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Colonisation of rehabilitated lands by termites (Dictyoptera), Rio Tinto Alcan Gove bauxite mine, Northern Territory, Australia

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Abstract

The pattern of termite colonisation and the production of termite constructs are reported from a 26-year age series of sites rehabilitated after bauxite mining in northern tropical Australia. Initial colonisation probably occurs at the time of profile reconstruction and termites were active within eight months of seeding in wood decomposing on the surface and partially buried in the profile.

Termite activity, as determined by consumption of paper baits, was observed at sites rehabilitated for three or more years after seeding and rapidly reached levels approaching that in adjacent unmined native forest ecosystems.

Termites colonising rehabilitated sites are predominantly those that feed on decomposing wood or are polyphagous; some litter-feeding species are transitorily present but disappear near the time of canopy closure. Common local species not observed so far in rehabilitated environments included Coptotermes acinaciformis and certain soil (humus)-feeding species.

Termite galleries were almost ubiquitous in the developing upper A horizons of sites rehabilitated for eight or more years and had penetrated to 40–50 cm at sites rehabilitated for 16 years. Surface mounds of wood- and litter-feeding species were apparent at sites rehabilitated for three or more years. Evidence of termite feeding was universal in dead plant materials although damage to living plants was minimal, sporadic and of little ecological consequence, except at one site rehabilitated after the deposition of red mud.

Forest development and the changing availability of food materials had a critical role in enabling colonisation of the rehabilitated environments by key termite groups. Colonisation in turn interplayed with soil development because of the increasingly diverse termite activities occurring in the rehabilitated environments with time. This emphasises the important roles termites play in decomposition and soil formation processes.

1 Introduction

Termites are widespread in the tropics and subtropics although few species occur at latitudes greater than 50 degrees (Eggleton, 1994) and their representation declines with increasing elevation. Where populous, termites play major roles in ecosystems, both directly through their effects on soils (Lavelle and Spain, 2001) and plants and in the creation of habitat for other organisms, a process known as ecological engineering (Bignell, 2006). In environments ranging from perhumid to arid, they play major roles in the initial reduction and decomposition of dead plant materials (Schuurman, 2005). They process much of the tropical world's dead wood (Cornwell et al., 2009) and provide a range of other soil and ecosystem services (Lavelle et al., 2006). Termites are therefore expected to play major roles in soil and ecosystem development in the post-mining environment, notably where phytostabilisation is used to rehabilitate post-mining landforms.

Previous studies of this topic appear to be limited to three Western Australian studies summarised by Majer et al. (2007), those of Reddell et al. (1992) and Hinz (1997 and 2001) at the present site and in Sierra Leone. Data presented here are from Spain et al. (2009).

This paper presents the results of studies undertaken to determine the patterns and effects of termite colonisation in relation to ecosystem development in lands rehabilitated for periods up to 26 years after bauxite mining. Results are considered in relation to the stage of ecosystem (including soil) development at the Rio Tinto Alcan (RTA) Gove mine. It reports the occurrence of termite attacks on dead plant materials and living plants and charts the temporal occurrence of termite constructs (workings and galleries on and within living plants, in litter and in standing and fallen wood, under rocks, on the soil surface, in the soil profile and in near-surface mounds) in rehabilitation chronosequences, or series of sites rehabilitated for different periods after bauxite mining. Some contrasts with unmined sites are presented. This work extends that previously reported from this site.

2 Methodology

2.1 The study site

The RTA Gove bauxite mine (12º 16'S, 136º 51'E) is located on the Gove Peninsula in the Northern Territory of Australia. Elevation throughout is less than 60 m, and annual precipitation averages 1,438 mm, largely concentrated between the months of December and April. Extreme long-term mean monthly minimum and maximum temperatures range from 19.2ºC (August) to 33.1ºC (November) (Bureau of Meteorology, 2010).

The dominant soils of the mine lease area are classified as ferralsols under the World Reference Base (International Union of Soil Sciences Working Group World Reference Base, 2007) and oxisols under Soil Taxonomy (Soil Survey Staff, 1999). Sites included in the present study comprised those with shallow, medium and deep sola over the indurate bauxitic layer; these changes in profile depth imply minor changes to the dominant eucalypt species. The undisturbed vegetation of the area is largely open forest, mostly dominated by *Eucalyptus tetrodonta* and *Eucalyptus miniata* overlying shrubby and grassy herbaceous strata: this is the most common vegetation association in north-east Arnhem Land (Wilson et al., 1990).

The successful rehabilitation process, instigated in 1970, aims to replicate the three-layered structure of these forests dominated by the above species but also includes species of importance to the traditional owners (Hinz, 1992). In restoring the soil profile, subsoils are briefly stockpiled while the upper soil layer (ca. 30 cm) is directly transported from a site that had been cleared but not otherwise disturbed (see Tibbett, 2010 for further details). While unmined native forests are subject to regular burning, rehabilitated areas are normally protected from fire although some sites have been accidentally burned. Site rehabilitation periods are given in relation to the year in which seeds were sown.

The information presented here was derived from observations made during field work conducted at the RTA Gove Mine between 1991 and 2004 and by D. Hinz over more than 30 years of observations on site.

2.2 Study methods

2.2.1 Observational studies

Observational (non-quantitative) studies were conducted in chronosequences of mined areas rehabilitated for periods ranging from 1–16 years (1991–92 studies) and 2–26 years (2001–02 studies) and in local unmined forests of different profile depths. The stems of living and dead trees and shrubs were examined for signs of termite runways: coverings of soil and organic materials created by the termites to protect themselves while feeding and foraging. Wood transported onto the sites with the replaced overburden materials and remaining on the soil surface or partially buried was also examined for termites or their recent feeding activities. Grass, tree and shrub litters were examined for signs of termite feeding activity, both in the field and in the laboratory. Termite mounds were examined where present.

Living trees and shrubs were examined for the presence of termite workings and damage to roots, stems and branches. Dead leaves, the crowns and associated roots of grasses were inspected for surface workings, galleries and living termites.

The soil surface and the upper 2 cm of the soil profile (for sites examined in 2001–2002 and rehabilitated for periods of eight or more years) were examined for termite constructs (galleries, nests, storage chambers). The interfaces between the undersides of rocks and large clods present at or embedded within the surface soil materials were similarly examined.

In April 1992, termites were hand sorted from soil samples taken in order to estimate the maximum depths of their occurrence (and therefore that of their galleries) in relation to rehabilitation period. Pits (c. 22 × 22 cm) of known dimensions were dug at five sites in the 16-year chronosequence of rehabilitated sites and in an unmined native forest site with a deep profile. Depth intervals were 0–5 cm, 5–10 cm and thereafter at 10 cm intervals to 50 cm.

2.2.2 Baiting studies

Baits were used to assess the activities of cryptic, wood-feeding, soil-nesting species that cannot be readily sampled using other methods. At each of the selected study sites, paper baits (plain toilet rolls) were exposed at the surface of the mineral soil to attract cryptic wood-feeding species. They were covered with black polythene plastic bags (1991–93 studies), or with foliage and branches (2001) to protect them from disturbance by large animals.

The intensity of termite attack on the baits was recorded using a ranked five-point scale. On this scale, 0 implies no attack, 1 minimal attack increasing to a maximum of 5 where the bait was completely destroyed or replaced by carton (a dark-coloured, largely-organic faecal material) or soil.

As part of a larger study, paper baits were exposed in 1991 within the 16-year age range of sites then available to determine how intensity of attack varied in relation to the site rehabilitation period. Baits were exposed in a stratified randomised design of four strata in sites of five rehabilitation periods. Baits were exposed on 27 October 1991 at seven sites, rehabilitation periods of 1, 3, 5, and 10 and at three sites rehabilitated for 16 years (one site had been accidentally burned three years before the study) in the chronosequence of rehabilitated sites. For comparative purposes, an additional exposure was made in an adjacent unmined native forest site with a deep soil profile. The incidences and intensities of termite attacks on these baits were assessed after 154 days exposure in the field. This period extended from late in the ‘dry’ season to the latter part of the following ‘wet’ season. Baits were assessed once and discarded.

A further exposure of baits was made on 3 April 1992 to compare intensity of termite attack at three unmined native forest sites with shallow (site Q), medium (site O) and deep (site M) soil profiles with three disturbed but unmined sites of equivalent soil profile depth. Baits were exposed at random locations in the above sites and in the disturbed forest soils with shallow (R), medium (P) and deep (J) profile depths. At the three disturbed sites, the vegetation had been felled, piled up and burned one year prior but the sites had not been further disturbed. Baits were assessed on 8 July 1992, after 125 days of exposure in the field.

Further baiting studies were conducted in 2001 to compare patterns of termite attacks within the 26-year chronosequence of rehabilitated sites then available. Ten paper baits were exposed on 25 or 26 September 2001 at random locations within two sites of each of the following rehabilitation periods: 2, 3, 4, 8, 13, 17, 21 and 26 years. For comparative purposes, baits were also exposed at three unmined native forest sites with shallow, medium and deep profiles. Paper baits (10) were also exposed at two recently-burned sites, one rehabilitated for 26 years and the other an unmined but recently-burned native forest site with a medium profile depth. These baits were assessed on 30 November 2001 after exposure in the field for 66 days.

2.2.3 Mound populations of *Amitermes vitiosus*

Distributions and populations of the mounds of the litter-feeding termite *A. vitiosus* were assessed at locations rehabilitated for seven and eight years. These sites represent areas of probable maximum mound populations. The latter site had been accidentally burned in August 2001, approximately one month before the present study was conducted.

Mound densities and distributions were estimated using the point-centred quarter (PCQ) method (Bonham, 1989) using four parallel transects of 100 m set up 50 m apart in both sites. Measures were taken every 20 m along all transects and mound maximum and minimum basal diameters were recorded to permit estimation of mound basal areas per unit area of the site. Observations were restricted to the mounds of *A. vitiosus* since the mounds of other species were very sparsely distributed.

3 Results and discussion

This section presents the termite species reported, the results of observational studies carried out at rehabilitated and native forest sites and the results of baiting studies.

3.1 Termite species reported

Table 1 lists the species reported from rehabilitated and unmined native forest environments at the RTA Gove mine (Hinz, 1997; Hinz, 2001; Reddell et al., 1992; present study), together with their feeding and nesting habits. These represent only the dominant species.

Table 1 Species recorded from study sites (data of present study and Hinz, 2001); feeding habits from Lee and Wood (1971), Watson and Gay (1991) and other sources

Species	Feeding Habits	Nests
Rehabilitated Sites		
Amitermes laurensis Mjöberg	Litter feeder, including animal dung	Epigeal mound
Amitermes vitiosus (Hill)	Litter feeder, animal dung	Epigeal mound
Ephelotermes melachoma Miller	Decomposing wood	Epigeal mound
Heterotermes vagus (Hill)	Decomposing wood	Subterranean nest
Heterotermes venustus (Hill)	Decomposing wood	Subterranean nest
Mastotermes darwiniensis (Froggatt)	Highly polyphagous, diet includes dung, sound and decaying wood, living plant tissues	Subterranean nest
Microcerotermes serratus (Froggatt)	Dung, decomposing wood, grass	Carton-rich epigeal mound or subterranean
Nasutitermes graveolus (Hill)	Sound and decomposing wood, plant detritus	Arboreal nest
Nasutitermes longipennis (Hill)	Polyphagous, diet includes dung, grass, wood	Epigeal mound
Schedorhinotermes breinli (Hill)	Wood	Subterranean nest or decomposing wood
Schedorhinotermes actuosus (Hill)	Wood, grass	Subterranean nest or decomposing wood
Tumulitermes sp.	Poorly known, includes grass and herbaceous species	Subterranean
Xylochomitermes melvillensis (Hill)	Decomposing wood	Epigeal mounds
Native Forest Sites Only		
Coptotermes acinaciformis (Froggatt)	Wood in all stages of decomposition	Epigeal mound
Microcerotermes nanus (Hill)	Dung, weathered wood	Epigeal mound

The termites found at the rehabilitated sites were taxonomically and ecologically diverse. They included species that forage for the litter of grass and herbaceous species and on the dung of domestic animals. Most other species feed predominantly on decomposing wood while a few species are highly polyphagous. Nesting sites included both subterranean locations and epigeal (near-surface) mounds.

Since termites disperse readily, most of the species recorded from the rehabilitated environments are also likely to occur in undisturbed native forest sites. In contrast, *Coptotermes acinaciformis* and soil (humus)-feeding termites of the 'snapping mandibles' (or *Termes* group, Miller, 1991) were never found in rehabilitated environments.

3.2 Temporal order of colonisation

Figure 1 presents the order in which termites have colonised the sites in relation to rehabilitation period and the approximate ecosystem developmental stages recognised by Spain et al. (2006): establishment, early development, canopy closure, woodland development and early maturity. *Amitermes vitiosus* colonises sites two years after establishment but dies out about the time of canopy closure when the environment becomes increasing tree-dominated. The other litter-harvesting species *Amitermes laurensis* was only found once at rehabilitated sites. An undescribed *Tumulitermes sp.* is typically found at sites rehabilitated for three or more years; grass fragments stored in underground chambers indicated that it is a litter-feeding species (Watson and Gay, 1991). The decomposed-wood-feeding species of *Heterotermes* found here were from sites rehabilitated for seven years or more years although, from evidence at other tropical mines, they are likely to be present from the earliest stages. The species of the 'snapping mandibles' group so far found to occur at the RTA Gove mine feed on highly-decomposed wood (Miller, 1991).

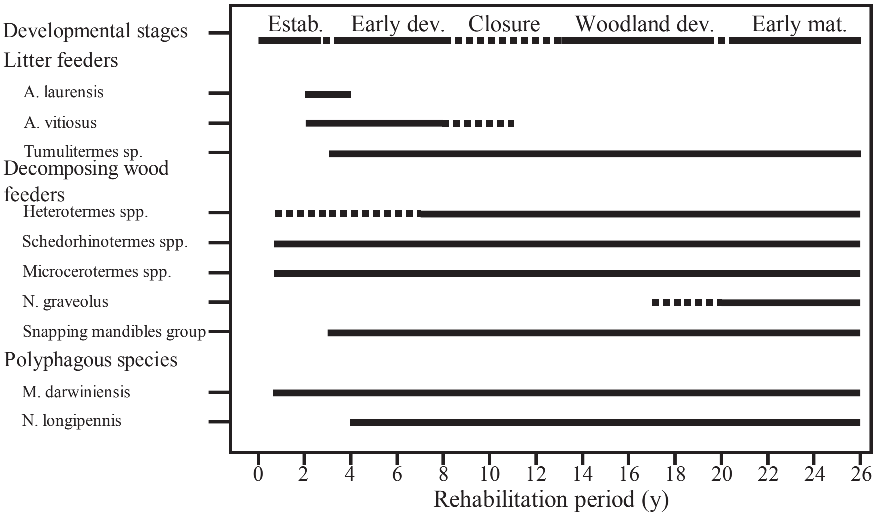

Figure 1 Termite colonisation of areas rehabilitated after bauxite mining at the RTA Gove mine (see text, dotted lines indicate areas of uncertainty or transition)

Mastotermes darwiniensis was found in transported wood within the first year after establishment. It subsequently occurred sporadically in the rehabilitated areas. *Nasutitermes longipennis* is a highly polyphagous species, often found at the RTA Gove mine with grass fragments in its earthen, near-surface mounds. Nests of *Nasutitermes graveolus* were very sparsely distributed on tree stems at sites rehabilitated for 20 years or more; this implies an earlier colonisation since nests initially establish in the soil or in wood on the ground and later move to arboreal locations (Gay and Calaby, 1970).

3.3 Termite baiting studies

3.3.1 Rehabilitated sites

Figure 2 presents the intensities of termite attack on paper baits exposed at the soil surface for 154 days from 27 October 1991 at seven sites in the 16-year chronosequence of rehabilitated sites. These are contrasted with similar results from an unmined native forest site with a deep solum.

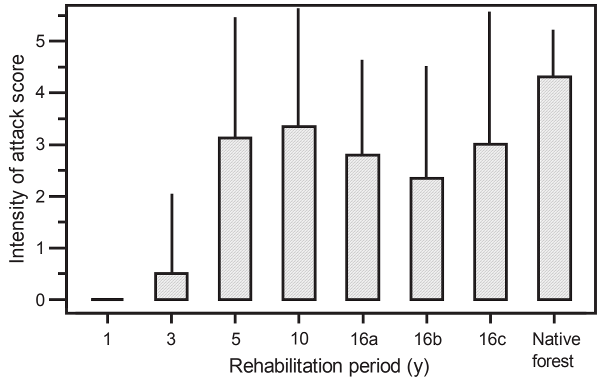

Figure 2 **Intensity of attack scores (means and standard deviations) (n = 10) for paper baits exposed for 154 days during the 1991–92 wet season in seven rehabilitated and one native forest site**

There was no attack on baits in sites rehabilitated for one year. Intensity of attack was minimal in sites rehabilitated for three years but increased in sites rehabilitated for five or more years to values only slightly lower than that of the native forest site. Site 16c had been burned in the year previous to the studies but mean intensity of attack was slightly greater than those of unburned sites of similar rehabilitation period.

Figure 3 presents the intensities of termite attack on paper baits exposed at the soil surface for 66 days from 25 September 2001 (late dry season) at 17 sites within the 26-year chronosequence of rehabilitated sites studied in that year. Intensities of attack were lower than in the 1991–92 studies because of the shorter bait exposure period and possibly the season of exposure. No attacks were recorded at the two-year-rehabilitated sites and notable termite attack only occurred in sites rehabilitated for three or more years. The mean intensity of attack changed little at sites rehabilitated for periods longer than in the 16-year chronosequence of sites sampled in 1991–92.

One of the sites rehabilitated for 26 years had been burned in 2001. While there were significant differences among the plots of this rehabilitation period ($F_{[2,\ 27]} = 8.14$, $P = 0.002$, ln transformation), posterior tests indicated that there was no significant difference in intensity of attack between the burned and the lower of the two unburned plots ($P > 0.05$).

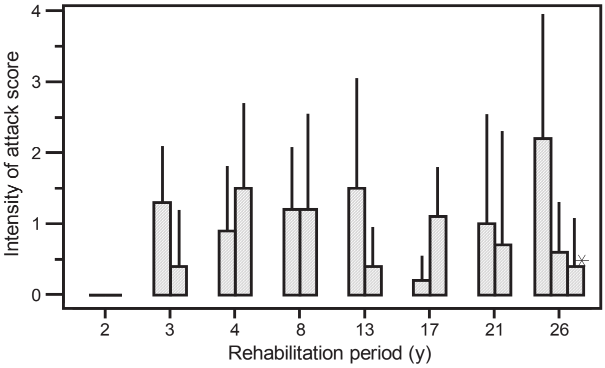

Figure 3 **Intensity of attack scores (means and standard deviations) (n = 10) for paper baits exposed in 17 rehabilitated sites for 66 days during the late dry season in 2001 (* burned plot)**

3.3.2 Unmined native forests and disturbed sites

Figure 4 presents data from baits exposed for 125 days from 3 April 1992 at three undisturbed native forest sites (sites M, O and Q) paired with sites of similar soil profile depths (J, P and R) that had been cleared and burned 12 months previously but had not been otherwise disturbed.

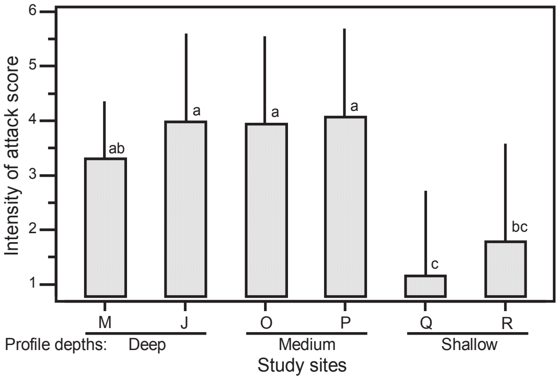

Figure 4 Intensity of attack scores (means and standard deviations) (n = 10) for paper baits exposed for 125 days in three paired native forest and disturbed sites, dry season 1992

The data from all sites reflected substantial termite activity and considerable variation between the soils. A nested analysis of variance of intensity of attack scores in relation to profile depth and disturbance (nested within profile depth) indicated that significant differences in intensity of termite attack occurred among sites of different profile depths ($F_{[2, 54]} = 14.73$, $P < 0.001$, no transformation) but that disturbance regime nested within profile depth was not significant ($F_{[3, 54]} = 0.76$, $P = 0.52$, no transformation). Posterior tests (Figure 4, Tukey's test, 5% level) indicated that significant differences existed among the sites of the three profile depths. The sites with shallow soil profiles had significantly lower intensity of attack scores than those with medium and deep profiles; sites with medium and deep profiles did not differ significantly.

Baits were again exposed for 66 days from 25 September 2001 in four native forest sites of different soil depths and burning histories (Figure 5). While three sites had not been recently burned, one site with a medium profile depth had been burned in 2001.

The intensities of attacks on baits followed the order of profile depth and that of the burned site was lower again. A one-way analysis of variance showed that the intensity-of-attack scores (Figure 5) differed significantly between the sites of different profile depths and the burned site ($F_{[3,36]} = 5.65$, $P = 0.003$). Posterior tests indicated that the site with the deepest profile had a significantly ($P < 0.05$) higher score than that with the shallow profile depth although the site with the medium profile depth was not significantly different ($P > 0.05$) from those with either shallow or deep profiles (Figure 5). Intensity of attack on baits at the burned site was not significantly different from that at the site with the medium profile depth.

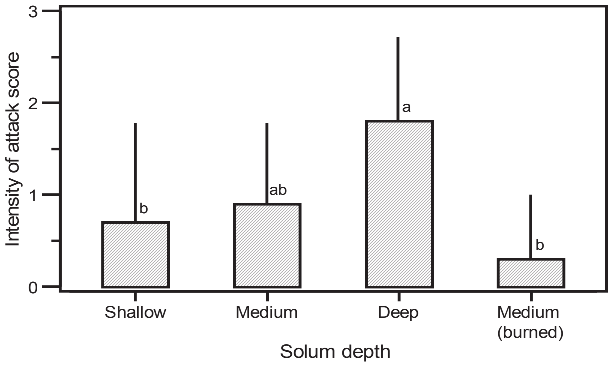

Figure 5 Intensity of attack scores (means and standard deviations) (n = 10) on paper baits exposed for 66 days late in the 2001 dry season in four native forest sites differing in profile depth

3.4 Termite presence at different profile depths

The depth distributions of termites and their constructs (nests, galleries) were determined by hand-sorting termites from soil materials dug from pits at random locations in an age series of sites studied in 1992 (Table 2). As indicated, termites and their galleries were observed in the pits at sites rehabilitated for five or more years and at sites rehabilitated for 16 years, termites occurred in the depth range 40–50 cm. In the mature native forest soil with the deep profile, termites were recorded to a maximum depth of 30–40 cm.

Table 2 Maximum depths (cm) of termite occurrence in soils rehabilitated after bauxite mining and in an unmined forest soil with a deep profile, as sampled in April 1992

Rehabilitation Period (years)	Number of Pits	Maximum Depth of Termite Observations	Number of Pits with Termites at the Maximum Depth Observed
1	5	Not observed	0
3	5	Not observed	0
5	5	10–20	4
10	1	0–5	1
16	5	40–50	1
Native forest site	8	30–40	1

3.5 Termite feeding resources and constructs

Figure 6 presents the resources available to termites in the rehabilitated environments of the RTA Gove mine in relation to rehabilitation period and the approximate ecosystem developmental stages recognised by Spain et al. (2006); see text associated with Figure 1 for interpretation of stages. The appearance and disappearance of resources and constructs is subject to temporal variation and differ between sites; transitional periods occur between adjacent stages. Such uncertainties and transitions are indicated by dotted lines. Underground resources (notably the large woody roots of the eucalypts) remain largely unquantified but are likely to increase substantially during ecosystem development and to eventually comprise important termite feeding resources. With time, resources for the humus-feeding termites are also expected to develop.

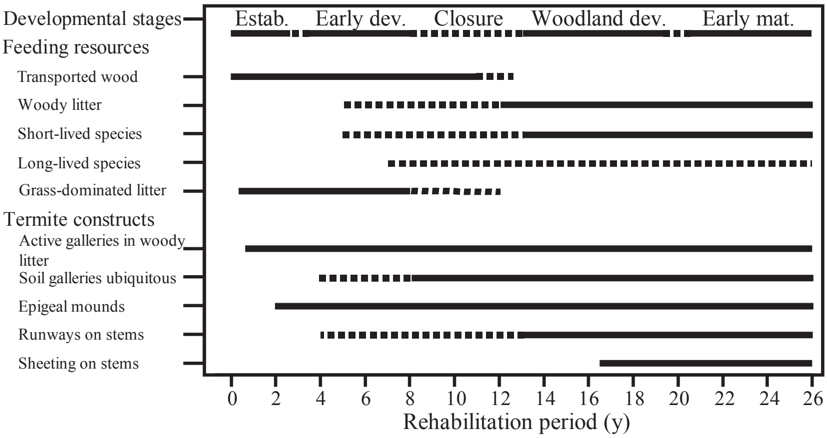

Figure 6 Approximate developmental stages, termite feeding resources and constructs observed in an age sequence of sites at the RTA Gove mine (see text for indication of lines)

Wood transported on to a site with the overburden partly decomposes in the period between vegetation clearing and application to a newly-rehabilitated site. Fungal attack makes such wood attractive to termites, which may be transported in galleries within woody materials or within clods forming part of the soil matrix. By 13 years, only the largest logs remain. Woody litter starts with the fall of dead twigs, small branches, bark, woody capsules and other reproductive structures. Locally-grown woody material starts to become available at much the same time from the short-lived acacias, grevilleas and other species while wood from the longer-lived eucalypts only becomes available in small quantities during the time period under consideration. The importance of grassy litter relative to that of broad leaved species starts to decline in importance from four years after site establishment; this process is largely completed by c. 15 years at which time woodland conditions prevail and the litter layer is increasing rapidly in mass.

Termite activity was apparent within eight months of site establishment in galleries within partially-decomposed wood transported onto the site with the topsoil during profile reconstruction. Before canopy closure, increasing woody litter fall and the death of the short-lived species starts to provide more feeding resources for wood-feeding termites. Galleries start to be found in the surface soil under stones and wood fragments within the first year after site establishment. They become locally common in surface soils not directly associated with these features four years after establishment and are virtually ubiquitous at sites rehabilitated for eight years and longer.

Termite mounds first became apparent two years after establishment with the appearance of the litter-feeding species *A. vitiosus*. Mounds of *Microcerotermes spp*. were present at sites rehabilitated for four years or more and those of the 'snapping mandibles' group (*E. melachoma* and *X. melvillensis*) from five years.

The populations of termite mounds were assessed at two locations selected for their apparently high densities and were limited to those of the litter-feeding termite *A. vitiosus*. Mound populations in the two study areas were estimated at 197 and 160 mounds ha^{-1} with, respectively, basal areas of 12 and 7 m^2 ha^{-1}. Such values are substantially lower than those frequently found in savanna landscapes in the Australian tropics, which, maximally, may exceed 1,000 mounds ha^{-1} (Spain et al., 1983).

Termites frequently construct earthen runways over materials that they wish to exploit as food resources. These were observed on grasses and on a few shrubs four years post establishment but those associated with trees only became common at sites established for 21 years or more. In the natural environment, *Schedorhinotermes spp*. occasionally build broad earthen covers (sheeting) over wide areas of the bark of a number of tree species beneath which they forage. Minor sheeting was apparent at sites rehabilitated for 16 years but increased substantially at longer-rehabilitated sites.

Damage to living plant species by termites in the rehabilitated environments at the RTA Gove mine is generally minor. *Mastotermes darwiniensis* occurs sporadically throughout the rehabilitated areas and occasionally kills or causes damage to living plants, including the long-lived eucalypts. In contrast, colonisation of an experimental planting on a rehabilitated 'red mud' landform on which substantial wood mulch had been placed lead to severe damage to the planted trees and to the crowns, associated roots and foliage of vetiver grass (*Chrysopogon zizanoi*des) planted for erosion control purposes.

4 Conclusions

The earliest colonisation by termites may occur within wood and soil materials during profile reconstruction. Most early colonisers feed on decomposing wood. These include species of the genera *Microcerotermes*, *Schedorhinotermes* and probably *Heterotermes*. Species of *Heterotermes* have been found in environments at the RTA Gove mine at sites rehabilitated for seven and more years. From their presence in other tropical Australian rehabilitated mine environments and in native forests (Dawes-Gromadzki and Spain, 2003), it is considered likely that they will also be found at sites rehabilitated for shorter periods. Other species in this category include the decomposing-wood-feeding species of the 'snapping mandibles' or *Termes* group (Miller, 1991) (*E. melachoma* and *X. melvillensis*) reported from sites rehabilitated for two years.

The litter-feeding species *A. vitiosus* is also an early coloniser although, in contrast to the other species, it dies out by the time of canopy closure due to the development of a woodland environment. The polyphagous species *M. darwiniensis* and *N. longipennis* may also be other early colonisers.

In contrast, *N. graveolus* is a later coloniser, dependent on the presence of larger trees for its arboreal nesting sites. However, it always maintains connections to the ground where it forages for decomposing woody materials (Gay and Calaby, 1970).

The species that were not found in the rehabilitated environments but which are widely present in unmined local native forests were *C. acinaciformis* and the soil (humus)-feeding species of the 'snapping mandibles' group. The principal food of *C. acinaciformis* is the wood of eucalypts (Lee and Wood, 1971) and since this does not become available in any quantity within the twenty-six-year rehabilitation periods of the present study sites, it may be some years before this species is able to colonise these rehabilitated environments. It is expected that termite diversity will only rise to that expected in local native forest environments (Braithwaite et al., 1988) after extended periods.

Although only effective for wood-feeding species, baiting is a useful method of determining the presence of many cryptic termite species and the intensities of their feeding activities. Attacks were not recorded until sites had been rehabilitated for three years. Thereafter, the intensity of termite activity increased rapidly with rehabilitation period values near to those of the local native forest environments; no subsequent trends were apparent over the 26-year age series of sites. Some variation occurred among native forest types with lower intensities of attack on baits exposed in soils with shallow profiles.

One year following the gross disturbance associated with vegetation clearing, the effects of this disturbance on termite activities seemed to be minor. Similarly, termite activity after fire was not significantly reduced, in contrast to the findings of Dawes-Gromadzki (2007) from unmined savanna environments elsewhere in the Northern Territory. However, variability between sites of similar age is very large and makes such comparisons difficult. Further, there is likely to be seasonal variation in activity indicating the need to standardise on a particular time of year for this type of study (Abensperg-Traun, 1991; Dawes-Gromadzki and Spain, 2003; Freymann et al., 2010).

The on-going formation of termite constructs in soils and plant materials evidences the substantial scale of their activities in the rehabilitated environments at the RTA Gove mine and can therefore act as an indicator of soil formation and decomposition processes (Schuurman, 2005). By eight years after site establishment, termite galleries are almost ubiquitous in the near-surface soils and, over the 26-year age range of sites studied, termite activity has lead to substantial and ongoing modification of the entire soil profile through processes of gallery, aggregate, subterranean nest and near-surface mound formation. In the long term, termite-mediated transport of soil to the surface during the formation of mounds, earthen runways over food materials and other constructs will lead to further profile re-organisation. Incorporation of the breakdown products of woody materials and the litters of grasses and other plant species into the soil is an integral part of soil development and leads to an increase in the fertility of these highly-weathered materials.

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