

Termites and Forest Management in Australia¹

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Abstract: Termites have long been regarded as major pests of Australian forests. Drawing together research on termite ecology and mammal conservation, this paper argues that this perception is wrong; termites are a vital component of native forests.

Australian forests are dominated by eucalypts. More so than on any comparable landmass, Australian forests are characterized by members of this one genus comprising more than 450 species³. Eucalypts first appeared 35 million years ago, and are believed to have evolved on the margins of the then extensive rainforests. With climatic change and the retreat of rainforests in the late Tertiary, distinct seasons arose and the great radiation of the eucalypts began as adaptation to varying water supply became favored (White 1986).

The second major genus of Australian forest trees is Acacia, the wattles. Although Australia has more than 600 species of Acacia, they rarely dominate forests, and usually form an understory below a eucalypt canopy. Wattles are relatively resistant to termites, and standing wattles are mostly degraded by beetles. The third major genus, Callitris, is the only mainland

gymnosperm to form extensive forest and occurs widely in semi-arid regions of eastern Australia. Callitris is particularly resistant to degradation by termites⁴.

Australia has very little forest. In a land mass of 760 million hectares, only 42.5 million hectares, less than six percent, are forested. These forests occur in a coastal belt, limited by rainfall (Senate 1977), and have been significantly fragmented since the arrival of Europeans. Inland Australia is arid, with vast areas of extremely sparse woodland where herbivory is generally unimportant and much of plant production goes directly to the detritivores. Termites are thus very important and these inland regions may be thought of as lightly wooded deserts with a fauna dominated by termites, ants and lizards. Recent studies (Tongway and others 1989) point to termites as promoters of small-scale fertile patches which are refuges for many desert plant species.

LOSS OF TIMBER TO TERMITES--HISTORIC PERSPECTIVES

The earliest records of termite damage to timber in Australia date from the late nineteenth century and report the impact of indigenous termites on introduced horticultural tree crops and vines (French 1893). At this time most of the timber produced by forest clearing was simply burnt, and it was not until the native forests were commercially harvested on a large scale that the activities of termites received attention.

Thirty years ago--even five years ago-- I would have reported that termites are major pests in Australian forests, that they consume large quantities of merchantable timber and that the intensity of their attack is often much greater than in other bioregions (Carne

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³Although Eucalyptus is still a single genus, revision of the genus was first suggested by Carr and Carr (1959). Pryor and Johnson (1971) recognized four subgenera which in a later (1981) paper they regarded as being equivalent to genera, but did not promote at that time. It is probably only a matter of time before the group is revised into at least four genera (Florence 1981).

⁴For tabulations of the durability of Australian timbers, see Johnson and others (1986).

and Taylor 1978, Greaves and others 1967, Greaves 1962b, Harris 1966, Perry and others 1985, Ratcliffe and others 1952).

The first researchers calculated the "cost" of termites in terms of the volume of timber lost" by surveying the extent of degraded timber that contained evidence of termite activity. Studies showed that in both highland and lowland forests, termites "reduced" timber yield by 25 percent or more (Greaves and others 1965, 1967). This indicated loss in potential profitability lead to novel control proposals, including the treating of individual trees with arsenic trioxide or organochlorines applied by injection, the removal of all mature trees that might potentially harbour termites and the replacement of susceptible native forest with plantations of Pinus spp. (Greaves 1959, Greaves and others 1967). However, with the exception of conversion to pines, none of these termite control measures have ever been economically feasible.

In the main, only five termite species are responsible for almost all of the attack in commercial Australian forests. The primitive Giant Northern Termite (Mastotermes darwiniensis Froggatt) (Mastotermitidae) is a major impediment to tropical forestry, the dampwood termite (Porotermes adamsoni [Froggatt]) (Porotermitidae) occurs in cool or mountainous forests along the eastern seaboard, but by far the most important are of the genus Coptotermes Wasmann (Rhinotermitidae): C. acinaciformis Froggatt (C.a. raffrayi in Western Australia), C. frenchi Hill and C. lacteus (Froggatt).

Species of Coptotermes are very adaptable; they may nest in the ground, in mounds of their own construction, or in trees. Their distribution in Australia is almost as wide as the eucalypts they eat: desert, woodland, cool temperate forest and rainforest (Calaby and Gay 1959).

ATTACK ON TREES

Termites prefer to consume decayed wood (Wood 1978, French and others 1981, 1987) and there is evidence that they are healthier if they do (Hendee 1935, Lenz and others 1980). Attack on trees is more likely to occur when the tree is wounded (Greaves and others 1965). Colony formation by founding-pairs is through scar tissue, typically reported to be fire scars at the base of trees

(Greaves and others 1965, Perry and others 1985), but entry through less easily observed routes such as branch stubs, damaged roots and the exit holes of beetles and moths is also probable. Attack is also initiated when termites extend galleries in the soil and enter other trees, typically from galleries running on the underside of roots and entering the heartwood at the root crown, a habit common in Coptotermes. This method of attack may occur over distances of 50 meters with a single colony feeding on more than 15 trees (Greaves 1962a) and is eased by the high incidence of natural root grafting among eucalypts (Ashton 1975).

Coptotermes build a central nest, at the base of the tree, with the nursery being below ground level in cool climates and elevated in warmer areas. The termites consume the heartwood, as its natural anti-feedant chemicals degrade through decay organisms and natural ageing. Porotermes consume the timber in a similar manner, but do not maintain a central nest, rather, they work through the tree as a travelling population. Thus the main "pest" species are consuming dead and decayed heartwood and decayed areas of timber which are of negligible commercial value. Rather than being primary agents of timber degradation, their presence is secondary: an effect rather than a cause. Timber is not a limiting resource for the termites, but appropriately degraded timber is; termites select their food for the presence of appropriate decay.

Shigo's model of compartmentalization of decay in trees (CODIT) (Shigo 1984) is widely ignored by Australians (see, for example, Perry and others 1985), but the patterns of termite activity in eucalypt timber closely follow Shigo's predicted areas of response. His model is particularly useful in understanding the co-evolutionary balance between termites and trees: although termites feed within the tree, the tree is able to limit their activity and protect its structural integrity, by compartmentalizing scar tissue. It does a tree no harm to be hollowed and may even provide some structural advantage (Dickinson and Tanner 1978, Janzen 1976). The longevity of termite infested eucalypts show that this balance between growth and consumption may be held for more than two centuries, with the process of hollowing extending into all the main branches.

Early growth of eucalypts concentrates on the attainment of height.

Crown growth dominates mid-life, with maturity occurring when the crown reaches the limits of dimensional stability. The term "overmature" is used to describe trees where the growth of the crown is balanced by more or less continual branch shedding. Most young trees do not suffer termite infestation until about 70 cm dbh⁵ although the risk is greater where injuries have occurred (Carne and Taylor 1978, Elliott and Bashford 1984, Mackowski 1984).

Fire is considered to be the major cause of such injury (Elliott and Bashford 1984, Perry and others 1985), particularly when prescribed burning is involved. Even where eucalypts are planted as exotics, termite attack is secondary to some other stress-causing factor (Chatterjee and Singh 1967). Any significant breach of the tree's defences will result in the formation of attractive scar tissue. Thus today, a tree's chances of early termite infestation are increased by roading and logging machinery, which cause mechanical damage to the cambium at the base of trees and also, by logging and silvicultural thinning due to collisions with falling trees.

However, my observations in the Boola Boola State Forest in eastern Victoria (Ewart 1988) suggest that regrowth is being rotated while it is too small to support large colonies of the major pest species. These termites require large timber for nesting, and attack on small regrowth trees is most commonly initiated from colonies located in remnant old-growth trees or stumps. Thus while management may make more palatable timber available to termites, the populations of termites will diminish drastically, unless sufficient colony-sites remain.

SPECIES DEPENDENT ON TERMITE-CREATED HOLLOWES

The excavations of termites alter the structure of trees and provide spaces which have become a necessary part of the habitat of many vertebrate species. These beneficial activities are increasingly recognized by wildlife researchers (Ambrose 1982, Mackowski 1984, Saunders 1979) but remain largely ignored by termite biologists (e.g. McMahan 1986). Termites do not create these hollows directly; their excavations, apart from the minimum space

needed for access, are quickly filled with mud and feces ("mudgut"). Mudgut pipes may extend the full height of the tree and into each of the major limbs. Eventually the mudgut column compacts under its own weight or erodes as water enters through openings created by shed branches. This creates cavities which other animals readily utilize.

A wide range of bats, birds and arboreal marsupials are entirely dependent on hollows of particular volume, depth and opening diameter for nest sites. Australian vertebrates, unlike some of their northern hemisphere counterparts, do not excavate their own tree hollows but are limited in their efforts to minor maintenance, relying instead on the actions of termites.

Fallen, hollowed limbs and trunks of overmature trees provide habitat for ground-dwelling reptiles and mammals. A particular example of this is the specialist termite eater, the Numbat (*Myrmecobius fasciatus* Waterhouse) (Marsupialia: Myrmecobiidae). Numbats feed exclusively at secondary aggregations of termites on the forest floor and require numerous hollow logs for shelter. They were once widespread across southern Australia, but their range has now been reduced to a small area of southwestern Australia due to the loss of habitat (Christensen and others 1984, Friend 1982). Wildfire and logging reduce the supply of suitably hollowed fallen wood and without shelter, numbats quickly fall prey to the introduced European foxes.

FUTURE MANAGEMENT CONSIDERATIONS

Typically, a eucalypt does not develop hollows until between 90 to 120 years old, well after the age at which termites begin to feed, but also well beyond the present 40 to 80 year age at rotation. Management prescriptions call for the retention of a few overmature "habitat" trees in each logging coupe. However, although eucalypts may persist for two to three centuries after developing hollows, they will in time die and eventually fall. Thus the prescriptions are inadequate because they make no provision for recruitment to replace these habitat trees as they are lost.

The impending threat to wildlife populations is potentially serious. Populations will decline rapidly as nest sites become limiting. Even if corrective action is taken immediately, many forests will soon face a gap of a

⁵Diameter Breast Height Over Bark.

century or more before another generation of suitably hollowed trees can develop (Mackowski 1984).

This problem is compounded by the negative effects of logging on the retained habitat trees: few will be able to live to their full potential as the coupes in which they stand will be logged between three and seven times during this period. The cost of providing artificial hollows during this period will be enormous. Thus in areas where multiple use management includes the maintenance of wildlife, there is a need to retain not just habitat trees but also cohorts of replacement trees and populations of termites to transform them. Managers of native eucalypt forest need to change their perception of termites: termites are not pests, but have a vital role in forest ecology and must be seen as an intrinsic part of the system.

REFERENCES

- Ambrose, G.J. 1982. An ecological and behavioural study of vertebrates using hollows in eucalypt branches. PhD thesis, Department of Zoology, La Trobe University, Victoria, Australia.
- Ashton, David H. 1975. Studies of litter in Eucalyptus regnans forests. Australian Journal of Botany 23: 413-433.
- Calaby, J.H.; Gay, F.J. 1959. Aspects of the distribution and ecology of Australian termites. In: Bodemheimer, F.S.; Weisbach, W.W., eds. Biogeography and ecology in Australia. The Hague: Junk; 211-233.
- Carne, P.B.; Taylor, K.L. 1978. Insect pests. In: Hillis, W.E.; Brown, A.G., eds. Eucalypts for wood production. Melbourne, Australia: CSIRO; 155-168.
- Carr, D.J.; Carr, S.G.M. 1959. Floral morphology and taxonomy of Eucalyptus. Nature 184: 1549-1552.
- Chatterjee, P.N.; Singh, P. 1967. Preliminary observations on die-back and termite attack in eucalypts 1-3 years old in New Forest plantation. Proceedings of the All India symposium on fast growing tree species, Dehra Dun: 1-2.
- Christensen, P.; Maisey, K.; Perry, D.H. 1984. Radiotracking the Numbat, Myrmecobius fasciatus, in the Perup forest of Western Australia. Australian Wildlife Research 11: 275-288.
- Dickinson, T.A.; Tanner, E.V.J. 1978. Exploitation of hollow trunks by tropical trees. Biotropica 10(3): 231-233.
- Elliott, H.J.; Bashford, R. 1984. Incidence and effects of the dampwood termite Porotermes adamsoni, in two Tasmanian east coast eucalypt forests. Australian Forestry 47(1): 11-15.
- Ewart, Don McG. 1988. Aspects of the ecology of the termite Coptotermes lacteus (Froggatt). PhD thesis, Department of Zoology, La Trobe University, Victoria, Australia.
- Florence, R.G. 1981. The biology of a eucalypt forest. In: Pate, J.S.; McComb, A.J., eds. The biology of Australian Plants. Nedlands: University of Western Australia Press; 147-180.
- French, C. 1893. A handbook of the destructive insects of Victoria, with notes on the methods to be adopted to check and extirpate them. Part II. Melbourne: Government Printer; 222p.
- French, John R.J.; Donaldson, R.; Ewart, Don McG. 1987. Electronic monitoring of temperatures in air, a termite mound, trees and soil. Australian Forestry 17: 79-82.
- French, J.R.J.; Robinson, P.J.; Bartlett, N.R. 1981. A rapid and selective field assessment of termite feeding preference of the subterranean termite Heterotermes ferox (Frogg.) using toilet roll and small wood-block baits. Sociobiology 6(2): 135-151.
- Friend, T. 1982. The Numbat - an endangered specialist. Australian Natural History 20(10): 339-342.
- Greaves, T. 1959. Termites as forest pests. Australian Forestry 23: 114-120.

- Greaves, T. 1962a. Studies of foraging galleries and the invasion of living trees by Coptotermes acinaciformis and C. brunneus (Isoptera). Australian Journal of Zoology 10: 630-651.
- Greaves, T. 1962b. Termites in Australian forests. Proceedings of the 11th International Congress of Entomology 1960; Vienna; 238-240.
- Greaves, T.; Armstrong, G.J.; McInnes, R.S.; Dowse, J.E. 1967. Timber losses caused by termites, decay and fire in two coastal forests in New South Wales. Technical Paper, Division of Entomology, CSIRO Australia 7: 2-18.
- Greaves, T.; McInnes, R.S.; Dowse, J.E. 1965. Timber losses caused by termites, decay and fire in an alpine forest in New South Wales. Australian Forestry 29(3): 161-174.
- Harris, W.V. 1966. On the genus Coptotermes in Africa (Isoptera: Rhinotermitidae). Proceedings of the Royal Entomological Society, London. Ser. B. 35: 161-171.
- Hendee, E.C. 1935. The role of fungi in the diet of the common damp-wood termite Zootermopsis angusticollis. Hilgardia 9(10): 499-525.
- Janzen, D.H. 1976. Why tropical trees have rotten cores. Biotropica 8(2): 110.
- Johnson, G.C.; Thornton, J.D.; Saunders, I.W. 1986. An in-ground natural durability field test of Australian timbers and Australian Reference species. Material and Organismen 21(4): 251-264.
- Lenz, M.I.; Ruyooka, D.B.A.; Howick, C.D. 1980. The effect of brown and white rot fungi on wood consumption and survival of Coptotermes lacteus (Froggatt) (Isoptera: Rhinotermitidae) in a laboratory bioassay. Zeitschrift für Angewandte Entomologie 89: 344-362.
- Mackowski, C.M. 1984. The ontogeny of hollows in Blackbutt (Eucalyptus pilularis) and its relevance to the management of forests for possums, gliders and timber. In: Smith, Andrew P.; Hume, Ian D., eds. Possums and gliders. Sydney: Australian Mammal Society; 553-567.
- McMahan, E.A. 1986. Beneficial aspects of termites. In: Vinson, S. Bradleigh, ed. Economic impact and control of social insects. New York: Praeger; 144-164.
- Perry, D.H.; Lenz, M.I.; Watson, J.A.L. 1985. Relationships between fire, fungal rots and termite damage in Australian forest trees. Australian Forestry 48(1): 46-53.
- Pryor, L.D.; Johnson, L.A.S. 1971. A Classification of the eucalypts. Canberra: Australian National University Press.
- Pryor, L.D.; Johnson, L.A.S. 1981. Eucalyptus, the universal Australian, In: Keast, A., ed. Biogeography and ecology in Australia. The Hague: Junk.
- Ratcliffe, F.N.; Gay, F.J.; Greaves, T. 1952. Australian termites. Melbourne: CSIRO Australia; 124 p.
- Saunders, D.A. 1979. The availability of tree hollows for use as nest sites by White-tailed Black Cockatoos (Calyptrorhynchus baudinii latirostris). Australian Journal of Wildlife Research 6: 205-216.
- Senate. 1977. Woodchips and the environment: Report from the Senate Standing Committee on Science and the Environment. Canberra: Australian Government Publishing Service; 454 p.
- Shigo, A.L. 1984. Compartmentalization: a conceptual framework for understanding how trees grow and defend themselves. Annual Review of Phytopathology 22: 189-214.
- Tongway, D.J.; Ludwig, J.A.; Whitford, Walter G. 1989. Mulga log mounds: fertile patches in the semi-arid woodlands of central Australia. Australian Journal of Ecology 14(3):263-268.
- White, Mary E. 1986. The Greening of Gondwana. Frenchs Forest, New South Wales: Reed; 256.
- Wood, Tom G. 1978. Food and feeding habits of termites. In: Brian, M.V. ed., Production ecology of ants and termites. Cambridge: Cambridge University Press; 55-80.