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QDPI Fire Ant Control Centre

A fire ant on a pin head.

The silverleaf whitefly.

A seed-feeding weevil.

Butterfly nets, light-traps, specimens pinned in lines, literature intelligible to a rare few . . . such is the realm of the insect taxonomist. It's hardly glamour science, – the classification, evolution and biology of insects – but it plays an important role in weed and pest control, conservation, biotechnology, quarantine and public health. Much of Australia's insect taxonomy is carried out at CSIRO Entomology, home to the Australian National Insect Collection.

These four tales by **Steve Davidson** illustrate how insect taxonomy affects our lives.

insect

Fighting the fire ant

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Earlier this year, it was discovered that the fire ant – a tiny but menacing pest originally from South America – had entered Australia and established breeding colonies in parts of Brisbane.

The 'red imported fire ant', as it is known in the United States, which was colonised by the ant in the 1930s, is an aggressive species that can sting repeatedly. It is an urban, agricultural and environmental pest that has been described as a threat to our 'outdoor lifestyle' and not to be ignored or mistaken for more secretive and peace-loving small ants. The trouble is, that's exactly what happened!

The small reddish brown fire ant managed to gain a firm foothold in south-east Queensland before anyone realised they had reached Australian shores.

'In fact, the imported fire ant, *Solenopsis invicta*, has probably been here for two to five years,' Ken Priestly of the Queensland Department of Primary Industries (QDPI) says.

It may have been overlooked due to its similarity to a closely-related fire ant, *Solenopsis geminata*, a 'tramp' species found throughout Asia, or perhaps to one of our native *Solenopsis* ants.

Its real identity came to light when garden workers at Fisherman Island in Brisbane felt the wrath of the fiery ants, which attack en masse in response to vibration. They reported their experience to QDPI officers, who requested an identification from CSIRO.

The imported ants had a near-perfect disguise according to Dr Steve Shattuck, an ant specialist at CSIRO Entomology.

'Even after I received the specimens, I wasn't really convinced that we were looking at the imported species until we examined them more closely,' Shattuck says. 'The main morphological difference is a minute tooth or protuberance, just 1/50th of a millimetre long at the front of the head of the imported species, but absent in related ants.'

Once they had a positive identification, QDPI authorities moved quickly to limit the spread of imported fire ants in Brisbane and surrounding areas.

'We launched a "first strike" control campaign in March and a media and education campaign has alerted the general public to the hazard,' Priestly says. 'Low-toxicity baits have been used against ant colonies and people are discouraged from moving soil, mulch, potting mix, and the like, in and from infested areas.'

The department has also planned counter-measures that may achieve its eventual extermination.

Below: The fire ant is a tiny intruder that could have a big impact on Australian biodiversity, agriculture and outdoor life style. Imported fire ants are easily confused with similar species – until you feel the fiery sting!

Bottom: Scientists in Queensland checking the identity of ants as part of the fire ant control campaign.

QDPI Fire Ant Control Centre

asides

Which wasps for whitefly control?

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Paul De Barro

Above: A bin of tomatoes from a farmer's property showing one type of damage, here irregular ripening, caused by whitefly.

Inset right: Silverleaf whitefly is an accidentally introduced bug with the potential to devastate vegetable crops.

Paul De Barro

Below: One of the parasitic native wasps, *Encarsia accenta*, that scientists are assessing for biological control of whitefly.

Paul De Barro

Bottom: A juvenile whitefly (to the right) has been parasitised by a wasp. The black head and thorax of the wasp pupa are visible in the unfortunate whitefly. Three pupal cases from which the parasite emerged are also shown.

When CSIRO Entomology researcher Dr Paul De Barro and his colleagues set about developing a contingency strategy for control of a pest known as silverleaf whitefly, accidentally introduced here in 1994, they knew it would not be easy.

The pest probably first arrived in Coffs Harbour, New South Wales, then quickly and surreptitiously spread through the ornamental nursery industry in New South Wales, Queensland and the Northern Territory. It was first detected in a melon crop in the Northern Territory, adjacent to an infested nursery.

'Our research experience with the pest in Australia was virtually nil,' De Barro says. 'We did know, from evidence in the United States and from our modelling, that if populations built up, it was likely to cause annual losses in our vegetable crops of about $101 million in Queensland, $11 million in New South Wales, $6 million in Western Australia, and lesser amounts elsewhere. Cotton could also be affected.'

A small pale insect, the silverleaf whitefly (*Bemisia tabaci*) is actually a bug not a true fly and it causes damage by sucking on plants, by producing copious amounts of sticky honeydew that encourages sooty mould, and by spreading plant virus diseases like tomato leaf curl virus.

The species quickly develops resistance to insecticides, so reliance on chemical pesticides is a short-term solution. Biological control, using natural enemies of the pest – particularly tiny parasitic wasps which have a larval stage that feeds on the living whitefly – has proved feasible against whitefly overseas.

Given that at least one such wasp species was introduced in the 1930s, and that Australia has had a diverse indigenous whitefly fauna for millennia, it was likely that several parasitic wasps were also present in Australia.

The problem was that nobody knew how to identify them, what to call them, where they occurred, or how good they might be at controlling the newly introduced kind of silverleaf whitefly (biotype B). No key for identification of the wasps was available.

In short, the taxonomy of the potentially beneficial wasp group in Australia was, at best, an unresolved mystery and at worst something of a dog's breakfast. So the scientists had to start at the very beginning if they wanted to enlist the local parasitic wasps as control agents for the pest.

They began with a comprehensive survey of the wasp fauna associated with whitefly. After collecting parasitic wasps from both silverleaf whitefly and the closely related greenhouse whitefly, the morphological taxonomists in the division, Dr Ian Naumann and Dr Stefan Schmidt, sorted these into groups that looked the same on the basis of their physical characteristics.

The molecular taxonomists, Felice Driver, Leslie McKenzie and Dr John Curran, then took individual wasps from each of these groups, analysed their DNA, and identified those groups that looked like distinct species on the basis of their genetic make-up (DNA sequences), and those which seemed problematic.

This information went back to the morphologists who checked their classification again. This to-and-fro process was repeated several times, until the team finally had a series of groups that seemed to be true wasp species. Representatives of these groups were taken overseas to compare with type specimens housed in collections in the United States and the United Kingdom.

'This enabled us to identify species already known from overseas,' De Barro says. 'The remainder we presumed to be native wasp species.

'We also linked up with researchers undertaking a similar study in California. When we pooled our datasets, they actually matched and we were subsequently able to develop an easy-to-use illustrated key to the various wasp parasitoids of whitefly found in Australia. The interactive key is suitable for use by non-specialists, and is available on the World Wide Web.'

'This painstaking process of unravelling the taxonomy of our indigenous whitefly parasitoids took some 18 months, but it was an essential first step in our research program on whitefly,' De Barro says.

'We now know that 12 true species, belonging to two genera (*Encarsia* and *Eretmocerus*, both in the chalcidoid wasp super-family), occur here in association with silverleaf whitefly and we know their distribution. Following glasshouse and field-cage experiments comparing the abilities of several different wasps, we also know which ones are more effective at neutralising whitefly.

'This foundation work has enabled our group to better understand how the wasps choose hosts,' De Barro says. 'This is likely to be of immense use to biological control.

'We are now investigating the host-specificity of the various wasp species and the best way for growers to employ the wasp control agent in their commercial cropping systems. The long-term view is to augment and manage wild wasp populations for sustainable integrated control of a potentially devastating pest.'

One of the seed-eating weevil species enlisted to control Australian wattles that are invading South African plant communities.

University of Cape Town/Plant Protection Research Institute, South Africa

Weevil missions

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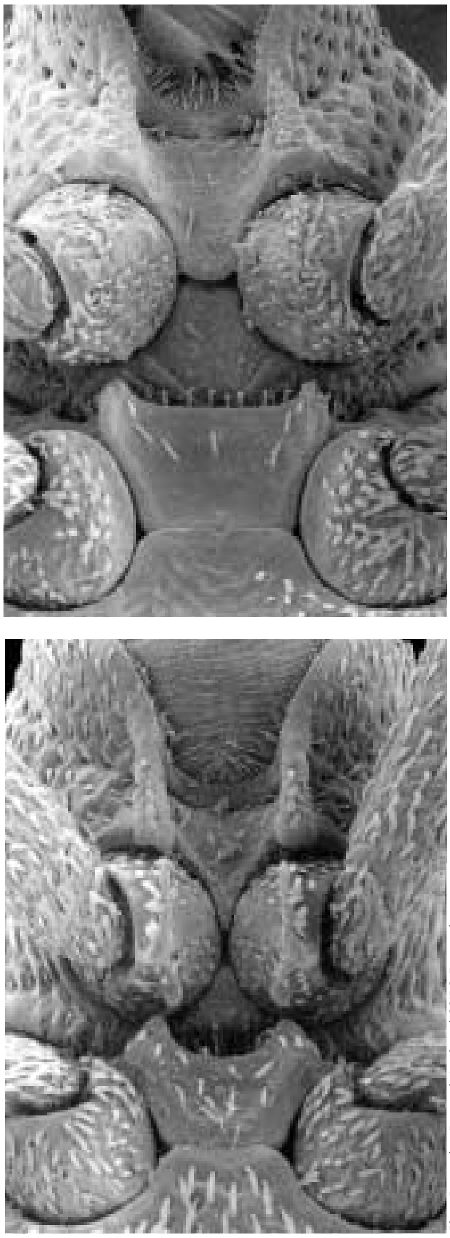
Minute Australian weevils are unobtrusively tackling a big problem in South Africa. The problem takes the form of Australian acacias introduced to stabilise sand dunes, as ornamentals, and for tannin production, but now causing severe environmental damage.

Some nine species of acacia – familiar trees such as black wattle, green wattle, silver wattle, blackwood and Cootamundra wattle – are weeds in many areas of South Africa where they invade native plant communities and cultivated forest. Water catchments in many mountainous regions are severely infested, resulting in reduced stream flow and soil water retention.

The South African government has launched an initiative called the 'Working for Water' program. It aims to remove invasive alien woody weeds and improve the quality and availability of water, while creating employment for underprivileged communities.

Seed-feeding weevils of the genus *Melanterius*, most the size of a proverbial pinhead, are prime candidates for biological control of the troublesome acacias. The first of these was released in the mid 1980s by scientists of the Plant Protection Research Institute (PPRI), South Africa, and subsequently three more Australian species have been released.



Although superficially similar, these two *Melanterius* species show distinct differences when viewed under a scanning electron microscope – here an underside view.

Plant Protection Research Institute/ CSIRO Entomology

CSIRO Entomology

Taxonomists are still sorting out the true identity of this acacia seed weevil, *Melanterius maculatus*, at the molecular level.

The taxonomy of some of the weevils released in earlier times was unclear and, in view of tighter quarantine and release criteria, scientists now need to know the exact identity and host-specificity of control agents in order to gain permission for their release.

Entomologists from PPRI are working with weevil specialists at CSIRO Entomology, Dr Rolf Oberprieler and Dr Elwood Zimmerman, on the daunting task of clarifying the taxonomy of the group.

'The *Melanterius* genus alone includes about 90 named species and there are undoubtedly many times that number yet to be described,' Oberprieler says.

'What's more, some 700 acacia species occur in Australia and it is possible that each of them has at least one weevil species that consumes its seeds. Fortunately, our South African colleagues sent us only half a dozen or so species, collected from several Australian acacias in both countries.'

The adult weevils feed on the developing acacia seeds. The female typically uses her elongated snout to bore a hole in the acacia seed pod into which she lays an egg. The beetle larvae feed and develop inside the individual acacia seeds. Seed predation rates by Australian weevils on acacias in South Africa reach up to 100%, so the cumulative effect on acacia reproduction and spread is significant.

And because the weevils in question are seed-eaters rather than borers, leaf-eaters or gall-makers, they do not worry commercial wattle growers in South Africa, who use wood from some of the Australian acacias for paper pulp, tanning, cabinet-making and firewood.

'As for the taxonomy, we have worked out exactly which species attack each acacia species and have put together a user-friendly key to enable others to identify them,' Oberprieler says. This was necessary because there was some confusion about the identity of the weevils in South Africa.

'One of the reasons we started this work was the fact that we suddenly found ourselves dealing with *Melanterius* species with the same name, but which attacked two or more different acacias.' PPRI entomologist Fiona Impson says. 'We needed to clarify whether we were in fact dealing with the same weevil species.'

'Our next step is to fine-tune our classification and key by using state-of-the-art molecular techniques,' Oberprieler says. 'For instance, where ambiguity exists, we might even be able to sacrifice a miniscule part (perhaps a leg) of a century-old'type specimen' for DNA analysis to determine which species should go by the original name.'

University of Cape Town/Plant Protection Research Institute, South Africa

A 'Working for Water' team clearing acacia weed in South Africa.

Abstract: Insect taxonomy plays an important role in weed and pest control, conservation, biotechnology, quarantine and public health. The fire ant, from South America, has established colonies in Brisbane. Its identification catalysed a campaign of counter-measures to combat the insect's spread. The silverleaf whitefly is an introduced horticultural pest. A survey of wasp fauna has identified possible agents for biological control. Minute seed-feeding weevils are candidates for biological control of Australian acacias in South Africa. Four species have been released. *Hypsipyla* is a genus of moths whose larvae bore into the shoots of their tree hosts. They have prevented commercial production of Australian red cedar. An international project is studying the biology and relationships of *Hypsipyla* species as a step towards biological control.
Keywords: fire ants, introduced species, insect pests, biological control, weed control, silverleaf whitefly, parasitic wasps, weevils, red cedar, cedar tip moth.

Above: Red cedar saplings before and after stem borer attack. The branching caused by tip damage destroys the timber potential of the tree.

Right: Australian scientists are working with scientists and communities in many countries to overcome the stem borer problem.

Secretive moths block cedar production

The tunnelling activities of the larvae of stem borer moths have prevented plantation production of precious red cedar and mahogany wood.

Red cedar has always been one of the most prized timbers growing in Australia. From as early as 1792, timber-getters, spared no effort to extract the giant trees from almost impenetrable rainforests.

This extensive logging and land clearing virtually wiped out red cedar in most regions. In north Queensland alone, harvesting of the precious timber declined from 2797 cubic metres, in 1878, to less than 200 cubic metres, from the entire state, in 1995. Harvesting from publicly-owned land has now effectively ceased.

Furniture makers and builders today still treasure the timber for its colour, grain and working qualities and are well aware that it is a scarce resource worth up to $3000 per cubic metre when sawn. So why don't we have hectares of lucrative commercial red cedar plantations along the east coast of New South Wales and Queensland, producing the characteristic pink-red timber?

The answer, in a word, is *Hypsipyla*, a genus of secretive nocturnal moths whose larvae bore and tunnel into the shoots of their tree hosts. These stem borers have managed to prevent commercial plantation production not only of Australian red cedar (*Toona ciliata*), but also of related species, such as the mahoganies of Africa, Asia and America.

Just one moth larva is enough to destroy the timber potential of a cedar sapling. By killing the growing shoot, the stem borer causes the young tree to branch out so that it more closely resembles a crooked fruit tree than a forest giant in the making.

Without a long straight trunk, the cedar is rendered useless for timber. Growth rates are also reduced and the tree sometimes dies. The native stem borer (also called cedar tip moth) is not a problem in natural forests, but numerous attempts at plantation establishment of cedars have failed due to its depredations.

Recently, researchers worldwide have renewed their efforts to find a way around the problem. At CSIRO Entomology, Dr Rob Floyd leads an Australian Centre for International Agricultural Research (ACIAR) funded project investigating the ecology and control of *Hypsipyla robusta*, the main pest of cedar and its relatives in the Old World.

'This moth has an extensive distribution in Australia, Africa and Asia,' Floyd says. 'It has slightly different biology in different regions, and throughout the world there are some 11 recognised species in the genus. Our first priority, with ACIAR support, has been to review what is known of its taxonomy.'

The division's moth taxonomy expert, Dr Marianne Horak, has conducted this preliminary review.

'We really need to understand the biology and relationships of the various species of *Hypsipyla* if we want to consider any sort of biological or integrated control,' Horak says.

'We have to know how different the populations of *H. robusta* on the different continents are if we want to use organisms for biological control or develop other counter-measures. There might even be related species in other genera, apart from *Hypsipyla*, living in Oriental and Australian cedars and their kin.

'Unfortunately, the group is notoriously difficult and has long defied taxonomists. They all look superficially similar, morphological differences are minimal, and the secretive adults are difficult to find.

'Nonetheless, a concerted, worldwide effort involving both morphological and molecular studies and information on biology and pheromone differences should resolve the taxonomy of the genus.'

Floyd's group is also running plantation-like trials in Australia and other Asian countries, in collaboration with the Queensland Forestry Research Institute and local scientists and communities in collaborating countries, (Philippines, Laos, Thailand, Vietnam and Malaysia), to identify individual trees that show greater natural resistance to stem borer attack.

These could eventually lead to the breeding of resistant varieties for establishing commercial plantations of cedar and mahogany trees. They are also exploring pruning as a remedy for the branching caused by stem borers.

If successful, these approaches, incorporated into an integrated control strategy, could resurrect the sustainable use of these beautiful timbers and perhaps avoid the extinction of some awe-inspiring rainforest trees.

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