Spectrum

Ants and antibiotics

Ants are more important than many of us realise — for example, they play a vital role in the ecology of many of our native plants, dispersing their seeds, and even providing a useful and fire-protected place for germination within their underground nests. (For more on this, see *Ecos* 53.)

Readers interested in entomological trivia may also know about the ant 'gardens' deep underground where the industrious creatures cultivate fungi, inoculating spores into piles of decomposing plant material and then harvesting the resulting fungal growth as a food source.

Of course, the moist, dark, and nutrient-rich environment within the nest is ideal for fungal — or, for that matter, bacterial — growth. And this can present a problem in the form of potential infection for the ants; their answer, scientists have recently found, is chemical defence, using antibiotic or antimycotic (fungi-killing) compounds.

This is another area where we may shortly be realising that ants are more useful than they seem when they ruin a barbecue. We too have problems with bacteria, and fungi to a lesser extent, and many common human-associated bacteria have developed resistance to several of the compounds in our arsenal of antibiotics. It's possible, therefore, that we may be able to benefit from stealing some of the ant's defence secrets.

The story of what put the ant into antibiotics starts with the observation by several ecologists over many years that ants — famed for their toil — are not very industrious when it comes to pollinating, unlike their very close relatives the bees and wasps. (All three groups of social insects are classed together in the order Hymenoptera.)

Although ants and plants have evolved several close relationships of mutual interdependence over the millennia (see *Ecos* 53 again), pollination does not appear to be one of them.

At first sight the reason may appear simple — the lack of wings. But, in fact, some ants forage further than bees, which don't like to stray too far from their nests, so the fact that most worker ants can't fly (winged forms do exist) is not the explanation. And, anyway, ants are very useful and effective in dispersing other plant products such as seeds and fruits.

Close study over decades has failed to reveal more than about a dozen clear examples of ant pollination, so one curious ecologist — Professor Andrew Beattie of Macquarie University — decided to put fresh pollen on ants and see what happened.

He and his assistants put ants into vials each containing pollen from one of four different plant species. After 30 minutes they removed the ants and transferred pollen from their bodies onto a culture slide suitably prepared for pollen germination. In every case, they found severely reduced germination and viability of the pollen that had been in contact with the ants. (Pollen left in vials without ants acted as a control and showed high levels of viability.)

And what has all this to do with antibiotics? Professor Beattie found reports in the literature from scientists overseas showing that certain

Professor Beattie keeping an eye on his bull ants.

compounds associated with ants were antimicrobial in the laboratory. He reasoned that these chemicals may also account for the pollen-inhibiting effects of ants.

He suspected that the source of the ants' pollen-killing secretions was the metapleural glands, not found in bees and wasps. To analyse the secretions from these glands, he decided to use large ants, which produce correspondingly large quantities. Bull-dog (or bull) ants — big (2·5 cm long), painful stingers, and a group unique to Australia and New Caledonia — seemed the best choice.

Drawing on the expertise of ant taxonomist Dr Bob Taylor of CSIRO's Division of Entomology to identify the species accurately for him, Professor Beattie collected the bull ant *Myrmecia nigriscapa*, whose metapleural glands are easily accessible.

Using fine fishing-line to tie them down, he kept ants of this

Ants of Australia

It so happens that Australia is a haven for ants. It has more sub-families and genera of ants than any other continent. Dr Bob Taylor, an ant taxonomist at the CSIRO Division of Entomology, believes that Australia may be home to about 4000 different species, of which only about 1300 have been formally named. By contrast, in Britain only about 50 species exist; and according to Dr Taylor just the small area of Black Mountain in the city of Canberra probably contains more genera than this, let alone species!

Our country is particularly rich in 'primitive' ants. Indeed, many ant specialists from overseas come to Dr Taylor's laboratory to study the behaviour of these unique insects. With the exception of one species in New Caledonia, the two most primitive sub-families in the world are endemic here.

Dr Taylor collected the world's most primitive known ant on a field trip in 1977. It lives only in a tiny area of the Eyre Peninsula, and entomologists believe it is very similar to the earliest ants that appeared on Earth 80 million years ago.

species immobilised for 12 hours to prevent them from grooming themselves and spreading the secretions over their bodies. (The unharmed insects were later returned to their nests.) With a micropipette, he then took the tiny drop (about 2 microlitres) of fluid that had accumulated at the opening of the gland and tested it for its activity against fungal spores.

His results showed that the secretions definitely prevented the germination of spores from six of the seven species of soil fungi tested. All seven commonly occur in ants' nests, and four can grow on insects.

The secretions will also inhibit the development of a fungal mat — the 'mycelium' — but from the ants' point of view suppressing germination provides a prevention of fungal infestation, which is clearly better than a cure brought about by inhibiting the growth of already established fungi.

Professor Beattie then decided to investigate what exactly these powerful secretions did to pollen, and why. In collaboration with Professor Bruce Knox, he used electron microscopy to examine the detailed structure of pollen that had been exposed to metapleural fluid.

He saw that both the outer cell membrane and the intracellular membranes were destroyed. Many pollen grains were killed before they could germinate.

Although grains have a protective exterior coating, this incorporates germinal pores for gas exchange and for the pollen tube to grow through; presumably the secretions were gaining access through these pores. Some grains did germinate, but in these cases the tubes either died quickly or developed abnormally.

But why should ants do this to pollen? Professor Beattie believes it is merely a side-effect of their effective

Ant pollination — an unusual sight. Here a winged male pollinates an Australian *Leporella* orchid.

chemical defence against micro-organisms. The interesting question is why the closely related bees and wasps don't have the same feature. The professor has an answer for that, too.

Ants keep all their eggs, larvae, and pupae together in a chamber of the nest — not individually in cells of wax (like bees) or paper (like wasps). A fungal infestation in the warm and nutrient-rich environment of the chamber could wipe out the entire future of the colony in one go.

By contrast, keeping larvae separate from one another in sealed cells helps contain the spread of any infection. (Bee wax also contains an antimicrobial substance.)

Nesting in the ground as ants do — rather than above it like bees — further increases the risk of attack by soil fungi. Thus smearing antibiotic substances on all members of the colony seems the best defence. It just so happens that these potent compounds also kill pollen, so ants, although they may incidentally become coated with the grains in the course of a day's foraging, are not effective pollinators.

Incidentally, a few ant species don't have metapleural glands, and one of these, Professor Beattie and his colleagues have discovered, is important for the pollination of an orchid in southern Australia. Only the males of this species lack the glands, and it is only they that bring about pollination by attempting to copulate with the orchid flower, to which they are presumably enticed by a scent resembling the sexual attractant of the female ant.

But to return to nest infections, the bees' adaptations by no means render them impregnable to microbial attack. In fact, the honeybees man keeps in large colonies suffer from quite a range of fungal and bacterial diseases, and it could be that the ant antibiotic would be helpful for commercial beekeepers, who can lose millions of dollars if epidemics strike their hives.

Professor Beattie has tested the activity of metapleural secretions against a range of bacteria, with help from the Department of Bacteriology at the Westmead Hospital in Sydney. Results showed that the secretions were effective against several bacteria of human significance, some of which are resistant to commonly used antibiotics.

We don't yet know whether ants will be a new source of useful antibiotics for human therapy, because we have no idea whether the compounds will prove too toxic to us. But bees are a different proposition. The ants must be resistant to the effects of their own product and, as bees are closely related, they may be too. Further work is planned to look at the secretions' activity against specific bee pathogens.

Whether bees, humans, or even industries that simply require sterilisation of their products are the ultimate beneficiaries, we need to know first what exactly the metapleural secretions contain. Professor Beattie is currently collaborating with Dr Mike Lacey of the CSIRO Division of Entomology to analyse the compounds.

Dr Lacey specialises in the technique of mass spectroscopy, which separates out molecules from a mixture according to their mass. He has found a number of phenolic compounds — well known to chemists for their antibiotic effects — in the fluid from the glands. He has made synthetic versions of these 'metapleurins', which, although not exactly the same as the originals, retain their antibacterial activity.

It could well be that any useful product will be a modified derivative like this. It may be possible to bring about a change that will reduce any unwanted effects of metapleurins while keeping their beneficial attributes. With this in mind, Professor Beattie is currently discussing options with three pharmaceutical companies.

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Pseudocopulation of an orchid by male ants: a test of two hypotheses accounting for the rarity of ant pollination. R. Peakall, A.J. Beattie, and S.H. James. *Oecologia* (Berlin), 1987, **73**, 522–4.