



Genetic fingerprinting helps keep track of insects

The secret life of termites

Termites are more than just a nuisance for anyone who owns a wooden house; these greedy insects can destroy entire buildings. Scientists working for Bayer CropScience in the United States are deploying tools used in the detection of crime such as DNA fingerprinting to investigate termite behavior. The results allow imidacloprid, the active ingredient from Bayer, to be used more efficiently.

They spend most of their lives underground and often colonize freshly cleared land, where trees have been felled to make way for new homes. The pests in question are termites, or to be more precise the genus *Reticulitermes*, which lives below ground. These hungry insects are widely feared by homeowners in the United States, Japan and parts of southern Europe, causing an estimated US\$ 22 billion in damages every year throughout the world. They can often nibble away undetected at buildings for many years because, unlike their counterparts in Brazil or northern Australia, they do not create huge above-ground mounds visible from afar. Cut off from their regular source of food – old, dead trees – entire colonies consider wooden structures as their ‘dining room’.

“The key to solving the problem of termites lies in understanding this pest’s social behavior,” explains Dr. Nick Hamon, Director of Development & Technical Services in the Environmental Science unit of Bayer CropScience in the United States.

Field studies on effective termite control

Since 2001, one member of Hamon’s team, Vince Parman, had been conducting comprehensive field and laboratory studies with Professor Edward Vargo from North Carolina State University to find out more about what secretly motivates these insects. “Only by fully understanding what goes on in termite colonies can we put a stop to the severe

Appetite for wood: termites can form colonies of up to three million insects and feed primarily on wood. Subterranean termites (photo, left) mainly infest wooden houses such as these in New England (photo, right), but also attack structures in Asia and southern Europe.





Termite researcher Vince Parman (left), who sadly died in January 2007, conducted numerous studies to investigate the behavior of termites. His work is now being continued by team leader Nick Hamon and his colleagues.

Termite hunters: once the wood-munching pests have decided to adopt a house as their own personal dining room, complex and expensive countermeasures are frequently required to eradicate them. For example, before the pest controllers can effectively combat some termite species it may be necessary to package the entire structure in a plastic film.

damage that termites cause once they infest a building," Hamon comments. Over the past ten years many possible methods have been tried out in an attempt to control termites: preventive strategies such as avoiding direct contact between soil and wooden buildings have only been partly successful, however. Even conventional termiticides rarely prevent infestation in the long term, partly because not all of the termites in a colony come into contact with the treatment.

Gene sequence marks colony membership

Imidacloprid is already being used in the fight against termites, but Parman and his colleagues wanted to make termite control even more effective. Marketed by Bayer Environmental Science under the trade name Premise®, imidacloprid is a member of the chloronicotinyl group of chemicals. It binds to certain receptors in insects' nervous systems, blocking the transmission of signals between neurons, causing gradual paralysis. As part of a large-scale field study, scientists from North Carolina State University and Bayer were the first to apply modern DNA technology to study the insects' distribution and behavior.

These studies involved close monitoring of twelve homes suffering from

severe termite infestation. An extensive grid of 'in-ground monitors' – devices used by the scientists to observe activity in the underground termite colonies – was set up around each house. The first task facing Parman and the team was to remove individual insects over a six-month period and subject them to DNA analysis. Using molecular genetic methods like those applied in paternity tests and crime investigation, Parman was able to decode the specific features of the various colonies by the genetic fingerprint of individual termites.

Microsatellites – short sequences of DNA that are repeated – unique to each colony were used as a means to distinguish individual colonies. The genotype of a colony forms particular patterns depending on the size of the two alleles, which are the genetic portions of DNA inherited from the mother and father respectively. These allow termites from different colonies to be distinguished in the laboratory. Every termite from a particular colony has the same genes, as they are all descended from the same king and queen, and have therefore inherited the same paternal and maternal genes. The likelihood of two unrelated termites having exactly the same genotype is less than one in ten million.

Termite colonies have a strict hierarchy: a queen, with her subordinate

king, rules over a population made up mainly of a large number of workers and a few soldiers. The insects recognize each other by nest-specific pheromones which are present on their cuticle.

Social behavior investigated below ground

It is highly unusual for insects to enter a nest other than their own: soldiers guard the extensive tunnel system against strangers. The workers keep the nest clean and collect food for the soldiers and the king and queen. The queen is responsible for reproduction. Once a year she produces a batch of eggs which develop into winged offspring, known as alates, which are capable of breeding. After a brief nuptial flight some distance from the nest, they may pair up with a partner of the opposite sex and found a new colony. However, this process rarely succeeds. Termite alates are a favorite food for birds, lizards, ants and numerous other predators, and very few survive to establish new colonies. New colonies are founded infrequently, but once established they can last for up to a century.

"For a long time it was not clear how insecticides were distributed inside a termite colony," explains Dr. Byron Reid, Product Development Manager for termiticides. "Thanks to this study,



Transparent pests: the study conducted by Bayer scientists provided insights into the social and colonization behavior of the underground termite genus *Reticulitermes* for the first time, and showed that several colonies are always involved in infestations of wooden houses.

we now understand the social and geographical organization of these insects underground. We have discovered some fundamental new information, such as the size and distribution of colonies around an infested house." This research has given scientists at Bayer important insights into the colonization activities of these insects, which is proving useful in developing more effective methods of applying Premise®. Most of the houses investigated during the study were under attack by one or two colonies, despite the fact that, on average, up to 36 colonies per acre (1 acre = 4,046 m²) were present around the house.

Cannibalism saves the colony in times of famine

After six to twelve months of observation, the scientists treated the infested houses with Premise® and conducted further genotype tests. They discovered that termites follow strict patterns of social behavior in their underground passageways. When one termite meets another, it uses its mouthparts to clean and tidy it. This behavior, which scientists refer to as 'grooming', opens up an opportunity for more effective control of termites, as it allows an active substance to be passed from one insect to the next. "This mode of transmission helps imidacloprid reach the furthest

corners of the complex system of tunnels inside a termite nest, so that it has the potential to affect the entire population very quickly," comments Reid. "Genetic analysis from the house studies has now proven this. Feeding on the wooden structure was stopped in days, termites disappeared within a week or two from soil monitors immediately outside the structure, and after three months all termite colonies attacking these structures were eliminated. After two years of monitoring since treatment, not one of these colonies has recovered."

During their research, the experts at Bayer also discovered the ultimate benefit of imidacloprid: the termites did not recognize the substance as being harmful. Insects which came into contact with imidacloprid did not display any noticeable avoidance behavior, and passed it on to other inhabitants of the colony. The Bayer team concluded from this that imidacloprid can be distributed via the cuticle of the termites. However, some insects also ingest it and pass it on by regurgitation. The scientists discovered a third transmission pathway: termites often practice cannibalism on dying insects. This survival mechanism, which is vital to insects that depend on a low-protein diet, helps keep the colony alive when food is scarce. A better understanding of social behav-

A truly inbred kingdom

A typical termite nest is founded by a king and a queen, who mate exclusively with each other until one of them dies. The dead partner is replaced by one of his or her offspring. Once both of the original royal couple have died, they are replaced by a sibling pairing.



Aids to digestion for wood-munchers

Termites survive by eating wood and wood-based products such as books. But termites' intestines are unable to digest wood without help. They depend on tiny micro-organisms that inhabit the gut. These micro-organisms are highly specialized, with many appearing only in the intestines of one termite species.

ior, resulting from the comprehensive findings of the study, together with the highly effective ingredient imidacloprid, should enable the Bayer team to allay the worries of homeowners in many parts of the world.



www.utoronto.ca/forest/termite/termite.htm

This website has extensive information about termites.