Subterranean Termites and Long-Term Productivity of Desert Rangelands

by

Walter G. Whitford[1]

ABSTRACT

Studies of soil properties, growth and species composition of vegetation, hydrology and patterns of organic matter removal were made on plots where termites had been eliminated and on plots with subterranean termites present. Subterranean termites affected all of the parameters measured. There was a negative correlation between termite abundance/activity and soil organic matter. Soils of termite free plots have lower infiltration and water storage but higher soil nitrogen. These soil properties have an effect on the species composition and productivity vegetation. The importance of subterranean termites as effectors of soil properties and vegetation suggests that these animals are key consumers in desert rangelands.

INTRODUCTION

Subterranean termites are abundant and widely distributed the semi-arid rangelands of the world. The presence of subterranean termites may largely go unnoticed except when environmental conditions are suitable for surface activity. Many species build foraging galleries around and over materials that are harvested or consumed in place. These surface foraging galleries are often the only indicator of the activity of these animals. La Fage *et al*. (1973), described a method for studying foraging of desert subterranean termites using toilet paper rolls as bait units. On a mid-slope section of Chihuahuan desert watershed, we estimated a density of subterranean termites of 1200/m^2, based on numbers of termite foragers in toilet roll baits (Johnson and Whitford, 1975). Haverty *et al*. (1975), reported a total density of 5 species of termites of 1025/m^2 at the Santa Rita Experimental

[1]Department of Biology, Box 3AF, New Mexico State University, Las Cruces, NM 88003.

Table 1. Range of removal of dead plant parts expressed as percent of the annual standing crop and removal of dung by subterranean termites. Data are from Whitford *et al.*, 1982; Whitford *et al.*, 1988; MacKay *et al.*, 1987; Silva *et al.*, 1985 and unpublished).

Material	Percent removed
Annual plants above-ground parts	40% -80%
Annual plants dead roots	50%-70%
Perennial grass above-ground parts	60%-90%
Perennial grass dead roots	50%-70%
Shrub leaves	0%-90% [a]
Dead wood	< 1%-5% [b]
Cattle dung	60%-100%
Rabbit dung	15%-50%

[a] Variation dependent upon shrub species, geographical location, and availability of other forage for termites.
[b] On hard wood subterranean termites scrape off the surface material softened by fungi.

to the lower slopes. There was, however, a significant negative correlation of soil organic matter with the abundance of subterranean termites ($r=-0.97$). In a multiple regression analysis of variation in soil organic matter using location, litter decomposition and termite activity index as variables, termite activity index was the only significant variable ($r^2=-0.95$, $F=28.9$, $p<0.01$).

The results of this study indicate that the activity of subterranean termites is the most important factor affecting the variability in soil organic matter. During the construction of a large excavation on the Jornada LTER watershed, I recorded active termite galleries between 3m and 10m depth. Transport of organic matter to these depths, plus the use of fecal material in cementing the surfaces of galleries and tunnels by subterranean termites, removes the organic matter from the root zone of most plants. Thus, it is not surprising that there is a highly significant negative correlation between soil organic matter of the soil and the activity of termites. Combining this analysis with the data on removal of dead plant tissues and animal dung, it is apparent that subterranean termites are largely responsible for the low organic matter contents of Chihuahuan Desert rangeland soils.

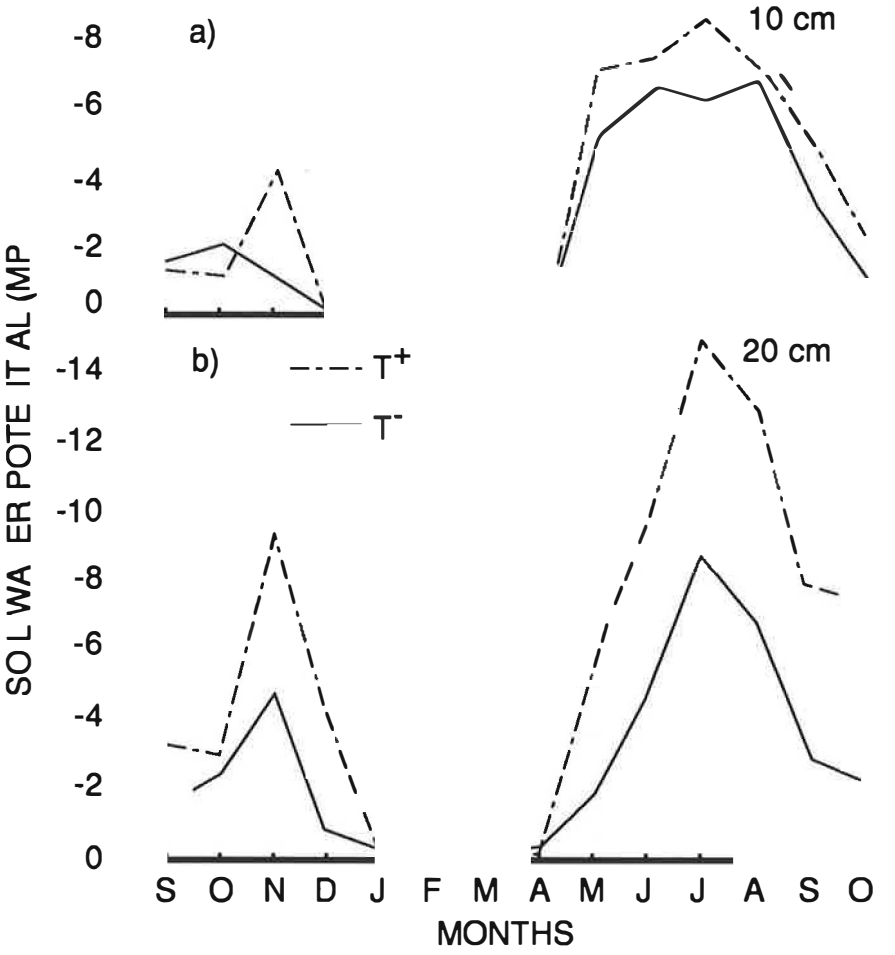

Fig. 1. A comparison of soil water potentials on plots with termites present and plots where termites had been eliminated.

the subterranean termites. Bulk flow of water into soil via macropores is especially important during intense rain storms. The long-term termite exclusion plots provided an opportunity to examine the effects of termites on water infiltration and soil water storage.

Because subterranean termites affect soil water, they indirectly affect species composition and growth rates of the vegetation. Both biomass production and species composition of spring annual

6.6cm compared with 4.2cm stem elogation of shrubs on irrigated, termite free plots (Gutierrez and Whitford, 1989). In a study of production by litter fall comparisons, we found significant differences in litter production (Fig. 2), with higher production on plots with termites present. The reduction in infiltration and deep water stores has thus affected the biomass production of creosotebush *L. tridentata*.

The rangelands of the southwestern United States have undergone significant vegetation changes in the past 150 years (Buffington and Herbel, 1965). With changes of that magnitude, we expected that the importance of termites might be reduced in desertified landscapes. However, that appears not to have happened. Subterranean termite activity was not reduced in the most desertified mesquite dune and tarbush habitats when compared to the black grama grassland habitats that formerly occupied those environments (Table 2).

Table 2. Termite activity measured as the average mass of paper consumed on toilet paper roll bait grids on sites on the Jornada that have experienced small to large changes in vegetation during the past 150 years. Plots are identified by numbers between 1 and 10 with 1 representing no change and 10 representing maximum change.

Site	% Baits attacked	Mass loss (g) $\bar{x}$, range
Black grama grassland A (2)	12	0.93, 0.5 - 1.3
Black grama grassland B (2)	60	0.5, 0.01 - 2.7
Creosotebush A (4)	80	4.3, 0.2 - 23.7
Creosotebush B (7)	96	6.0, 0.5 - 19.0
Creosotebush C (10)	52	1.9, 0.7 - 11.6
Mesquite grassland (3)	32	0.7, 0.1 - 1.1
Mesquite sand dune (10)	84	10.1, 2.0 - 22.8
Tarbush (10)	80	10.4, 0.7 - 70.5
Tarbush-burrowgrass (8)	72	4.3, 1.9 - 19.9

The comparisons of termite free plots with plots inhabited by termites have documented changes in virtually every aspect of this desert rangeland. The elimination of termites resulted in increased soil organic matter and increased soil nitrogen but reduction in soil porosity and infiltration. The changes in soil properties affected the vegetation primarily by reduced water availability but the increased nitrogen did enhance the growth of some nitrogen

Silva, S. I., W. P. MacKay and W. G. Whitford. 1989. Temporal patterns of microarthropod population densities in fluff grass (Erioneuron pulchellum) litter: relationship to subterranean termites. Pedobiologia 33:333-338.

Whitford, W. G., Y. Steinberger and G. Ettershank. 1982. Contributions of subterranean termites to the "economy" of Chihuahuan Desert ecosystems. Oceologia 55:298-302.

Whitford, W. G., K. Stinnett and J. Anderson. 1988. Decomposition of roots in a Chihuahuan Desert ecosystem. Oecologia 75:8-11.

Whitford, W. G., J. A. Ludwig and J. C. Noble. 1991. The importance of subterranean termites in semi-arid ecosystems in southeastern Australia. J. Arid Environ. In press.

Wood, T. G. and W. A. Sands. 1978. The role of termites in ecosystems, pp 245-292. IN: Brian M.V. ed. Production ecology of ants and termites. Cambridge University Press, Cambridge.