Science

Biologists blunt the sting of a

The Sirex wasp and its deadly passenger have brought the prospect of ruin to the pine industry, but geneticists have a shrewd plan to fight back

Sarah Wild

Wasps — some black, others black and orange — are pinned to a board of blue rubber foam. One begins to twitch and you register that some of them are still alive. You almost feel sorry for them, until you realise that if they are left alive millions of trees, more than R20-billion and 17 000 jobs are at stake.

They are *Sirex noctilo*, a woodwasp, native to Eurasia and North Africa. First detected in the southern hemisphere in 1900 in New Zealand, this invasive pest has spread throughout this half of the planet over the last century and, if left unchecked, spells disaster for South Africa's forestry industry.

There about 1.3-million hectares of plantation and the majority of those trees, about 51%, are pine trees, the food of choice of the *Sirex* wasp.

Bernard Slippers, a professor in genetics at the University of Pretoria and researcher leader of the Tree Protection Co-operative Programme and Centre of Excellence in Tree Health Biotechnology in the Forestry and Agricultural Biotechnology Institute, reaches out a fingernail and lifts the sheath surrounding the sting of one of the black wasps. The completely black wasp is female; those with orange on them, male.

"See that needle inside the sheath?" he asks me. "With that needle, she drills through the bark of a pine tree. [At its base] there's a little sac that's full of fungus — a very specific fungus — and in the hole she's drilled in the wood, she will put one or two eggs, the fungus and a bit of a toxin. The toxin affects the tree and the fungus starts growing."

And that is just the beginning. In this symbiotic relationship, this special fungus, called *Amylostereum areolatum*, begins to degrade the tree's cellulose, breaking it down into sugars that the wasp larvae feed on. The fungus will continue to spread through the tree and, when the young wasps leave the tree, the females will take the fungus with them to another tree, and the process continues.

"The fungus gets very safe passage into the next tree ... where there are no competitors. So it's good for both of them," Slippers says.

The wasp does not have predators in South Africa and can flourish unchecked.

In a book chapter called "The control of the *Sirex* wasp in diverse environments: The South African experience", authors from industry and academia detail the spread of the wasp. The first *Sirex* wasp was detected in the county in 1994, in Cape Town. In 2001 it was found near Knysna. This was followed in close succession by detection in the Eastern Cape and KwaZulu-Natal in 2002.

"By 2010, *S noctilo* had spread throughout KwaZulu-Natal and Mpumalanga — South Africa's main pine-growing province," the authors write.

In KwaZulu-Natal and the Eastern Cape, there was serious damage, with reports of a 35% mortality of pines in some stands and an average death of 6%, according to the book chapter.

Philip Croft, Forestry South Africa co-ordinator at the Institute for Commercial Forestry Research at the University of KwaZulu-Natal, says: "The *Sirex* woodwasp has been detected across the whole extent of pine-growing areas in South Africa ... from Cape Town to Louis Trichardt in Limpopo."

You can see the trees in which the wasp and fungus have their hooks — in a large green pine plantation, there are small patches of red-brown, where sick or dead trees stand. Over time, without intervention, that number will increase.

But industry, academics and government recognised that a plan was needed. As part of a memorandum of understanding between Forestry South Africa and the department of agriculture, forestry and fisheries, the department's forestry and natural resources management branch has pledged nearly R4.5-million in the 2015-2016 financial year.

"This funding [is for] a number of activities to address the impact of *Sirex*," says Forestry South Africa head of research Ronald Heath. These include "national monitoring activities, awareness, supplying biological control to small and emerging farmers, development of new biological control systems, silvicultural research to minimise the impact of *Sirex* and integrated forest protection research".

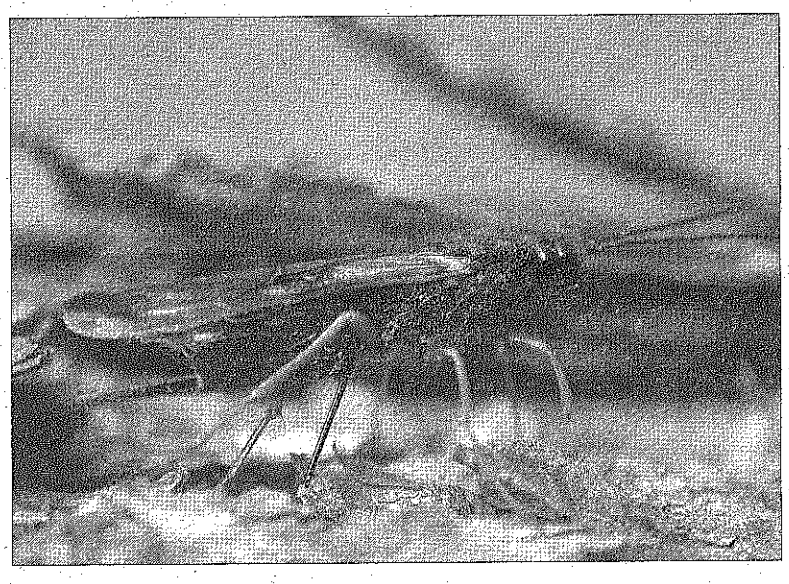
Croft says there are "semi-permanent monitoring plots across the pine-growing area".

At the University of Pretoria's biological control facility, Marlene Harney is measuring a cloudy liquid into what looks like a large sandwich bag. Inside the solution are microscopic worms, called *Beddingia* (or *Deladenus*) *siricidicola* — about six million of them, invisible to the naked eye. These little worms, known as nematodes, are one of the major weapons in the arsenal to fight the *Sirex* wasp.

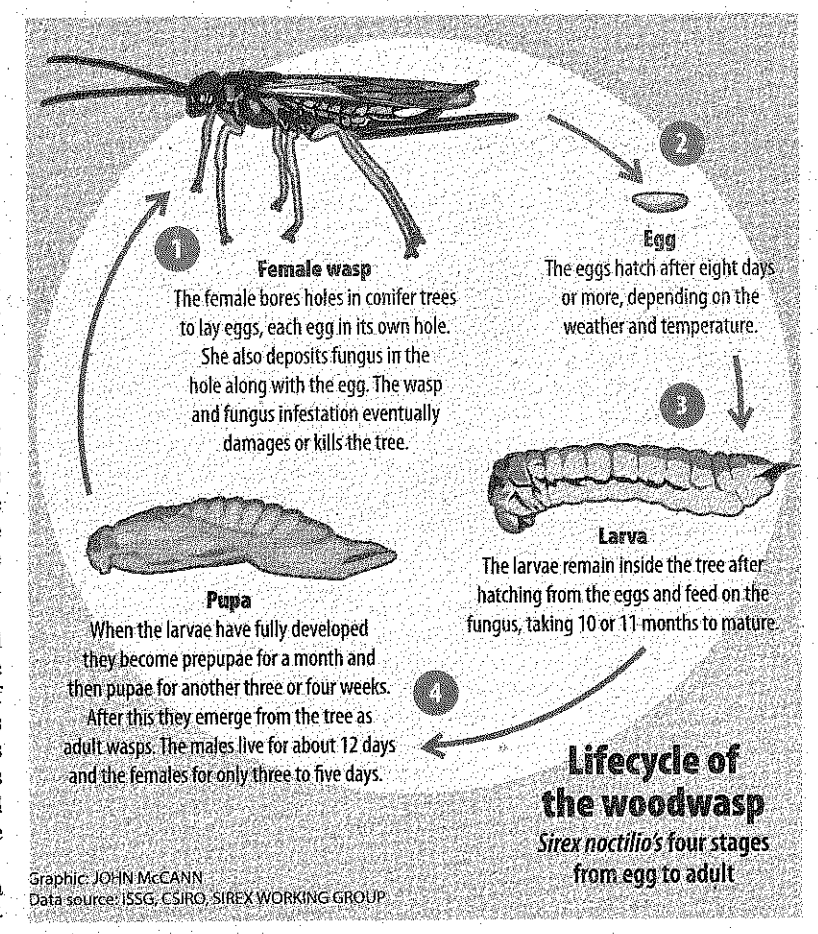
"This nematode co-evolved with the [wasp-fungus] system," Slippers explains, while Harney focuses on pouring the liquid and sealing the bags with a sealer. "It has two parts to its life cycle," he says. The one form eats the fungus in the tree; the other penetrates the wasp larvae which are now inside the wood, and breeds inside them.

When these larvae pupate and become wasps, the nematode remains inside them. In the case of female wasps, the nematode sterilises her eggs. "She still goes out and lays her eggs [in another tree]," Slippers says. "But they're now sterile, and then [the female wasp] spreads the nematode to the [new] tree."

The use of the nematode as a biological control method was developed in Australia, a country with a great deal of pine under plantation and a *Sirex* wasp problem. In 1967, Australian scientist Robin Bedding published an article in the scientific journal *Nature*, detailing how this specific nematode was detrimental to the *Sirex* wasp — both because it consumed its symbiotic fungus and sterilised the female wasp's eggs. The nematode was originally called *Deladenus siricidicola*, but was renamed *Beddingia siricidicola*, after Bedding. It was then changed back to *Deladenus siricidicola*, causing a fair amount of confusion.



Invasive pest: The *Sirex* woodwasp is not indigenous to South Africa and has no natural predators. The wasp's reproductive process kills pine trees and, if it is allowed to breed uninhibited, the country's pine plantation industry could be severely affected.
Photos: Delwyn Verasamy



Inside the biological control facility, in a fluorescent light-lit room the size of a closet, hundreds of half-litre beakers sit on shelves. Their tops are covered with tin foil and inside — amid a mixture of wheat, rice and the wasp-specific fungus — billions of nematodes are breeding.

Once they've reached the right age, the nematodes are washed out of the mixture and harvested. These nematodes are put in a water suspension, and that is what Harney is dividing into sandwich bags.

"The average adult is about 1.7mm to 2.7mm," she says, not taking her eyes off of the beaker she is tilting into the packet. "We count the juveniles and young adults, not the mature adults, because that's what industry wants to put into the trees ... [not] mature adults at the end of their life cycles."

Researchers in the facility harvest and ship these nematode packets every Monday. "It goes overnight to industry, so that they have the whole week to inoculate trees," Harney says, adding that this year they will produce about one billion nematodes for forestry companies.

Croft says that South Africa initially imported *Deladenus siricidicola* nematodes from Australia: "We needed a large quantity and the production [of the nematode] was still new to South Africa at that stage. [Now] the Forestry and Agricultural Biotechnology Institute at the University of Pretoria supplies the full demand of [the nematode]."

He says that, in 2007, about 50 000 trees were inoculated against the wasp. This was reduced to 38 000 in 2008 and has averaged about 10 000 trees a year since.

Once these cooled bags of nematodes arrive at a plantation, they are mixed with a jello-like gel by someone in the forestry company, who will mount a ladder against a tree and make holes in the tree with a special hammer. "They then take the jello-nematode mixture and put it in the holes," Slippers explains. "That jello mixture [which keeps the nematodes suspended, rather than sinking or collecting as they would in a water mixture] gives moisture to the nematodes for a while so that they can go ... into the wood and migrate up and down the tree and go and look for the wasp larvae or the fungus."

If there are no wasps or fungus,

tree-killing alien wasp

the worms will die.

This is slightly different from the way this biological control is used in Australia, Croft says. There, foresters "fell and inoculate their trees, but in South Africa ... we are able to do standing-tree inoculations using 3m ladders, thereby reducing the cost of the operation".

Asked if they charge for the service they provide to industry, Slippers says industry pays for the cost but "there's no profit for us. The connection [between academia and industry] is important for us. It gives us a system that we can use to study, say, diversity in these nematodes. We collect nematodes from other parts of the world and study their diversity and look at how they're interacting," he says, adding that there's an element of theoretical and academic interest.

"But as soon as we find something that's better than what we have at the moment, we can pass that directly back into the system."

That feedback loop is important because as the pests change — whether through resistance, inbreeding or the introduction of genetic diversity, so must the biological control. Yet the *Sirex* wasp is just one of many invasive pests finding their way into South Africa. Heath says there has been "a definite increase in the number of invasive pests entering the country".

Croft concurs but says "'invasive pests' is perhaps a strong term to be used generally. South African forestry — tree farming — is based on the introduction of species from Australia (eucalyptus and wattle) and from Mesoamerica and the United States (pines). In many instances, their natural enemies are catching up with them in their new environments."

But in other instances, new enemies are finding them. "*S Noctillo* [are] not the natural [enemy] of the pine species we grow and have become pests on pine species grown around the world."

Slippers is more emphatic: "There's been an incredible explosion. There are a couple of things we think influence it: trade, the movement of people, plant material that's moved around the world ... Biological control systems, such as *Beddingia siricidicola* for the *Sirex* woodwasp, now need to be developed for them all."

But in the case of the *Sirex* woodwasp, eradication is not possible, Croft says. "Through biological control, we reduce the wasp population to such an extent that the tree damage is below the economic damage threshold ... It is anticipated that *Sirex* will remain a threat to pines in South Africa into the future, but through constant monitoring and early response — [and] the deployment of biological control agents — it is a pest that can be managed successfully."

This article forms part of Sarah Wild's research for a book project to be published this year by the Gordon Institute of Business Science and Pan Macmillan South Africa

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