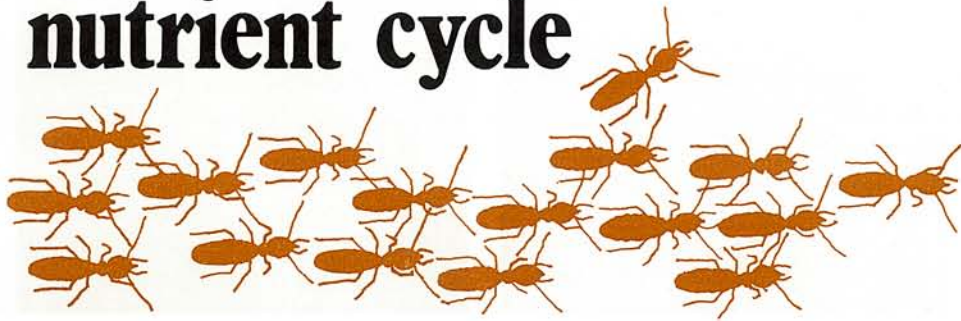


# Termites turn the nutrient cycle



Nobody loves termites, or 'white ants' as we often call them. They are regarded as pests—and not without reason. After all, here in Australia they cause millions of dollars' worth of damage each year to houses and other buildings, bridges, railway sleepers, telegraph poles, and forests. And it's not only here that they're bothersome. The United States also spends some \$200 million controlling them and repairing the damage.

In India, Indonesia, and the Philippines they damage grain and other crops such as sugar cane, cotton, vegetables, and fruit trees, while in other countries tea and rubber trees suffer from their depredations.

Nevertheless, without them the world would probably be far worse off. They are a vital part of the cycle of nature. Modern knowledge reveals that they are probably among the main agents bringing about recycling of nutrients in the soils of all the warmer parts of the globe. Here in Australia they get rid of a good deal of the litter lying around in the bush. Eliminate termites, and all sorts of unexpected things may happen.

In addition to recycling plant materials, it now seems that at least some species may actually add to the amount of nitrogen available to plants in the soil. Dr John French at the CSIRO Division of Building Research has shown that bacteria in the hind-guts of three Australian

species — collected from sites as far apart as Victoria, the Australian Capital Territory, and Townsville in northern Queensland — can fix atmospheric nitrogen in a form that the termites can use. Some Northern Hemisphere ones do this also.

Only a few of our many termite species may really be described as pests. The problem is that these tiny relatives of the cockroach feed on the cellulose in wood or other plants, be it dead or alive. As in cattle, sheep, and goats, protozoa and bacteria in the gut digest this cellulose. In addition, some species can digest at least some of the lignin in wood — a disputed claim now proved correct by Dr French.

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*Before we came along,  
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## Kept their place

Before we came along, termites had their place in nature and they kept to it. Now we very obligingly provide them with extra food in the form of wooden structures of one type or another, and their habit of living in colonies makes them very adept at eating these offerings.

Most people have seen pictures of the famous 'magnetic' mounds near Darwin. Wander into the bush practically anywhere in Australia and you will see other less-spectacular termite mounds. These are one type of nest. Others may be completely underground, up trees, or even inside them. To timber-cutters, termites hollowing out the trunks of tall trees and filling them with the muddy material out of which they make their nests are a curse.

All these varied nests serve one purpose: to maintain the right conditions of temperature and humidity to enable colonies of the insects to thrive. The secret of the north-south pointing magnetic mounds seems to be that this configuration presents the smallest area to the hot midday sun, so it keeps the temperature down.

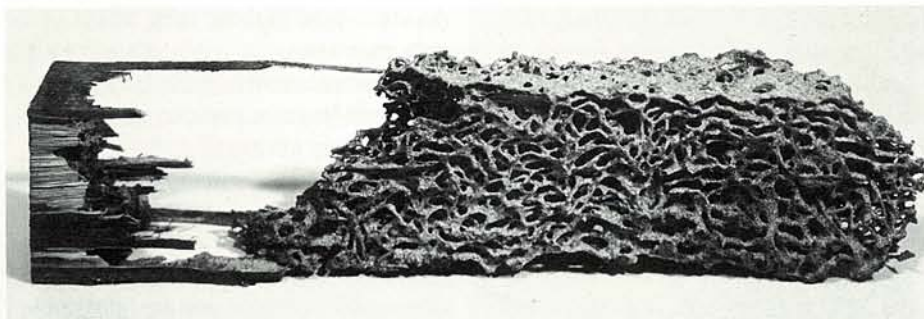
All termites live in highly organized colonies in which different social 'castes' carry out the tasks required to maintain the whole organization.

All colonies contain three castes — the royal pair, workers, and soldiers.

The royal pair — the king and queen — founded the colony, and typically remain the only individuals able to breed. The huge-bodied queen becomes little more than an egg factory. Workers feed her and the king, as well as doing all the building and provisioning of the colony.

The workers forage for food outside the nest. To do this they make protective tunnels. These may be within susceptible materials like timber, or above or below the surface of the ground or whatever else lies in the termites' path between their nest and their food. Tunnels that stretch up brick walls to sources of food such as roof beams will be a familiar but none-too-welcome sight to many people.

The soldiers, of course, defend the colony. How they do it depends on the



This was a bearer beneath a house before termites got to it.

species. Most have large biting jaws with which they can inflict wounds on their attackers. However, soldiers of the most 'advanced' termite genera, of which *Nasutitermes* is an example, use a much more sophisticated system. They have an elongated snout, which they use like a built-in rifle to fire a sticky substance at intruders. The name of the genus comes from *nasutus*, Latin for long-nosed.

### Earthworms of the tropics?

Biologists have thought of termites as the earthworms of the tropics. In many ways their effects on the soil seemed to be similar. They take dead plant litter, break it down, and return its nutrients to the soil. Since earthworms are comparatively few and far between in much of the tropics and subtropics, it appeared that termites must be the main influence breaking down and helping recycle the minerals contained in the vegetation.

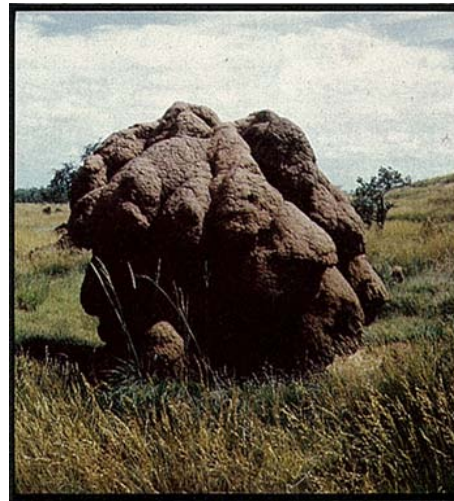
With this idea in mind, Dr Ken Lee and Dr Tom Wood, of the Division of Soils, looked at about a dozen common species, most of which excavate the subsoil and build mounds. They concluded that, although the analogy contained a grain of truth, termites in fact affect the soil rather differently from earthworms. Earthworms increase the porosity of the soil, and mix the topsoil. Termites don't seem to. Indeed, by bringing up subsoil from deeper regions they tend to cover the topsoil.

Termites' habit of living in colonies must produce its own peculiar effects. Earthworms eat plant litter on the spot where they find it. Termites on the other hand go out and forage for wood, grass, dung, or other food and bring it back to the nest. Thus each colony concentrates large amounts of the nutrients in its neighbourhood within its nest. These become sealed in the mound until the colony dies. Only then, as a result of erosion, will the nutrients spread into the surrounding soil.

Measurements by Dr Lee and Dr Wood showed that termite mounds can contain up to 60 tonnes of soil per hectare. In tropical savannah country near Darwin, where the spinifex termite *Nasutitermes triodiae* builds great numbers of large mounds, they estimated that these mounds, although containing only 2% of the available topsoil, locked up 3% of the available sodium, 5% of the nitrogen and phosphorus, 9% of the available calcium, 13% of the potassium, and no less than 22% of the available magnesium. Mounds of two other species



Workers and long-nosed soldiers of the termite *Nasutitermes exitiosus*.



Termite mounds come in strange shapes: spinifex termites made this one in Western Australia.

at another site contained about 3% of the topsoil, 3.5% of the available sodium, 5% of the available calcium and magnesium, and 7% of the potassium.

So termites must concentrate a sizeable fraction of the available plant nutrients in their colonies.

### Overland telegraph line

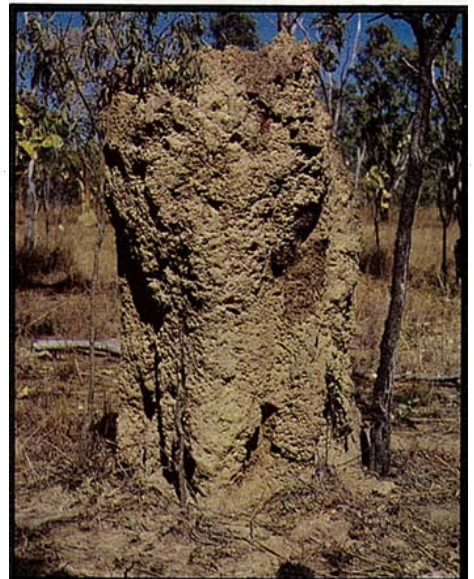
How long the nutrients remain locked up depends on the species. It may be 5 years, or possibly as long as 100. One termite mound studied in East Africa was probably about 700 years old.

What is probably the oldest recorded Australian termite mound stands about 7 km north-west of Pine Creek in the Northern Territory. It used to contain a colony of the spinifex termite and is known to have been inhabited for at least 65 years.

In 1872 it happened to lie in the path of the overland telegraph line that was being constructed between Adelaide and



'Magnetic' mounds near Darwin.



The spinifex termite mound that had its top cut off in 1872 to allow the wires of the overland telegraph line to clear it.

Darwin at that time. It was reduced from 4½ metres in height to just under 2½ so that the wire would clear it. Entomologists visited the mound in 1913, 1935, and 1936, and each time it was still inhabited by the spinifex termite. How long the colony remained after that nobody seems to know. What was almost certainly the same mound was located once more in 1970, by which time the colony appeared to have been dead for some time.

Since the mound was already more than 4 metres high in 1872, it was probably then about 40 years of age. On this basis the mound was attributed an age of about 100 years in 1936, when the colony was last seen alive.

Even if plant nutrients get locked up for 100 years this doesn't mean that the landscape as a whole is losing all its nutrients. There will be mounds of all ages, and so, as nutrients are being stored in some, they are being eroded out of others.



**Forest of nests**—the termites inside help recycle the plant litter.



**Termite damage in a wooden building in Townsville.**

However, what proportion of the plant litter is actually being processed by termites? After all, other organisms also break down plant material. This was another side to the studies of Dr Lee and Dr Wood. They followed through the way that one species, *N. exitiosus*, dealt with litter on the forest floor near Adelaide. They calculated that this species, which eats mainly sound dead wood, accounted for about one-fifth of the total wood fall. Of this, just over half seems to be decomposed and lost as carbon dioxide and water. Most of the rest is excreted to form humus-like 'carton' for use as a structural material in mounds or as a lining for the species' subterranean tunnels.

Since this species was only one of seven wood-eating termites that occurred at the site, they concluded that, between them, these seven species may well consume about 40% of the total wood fall in that particular woodland.

### Competing with cattle?

Some termite species specialize in eating grasses and plants, and in the farm situation they may be regarded as competitors with domestic stock for the feed. In fact, in arid country at least, the biomass of termites may often equal that of domestic stock. However, joint studies on harvester termites — carried out near Alice Springs by Dr Tony Watson of the Division of Entomology and Mr Colin Lendon and Dr Bobbi Low, of what was then the Rangelands Research Unit — suggested that in spite of this the two were rarely competing.

The very large paddock in which they did their observations consisted of two mulga-grass communities — one with perennial grasses and one with short annual ones — savannah and shrubby woodlands, and grasslands. The main grazing species were cattle, kangaroos, and nine species of harvester termites. Grazing cattle and termites probably both averaged about 10–15 kg liveweight per hectare, and the kangaroos the very much lower figure of about 0.15.

The scientists' observations showed that the termites were concentrated in the mulga communities, particularly in the mulga-perennial grass one. Cattle on the other hand gave the mulga communities low priority, and grazed in the mulga-perennial grass one least of all. The kangaroos consistently preferred the savannah woodland and the mulga-short grass communities, and once again the mulga-perennial grass one got very short shrift.

Cattle and kangaroos concentrated on any available green feed. The harvester termites on the other hand generally took their food in the dry state after it had hayed off. In addition, at least one of the termite species did not feed in winter, so



**Chopped grass stored in a harvester termite nest.**



**Giant northern termites mill about on a nest taken from a fence post near Townsville.**

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*In arid country at least, the biomass of termites may often equal that of domestic stock.*

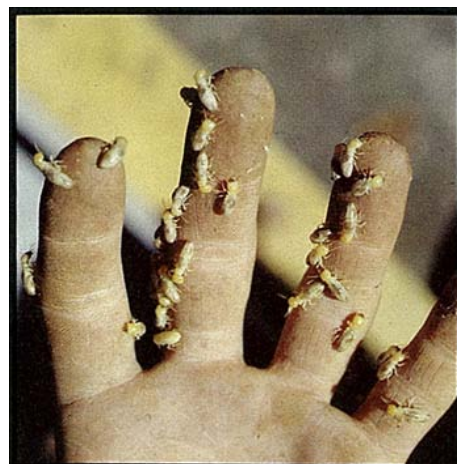
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any plants that responded to winter rain escaped its attentions.

In spite of these observations, cattle and termites must compete during times of drought, when the long standing-hay crop must act as a drought reserve for cattle and termites alike. Even so, all the main forage plants returned following a 9-year drought in the area, so the mulga-grass community in the Alice Springs area at least must be very stable.

This is not so everywhere. Dr Watson has documented a case in south-western Queensland where the mulga community came unstuck. Here sheep were the grazing domestic animal, and *Drepanotermes perniger*, one of the species present on the Alice Springs paddock, the main harvester termite.

Over the years, fires and sheep grazing on young mulga shoots had thinned the tree cover. During the two or three periods when rainfall was higher than usual, grasses had grown more prolifically



**Giant northern termites—the soldiers bite, but it doesn't hurt too much!**

under the thinned canopy. Consequently both sheep and termite numbers increased greatly. When the rainfall dropped once more to a lower level, sheep and termites denuded the grassy areas. In addition, the harvester termites attacked the bases of the perennial grass tussocks, and so many of these died. Severe erosion followed.

Ironically, had the original mulga remained, things would not have been so bad, for then the termites would have collected mulga debris, thus relieving the pressure on the grasses.

The situation was made worse by the termites' nesting habits. In that area they form compact nests at or just below ground level. Each nest has a hard cap 2-3 metres in diameter on which plants cannot grow. Where termite colonies had built up to large numbers they occupied up to 20% of the soil surface, thus making it much harder for the vegetation to recover.

So, termites can be as troublesome to pastoralists as they are to developers. However, the other side of the coin should always be remembered — they help recycle plant nutrients and prevent litter build-up under the vegetation, thus helping to maintain plant growth and reduce the bushfire hazard.

In the farm situation the only sensible thing to do seems to be to learn to live with termites and use management techniques that do not advantage them too much. Controlling these insects would be far too expensive, and probably ecologically undesirable anyway.

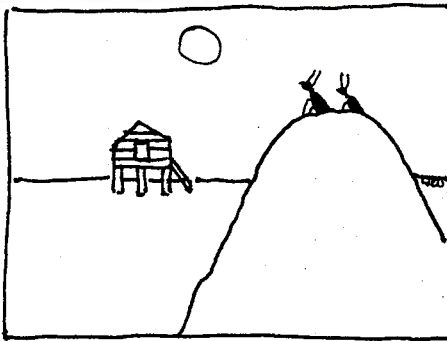
### Alternative control

What about protecting buildings, bridges, and other wooden structures? Up to now one of the main approaches used has been to impregnate timber and the soil in the near vicinity with persistent, broad-spectrum, chlorinated-hydrocarbon insecticides. However, it has become increasingly obvious that this is not a complete answer. The side effects on the environment are undesirable.

In fact many entomologists doubt that there is a single simple solution. Instead, they have come to think that we will have to come to terms with termites and keep their numbers as low as possible by using a whole battery of techniques to maintain an environment unsuitable for them. In other words, we will have to use the integrated-pest-management approach.

Doing this requires detailed knowledge of termites' biology, since only then can we know their vulnerable points. With

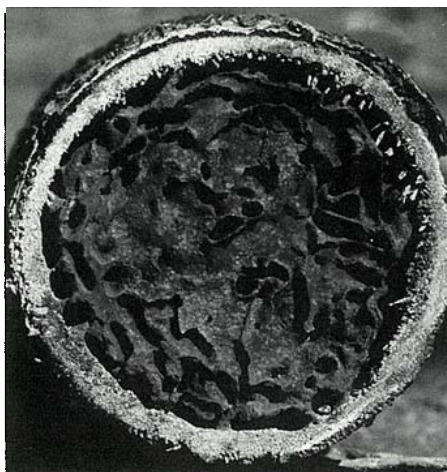
## We will have to use the integrated-pest-management approach



such knowledge we can use techniques that minimize the damage termites do to buildings or forests.

One such approach involves using repellents, and other substances that confuse the termite colony's social organization. Coordination of the whole complicated social organization of termite colonies depends on pheromones — chemical messenger substances. Pheromones control which castes develop in any given situation and how the individual insects behave. Thus a pheromone stimulates the soldiers into action when anything attacks the colony. However, the dependence of the colonies on these substances makes them vulnerable to outside manipulation by Man.

In fact, as so often happens, nature has beaten us to it. For example, pinenes in living radiata pines seem to repel some common Australian termite species, thus preventing attacks. Even the dry timber is resistant to *Nasutitermes exitiosus*. Indeed, this termite will even die out in an area if pines are planted.



There's not much left of this *Pandanus* palm after giant northern termites got to it. The earthy material is their nest.

Cypress pines are a native species known for being termite-resistant. At the Division of Building Research, Dr Ted Hillis and his research team are identifying and analysing chemical fractions from cypress pines that repel termites. They hope that in time it will be possible to synthesize some at least of these substances for commercial use.

Synthetic juvenile hormones are already available. These hormones control the growth and development of insects. Applying synthetic juvenile hormone to one common Australian termite species causes more workers than normal to develop into soldiers — with obvious disastrous effects on the provisioning of the colony.

Using the pest-management approach on termites will not eliminate using persistent insecticides. It will, however, greatly reduce the amounts we have to use. For example, Mr Bob Paton of the Division of Forest Research has carried out work on the giant northern termite in the Northern Territory, in collaboration with the Australian Atomic Energy Commission. Use of radioactive tracers made it possible to track down exactly where nests were, how far the termites moved to forage, and where the workers went within the colony. Using this sort of knowledge it will be possible to apply small amounts of insecticides to individual nests very effectively.

It is already possible to kill colonies of some other Australian termites by injecting insecticide into exactly the right part of the nest to kill the king and queen — thus destroying the ability of the colony to breed. And by using baits and slow-acting insecticides whole colonies of other species can be destroyed, since these insects pass around and share their food in the nests.

So, useful control techniques for termites are becoming available for situations in which these insects have become an intolerable nuisance. However, the other side of the coin should always be remembered. In most places termites are fulfilling an essential role in the natural cycle. Kill them indiscriminately and we may lose more than we gain.

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## The northern giant

In tropical Australia the giant northern termite, *Mastotermes darwiniensis*, has a legendary reputation. It seems to eat just about anything. As well as eating wood — be it in buildings or in sleepers beneath the railway lines servicing the great northern mining developments — it has been known to include on its menu such choice items as bitumen, plastic- and lead-sheathed telegraph cables, inflated rubber tyres on vehicles, car batteries, and even ivory and billiard balls. It also attacks a wide range of living plants.

This termite is also remarkable to biologists for another reason. It is the only surviving species of an ancient family that once occurred in most continents of the world. Fossils have been found in Australia, Europe, and the Americas.

In many ways the giant termite has many similarities with its close relatives the cockroaches. However, unlike the cockroaches, it builds up into large colonies. Its destructiveness depends partly on its size, partly on the large size of its colonies, and partly on its unusual social organization.

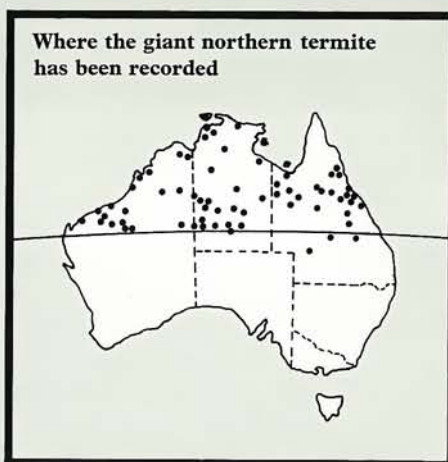
Like those of other termites, its colonies contain soldiers and workers. However, unlike most others, workers commonly develop into individuals that can breed. Dr Watson has shown that this happens continuously, although normally these individuals are killed within the colony before they lay eggs. If the food supply increases then these breeding individuals are permitted to live, and in fact their presence stimulates more to develop.

Obviously, since it can continuously produce egg-laying forms, this termite can breed up much faster than other species when the circumstances permit. And this no doubt helps explain why it can be so troublesome.

In fact the species benefits greatly from human activities. In its natural state the giant termite, which nests in dead trees, stumps, logs, or roots below ground, is generally not very abundant. It occurs almost everywhere north of the Tropic of Capricorn, but rather patchily.

Normally food shortages keep numbers down. However, if Man obligingly adds to the food supply by laying rail tracks on wooden sleepers, or constructing wooden buildings, then the nearby small colonies can breed up very rapidly. At the same time other colonies may bud off those already existing, thus adding to the upsurge in termite numbers. Developers have already learnt of the results to their cost, and as more people move into the north the giant termite may well become an even bigger problem.

The very adaptability of the insects adds to the damage they do. They continuously explore their surroundings for new food sources, with the result that they will often turn their attention to most unlikely dietary items.



The giant northern termite occurs almost exclusively north of the Tropic of Capricorn.

Up to now our main defences against these insects have been to use insecticides, like dieldrin or copper-chrome-arsenic formulations, or carefully worked out building practices.

However, until recently it has been difficult to test control techniques on the giant termite because nobody knew how to keep it thriving in the laboratory.

Mr Doug Howick of the Division of Building Research and Dr Watson have now cracked this one. As a result it has been possible to test various treatments commonly carried out to make wooden railway sleepers termite-proof. For example, two treatments — injecting the wood with dieldrin and using copper-chrome-arsenic formulations — seemed to work fairly well. However a third treatment using pentachlorophenol didn't seem to have much effect at all.

In the long run, using poisons probably isn't the answer. When treated, most railway sleepers made from Australian timbers have a susceptible core surrounded by a layer of toxic wood. In time the nibbles of hundreds of individual termites before they die accumulate, exposing the susceptible wood. Then the battle is lost.

When they become available, repellents should be more effective, since the wooden sleepers shouldn't even be nibbled.

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