pests in horticulturalists' glasshouses and banana plantations and is being tested for the control of scarab grubs that ruin turf.

In China, it has the potential to save about a million hectares of apple trees from destruction.

All this is the result of the scientific ingenuity of Dr Robin Bedding and his team at CSIRO Entomology.

The advantage of using these worms to control insect pests is that it avoids the need for chemical insecticides.

The estimated savings for Australian pine plantations would be nearly twice the amount required to pay for the entire research effort of the Entomology Division, which has an annual budget of around \$28 million.

Dr Bedding was awarded the 1997 Sir Ian McLennan Award for Industry for his pioneering application of nematode worms to pest control.

Nearly all species of insect can be parasitised and killed by nematode worms.

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The female siren wasp drills holes about 2cm deep into pine trees and injects a toxin and a fungus along with her eggs. The larvae feed on the fungus as it grows within the dying tree.

However, only a few insect species can be controlled cost-effectively by nematodes at present. The advantage of using these worms to control insect pests wherever possible is that it avoids the need for chemical insecticides.

Chemicals are increasingly a cause of concern because they may kill non-target (and beneficial) insect species and leave long-lasting residues in the environment or on harvested produce destined for human consumption.

As a result, there is growing resistance to their use from consumers and regulatory authorities. By contrast, a carefully-chosen biopesticide (such as a nematode species) can be selective in what it kills and will have little effect on any other components of the ecosystem.

Controlling apple pests

In China, the fruit-boring moth is the most serious pest of apple orchards. Moths can also kill shade trees, which are important in the streets in China's north.

Research has shown that naturally-occurring soil nematodes can infect the moth.

Like microscopic missiles they home in on it, attracted by the carbon dioxide it emits, and burrow inside it.

Bacteria living in the nematode produce a toxin that kills the moth. The nematodes then feed off the corpse.

These worms are quite different in their mode of action from the famous *Sirex* nematodes that saved Australia's pine plantations. Dr Bedding and his team have devised new technologies to massproduce many different strains of nematodes,

store them in partially dried form and transport them to target areas in Australia or overseas. Ingenious ways of applying nematodes in different situations have also been developed and CSIRO is now busy selling concentrated worms.

The *Sirex* story

One of the worst scourges of pine plantations is the *Sirex* wasp. After mating, the female drills holes about 2cm deep into the wood of pine trees and deposits fungal spores and eggs. The growth of the fungus over the next few months dries out the nearby wood.

Like microscopic heatseeking missiles they home in on the carbon dioxide the moth emits, and burrow inside it.

The wasp eggs are triggered to hatch by these drier conditions and the larvae then feed on the conveniently-placed fungus. About this time the tree dies as a result of the fungal infection, although it can remain standing for a while.

After many months within the tree, the larvae emerge as adult wasps for the cycle to repeat. Dr Bedding and his colleagues found that only one species of nematode was suitable for controlling *Sirex* in Australia.

It has a complex biology but, under the right conditions, can parasitise almost an entire *Sirex* population.

The nematodes feed on the *Sirex* fungus and breed up within the tree before developing into specialised forms that infect the *Sirex* larvae without killing them. By the time these larvae become adult wasps the nematode has reproduced and the wasp is host to thousands of juvenile worms. This causes sterility in the female wasps but does not kill them. The females therefore continue to try to deposit eggs and fungi in trees.

In the process, they end up inoculating nematodes. Hence the control agent, once introduced into an area, is naturally spread and the population of *Sirex* is kept to a very low level.

Of course, as the *Sirex* population declines so too will that of its nematode parasite. But low levels of both species will remain and, if ever *Sirex* starts to increase, the nematode will respond.

Over time the nematode may lose some of its effectiveness because of natural genetic changes in the population.

If the population is regularly sampled, unaltered nematodes can be re-introduced (by injection into a small proportion of trees) when required.

After outbreaks of *Sirex*, affecting at least half of our pine plantations and with a tree kill rate of up to 80 per cent, the wasp is now under control.

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