

# Detection of Termite Infestation by J.F. Easey, Australian Atomic Energy Commission

## INTRODUCTION

Over the past 10 years, the Australian Atomic Energy Commission has had a program of research into the use of radioisotope techniques for studying termite infestations. The studies have been divided between two aspects of termite behaviour; their behaviour in a 'natural' environment, and their behaviour in an urban environment where they co-exist with man and have to cope with his attempts to disturb or eradicate them.

About 20 years ago Kannowski (1), Cosswald and Kloft (2), Courtois and Lecompte (3), Alibert (4) and McMahan (5) used a variety of radioisotopes to study food exchange and areal distribution of colonies of termites and ants.

The AAEC involvement with termites arose out of problems in experimental tree plantations in the Northern Territory of Australia which were managed by the then Forestry and Timber Bureau, now the CSIRO Division of Forest Research. The termite Mastotermes darwiniensis had caused very considerable damage to experimental plantations of pines and introduced hardwoods. Methods for controlling them had not been developed largely because of lack of information on the organisation of the colony: this termite does not build mounds or any other readily detectable structure; it is a very primitive type and the sole remaining example of the Mastotermes family.

M. darwiniensis is not the only termite to be found in Australia; Table 1 lists the various Australasian termites and their food habits. Following the success of its investigation with the M. darwiniensis species (7,8), the AAEC has undertaken further experiments on termites infesting the timbers of buildings in the Sydney area, the most common species being Coptotermes acinaciformis.

## DEVELOPMENT OF TERMITE TRACING BAITS

To study the colony systems of the M. darwiniensis and other termite species three problems have had to be overcome:

- i) selection of a radioisotope of a nontoxic element of such a chemical form that it has a short biological half-life to allow trophallaxis and excretion to occur, a longer physical half-life to allow the biological processes to take place, and energetic  $\gamma$ -rays to allow monitoring through several inches of soil;
- ii) incorporation of the radioisotope tracer in a food for the termites which they would eat in

preference to the ample food supply in which they live;

- iii) selection of a radioisotope which would pass through the colony by trophallaxis and not be incorporated into the termite's metabolism.

Because the work was being carried out in the Northern Territory, some 3,000 km from the AAEC Research Establishment at Lucas Heights, a longer lived radioisotope had to be selected. The one used for this initial work was scandium-46 (half-life 84 days); it emits a  $\beta$ -particle with a maximum energy of 0.39 MeV and  $\gamma$ -rays with energies of 0.89 and 1.12 MeV; its biological half-life in mammals is about 24 h; and its low  $\beta$ -energy should minimise the radiation dose to the insect, and high  $\gamma$ -contribution could allow detection through several inches of soil.

After selection of a likely radioisotope, the next problem was the formulation of the food. Initially a food containing cellulose and agar gel was tried which the termites ate but when scandium chloride solution was incorporated it was not eaten. Later, it was found that the termites would accept baits containing finely ground scandium oxide suspended in the mixture. Laboratory experiments showed the scandium to be ingested with the cellulose and it was also shown that the scandium was passed to soldiers and other workers. The excreta also contained scandium. The biological half-life of the scandium was found to be 24 to 36 hours for the workers and five days for the soldiers.

Although cellulose proved satisfactory in the initial laboratory experiments, subsequent laboratory and field work showed irregular uptake. Better uptake was obtained with baits made from sawdust in agar gel. It was observed that the larger sawdust particles were rejected by the termites. Baits using sawdust with particles less than 500  $\mu$ m in diameter had an improved uptake. Nutrients, such as glucose and trace elements, were added to the baits but no improvement in uptake was noted. The wood used initially came from a variety of eucalyptus tree known as E. regnans. In free choice experiments where the termites were given a choice of woods, they preferentially selected another wood from the eucalyptus family, E. tetrodonta (Northern stringy bark).

The final baits consisted of a paste of sawdust in 1% agar gel containing finely ground scandium-46 oxide. The material was packed into a 1 cm hole drilled in 1.25 cm diameter commercial wood dowelling. Some 4 g of paste could be packed in a 10 cm deep drill hole. This dowel is inserted into a hole in an infested tree.

In one trial carried out near Darwin NT, two dowels were put in an infested E. tetradonta tree and after two days, 75% had been removed. At weekly intervals four baits were placed in nearby trees that were found to be radioactive. The baiting was stopped when no further spread of activity was observed. By this time, a total of 1 millicurie of scandium-46 had become spread over an area 80 m by 84 m in 31 sites.

A shrub, a stump, two logs and three trees, which were all radioactive, were cut open and examined. The scandium-46 was found fixed in the structural material built into the wood by the termites. The baiting technique had proved the value of the method for identifying subcentres in a colony but not the presence of the interconnecting galleries.

The relatively long half-life of the scandium-46 was not suitable for general tracing and so lanthanum-140 (half-life 40 h) was substituted since its general chemistry is very similar to that of scandium. It has a 97% emission of a  $\gamma$ -ray at 1.596 MeV, whereas the  $^{46}\text{Sc}$   $\gamma$ -rays are 0.88 MeV and 1.12 MeV and hence  $^{140}\text{La}$  enables more deeply tunnelling termites to be 'seen'. Furthermore, the much shorter half-life of  $^{140}\text{La}$  has the advantage of minimising radiological hazards, a very important factor when carrying out tracing work in areas involving the general public. In addition, it has a short 'memory effect' so that the effect of termite eradication work can be investigated a few weeks after the original tracing, and termite studies of multiple colonies inhabiting similar territory can be undertaken over a short time period.

It was also found that the use of the radioisotope tracers in the form of oxides was not really suitable, since the particle size of the oxides varies, mainly because of clumping. This variation led to anomalous situations where some termites had orders of magnitude differences in radioactive content, causing difficulties in discriminating between single termites and groups. Because simple salts, such as chloride solutions, had been previously rejected (qv), laboratory taste trials were conducted on C. acinaciformis on the diethylene-triamine-penta acetic acid (DTPA) complex of lanthanum and found to be acceptable. The use of the lanthanum DTPA complex gives a much more controlled distribution of the tracers through the termite colony and hence a more reliable indication of areas of high termite activity from the measurement of high radioactivity. Success has been obtained with this modified lanthanum-140 DTPA bait with positive acceptance by the termites in over 90% of trials. This bait has also been used successfully with other species (see below).

#### TERMITES IN URBAN ENVIRONMENTS

The cost of termite damage in the State of New South Wales alone is said to be in excess of \$60 million/year. Expressed another way, the total cost of damage caused by all natural disasters, e.g. flood, droughts, fires etc. in NSW this century is said to be less than one year's cost of termite damage in Australia.

Much of the structural damage to buildings has been attributed to the C. acinaciformis.

It was found that the tracer bait formulation that had been developed for M. darwiniensis was suitable for C. acinaciformis. In an urban environment, C. acinaciformis do not have readily observed mounds. They live within and burrow within the timbers they eat and their entry into timbers can be very difficult to detect until some structural defect develops. The use of a radioisotope tracer to identify the termite affected timbers in a building is obviously important but the general use of this technique in public housing is not practical because of problems with the control of radioisotopes. So the work was restricted to an area where there was a specialised need - the renovation and restoration of historic buildings.

In Sydney, there has been a program of restoration of historically significant buildings by the NSW Public Works Department. The AAEC has carried out over 50 tracings in a number of these buildings where there were active termite infestations. The radioisotope tracing technique is particularly valuable for this type of work since

- i) knowledge of the location of the termite nest is not required;
- ii) only one active foraging galley has to be located in order to define the extent of the colony;
- iii) interference or damage to the historic building is minimal.

Various tracing experiments have resulted in:

- i) location of termite nests, allowing effective eradication to take place;
- ii) location of currently active termite galleries, allowing timbers to be replaced where required;
- iii) determination of whether or not all termite infestations belong to the same colony, ensuring all the termite colonies are eradicated.

#### TERMITES IN NATURAL ENVIRONMENTS

The AAEC has also been studying the behaviour of termites in their natural environments. One major project is being carried out in cooperation with the CSIRO Division of Soils in Townsville, Queensland. In this particular case, the termites are not species that affect building timbers; they are mound-building harvester termites, Amitermes vitosus, Drepanotermes rubriceps and Tumulitermes pastinator which mainly live off grasses. The particular area of the study has a semi-arid tropical climate. The termites are probably the most important soil animals particularly for this climate. Termites are known to be prime agents of soil forming processes and possibly regulators of nutrient cycling rates. As part of the evaluation of the role of these mound-building termite estimates of population levels are required. These data, integrated with studies on rates of mound erosion, pasture consumption and nutrient levels in mounds and in soils beneath mounds, will allow accurate assessment of the physical and chemical effects of termites on soils.

For this work it has been necessary to design a suitable bait containing a radioisotope tracer that will be acceptable to these termites. To assess the suitability of the tracers used for this work, gold-198 and iodine-131, the excretion rates and the trophallaxis rates of the tracers for the particular species of termite were measured. Preliminary work has been carried out in the laboratory using small groups (up to 100). It is very difficult to maintain such colonies for more than a few days before unacceptably high death rates occur. The experimental life time of some species has been extended by incorporating soil, grass and/or wood as appropriate. Since the termites in small groups are under stress, the information gained on excretion and trophallaxis rates is taken as being only an indicator of the real rates. Laboratory experiments are being carried out with complete colonies to obtain more representative rates.

It has been found that the harvester termites will accept a bait made from agar gel into which either gold-198 in the form of gold colloid or iodine-131 as iodide has been added. For the measurement of population numbers, both the marked capture and the isotope dilution techniques have been used with these isotopes. Preliminary results on A. vitosus, D. rubriceps and T. pastinator, in an area mainly devoted to grazing cattle, indicate that they constitute a major factor in the ecology of the area, because it appears as though the area supports twice the cattle mass in termites. The area distribution of termite colonies is being studied to determine such factors as: the extent of a colony's foraging area; whether certain colonies occupy more than one mound; the effects on a colony structure if the main nest is destroyed by pesticide.

#### CONCLUSION

In Australia, termites are important because of both the potential and actual damage they caused and their beneficial influence in soil formation. The AAEC has used and is continuing to use radioisotope tracers to gain knowledge of how the termites behave in both natural and urban environments.

#### REFERENCES

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Table 1. The Food Habits of Australasian Termites\*

Genus	Number of species in genus	Number of species considered	Wood			Grass	Various plant debris	"Living herba- ceous and woody plants	Dung	Carton" in occu- pied term- itaria
			Living	Sound dead	Rotten dead					
Mastotermitidae										
Mastotermes	1	1	1	1				1	1	
Kalotermitidae										
Neotermes	1	1		1	1					
Kalotermes	7	6	3	6	1					
Ceratokalotermes	1	1	1	1						
Glyptotermes	5	3	3	3						
Bifiditermes	1	1	1	1						
Cryptotermes	3	1	1	1						
Hodotermitidae										
Stolotermitinae										
Stolotermes	5	4		1	4					
Porotermitinae										
Porotermes	1	1	1	1	1					
Rhinotermitidae										
Rhinotermitinae										
Parrhinotermes	1	1			1					
Schedorhinotermes	2	2	2	2	1		1	1		
Heterotermitinae										
Heterotermes	4	4		4	4		1			
Coptotermitinae										
Coptotermes	6	6	4	6	1		2			
Termitidae										
Amitermitinae										
Amitermes	57	19		12	5	5	8	1	7	
Drepanotermes	2	1				1	1			
Ahamitermes	3	3								3
Incolitermes	1	1								1
Microcerotermes	11	6		6			1	1		
Termitinae										
Protocapritermes	1	1		1			1			
Paracapritermes	2	1		1						
Termes	19	3		3						
Nasutitermitinae										
Nasutitermes	19	10	1	7	4	4	4			
Tumulitermes	17	7		2	1	7	5			
Occasitermes	1	1								
Occulitermes	1									
Australitermes	1	Feeding habits unknown								
Macrosbulitermes	2									

\*From Lee and Wood (6)