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Contributions of Subterranean Termites to the "Economy" of Chihuahuan Desert Ecosystems

Walter G. Whitford, Y. Steinberger*, and George Ettershank**
Department of Biology, Box 3AF, New Mexico State University, Las Cruces, NM 88003, USA

Summary. We examined the role of subterranean termites in decomposition of cattle dung, various herbaceous plant species and wood in a Chihuahuan desert ecosystem. From July–September, termites removed dung at a rate of 0.63 g·day^{-1} accounting for a percent mass loss of 19.5–100%. During the autumn subterranean termites consumed more than 50% of the leaves of the shrub *Larrea tridentata*, the grass *Erioneuron pulchellum* and annual plant *Lepidium lasiocarpum* and *Baileya multiradiata* but used very little of two other annuals *Eriastrum diffusum* and *Eriogonum trichopes*. *Yucca* inflorescence stalks on plots with termites lost 23% of their original mass in 30 months while those on termite free soils lost 11%. Elimination of termites resulted in reduction of fluff grass, *Erioneuron pulchellum* biomass, thereby affecting the structure of the ecosystem.

Introduction

Johnson and Whitford (1975) provided a general survey of the foods selected and climatic factors affecting the foraging of subterranean termites in Chihuahuan desert ecosystems. They discussed the feeding behavior of Chihuahuan desert subterranean termites on wood and cattle dung suggesting that termites are probably very important in wood and dung breakdown, but provided no quantitative data. Studies by Allen, Foster and Ueckert (1980), examined the seasonal food habits of the subterranean termite *Gnathamitermes tubiformans* in West Texas grasslands. They reported that the highest feeding activity was in autumn and that the diet consisted primarily of dead grasses. They attributed most of the grass litter disappearance in a semi-arid grassland to the feeding activity of subterranean termites *G. tubiformans*. Haverty and Nutting (1974, 1975a and b) examined wood feeding and relationships of termites to wood in Sonoran desert habitats and concluded that termites were very important in wood turnover in that ecosystem. Ferrar and Watson (1970) and Anderson and Coe (1974) described the importance of termites in the breakdown and turn-over of dung in semi-arid ecosystems.

The studies of Schaefer and Whitford (1981) provided a general assessment of turnover of nitrogen, phosphorous and sulfur by subterranean termites but their work left many aspects of the feeding activity and importance of termites in this desert ecosystem unresolved. For example, Fowler and Whitford (1980) reported that termites did not utilize creosotebush leaves but later qualitative observations indicated that this was an erroneous conclusion.

In 1977, we established a series of plots on which we treated the soil with the insecticide chlordane (TM) to eliminate termites in order to examine changes in the absence of the dominant detritivore in this ecosystem. We used these plots to examine wood turnover, selection of various plant species by termites as well as vegetation changes like those reported by Parker et al. (1982). Here we report the results of these studies.

Study Site

The studies were conducted on a watershed on the northeast slopes of the Dona Ana Mountains on the New Mexico State University Ranch, 40 km NNE of Las Cruces, New Mexico. Dung decomposition studies were conducted on a 4-ha plot characterized by a sandy loam with a hard-pan, calcium carbonate deposition layer (caliche) at ca. 100 cm. This area is a grazed pasture on the lower portion of the watershed.

The other studies were conducted on a creosotebush, (*L. tridendata*) (DC)-dominated desert pavement community on shallow soils. This portion of the watershed is ungrazed. On the highly dissected slopes of the watershed, the creosotebush community supports a variety of annual plants which occur at low densities during summer rainy periods (ca. 10,000 h^{-1}) Parker et al. 1982, Whitford 1973).

Methods

Dung feeding: This study was conducted from May 31, 1979 to September 24, 1979. We collected fourty-eight cow dung pats that were termite free and oven dried these at 60° C for 24 h. The pats were arranged on a 12×4 grid with 1.5 m spacing. One half of the pats assigned at random were placed on soil that had been soaked with a 10% chlordane (TM) solution to prevent termites from entering the pats. At 28 day intervals, 6 pats from the untreated soil and 6 from the chlordane treated soil were collected. In the laboratory, the dung pats were examined for termites and mineral soil; gallery carton was separated from the dung by floatation, and then the sample was dried and

* *Present addresses:* Department of Biology, Bar Ilan University, Ramat-Gan, Israel
** Department of Zoology, Monash University, Clayton, Victoria, 3168 Australia

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weighed. Dung pats from the untreated soil were broken up and placed in modified Tullgren funnel (Santos et al. 1978) to extract microarthropods. Percent weight loss data were arc-sine transformed and analyzed by ANOVA.

Litter-feeding: The rate of litter removal by subterranean termites was studied by enclosing litter species in aluminum window screen cylinders. The cylinders were held to the soil surface by large nails driven into the soil. This prevented litter from being scattered by wind, but allowed for litter soil interface without interferring mesh screen. In 1979, we studied three litter types: creosotebush leaves and small twigs (*Larrea tridentata*), fluff grass (*Erioneuron pulchellum*) and pepperweed (*Lepidium lasiocarpum*). In 1980, we studied creosotebush, buck wheat (*Eriogonum trichopes*), phlox, (*Eriostrum diffusum*), and desert marigold (*Baileya multiradiata*). One half of the cylinders were placed at random on plots treated in 1977 with chlordane at 10.3 kg ha^{-1}. These plots are termite free. The other half were placed on untreated plots.

In 1979, we had 96 cylinders of each species containing 10 gms of litter per cylinder. In 1980, we had 20 cylinders of each species. In 1979, cylinders were placed in the field on August 15, and 12 cylinders per treatment collected on September 15, October 1 and 15, and November 15. In 1980, cylinders were placed in the field on October 3 and collected on November 21. The material remaining in the cylinders was carefully removed and placed in separate bags in the field. The litter, soil and gallery carton were separated in the laboratory and weight loss expressed as percent of original mass. Data were arc-sine transformed and analyzed by ANOVA.

Wood Turnover

In June 1978, we harvested one year old inflouresence stalks of soaptree yucca (*Yucca elata*). These stems were cut into 40 cm segments, dried to a constant weight and labeled with aluminum tags. Twenty-five segments were placed around the base of *Yucca elata* plants on the termite free plots and the other 25 segments were similarly placed on untreated plots. The segments were collected in December 1978, 1979 and 1980, returned to the laboratory dried, mineral soil and carton brushed away and weighed. They were then returned to the same areas in the field. In December 1978, we placed 26, 30 cm segments of creosotebush branches in the field, half on the termite free plots. These were treated in the same manner as the yucca stalk segments.

Gallery Carton

Production of termite gallery carton was estimated during late October or early November 1978, 1979, and 1980. All gallery carton in fourty-eight randomly placed one square meter quadrats was collected, placed in bags and returned to the lab. The carton material was oven dried to a constant weight, weighed and percent composition measured by passing the material through a series of seives.

Following maximum termite surface activity, we sampled all remaining organic materials on the termite free plots and on the control plots. Twelve 1 m^2 quadrats were harvested under the canopy of creosotebushes and twelve 1 m^2 quadrats were harvested in the intershrub spaces on each treatment. Quadrat samples were randomized on each plot. The collected material was returned to the laboratory, dried at 60° C for 72 h or longer, separated into the following categories: rabbit feces, creosotebush leaves, stems, fluff grass (*Erioneuron pulchullem*), and ephemeral plant parts, then weighed.

Results

Dung decomposition: There was no difference in mass of dung pats between treatments on the first sample date ($F=2.05$, $p>0.05$). The combined average mass loss was $1.8\pm1.3\%$, range: 0.16–3.7%. There was little measureable rainfall during that period. Cumulative rainfall totals during the periods between dung pat collections in sequence were 4.81 mm, 33.5 mm, 67.03 mm, and 12.7 mm, June 4 – September 24. Dung pats collected on day 56 contained galleries and termites. Problems encountered in clearing mineral soil from the dung resulted in weight estimate errors, hence we had data on only three dung pats from the untreated soil: $\bar{x}$ mass loss$\pm$SD was $4.3\pm3.85\%$ with a range from 0.4–8.1%. By day 84, dung pats on untreated soil contained large numbers of termites and extensive galleries. These had an average mass loss of $44.2\pm32.5\%$ (range 11–51%). There was no evidence of termite activity in pats on the chlordane treated soil which had a weight loss of $4.13\pm2.9\%$ (range 0.5–7.0%). Weight loss of dung with termites was significantly higher than that of dung on termite free soil ($F=5.87$, $P<0.01$). On the last collection date, dung pats attacked by termites had lost between 19.5% and 100% of the original weight ($\bar{x}=46.6\%$) while dung pats on chlordance treated soil lost between 0% and 15.8% ($\bar{x}=4.4\%$). Overall, termite attacked dung pats lost more mass than termite free pats ($F=9.32$, $P<0.01$). Dung pats on untreated soil contained termites on the July 30, August 27, and September 24 collection dates. Over the duration of the experiment the average mass loss from the dung pats on untreated soil was 0.63 g$\cdot$$day^{-1}$. Numbers of termites per pat ranged from 13–423 with an average of 273 per pat. Most pats contained *Gnathamitermes tubiformans* and *Amitermes wheeleri* was taken from one pat.

Average numbers of microarthropods per pat were sminthurid collembolans – 3, isotomid collembolans – 3, psocopterans – 4, oribatid mites – 3, tarsenomid mites – 4, and mites – 2.

Litter consumption: Termites rapidly removed a large fraction of the plant material present on the soil surface when high relative humidity allowed these insects to build their mud galleries around and over the material (Fig. 1). Termites removed significant quantities of *L. tridentata, L. lasiocarpum, E. pulchellum* and *B. multiradiata* litter (Fig. 1), ($F=34.6$, $P<0.001$), but utilized very little of the *E. diffusum* and *E. trichopes* litter. *E. diffusum* on the untreated soil lost $16.5\pm1.8\%$ and on the chlordane treated soil lost $13.9\pm2.2\%$ ($F=7.02$, $P<0.025$). The mass loss from *E. trichopes* on untreated soil was $17.8\pm3.5\%$ and on the insecticide treated soil was $13.6\pm3.2\%$ ($F=1.71$, $P>0.1$).

The termites moved large amounts of mineral soil around the litter as gallery carton (Fig. 1), but built no galleries around *E. trichopes* and less than 3 gms of gallery per cylinder of *E. diffusum*. There was significant difference in weight loss of creosotebush litter *L. tridentata* on the untreated soils in 1980 compared to that on the termite free soils 19.1 ± 3.04 and 15.2 ± 2.5 respectively ($F=5.2$,