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PROTECTION OF TIMBER IN CONTACT WITH THE GROUND FROM THE TERMITE *Mastotermes darwiniensis* IN THE PILBARA REGION OF WESTERN AUSTRALIA

by

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SUMMARY

A trial was installed in 1972 near Port Hedland, Western Australia, to test the possibility of protecting wooden sleepers from destruction by the termite *Mastotermes darwiniensis* Froggatt by treating them with termiticides. Results indicated that to protect the timber, near-complete penetration of the preservative is essential. *Mastotermes* repeatedly breached barriers of dieldrin, arsenic and creosote of various depths, and even excavated exploratory galleries into sleepers fully impregnated with creosote but always abandoned them.

It has proved difficult to protect Australian hardwood sleepers because complete penetration of preservative is not possible using currently available techniques of application.

INTRODUCTION

The Mt. Newman Mining Company mines iron ore at Newman in the Pilbara region of Western Australia and ships it overseas from Port Hedland. The ore is transported by rail from the mine to the port, a distance of 426 km. Construction of the railway was completed in 1968 and it became operational in December of that year. Most of the continuously welded track was laid on jarrah (*Eucalyptus marginata* Sm.) sleepers measuring 23 x 15 x 259 cm, but a small number of wandoo (*E. wandoo* Blakely) and blackbutt (*E. patens* Benth.) sleepers were also used (Fig. 1). All these sleepers were untreated. In July 1971, approximately 38 km from Port Hedland, several jarrah sleepers were found to be infested by the termite *Mastotermes darwiniensis* Froggatt (Figs. 2 and 3). A survey made in 1972 along the railway showed that only limited sections of the track were likely to be at risk, since *Mastotermes* does not occur continuously throughout the Pilbara region but is confined to areas where woody shrubs and trees form part of the vegetative cover. It is of interest that whereas *Mastotermes* occurs abundantly immediately north of Kalgan Creek, 390 km south of Port Hedland, it was not located south of the Creek despite a very intensive search. There are no apparent differences in soil, vegetation or elevation that might limit distribution southwards. Further, since the survey was carried out there has been no instance of *Mastotermes* attack on sleepers between the Creek and the mine site at Newman.

The following plant genera, common to the Pilbara, are an acceptable food source to *Mastotermes*: *Acacia*, *Hakea*, *Grevillea*, *Cassia*, *Eremophila*, *Owenia* and *Eucalyptus*. Eucalypts are generally confined to the river systems and flood plains, and it is here that colonies of *Mastotermes* are most numerous. In other ecosystems where trees and shrubs are small and scattered, the colonies occur infrequently and may be absent altogether from extensive areas.

Consideration was given to treating sections of the track infested by *Mastotermes* with aldrin, but apart from the fact that the effectiveness of such a treatment was unknown, the suggestion was rejected for environmental reasons. The Pilbara region is subject to cyclonic storms and consequent heavy flooding, and such floods are liable to wash away extensive sections of rail formation so that the insecticide may be drained into the river systems.

An alternative suggestion was to replace the sleepers in *Mastotermes*-infested sections of the track with sleepers that had been given a preservative treatment with one or more termiticides. Unfortunately, however, sleepers of Australian hardwood (*Eucalyptus* spp.) are extremely resistant to penetration across the grain by preservative. Whilst little was known regarding the ability of *Mastotermes* to penetrate a preservative-treated barrier, it had been known to penetrate up to 10 mm into timber treated with Tanalith (copper, chrome, arsenic) in Darwin (R.E. Fox, personal communication). This indicated that control might be achieved only with complete or near-complete penetration of the preservative through the sleeper.

It is known that *Mastotermes* can increase its population numbers very rapidly if abundant food is available. Once a colony has contacted a food source such as untreated hardwood sleepers supporting a railway line, it spreads very rapidly along the track. To prevent this proliferation a decision was made to replace all sleepers within 100 m in both directions from the last sleeper under attack with Malaysian keruing (*Dipterocarpus* spp.) sleepers that had been completely or almost completely impregnated with a mixture of creosote and furnace oil. The distance of 100 m was decided on since *Mastotermes* runways are known to exceed 100 m in length (Hill, 1942), a distance which is probably well within the normal feeding range of the species.

The distance over which new sleepers were to be laid has been effective. There were two occasions on which untreated sleepers just beyond the 100 m limit were destroyed, but in each instance a search into the vegetation alongside the track revealed *Mastotermes* to be present. There was a strong possibility that the attacks could have originated from here rather than from sleepers further along the track.

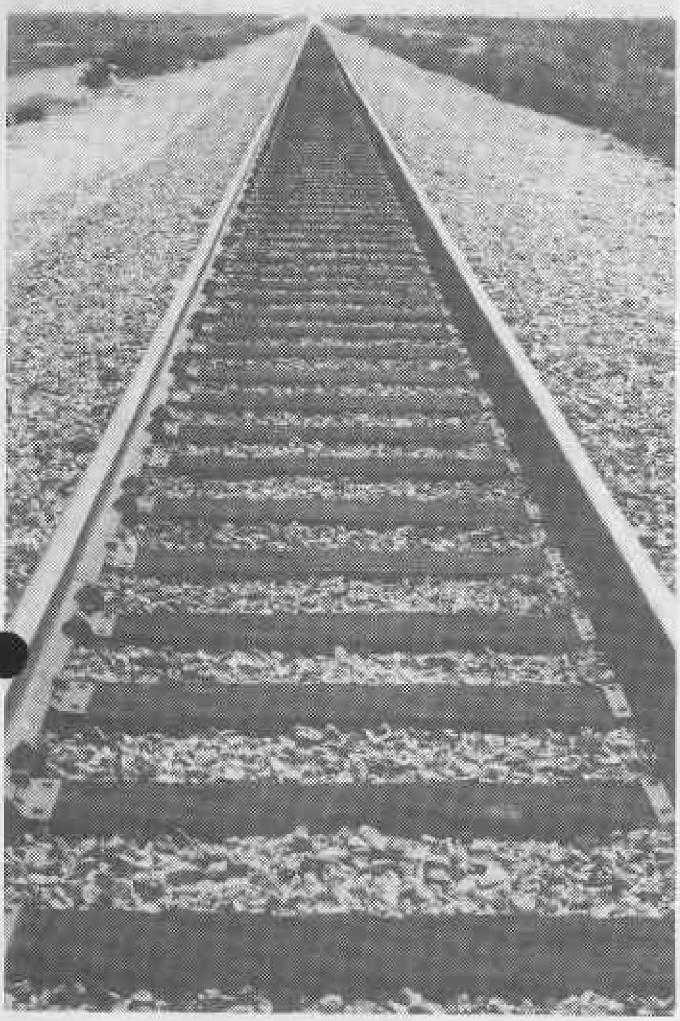


FIGURE 1: A section of the Mt. Newman railway, showing details of construction.

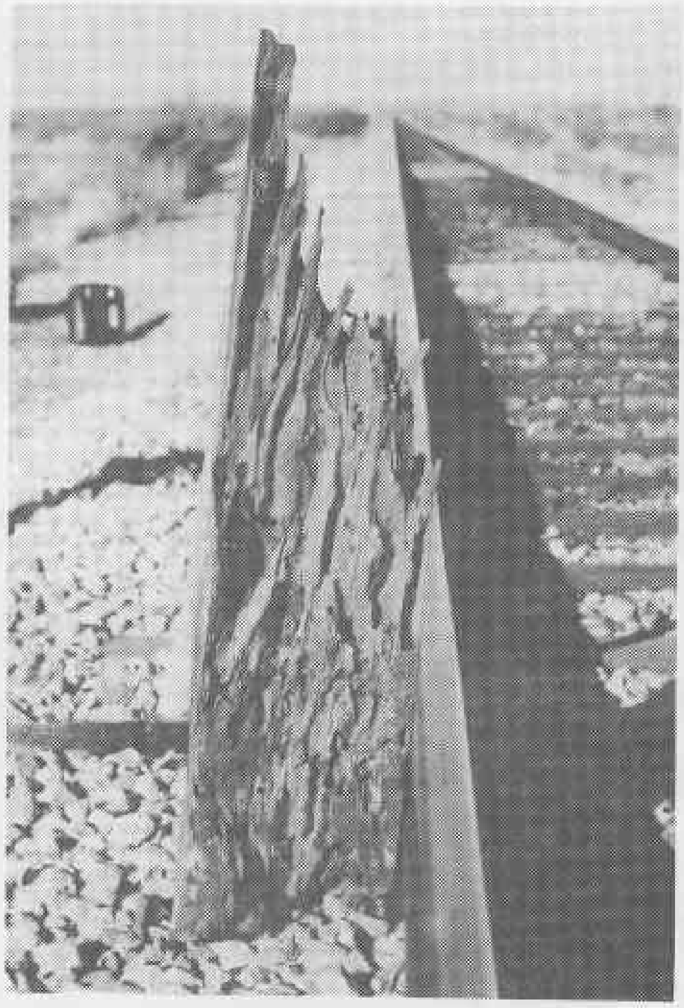


FIGURE 2: The remains of an untreated jarrah sleeper after only 2 years of service. This piece weighed approximately 2 kg; the rest of the sleeper disentegrated into small fragments as it was removed from the track.

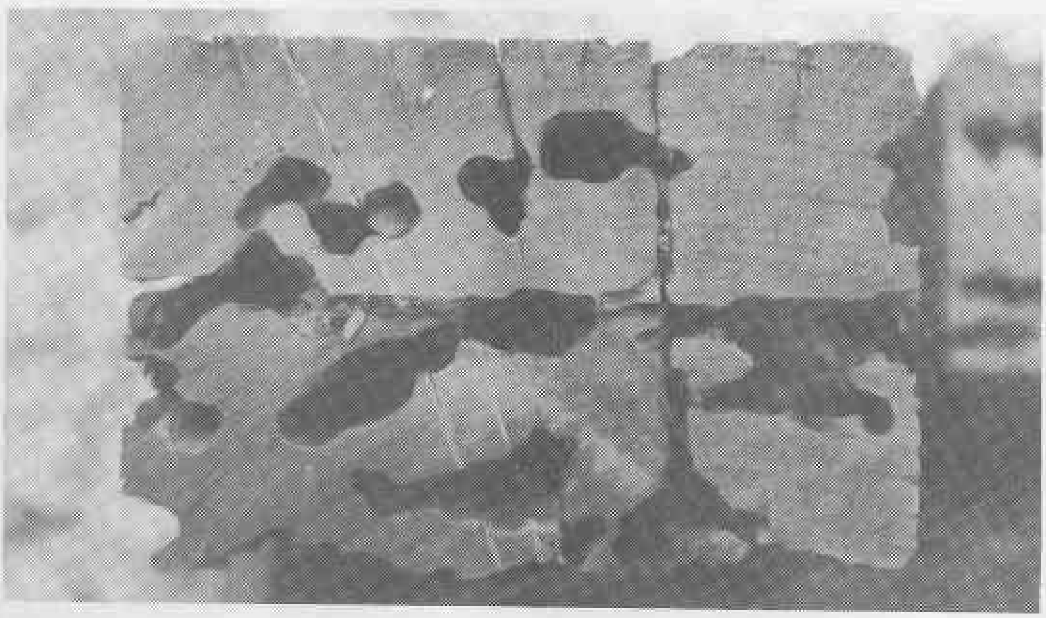


FIGURE 3: An untreated jarrah sleeper, showing galleries being excavated by *Mastotermes darwiniensis*.

Examination of treated sleepers withdrawn from the track revealed that *Mastotermes* excavated quite extensive tunnels into the creosote-saturated wood and then abandoned them.

To obtain more information about the ability of *Mastotermes* to penetrate a protective barrier of termiticide, it was decided to set up a trail at a suitable site along the Mt. Newman railway line. This decision followed discussion between representatives of the Forests Department of Western Australia, the milling companies involved in the sleeper trade, the CSIRO Division of Building Research and the Mt. Newman Mining Company.

It was also decided to duplicate the trial at Darwin in the Northern Territory, at a site to be selected by officers of the Forest Research Institute (now the CSIRO Division of Forest Research). This section of the trial is still current.

METHOD

A suitable site for the trial (Fig. 4) was chosen close to the railway line 16.2 km from Port Hedland. There was a very large population of *Mastotermes* in the area. The site was not subject to flooding, was easy to protect from fire and was reasonably free of interference by people. The site was prepared by setting out rows of karri (*Eucalyptus diversicolor* F. Muell.) bearers measuring 76 x 25 mm in cross-section so that their upper surfaces were flush with ground level.

The test pieces included full-sized sleepers of kempas (*Koompassia malaccensis* Benth.) and keruing and half-length sleepers of jarrah and karri.

Some of the sleepers were incised by passing them between rollers fitted with short steel knives about 15 mm long to give rows of incisions parallel to the grain and 15 mm deep (Fig. 5). This treatment was devised to encourage a deeper penetration of the preservative. However, it was found that in all cases penetration of the preservative was limited to 2 to 3 mm except at the points of incision and to some extent along the grain between them, as well as in the sapwood and along the seasoning cracks. Here, penetration varied from 20 to 40 mm. There was very little movement across the grain between the rows of incisions (Fig. 6).

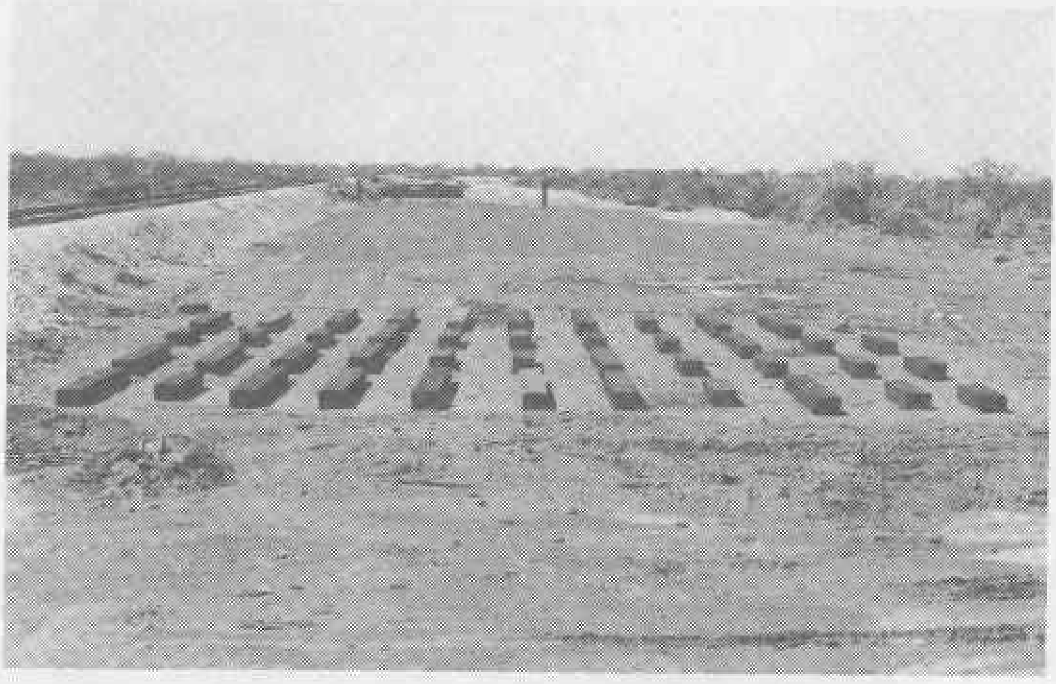


FIGURE 4: The trial shortly after installation in December 1972, alongside the Mt. Newman railway 16.2 km from Port Hedland.

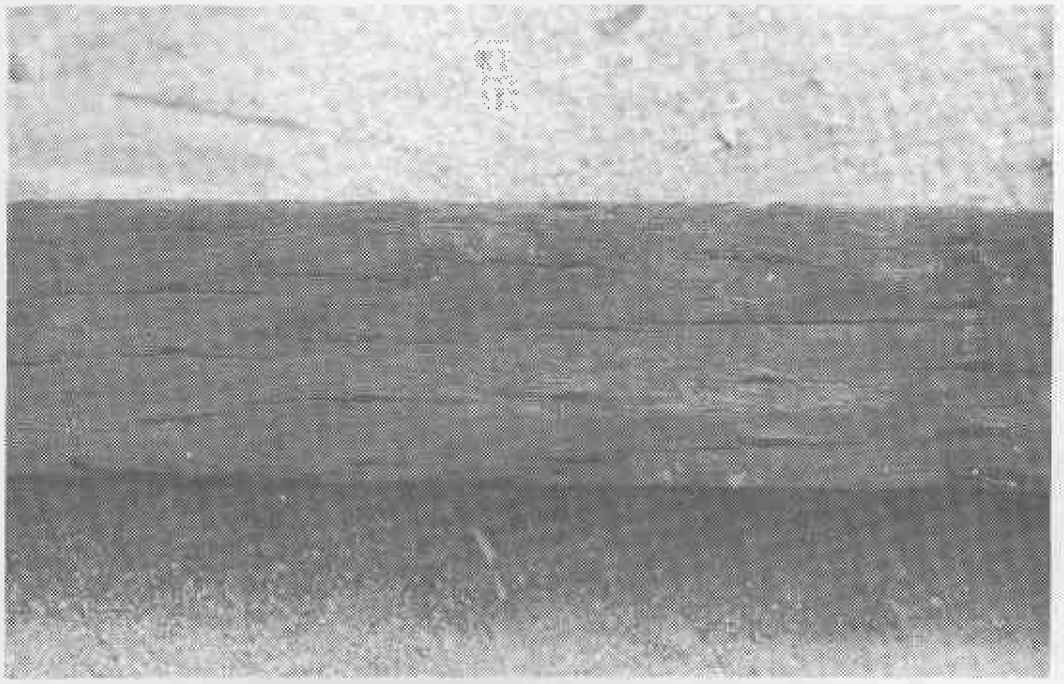


FIGURE 5: The external face of an incised and treated karri billet.

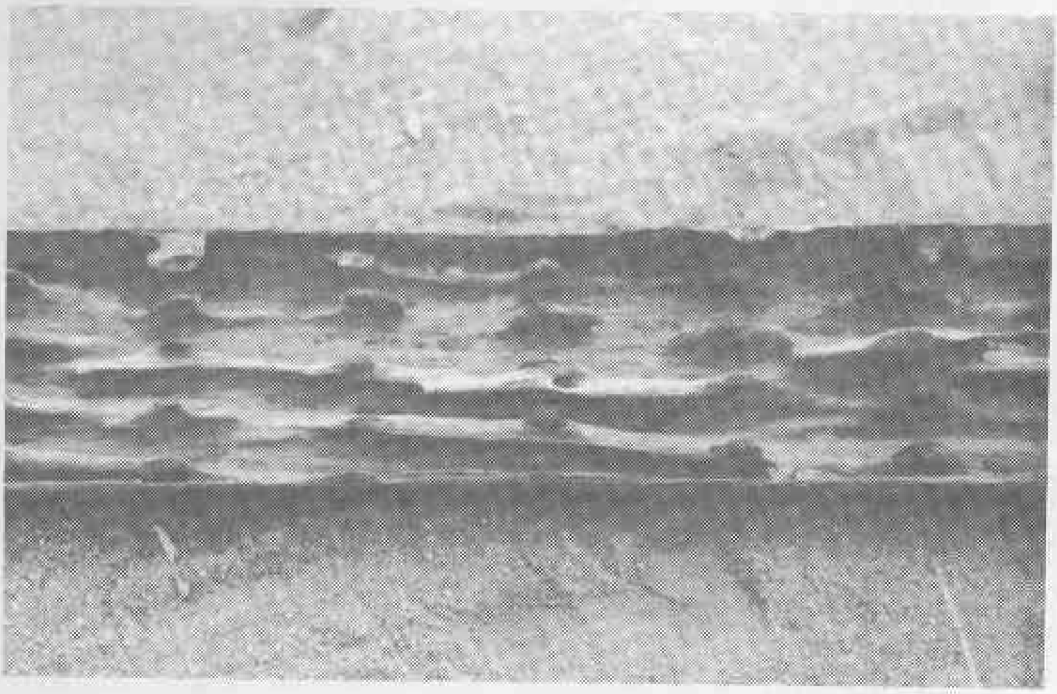


FIGURE 6: The internal face of the karri billet shown in Figure 5. *Mastotermes* has consumed all the untreated wood, leaving the treated wood intact. The extent of penetration of the preservative at the incision points and along the seasoning cracks between them is clear. The protective envelope around the incisions is approximately 3 mm thick.

The following four treatments were applied to forty sleepers, and in December 1972 they were laid on the bearers in a completely random fashion in four rows and at intervals of approximately 80 cm. Figures for retention and penetration of the preservative are given where available.
1. Ten non-incised kempas sleepers, pressure-treated with a mixture of creosote (40%) and furnace oil (60%) to an average retention of 161.8 $kg \cdot m^{-3}$. Penetration ranged from 3 to 30 cm.
2. Ten non-incised keruing sleepers given the same treatment as Treatment 1. Penetration of the preservative was very good and in many instances complete.
3. Ten incised karri half-length sleepers, pressure-treated with a mixture of creosote (70%), furnace oil (29.5%) and dieldrin (0.5%). The average retention was 70 $kg \cdot m^{-3}$.
4. Ten incised jarrah half-length sleepers given the same treatment as those in Treatment 3.

In May 1974, a further six treatments were added to the trial. The treatments were not randomized, however, because there were not enough sleepers. (There had been difficulties with both the transport of sleepers to the trial site and facilities for their treatment.) Details are as follows.
5. One incised karri half-length sleeper, treated with Tanalith (12%) and then pressure-treated with a mixture of creosote (70%), furnace oil (29.5%) and dieldrin (0.5%).
6. One incised karri half-length sleeper, treated with Tanalith (12%) and then pressure-treated with furnace oil only.
7. Two incised karri half-length sleepers, treated by dip diffusion with a strong arsenical concentrate (Johanson, 1975); the composition of the concentrate is given in Appendix I. The sleepers were then pressure-treated with creosote (70%), furnace oil (29.5%) and dieldrin (0.5%).
8. Two double-incised karri half-length sleepers, pressure-treated with a mixture of creosote (70%), furnace oil (29.5%) and dieldrin (0.5%). Retention was 81.7 $kg \cdot m^{-3}$. By incising the sleepers twice, absorption of the preservative was increased by approximately 16 $kg \cdot m^{-3}$, but there was still a penetration of only 2 to 3 mm over much of the sleeper.
9. Two incised jarrah half-length sleepers, treated by dip diffusion with the arsenical concentrate for Treatment 7. Penetration of the preservative was not determined, but was estimated at 2 to 3 mm, increasing to 20 to 23 mm at the incision points.
10. Two incised karri half-length sleepers, treated by dip diffusion with the arsenical concentrate as for Treatment 7. Penetration was assumed to be similar to that in Treatment 9.

RESULTS AND DISCUSSION

The results are summarized in Table 1. The method adopted to assess the effectiveness of the treatments in discouraging *Mastotermes* attack was to record the number of termite penetrations in each sleeper and their depths. This proved satisfactory for recording the degree of attack in the earlier stages of the trial but of course would not reflect the amount of damage at a later stage if the termites began excavating the wood on a greater scale. It was therefore planned to assess termite excavation by weighing the sleepers when this stage was reached. A satisfactory weighing method was devised, and the sleepers were weighed for the first time in June 1975.

However, the termite colonies disappeared from the site before measurable results could be obtained. This was probably brought about by the removal from the vicinity of the trial of all other sources of food, such as old sleepers and crossing timbers. In the absence of a good food supply, the termites were forced to concentrate their attack on the timber protected by preservative. Their continuous ingestion of the termiticides over a period of several years may have led to their premature death. However, *Mastotermes* has been known to desert a trial site at Rollingstone, Queensland, where only plastics not treated with termiticides were being tested (J.A.L. Watson, personal communication) and in the light of this it cannot be stated with absolute certainty that ingestion of termiticides at the Port Hedland site caused the termites' disappearance.

Because the termites were no longer present there was no further destruction of the untreated wood within the sleepers, and it was therefore impossible to continue the trial at this site.

TABLE 1

Number of penetrations by *Mastotermes* and total length of penetrations for the ten trial treatments

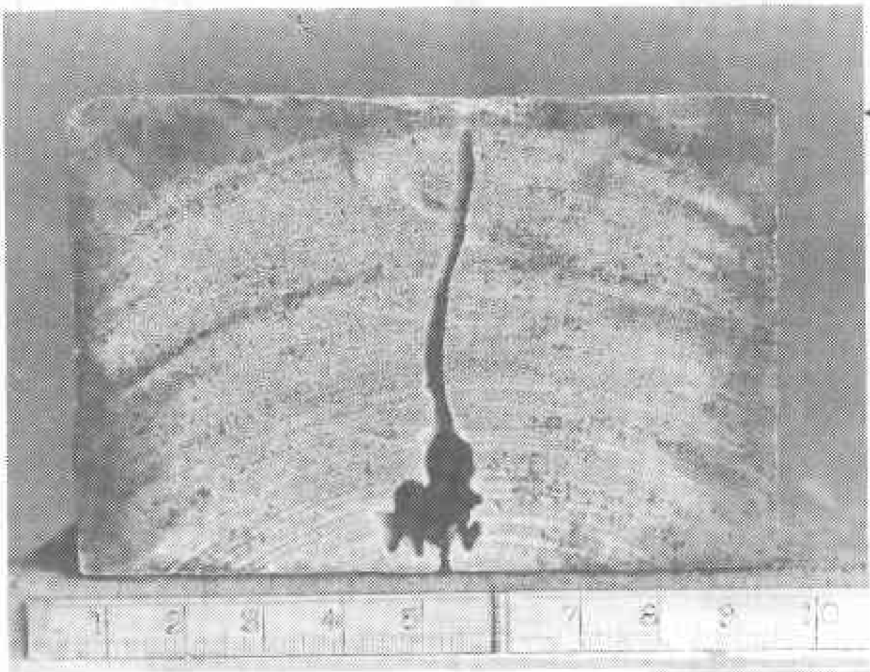
Treatment no.	Timber	No. of sleepers	Preservative treatment	No. of penetrations	Total length of penetrations (mm)
1	Kempas	10	Creosote & furnace oil	77	1360
2	Keruing	10	Creosote & furnace oil	55	360
3	Karri	10	Creosote, furnace oil, dieldrin, incised	32	2539
4	Jarrah	10	Creosote, furnace oil, dieldrin, incised	25	709
5	Karri	1	Tanalith, creosote, furnace oil, dieldrin, incised	6	735
6	Karri	1	Tanalith, furnace oil, incised	12	144
7	Karri	2	Arsenic, creosote, furnace oil, dieldrin, incised	9	348
8	Karri	2	Creosote, furnace oil, dieldrin, double-incised	7	357
9	Jarrah	2	Arsenic, incised	Nil	Nil
10	Karri	2	Arsenic, incised	Nil	Nil

Another factor influencing results was the undesirably high frequency of inspections (initially at intervals of three months), which involved lifting the sleepers and hence rupturing the termite tunnels into the wood. This forced the termites to repeatedly excavate new access tunnels through the poisoned wood, with a consequent increase in the quantity of poison ingested. It was realized that too frequent inspections might affect the validity of the trial but it was necessary to obtain information fairly quickly so that specifications could be given for large orders of new sleepers.

Figures 7, 8, 9 and 10 show the variation in preservative penetration and *Mastotermes* attack for various timbers and various treatments.

Table 2 gives details of the number of sleepers observed to be under attack, and hence the intensity of attack, for each year during the six years of the trial.

An intensive search of every dead bush, tree, log and discarded piece of timber within a radius in excess of 200 m of the test site in June 1977 and again in August 1978 failed to locate any *Mastotermes*. However, other species of wood-eating termites were abundantly present, for instance two species of *Microcerotermes* and one species of *Schedorhinotermes*. These species failed to penetrate any of the test sleepers.



◀FIGURE 7: Kempas sleeper (Treatment 1). Penetration of the preservative varied from 3 mm to 25 mm, with limited penetration along isolated vessels (shown by the scattered dark spots). Penetration of the heartwood at the bottom of the sleeper is minimal. Excavation by *Mastotermes* of the untreated wood is well under way.

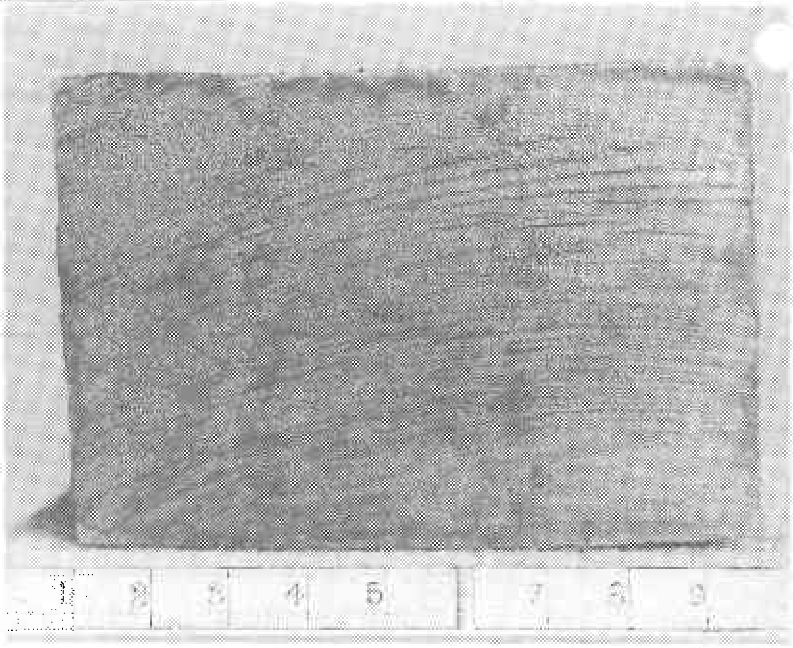
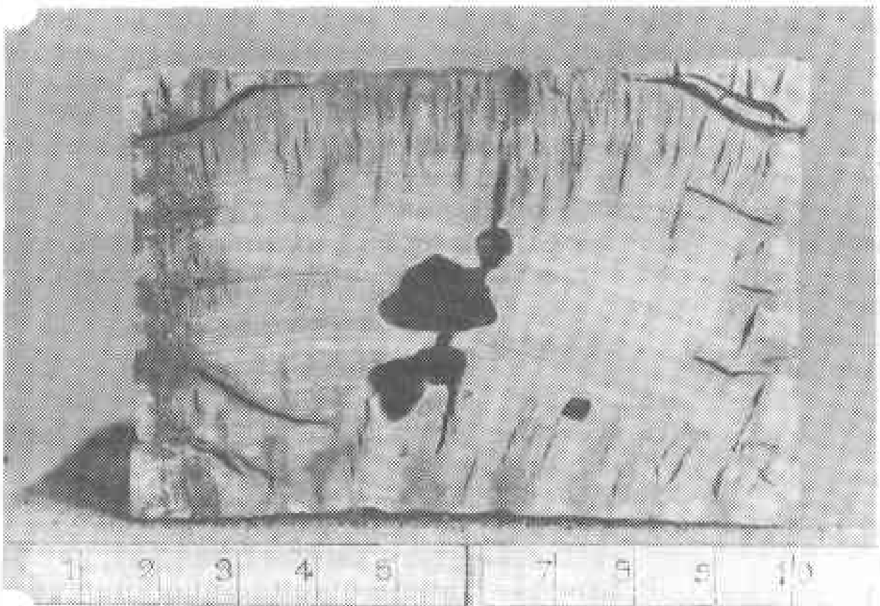


FIGURE 8: Keruing sleeper (Treatment 2). The preservative has penetrated the wood completely. There were ten penetrations of this sleeper by *Mastotermes*, the deepest being 21 mm. ▶

TABLE 2

Intensity of *Mastotermes* attack (gauged by the number of sleepers under attack) for each year of the trial

Date	No. of sleepers under attack
Dec. 1972	Trial installed
Dec. 1973	24
June 1974	36
Dec. 1974	32
June 1975	18
May 1976	15
June 1977	Nil
Aug. 1978	Nil



◀FIGURE 9: Jarrah sleeper (Treatment 4). Penetration of the preservative is mainly confined to the incision points and the seasoning cracks. Excavation of the untreated wood by *Mastotermes* is in progress.

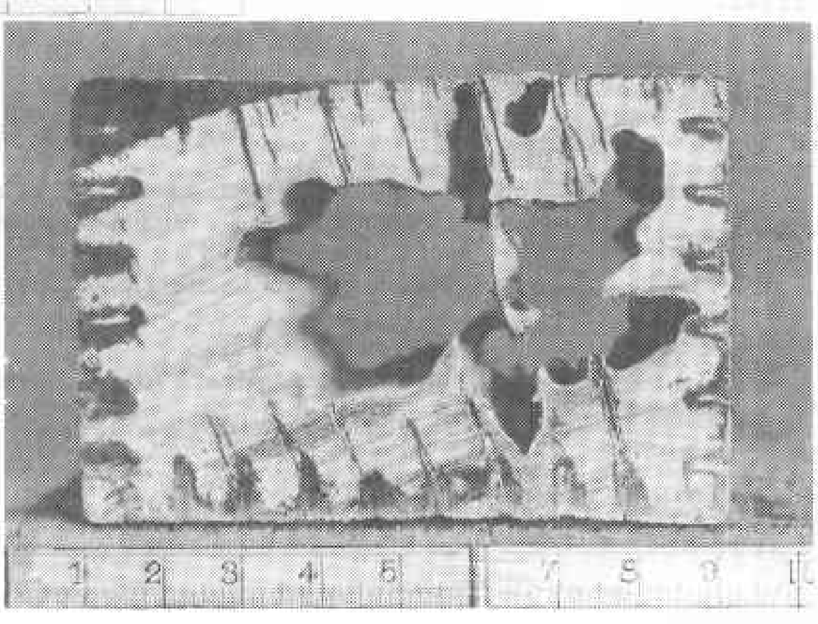


FIGURE 10: Karri sleeper ▶ (Treatment 6). Penetration of the preservative into incisions, seasoning cracks and sapwood (top left) is clearly shown. There has been extensive consumption of untreated wood by *Mastotermes*.

From the results it appears that there is at present no termiticide that will deter *Mastotermes* from penetrating timber in contact with the ground in the Pilbara region under the trial conditions, which included a degree of forced feeding. The termite frequently breached all the protective barriers presented to it, and whilst there was some reluctance to attack the four sleepers treated with arsenic (Treatments 9 and 10), the sleepers in Treatment 7, which also included arsenic in the formulation, were penetrated on nine occasions (Table 1).

The results for the keruing sleepers demonstrate that a timber capable of absorbing a preservative throughout its whole dimension is immune to destruction. It will almost certainly be penetrated by *Mastotermes* in an exploratory way but once the termite has determined that there is no untreated wood available, the attack will be abandoned.

The method adopted to instal the sleepers in the trial proved effective. The karri bearers on which they were laid had been located by *Mastotermes* and were under heavy attack within three months of installation, and several of the test pieces had also been penetrated. The bearers were developed into major runways, so that it was easy to determine which of the sleepers had been contacted by termites.

The incising of sleepers prior to preservation treatment gave no added protection from *Mastotermes* in this trial.

ACKNOWLEDGEMENTS

It is desired to acknowledge the many contributions made to this trial by individuals, companies, and organisations and the continuing interest many of them have shown in the results. Particularly I would thank the Mt. Newman Mining Company for the kindness and courtesy extended to me during the long period the trial was current and especially Harold Lowe for his interest and encouragement and Geylan Nisich and Dixie Stephens for their co-operation and assistance in maintaining the trial at Port Hedland for so many years.

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APPENDIX I

Composition of arsenical concentrate (Johanson, 1975) used for treating sleepers in Treatments 7, 9 and 10. Percentages are by weight.

Diarsenic trioxide (As_2O_3 or As_4O_6)	19%
Water	28%
Borax pentahydrate ($Na_2B_4O_7 \cdot 5H_2O$)	41%
Sodium hydroxide (NaOH)	12%