

Effects of Habitat Characteristics on the Abundance and Activity of Subterranean Termites in Arid Southeastern New Mexico (Isoptera)

by

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ABSTRACT

Amitermes wheeleri was the most abundant termite species in most of the habitats. *Gnathamitermes tubiformans* was the most abundant subterranean termite species in habitats dominated by creosotebush, *Larrea tridentata*. Subterranean termite abundance measured by numbers of termites extracted from baits, mass of paper removed from baits, proportion of dung pats attacked, and quantities of surface foraging galleries all indicated that subterranean termites were most abundant in mesquite (*Prosopis glandulosa*) dune and creosotebush habitats, and least abundant in grassland and shinnery oak (*Quercus harvardii*) habitats. Subterranean termite abundance was not affected by soil stability, but was affected by the dominant vegetation. Subterranean termites consumed more than 80% of the creosotebush leaf litter from litter bags between August and December. There was no evidence that termites consumed shinnery oak leaves or grass stems and leaves.

INTRODUCTION

Termites are important animals in the world's arid and semiarid ecosystems. They affect soil properties and decomposition and nutrient cycling processes (Whitford *et al.* 1982, Lobry de Bruyn and Conacher 1990, Whitford 1991, Nash and Whitford 1995). Despite their abundance and importance, there are few studies that address the variables that effect the spatial distribution of subterranean termites. Most ecological studies of North American termites have focused on the abundance of termites in a single ecosystem type, i.e. short grass prairie (Bodine and Ueckert 1975), creosotebush (*Larrea tridentata*) dominated shrub desert (Johnson and Whitford 1975), mesquite savanna (Haverty *et al.* 1974, 1975), shortgrass steppe (Crist 1998), and Chihuahuan Desert grassland (Tracy *et al.* 1998). A recent long-term study reported that patterns of relative abundance of subterranean termites were not different in degraded and relatively unchanged desert grassland and

shrubland ecosystems (Whitford 1999). There are no studies of termite communities in ecotonal areas or areas that are transitional between biomes.

Southeastern New Mexico is a region that is transitional between the semiarid shortgrass prairie of the Llano Estacado of West Texas and the Chihuahuan Desert. Landscapes in this transitional vegetation region are comprised of a mixture of desert scrub and grassland ecosystems. As is true of many regions of the western U. S., the ecosystems of this region have been degraded as a result of the interaction of drought and overstocking during the past century. Degradation has resulted in increased cover of invasive shrubs such as mesquite (*Prosopis glandulosa*) and unstable surface soils that have experienced loss of fines. The remaining sands are mobile and have formed dunes over much of the landscape.

It was hypothesized that subterranean termites would be more abundant in areas of stable soils and where vegetation change had been minimal. The chronic disturbance of the landscape by blowing sand, and the impacts of this disturbance on the vegetation may not only affect abundance of termites, it can affect the ability of these animals to provide ecosystem services such as decomposition and soil turnover. Here, I report the results of studies designed to test this hypothesis and to address the question of how disturbance affects termite activity.

METHODS

The studies were conducted in southeastern New Mexico at Los Medanos which is now the location of the Waste Isolation Pilot Plant (a radioactive waste material repository). The Los Medanos is located approximately 40km east of Carlsbad, N.M..

The topography is dissected tablelands with drainages to the Pecos River to the west via broad outwash plains. The tableland landscapes are mosaics of shrub dominated communities with small patches of interspersed grasslands. The area is semiarid with an average rainfall of 300mm/yr⁻¹.

Termite activity was measured using standard bait units (toilet tissue rolls) (Johnson and Whitford 1975, Haverty *et al.* 1975). In the first year of the study, we established grids in five locations to measure paper consumption and to collect soldiers for species identification. Each grid was 7 x 7 bait stations with 1m spacing. The grids were located in the following habitats: 1) creosotebush (*Larrea tridentata*) shrubland, 2) mesquite (*Prosopis glandulosa*) grassland, 3) mesquite coppice dune, 4) shinnery-oak (*Quercus harvardii*) – mesquite hummock dune 5) interdune blowout area between mesquite coppice dune.

In order to evaluate the spatial variation in termite activity within a habitat, three replicate grids of 5 x 5 bait stations with 1m spacing were established in three of the habitats: 1) creosotebush shrubland, 2) interdune area in mesquite coppice dune, and 3) shinnery oak – mesquite hummock dunes. All grids were established in February.

The bait rolls on the 5m x 5m grids were checked every two to four weeks to obtain estimates of termite numbers. The baits were checked in the early morning. The termites in the bait rolls were emptied into a flat pan for counting. Where several adjacent baits were attacked, the termites from those baits were recorded as a foraging group.

Termite activity on the smaller grids was measured by the mass of cellulose consumed by the termites over the growing season. In November, the bait rolls were collected, tagged for identification, and returned to the laboratory. The bait rolls were cleaned and the voids in the roll were cast with plaster. The dried plaster was removed, and the volume estimated by displacement. The mass of toilet tissue per unit volume was determined, and the plaster cast volumes were converted to mass of paper consumed.

Other estimates of termite activity were made by collecting gallery carton and by censusing cow dung pats for the presence of termites. Termite gallery carton present on the soil surface was collected on five, 10m x 1m transects in each habitat. Carton was returned to the laboratory, dried and weighed. We estimated the abundance of termites in dung pats on six replicate, 100m x 1m transects. Dung pats encountered on the transects were examined for presence of termites and/or termite galleries. Dung was collected dried and weighed to obtain an estimate of dung inputs in each of the habitats sampled.

A total of 120 litter bags were constructed with 1.5mm fiberglass mesh and assigned to 3 groups of 40 bags: creosotebush (*Larrea tridentata*) leaves and small stems, shinnery-oak (*Quercus harvardii*) leaves, and foliage from a mixture of grasses that included *Sporobolus* spp., *Aristida* spp. and *Bouteloua eriopoda*. Each litter bag was filled with approximately 10 grams of the assigned material. Litter bags and contents were dried to a constant weight and an aluminum tag with the weight and identification number was stapled to each bag. The litter bags containing a type of litter were placed in the habitat dominated by the plant species matching the litter. Ten bags of each litter type were retrieved from the field at 1, 3, 9, and 13 months after placement. The litter bags were returned to the laboratory, dried to a constant weight and a final weight recorded. Evidence of termite feeding in the litter bags was noted.

In mid-October and mid-November, we collected gallery carton in

fifteen randomly located 1m² quadrats in three of the habitats: creosotebush, mesquite dune, and oak dune. Gallery carton was carefully lifted into paper sacks, and returned to the laboratory where it was dried and weighed. We also searched the litter and woody material in each of the quadrats for active termites.

Data were analyzed by one way ANOVA. Where data failed the normality test, a Kruskal-Wallis One Way ANOVA On Ranks was performed.

RESULTS

Three species of termites were identified from soldiers collected from

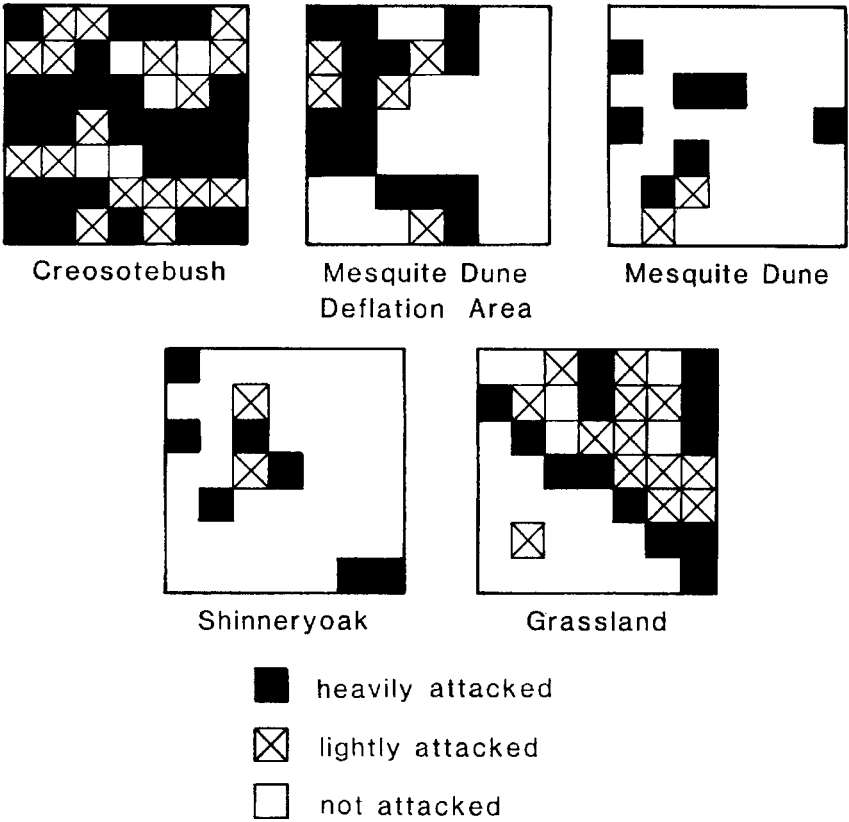


Fig. 1. Proportion of bait rolls attacked by termites in southeastern New Mexico habitats during the first year of study. Baits marked by X exhibited evidence of attack but the mass of paper removed by termites was not measurable.

the bait rolls. *Amitermes wheeleri* (Termitidae) were most abundant and were recorded on all of the grids. *Reticulitermes tibialis* (Rhinotermitidae) was found only in the mesquite dune areas in a few of the baits that were not attacked by *A. wheeleri*. *Gnathamitermes tubiformans* (Termitidae) were found in all of the habitats but were most numerous in the area dominated by creosotebush.

There were large differences in the percentage of bait rolls that were attacked by subterranean termites in the different habitats during the

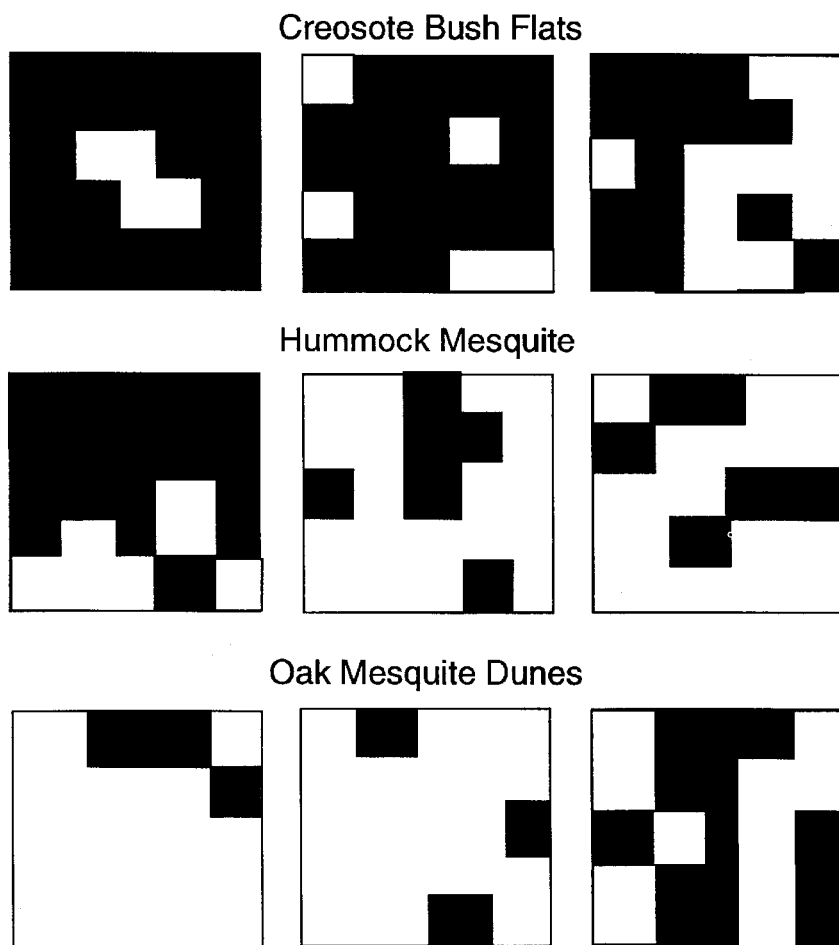


Fig. 2. Proportion of bait rolls attacked by subterranean termites in three southeastern New Mexico habitats during the second year of study. The dark squares represent bait rolls with visually distinct consumed portions.

first year of the study (Fig. 1). The proportion of baits from which termites removed a measurable quantity of paper ranged from 55.1% in the creosotebush habitat to 14.3% in the shinnery oak habitat. More baits were attacked in the interdune deflation areas (32.6%) in the mesquite habitat than on the dune flanks (16.3%). The proportion of baits attacked in the grassland habitat (26.5%) was similar to that recorded in the mesquite dune area (Fig. 1). There were large differences in quantity of paper consumed on the three grids during the growing season (June through September). The total paper consumed on the grids was: grassland – 25.5kg/ha, mesquite dune flank –20.2kg/ha, mesquite dune deflation area –66.2kg/ha, creosotebush –169.5kg/ha, and shinnery oak – mesquite low dunes –7.0kg/ha.

Subterranean termites removed measurable quantities of paper from significantly more bait rolls in the creosotebush habitat than in the oak-mesquite dune area ($F_{2,6} = 5.97$, $p < 0.03$) but not in the other habitat comparisons ($p > 0.17$) (Fig. 2). The coefficients of variation of the average number of bait rolls attacked in the mesquite dunes (73%) and shinnery oak (69%) were considerably higher than in the creosotebush habitat (14%).

The variability in numbers of rolls from which termites removed measurable quantities of paper was reflected in the estimated numbers of termites removed from the bait grids on the sampling dates (Fig. 3). The numbers of termites removed from the baits on the grids varied between 0 and 1350. There were termites present in the bait rolls in the creosotebush and mesquite dune habitats on most sampling dates. There were few dates when termites were collected from the plots in the shinnery oak habitat. The median numbers of termites collected from bait grids in the creosotebush and mesquite habitats were not significantly different (Kruskal-Wallis ANOVA on ranks, $q = 0.167$, $p > 0.05$) but the median number of termites collected from bait grids in the shinnery oak habitat was significantly lower ($q = 5.0$ and 4.8 , $p < 0.05$). The estimated cumulative number of termites per hectare collected from the plots were: creosotebush – $716,000 \pm 152,000$, mesquite dunes – $810,000 \pm 270,000$, and shinnery oak – $175,000 \pm 78,000$. These numbers represent a biomass of subterranean termites of approximately 2kg/ha in the creosotebush and mesquite habitats but only 0.44kg/ha in the shinnery oak habitat.

There was no evidence that termites consumed or harvested any of the shinnery-oak or mixed grass litter (Fig. 4). However the litter bags retrieved from the creosotebush habitat had numerous holes cut in the fiber glass mesh that was in contact with the soil and in some of the bags there were still traces of gallery carton. Most of the creosotebush litter

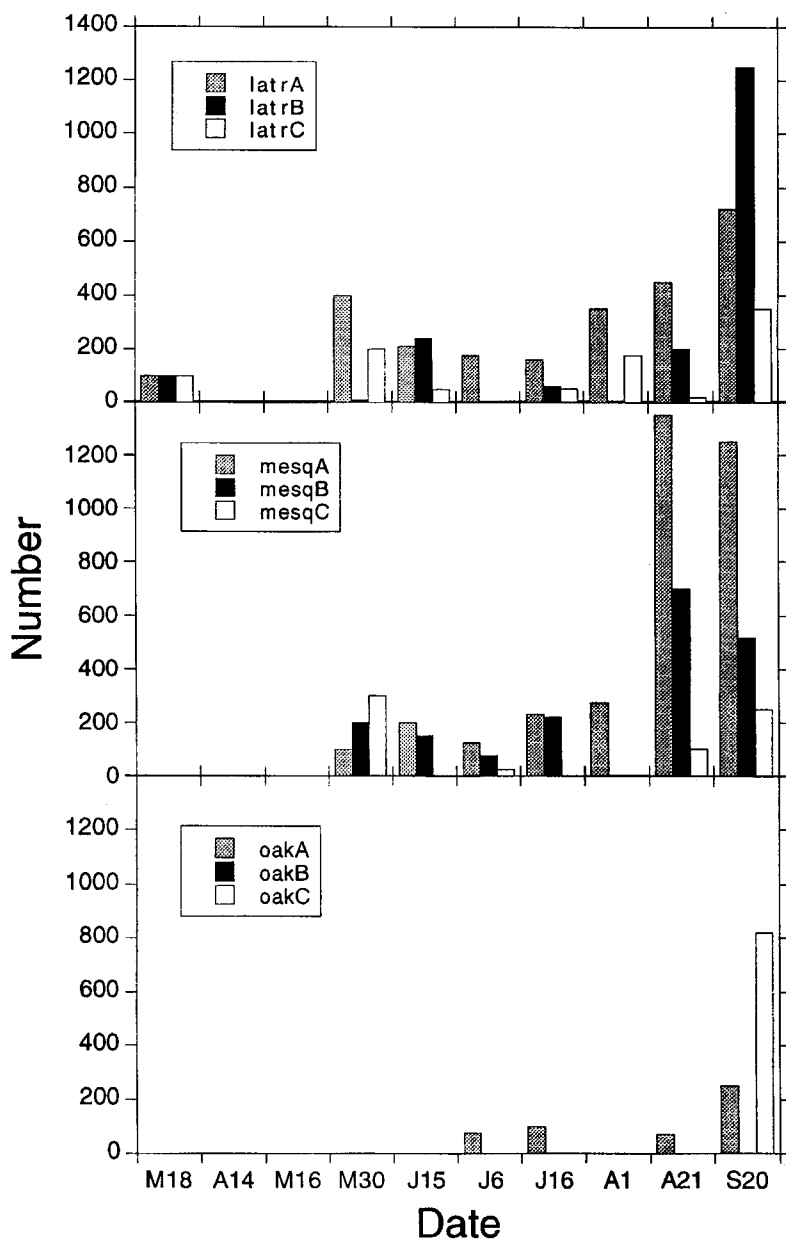


Fig. 3. Seasonal variation in numbers of termites removed from bait rolls in three habitats in southeastern New Mexico. Latr – creosotebush (*Larrea tridentata*) dominated habitats, mesq – mesquite (*Prosopis glandulosa*) coppice dune habitats, oak – shinnery oak (*Quercus harvardii*) habitats.

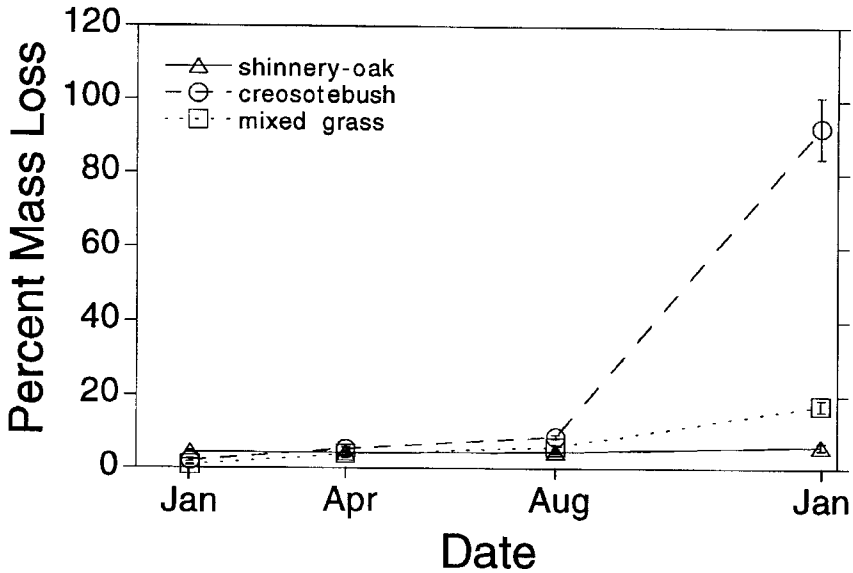


Fig. 4. Average percent of original mass of litter lost from litter bags containing three types of litter. Creosotebush litter bags retrieved on January 2 had numerous holes cut in the mesh by termites.

bags had little or no measurable litter remaining (Fig. 4).

In the creosotebush habitat there was approximately 25kg/ha of livestock dung. Termites, galleries, and gallery carton were found on 22.7% of the dung pats. In the mesquite dune habitat there was approximately 84.4kg/ha of dung and termites, galleries, and carton were found in 2.3% of the dung pats. In the oak-mesquite dune area there was an estimated 107.5kg/ha of dung but only 1.9% of the dung pats had evidence of termite attack.

There was more evidence of termite activity in the creosotebush habitat than in the other habitats. In mid-October, gallery carton was collected from 12 quadrats and in mid-November all 15 quadrats had gallery carton. The mean mass of gallery carton collected was $30.8 \pm 26.7 \text{ g/m}^2$ in October and $17.9 \pm 8.1 \text{ g/m}^2$ in November. In October, there was between 10 and more than 100 termites present in ten of the quadrats sampled. In November there was between 10 and 20 termites present in three of the quadrats sampled. In the mesquite dune habitat there were no termite galleries and no termites collected from surface materials. In the oak dune habitat there were no surface galleries in October and only 0.16 g/m^2 of gallery carton collected in November. Active termites were found in 6 quadrats in dung pats and in 1 quadrat in a dead mesquite bole. We collected more than 1000 foragers from the

mesquite bole. We also found a small number of termite forages in a dead oak stem in one of the quadrats in the oak dune habitat.

DISCUSSION

The termite species recorded in the habitats in this transitional region between Chihuahuan Desert and prairie grasslands are the same species recorded from shrub and desert grassland habitats in the northern Chihuahuan Desert (Johnson and Whitford 1975). However *Amitermes wheeleri* is the most abundant and widely distributed species in these southeastern New Mexico habitats and *Gnathamitermes tubiformans* is the most abundant species in the northern Chihuahuan Desert and in the West Texas grasslands (Bodine and Uekert 1975). *A. wheeleri* was found in nearly all of the dung pats examined in the surveys and was found in some of the dead wood. The only habitat where there were large numbers of surface foraging galleries (mud and sand tubes and sheets) produced by *G. tubiformans* was the creosotebush habitat. In this habitat there were galleries around dead grass stems, and dead shrub stems and sheets of gallery carton over the accumulations of senesced leaves of *Larrea tridentata*.

There was no relationship between the abundance and species composition of the subterranean termite community and the degree of vegetation and soil change experienced by the communities in the region. The mesquite coppice dune communities represent the greatest change in community structure, following the development of the commercial livestock industry in the region. However, the mesquite coppice dune areas supported higher termite densities than the shinnery-oak and mixed grass communities. Shinnery-oak communities and mixed grass communities were historically present, and with the exception of some mesquite invasion, have undergone little change (Peterson and Boyd 1998). It is probable that the creosotebush community was also a part of these landscapes prior to the livestock industry.

The low abundance of subterranean termites in the shinnery-oak habitats in comparison to the other habitats, may be due to food limitations or unsuitability of soils. The bait roll data suggest that the termites are more abundant in the stable, more consolidated soils of the interdune spaces and in the creosotebush habitat. There was no evidence of termites utilizing the dead leaves of shinnery-oak or mesquite. It is possible that the high tannin content of oak and mesquite leaves keep litter-feeding species such as *G. tubiformans* from feeding on these materials (Grime *et al.* 1996). In a study of subterranean termites in a variety of Chihuahuan Desert habitats, Nash *et al.* (1999) reported that soil properties were the most important variables

affecting the abundance of subterranean termites. Soil stability (resistance to movement by wind) is a factor determining the relative abundance of subterranean termites in the dune systems.

Seasonal and interannual variation in rainfall and plant production affect the intensity of attack on paper baits. The quantity of paper consumed by termites was inversely related to the seasonal and annual plant production (Nash *et al.* 1999). In this study, there was a marked reduction in the presence of termites in bait rolls during the driest period of the growing season, which suggests that soil moisture is an important variable affecting the seasonal surface foraging activity of subterranean termites in this region. This study was not long-term and cannot address interannual variation.

The importance of cattle dung as a food source for subterranean termites in all of the habitats studied provides evidence that the introduction of livestock may have resulted in increased abundance of subterranean termites. The addition of dung as a microhabitat and food source may more than compensate for any negative effects of livestock grazing. The data from this study are consistent with the conclusion that livestock grazing and ecosystem degradation have had no adverse effect on the abundance or species richness of termites in the ecosystems of a transitional region. These results are similar to those reported for other species in desert grasslands (Whitford 1997).

The abundance of surface foraging galleries in the creosotebush habitat during November, accounts for the large mass losses recorded from the creosotebush leaf litter bags when they were retrieved two months after the gallery carton measurements. It was obvious that subterranean termites were responsible for the removal of the leaf litter because of the holes cut in the fiberglass mesh and the gallery carton sheeting that remained in some of the bags. Between September and December, *G. tubiformans* removed > 80% of the *L. tridentata* leaf litter from litter bags. If the creosotebush litter was not removed by termites, there would have been less than 10% mass loss based on the rates of decomposition of creosotebush litter prior to termite surface foraging and the rates of decomposition recorded in the other two habitats. Elkins and Whitford (1982) reported that mesquite litter on the soil surface in this region lost less than 15% of its mass in one year. There was no evidence of termite activity in the litter bags placed in the oak or grassland habitats. *G. tubiformans* was not deterred from using creosotebush leaf litter despite the high concentrations of anti-herbivore defense compounds in the *L. tridentata* leaves (Rhoades 1977). In the transitional habitats of southeastern New Mexico, the relationship between anti-herbivore compounds and decomposition rates of leaves

reported by Grime *et al.* (1996) was absent. In the northern Chihuahuan Desert creosotebush habitats, MacKay *et al.* (1987) reported no evidence of *G. tubiformans* utilizing creosotebush leaf litter. They suggested that the abundance of other potential foods (dead annual plants and dead fluff grass (*Erioneuron pulchellus* foliage) accounted for the failure of the termites to use the creosotebush leaf litter. In the creosotebush habitat in southeastern New Mexico, dead annual plants were virtually absent and perennial grasses were very sparse. This may account for the high use of creosotebush leaf litter in this habitat.

The difference in termite species probably explains the absence of termite use of dead grasses in the mixed grass habitat. *G. tubiformans* is known to use dead grasses (Bodine and Ueckert 1975, Whitford *et al.* 1982) but the other termite species appear to be dung and dead wood feeders. Although *A. wheeleri* attacked dung pats, there was no evidence of this species feeding on dead grass or on mesquite and shinnery-oak leaves in the habitats where it was numerically dominant.

It has been suggested that subterranean termites are keystone species in desert rangelands (Whitford 1991). The data from this study show that in some of the ecosystems, subterranean termites are sufficiently abundant and feed on a sufficient variety of materials to be considered keystone species. However, in the shinnery-oak communities and mixed grass communities in this region, termites appear not to function as keystone species.

ACKNOWLEDGMENTS

Ned Elkins and Douglas Schaefer assisted with the field research. The preparation of this paper was supported by the U. S. Environmental Protection Agency through its Office of Research and Development. This paper has been subjected to the Agency's administrative review and approved as an EPA publication.

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