Journal of Arid Environments (1992) 22: 87–91

The importance of subterranean termites in semi-arid ecosystems in south-eastern Australia

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(Received 6 December 1990, accepted 30 January 1991)

In mulga, *Acacia aneura,* woodland in north-western New South Wales, Australia, subterranean termites constructed foraging galleries over organic debris, litter fragments, litter trains, dead wood, dead grass in perennial grass clumps and kangaroo and sheep dung. The larger quantities of litter, litter trains and dead wood in the mulga groves resulted in higher cover of termite gallery sheeting in this habitat, 6·56 ± 1·02%, than in the intergrove erosion slopes, 2·28 ± 0·32%. In the upper 20 cm of soil there were 51·1 storage galleries m^{-2}. In mallee-spinifex habitats in south-western New South Wales, there was no evidence of subterranean termite feeding on dung or the dead stems of spinifex grass, *Triodia iritans*, but dead stems of mallee, *Eucalyptus* spp. were galleried and etched by termites. The numbers of sub-surface termite storage galleries in this habitat averaged 137·5 m^{-2}. These galleries ranged between 4·5 and 49·0 cm^3. These data suggest that subterranean termites in these Australian ecosystems may be more important as detritivores and in their effects on hydrological properties of soil than has been documented for subterranean termites in the Chihuahuan Desert of North America.

Introduction

Termites may be the most important consumers in sub-tropical or tropical dryland ecosystems and, in addition, may affect the hydrological and nutrient cycling processes in these systems (Lobry de Bruyn & Conacher, 1990). In the northern Chihuahuan Desert of North America, termites have been found to consume up to 60% of the dead herbaceous material, up to 80% of the dead root biomass, more than 90% of the large and intermediate size herbivore dung and most of the dead wood (Johnson & Whitford, 1975; Whitford *et al.*, 1982; Whitford *et al.*, 1988). In this desert, termites also affect soils, increasing infiltration and water storage and reducing runoff (Elkins *et al.*, 1986). There are numerous studies of mound-building termites in the moist tropics of Australia (Holt *et al.*, 1980; Holt & Coventry, 1982; Spain *et al.*, 1983*a*,*b*; Holt, 1987; Spain & McIvor, 1988), but few studies of subterranean termites in temperate arid and semi-arid ecosystems. In much of the arid zone of Australia, termites are abundant, diverse, but not conspicuous elements of ecosystems (Noble *et al.*, 1989; unpubl. obs.). In the large regions of Australia dominated by mallee (multi-stemmed *Eucalyptus* spp.) and mulga (*Acacia aneura*), most of the termites are subterranean and produce no visible nest structures. The exception to this are the nest caps of *Drepanotermes perniger* (Noble, 1989).

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Here we report on the activities of subterranean termites in mallee and mulga habitats in New South Wales to provide comparisons with the North American Chihuahuan Desert and to call attention to the probable importance of subterranean termites in the Australian arid zone.

Characteristics of study areas

Studies on the mallee sites were conducted at the Birdwood Station, 30 km east of Pooncarie (33°24'S, 142°36'E), New South Wales. The vegetation is dominated by several species of mallee (*Eucalyptus* spp., in which numerous stems emanate from a subterranean lignotuber) with an understory of porcupine grass or spinifex (*Triodia iritans*) (Noble, 1989). The rainfall in this region is 250 mm year^{-1}, and is evenly distributed throughout the year, with an average potential evapotranspiration, as estimated by class A pan evaporation, of 730 mm year^{-1}. The dunefield topography is characterised by old dunes separated by sand plains and interspersed sandy-loam run-on zones. These swales generally have lower mallee density with a dense cover of speargrass, *Stipa nitida*, following above-average rainfall.

Studies in the mulga region were conducted at the Lake Mere station 35 km north of Louth (30°16'S, 144°53'E), New South Wales. The topography is low undulating ridges that drain by sheet flow into weakly defined dendritic drainage lines. Slopes are generally less than 0·5%. The soils are classified as massive red earths with a texture of fine sandy clay loam. The vegetation is patterned with groves of mulga (*Acacia aneura*) separated by erosion zones with scattered clumps of grasses, woolly butt (*Eragrostis eriopoda*) and bandicoot grass (*Monachather paradoxa*) (Tongway & Ludwig, 1990). Average rainfall is 308 mm.

Methods

At the mallee sites, we excavated the root zone of *Triodia* clumps for termite galleries and live termites. We examined the dead wood lying on the surface for evidence of termite galleries. Surface caps (pavements) of nests of *Drepanotermes perniger* were evident on the speargrass run-on zones. We estimated the densities of these caps by the wandering quarter method (Cantana, 1963). In addition, we carefully excavated quadrats 8 cm wide × 16 cm deep × 20 cm long. We recorded the size and volume of termite storage galleries in these excavations.

Studies of the mulga site were conducted 3 weeks after 72 mm rainfall. We laid out 100-m lines at random in a series of paddocks that are stocked at different levels and, hence are subject to different rates of forage removal. Sampling in each paddock was stratified with one 100-m line across an erosion slope and one 100-m line through a mulga grove. Ten 1·0-m^2 quadrats were measured at 10-m intervals along each line. We recorded the per cent cover by subterranean termite foraging gallery sheeting and the materials being consumed in each quadrat. We also sampled dead wood, grass roots and excavated soil quadrats as in the mallee area. We made more than 40 excavations of pits that were approximately 15 cm × 30 cm × 20 cm deep in open areas, under shrubs. In addition, we excavated intact grass clumps.

Results and discussion

On most plots with some organic matter, termite activity was evident by foraging gallery sheeting or massive gallery carton tunnels. Of the 160 plots, only eight were devoid of organic matter and of the remaining plots, 18 exhibited no evidence of termite activity.

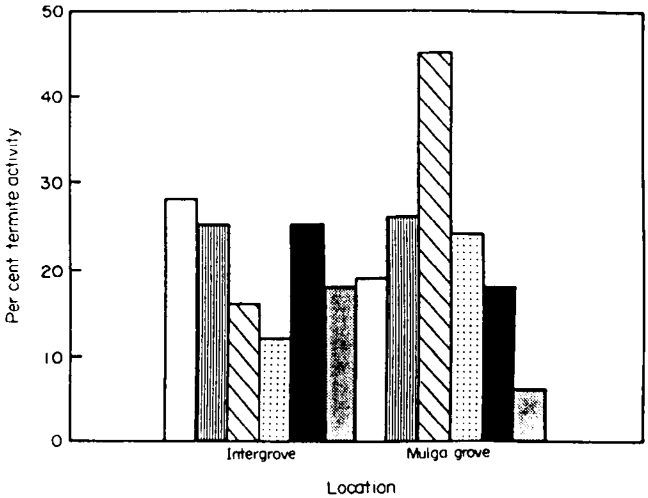

Figure 1. Per cent of quadrats with subterranean termite foraging galleries in or on the classes of food materials in intergrove areas and mulga groves at Lake Mere, New South Wales, Australia. Sheeting was recorded when small fragments of grass, wood and other plant debris was covered by sheets of gallery carton. □, Sheeting; ▥, litter; ▧, litter train; ⊡, wood fragments; ■, dead grass crowns; □, dung.

Termites also constructed gallery sheeting on the trunks of live mulga at the edges of the groves. The frequency of sheeting on mulga trunks ranged from 0·02 to 0·05. The high frequency of sheeting on live mulga occurred on trees at one end of a linear grove.

There were differences in the frequency of various kinds of subterranean termite activity in the locations sampled (Fig. 1), especially the litter trains as well as in the per cent ground cover by gallery sheeting (Table 1). Litter trains are lines of litter varying in length from approximately 0·5 m to as much as 25–30 m in length; between 15 and 45 cm wide and 5 cm to 15 cm deep. The litter trains result from overland flow of water that transports leaves, stems, dung, sticks, etc. Deposition of litter trains occurred where water flow was impeded.

There were significant differences in the per cent ground cover of various types of termite activity between groves and erosion slopes (Table 1). Because the groves function as sites that retard overland water movement, litter dams or trains are deposited at the base of grass clumps and other obstructions. Groves are the only locations where leaf litter

Table 1. *Per cent cover (±s.e.) of termite gallery covered materials in the mulga groves and on intergrove erosion slopes*

Types of termite activity	Intergrove	Grove	p
Sheeting	0·69 ± 0.18	0·66 ± 0·22	>0.9
Litter	0·38 ± 0·10	1·75 ± 0·66*	<0·04
Litter train	0·63 ± 0·22	3·00 ± 0·66*	<0·001
Wood	0·22 ± 0·13	0·74 ± 0·23*	<0·05
Crown	0·30 ± 0·08	0·33 ± 0·15	>0·8
Dung	0·06 ± 0·04	0·03 ± 0·01	>0·4
Total	2·28 ± 0·32	6·56 ± 1·02*	<0·001

p probability that values are not different.
* Significant difference.

accumulates. In most plots, organic matter accumulations were completely riddled with foraging galleries or covered with gallery sheeting. The exceptions were in dense groves in drainage lines where surface litter cover was greater than 30%. In the groves, areas that had 100% canopy cover by *Acacia aneura* frequently had no evidence of surface foraging activity by subterranean termites (12 plots of the 33 plots with 100% canopy cover of *A. aneura*).

In virtually every excavation, we noted storage galleries with grass and other plant fragments and in three of the excavations, we found termite workers in the storage galleries. The average number of galleries per excavation was 2·3 ± 0·6, range 0·5–6·0, or 51·1 galleries m^{-2} in the upper 20 cm of soil. There were only two excavations in which we did not record a termite gallery. Several of the excavated grass clumps had termites in the root mat. These termites appeared to be feeding on the dead roots within the root mat.

In the mallee habitats, the caps of *Drepanotermes perniger* were limited to the sandy-loam run-on areas. We estimated *D. perniger* cap densities at 83·8 ha^{-1}. Only a small percentage of these were convex new nest caps (12·5%) while 65% had concave surfaces that showed evidence of degradation. The remainder were intermediate in terms of erosion of the central pavement.

The dead stems of the mallee *Eucalyptus* spp. were galleried by termites and exhibited surface etching characteristic of termites feeding on the wood surface. Despite the prevalence of shallow soil storage galleries, there was no evidence of termites feeding on either kangaroo or sheep dung or on the dead stems in the clumps of porcupine grass. The absence of gallery sheeting on these potential food sources is most probably a function of the length of time since a soaking rain. Surface sheeting in the mulga habitats was only recorded after rains and was absent during dry periods.

The pits that were carefully excavated in the mallee area, produced numerous voids that were obvious with a black sheet of carton mixed with faeces lining the void. In two of the pits we found termites in the storage galleries. There were grass and grass root fragments plus fine organic material in most of the storage voids. The average volume of the voids in a 1000-cm^3 excavation was 24·4 cm^3 ± 11·8 cm^3 ($n = 10$). The range in volume of voids was 4·5–49·0 cm^3 1000 cm^{-3}. There was an average of 2·2 voids per pit (range 0–4 voids) or an average of 137·5 m^{-2}. In one of the pits there was a silk-lined spider tunnel in addition to the termite storage galleries.

The data collected in this study suggest that subterranean termites may be as important in the mulga and mallee habitats in Australia, as they are in the Chihuahuan Desert in North America. The presence of gallery sheeting on virtually all types of organic matter (wood fragments, shrub and tree leaf litter, dead grass crowns, and sheep and kangaroo dung) is evidence that one or more species of termite utilises that material. In North American studies, Whitford *et al.* (1982) utilised plots from which termites had been chemically excluded to obtain data on quantities of various types of organic matter removed by subterranean termites. In that system, termites accounted for nearly 90% of the cattle dung removal and more than 50% of much of the organic matter, including the removal of surface layers of dead wood. In the Australian ecosystems sampled in this study, the physical evidence of termite activity far exceeded that reported by Johnson & Whitford (1975). In addition, we have never found shallow storage galleries in the northern Chihuahuan Desert. The abundance of shallow storage galleries and surface sheeting in the Australian temperate arid, suggests that termites may be processing a larger fraction of the organic matter in these systems than has been measured in North America.

The abundance of surface *Drepanotermes perniger* nest pavements in the drainage areas in mallee habitat was comparable to that recorded in mulga communities (Noble *et al.*, 1989). Since these pavements of *D. perniger* are primarily clay, this species may be limited to soils with sufficient clay for the next construction or may simply not build water-repellent pavements in well drained sandy soil.

The evidence for high densities of subterranean termites and their galleries in the mallee and mulga habitats suggests that these animals may be important as producers of macropores in the soils. The activities of subterranean termites can affect soil bulk density and porosity, thus affecting infiltration and water storage (Elkins *et al.*, 1986). The data from this study suggest that subterranean termites may affect the hydrological properties of the soils in the Australian arid zone as well as processing a large fraction of the dead organic matter. We suggest that subterranean termites may be key elements in Australian arid ecosystems as they have been shown to be in comparable North American systems.

We thank David Lightfoot, David Tongway and W. Brett Whitford for field assistance and helpful discussions. W. G. Whitford was supported by funds from the New Mexico State University Foundation and collaborative research funds from CSIRO Division of Wildlife and Ecology.

References

Cantana, A. J. (1963). The wandering quarter method of estimating population density. *Ecology*, **44**: 349–360.

Elkins, N. Z., Sabol, G. V., Ward, J. J. & Whitford, W. G. (1986). The influence of subterranean termites on the hydrological characteristics of a Chihuahuan desert ecosystem. *Oecologia*, **68**: 521–528.

Holt, J. A. (1987). Carbon mineralization in semi-arid north eastern Australia: the role of termites. *Journal of Tropical Ecology*, **3**: 255–263.

Holt, J. A. & Coventry, A. J. (1982). The effects of mound-building termites on some chemical properties of soils in northeastern Australia. In Lee, K. E. (Ed.), *Proceedings 3rd Australasian Conference on Grassland Ecology*. pp. 313–319. Adelaide, 30 November–4 December 1981. Adelaide: S.A. Government Printer.

Holt, J. A., Coventry, R. J. & Sinclair, D. F. (1980). Some aspects of the biology and pedological significance of mound-building termites in a red and yellow earth landscape near Charters Towers, North Queensland. *Australian Journal of Soil Research*, **18**: 97–109.

Johnson, K. A. & Whitford, W. G. (1975). Foraging ecology and relative importance of subterranean termites in Chihuahuan desert ecosystems. *Environmental Entomology*, **41**: 66–70.

Lee, K. E. & Wood, T. G. (1971). *Termites and Soils*. New York and London: Academic Press.

Lobry de Bruyn, L. A. & Conacher, A. J. (1990). The role of termites and ants in soil modification: a review. *Australian Journal of Soil Research*, **28**: 55–93.

Noble, J. C. (1989). Fire studies in mallee (*Eucalyptus* spp.) communities of western New South Wales: the effect of fires applied in different seasons on herbage productivity and their implications for management. *Australian Journal of Ecology*, **14**: 169–187.

Noble, J. C., Diggle, P. J. & Whitford, W. G. (1989). The spatial distributions of termite pavements and hummock feeding sites on a semiarid woodland in eastern Australia. *Acta Oecologia Oecologia Generalis*, **10**: 355–376.

Nutting, W. L., Haverty, M. I. & La Fage, J. P. (1987). Physical and chemical alteration of soil by two subterranean termite species in Sonoran Desert grassland. *Journal of Arid Environments*, **12**: 233–239.

Spain, A. V. & McIvor, J. G. (1988). The nature of herbaceous vegetation associated with termitaria in north-eastern Australia. *Journal of Ecology*, **76**: 181–191.

Spain, A. V., John, R. D. & Okello-Oloya, T. (1983*a*). Some pedological effects of selected termite species at three locations in north-eastern Australia. In Le Brun, Ph., Andre, H. M., De Medts, A., Gregoire-Wibo, C. & Wauthy, G. (Eds), *Proceedings 8th International Colloquium of Soil Zoology*. pp. 143–149. Louvain-la-neuve (Belgium), 30 August–2 September. Louvain-la-neuve: Dieu Birchart.

Spain, A. V., Okello-Oloya, T. & Brown, A. J. (1983*b*). Abundance, above-ground masses and basal areas of termite mounds at six locations in tropical north-eastern Australia. *Revue Ecologie et Biologie du Sol*, **20**: 547–566.

Tongway, D. J. & Ludwig, J. A. (1990). Vegetation and soil patterning in semi-arid mulga lands of Eastern Australia. *Australian Journal of Ecology*, **15**: 23–34.

Whitford, W. G., Steinberger, Y. & Ettershank, G. (1982). Contributions of subterranean termites to the economy of Chihuahuan Desert Ecosystems. *Oecologia*, **55**: 298–302.