Comparison of Field Methods to Detect Termite Activity in the Northern Chihuahuan Desert (Isoptera)

by

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ABSTRACT

The subterranean termites, *Gnathamitermes tubiformans* (Buckley) and *Amitermes wheeleri* (Desneux), play an essential role in terrestrial ecosystems of the northern Chihuahuan Desert. They regulate nutrient turnover, contribute to patterns of nutrient concentration, and determine the diversity and heterogeneity of desert plant communities. Therefore, they are considered keystone species in northern Chihuahuan Desert ecosystems. Our objectives were to compare the efficiency and cost effectiveness of six field procedures to detect termite activity. Efficiency was defined as the relative ability to attract termites during a given period of time. Cost effectiveness was based on the number of hours involved in preparing, handling and processing the samples. The methods included artificial baits, natural baits, and litter sweeps. The specific baits were: uncoated corrugated cardboard blocks, unscented generic rolls of toilet paper, cattle dung, fluff grass (*Dasyochloa pulchella*), and soap-tree yucca (*Yucca elata*) stalks. In addition, termites were collected with litter sweeps. Results show that cattle dung is the most efficient in detecting termite activity, and litter sweeps the most cost effective, although also least efficient. The results of this study will benefit future termite studies on consumption rates, and relative population densities.

INTRODUCTION

The role of termites in desert ecosystems has received increasing attention over the past twenty years. Studies from the northern Chihuahuan Desert show that subterranean termites consume a large portion of the standing crop in communities in which they are present: 40-80% of the above-ground parts of annual plants, 50-70% of the annual plant roots, 50-60% of the standing dead leaves, and roots of perennial grasses, 60-100% of the dung of cattle, 15-50% of rabbit

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dung, and less than 1-5% of the dead wood (Whitford 1991). Nash and Whitford (1995) reported a strong negative correlation between abundance of subterranean termites and soil organic matter (r = - 0.97), indicating that abundance of termites is related to the variability in soil organic matter. Termites increase water infiltration, water availability, and soil aeration (Elkins *et al.* 1986; Gutierrez & Whitford 1987). Subterranean termites also process carbon more efficiently than do free-living microbes in the soil (Lee & Wood 1971b; Nutting *et al.* 1987). Termites also contribute to mixed patterns of nutrient concentration, and to the diversity and heterogeneity of plant communities in the Chihuahuan Desert (Gutierrez & Whitford 1989; Whitford 1991). Therefore, termites are considered keystone species, and their removal can result in a series of changes in the structural and functional integrity of desert ecosystems (Schaefer & Whitford 1981; MacKay *et al.* 1987).

Several methods (see Table 1) have been used to estimate subterranean termite populations and consumption rates (Haverty & Nutting 1974), population densities (Haverty & Nutting 1975b; Haverty *et al.* 1976), colony density and the size of foraging territories (Haverty *et al.* 1975), foraging populations and territories (Su, & Scheffrahn 1988), foraging activity (Buxton 1981a), and food preference (Haverty & Nutting 1975a). Methodology used in past studies of population and foraging ecology, swarming and reproductive status, predation, and geographic distribution of subterranean termites was reviewed by Nutting & Jones (1990). The previous methods have been found to be effective in characterizing termite activity patterns. However, no studies have been conducted to determine the relative effectiveness of each method in assessing subterranean termite activity and to determine the cost effectiveness of each.

The objective of this study was to compare the efficiency and cost effectiveness of six field methods and procedures used in previous studies of subterranean termites. The following five baiting methods were compared with each other and with litter sweeps: rolls of generic unscented toilet paper, uncoated corrugated cardboard blocks, *Dasyochloa pulchella* (fluff grass), *Yucca elata* (soap -tree yucca) stalks, and cattle dung (2 sizes).

MATERIALS AND METHODS

Study Site

The study area is located in the northern Chihuahuan Desert on the USDA-ARS Jornada Experimental Range in the Jornada del Muerto Basin in southern New Mexico, 37 km NNE of Las Cruces, Doña Ana

Table 1. Summary of methods and procedures to sample termites.

Author & Date	**Species**	**Location**	**Method**
Abensperg-Traun 1993	*Heterotermes occiduus*	Western Australia	Undecayed/Untreated:
	Coptotermes acinaciformis		Season wooden stakes
	Amitermes neogermanus		Sawdust
	Nasutitermes exitiosus		Toilet paper rolls
	Occasitermes occasus		
Buxton 1981a	*Odontotermes mediocris*	Tsavo, Kenya	Discs of dead branches
	Odonotermes zambesiensis		
	Microtermes allaudanus		
	Synacanthotermes zanzibarensis		
	Amitermes sciangallorum		
	Microcerotermes parvus		
Ettershank *et al.* 1980	*Gnathamitermes tubiformans*	Southern New Mexico	Trench w/polyethylene film:
	Amitermes wheeleri		Soil or dungpats over
			Trench w/o polyethylene film:
			Dungpats over
Ferrar 1982b	*Cubitermes*	South Africa	Soil Cores
	Promirotermes		
	Agonotermes		
	Lepidotermes		
Ferrar 1982a	*Microcerotermes*	South Africa	Toilet paper rolls tied with string
	Macrotermes		
	Microtermes		
	Odontermes		
	Allodontermes		
	Aganotermes		
	Promirotermes		
	Trinervitermes		
	Fulleritermes		

Table 1. (Cont.) Summary of methods and procedures to sample termites

Author & Date	Species	Location	Method
Haverty *et al.* 1976	*Heterotermes aureus*	Tucson, Arizona	Toilet paper rolls
	Gnathamitermes perplexus		Circular quadrats (circledrats)
	Paraneotermes simplicicornis		
	Amitermes wheeleri		
	Amitermes minimums		
	Amitermes emersoni		
	Amitermes silvestrianus		
Haverty & Nutting 1975b	*Paraneotermes simplicicornis*	Tucson, Arizona	Circular quadrats (circledrats)
	Hetereotermes aureus		
	Gnathamitermes perplexus		
	Amitermes wheeleri		
Johnson & Whitford 1975	Subterranean termites	Southern New Mexico	Toilet paper rolls
			Yucca elata
			Cattle dung
La Fage *et al.* 1973	*Gnathamitermes perplexus*	Tucson, Arizona	Toilet paper rolls
	Heterotermes aureus		Fir wood blocks
MacKay *et al.* 1987	*Gnathamitermes tubiformans*	Southern New Mexico	Standard fiberglass mesh litter bags
MacKay *et al.* 1986	*Gnathamitermes tubiformans*	Southern New Mexico	Pits filled with dead plant litter:
			- size of pits: 12.5 cm in diam
			6.0 cm in depth
			- senescent stems and leaves of:
			= *Baileya multiradiata*
			= *Erioneuron pulchellum*
			= *Larrea tridentata*
			Fiberglass-mesh litter bags:
			- size of bags (Santos, 1984)
			- bags were placed on the soil surface
Malcolm 1977	*Odontotermes*	Tsavo East Kenya	Soil Cores
Nash & Whitford 1995	*Gnathamitermes tubiformans*	Southern New Mexico	Rolls of toilet paper
	Amitermes wheeleri		wrapped with aluminum foil *Microtermes*

Table 1. (Cont.) Summary of methods and procedures to sample termites

Author & Date	Species	Location	Method
Nutting *et al.* 1987	*Gnathamitermes perplexus*	Tucson, Arizona	Rolls of toilet paper wrapped with tape
	Heterotermes aureus		
Sands 1972	*Microtermes*	Africa savanna soil	Shallow core sample
	Macrotermitinae		Deep pits
	Ancistrotermes	Indian savanna soil	Baits
	Amitermitinae		
	Pseudacanthotermes		
	Synacanthotermes		
	Allodontermes		
	Odontotermes		
Schaefer & Whitford 1981	*Gnathamitermes tubiformans*	Southern New Mexico	Toilet paper rolls
Sheppe W. 1970	*Odontotermes latericius*	Lusaka, Zambia	Soil Cores
Silva *et al.* 1985,1989	Subterranean termites	Southern New Mexico	Open-bottomed screen cylinders
Spears *et al.* 1975	*Gnathamitermes tubiformans*	Garza County, Texas	Soil Cores
Su and Scheffrahn 1986	*Coptotermes formosanus*	Ft. Lauderale, Florida	Wooden stakes driven into the soil
Ueckert *et al.* 1976	*Gnathamitermes tubiformans*	Garza, County, Texas	Soil Core Sampling
			Quadrats - sweep litter
			Vacuum - utilize a 12 V
Whitford *et al.* 1982	*Gnathamitermes tubiformans*	Southern New Mexico	Oven dried & termite free cow dung pats
	Amitermes wheeleri		One year old soaptree yucca, cut & dried inflouresence stalks.
			Litter feeding
			L. tridentata, E. pulchellum,
			Lepidium lasiocarpum,
			Eriogonum trichopes,
			Eriostrum diffusum
			Baileya multiradiata
Whitford *et al.* 1988	*Gnathamitermes tubiformans*	Southern New Mexico	Fiberglass-mesh litter bags:
	Amitermes wheeleri		- litter bags were buried
			- size = unknown
			- mesh size = 1.5 mm.

County, New Mexico. The climate is arid to semi-arid with an average of 230 mm precipitation annually. Both the total amount and seasonal distribution of precipitation are highly variable (see <http://jornada.nmsu.edu/OVERVIEW.HTM>). This region is characterized by three seasons. The first is a hot-dry windy spring season during the months of April through June. Daily maximum temperatures range from 20-40 °C, accompanied by 12% of the mean annual precipitation. The second is a hot-summer season during the months of July through October. The daily maximum temperatures during this season range from 30-40 °C, and 64% of the mean annual precipitation occurs during these months. The third is a cool-dry winter season during the months of November through March. The average daily minimum temperature during this season is often below -5 °C. There are five major vegetational communities in the area: black grama grassland (*Bouteloua eriopoda* (Torr.) Torr.), creosotebush scrub (*Larrea tridentata* (DC.)), mesquite duneland (*Prosopis glandulosa* Torr.), tarbush shrublands (*Florencia cernua* (DC.)), and playa. The soils at the Jornada Experimental Range vary from unconsolidated alluvium in the mountains, sandy loams in the plains, to clay in the playas (Buffington & Herbel 1965).

This study was conducted at three sites disturbed to varying extents by cattle grazing: a slightly disturbed area (West Well 3A, UTM Coordinates 336616.7E 3607715N); a moderately disturbed area (West Well 1A, UTM Coordinates 326623.0 3608512N); and a heavily disturbed area (West Well 0, 326663.2E 3608734N) (locality data provided by Barbara Nolen in 1996).

Each plot measured 80 x 90 m and was divided into 48 blocks of 10 x 15m. Six points 5m apart were located in each block (Taylor 1996). Samples of rolls of toilet paper, cardboard blocks, large cattle dung, small cattle dung, fluff grass, and yucca stalks were randomly assigned to each of the points within each block. Baits were placed between August 27 and September 10, 1995, and collected on November 5, 1995. The purpose for this experimental design was to provide the termite population an equal opportunity to chose between the six samples in each block. Termite activity was estimated based on the following factors: relative number of termites, presence of gallery (carton), and the presence/absence of termites. The cost effectiveness of each method was assessed based on the costs involved in processing and handling the samples.

Artificial Baits

Cardboard Blocks Method: Uncoated corrugated cardboard sheets were cut with a sharp knife and a paper cutter. The blocks were then put together by stacking seven pieces of cardboard and tied with twine

(100% nylon) to yield 11x11x3 cm high blocks (Taylor 1996). The cardboard blocks were set up at their specific randomly determined locations and fastened to a 1 cm steel rebar rod using ~ 50 cm long piece of twine. The blank side of the block was placed flat against the ground to prevent the indelible ink on the label from interfering with termite activity, and to allow for easy identification. Termite activity was based on the presence/absence of termites and the presence of gallery.

Rolls of Toilet Paper Method: The rolls of toilet paper (#150, Fort Howard Paper Co., Racine, Wisconsin, single-ply, unbleached, 100% total recycled, >95% post consumer fiber content) were weighed, wrapped with heavy aluminum foil to protect the sample, reinforced with duct tape to prevent unraveling (LaFage, *et al.* 1973), and labeled with location identification with indelible ink (Taylor 1996). Each roll of toilet paper was placed over a rebar with the uncovered bottom in contact with the soil. The foil cover shaded the top of the steel rod. The presence/absence of termites and the presence of gallery were used to identify termite activity in the samples.

Natural Baits

Fluff Grass Pits Method: Approximately 10 kg of *D. pulchella* were collected from near Transmountain Road in El Paso. The grass was allowed to air dry at room temperature for seven days and then was sieved in a 2 mm mesh to remove the sand and soil particles. Forty gram samples were weighed and stored in reclosable labeled plastic bags. Pits 3 cm in depth and 12.5 cm in diam were made using two-pound coffee cans with both ends removed. The can was pressed into the soil to a 3 cm mark, and the soil was removed by hand. The grass was placed inside the can and pressed down. The can was then removed carefully. Samples were hand collected at the end of the experimental period and placed into prelabeled paper bags (Taylor 1996). The relative number of termites and the presence of gallery were used to identify termite activity.

Cattle Dung Method: Dung was collected between 6:00 and 8:00 a.m. from a privately owned dairy cattle farm on September 10, 1995. Sufficient dung was collected to prepare all the samples for the three plots. The dung was placed in large plastic storing boxes for transport to the sites. Two cans were used as molds to set-up the samples as follows: a two pound coffee can with a 12.5 cm diameter, and an eight ounce vegetable can with a 6.25 cm in diameter. The bottom and the top of both cans were removed. Two calibration containers were made to be used regularly while measuring the samples at the sites: a 120 g container for the small samples, and a 420 g container for large samples. A ten pound kitchen scale (calibrated with a laboratory electronic balance), plastic sandwich bags, two 52 quart ice chests, one 48 quart ice chest and a thick plastic cover were used to carry out the entire procedure. The dung was mixed with water at the site to compensate for evaporation loss during collection of the dung and placement of samples at their specific location. Moisture samples were removed at the beginning and periodically throughout the day to estimate the average moisture content (Taylor 1996). Disposable plastic gloves were worn at all times for weighing and setting up the samples. The kitchen scale was used to weigh each sample, and sandwich bags were used to store and transport samples. Calibrations to volume were prepared for both sizes of dung, and were used throughout the day to reduce errors. Weight and volume were used to produce baits with the same mass and soil-surface contact area. The can (without top or bottom) was placed on the ground, and the dung inside the sandwich plastic bag was thoroughly removed by turning the bag inside out and scraping as much of the sample as possible (> 98%) into the can. The walls of the can were also scraped. At the end of the study period, the sample was collected by hand, and placed into a prelabeled paper sack. The area covered and dry weight was used in estimating termite activity (Table 2).

Yucca Stalks method: One year old soap-tree yucca stalk segments (40 cm) were used, as reported by Whitford *et al.* (1982). The stalks ranged from 2 to 3 cm in diameter approximately. Metal tags were used to label the samples with the location identification number. Each stalk was placed flat on the ground with the metal tag tucked under the stalk to reduce rodent disturbance (Taylor 1996). At the end of the study, the sample was placed inside a paper sack prelabeled with indelible ink. The area covered and dry weight was used in estimating termite activity (Table 2). Presence/absence of termites and presence of gallery was used to determine termite activity.

Litter Sweeps Method: This method required a 1.0 mm sieve with a collecting tray, a trowel 11x11x2 cm (Taylor 1996), and one quart resealable plastic bags. A total of three litter sweeps were done. The first litter sweep was done on September 24, the second on October 15, and the third on November 5. Since termites are active on the dry soil surface during the summer only during the early hours of the morning or in the late hours of the evening, we chose to start collecting around 7:30 am. A total of 50 randomly located samples were collected during the first sweep at each of the plots, and a total of 100 random samples were collected during the second and third sweeps. The samples were collected within the plot every ten steps, and turning in a different

Table 2. Average dry weight and the area covered for the five type of baits.

Type of Bait	Average Dry Weight (g)	Area Covered (cm)
Artificial Baits		
Cardboard blocks	50	121
Toilet paper	225	95
Natural Baits		
Fluff grass	38	123
Small dung	22	31
Large dung	77	123
Yucca stalks	23	80 - 120

direction at random after each sample. The sample was placed on the sieve and inspected for the presence of termites. If termites were present, the sample was placed inside a resealable plastic bag.

Species Identification: The termites were identified to species based on morphology of the mandibles of the soldiers using Weesner (1965). Only nine soldiers were collected out of 1,988 specimens. The only species identified at the three sites was *Gnathamitermes tubiformans*, (Buckley) however, *Amitermes wheeleri* (Desneux) may be present (Ettershank *et al.* 1980).

RESULTS AND DISCUSSION

Artificial Baits

Cellulose baits, such as rolls of toilet paper, have been used in the past to estimate relative consumption rates (Johnson & Whitford 1975), species diversity and species frequency (Abensperg-Traun 1993), population density (Nash & Whitford 1995), and termite foraging behavior and spatial distribution (La Fage *et al.* 1973; Haverty *et al.* 1976). Since termites have a strong affinity for cellulose, rolls of toilet paper have been used to measure foraging populations of subterranean termites (Sheppe 1970; Spears *et al.* 1975; Haverty *et al.* 1976; Ueckert 1976; Ferrar 1982). The limitations of the baits depend on a variety of factors, such as the number of samples in a plot, availability of natural bait in the area, and disturbance by wildlife and cattle (La Fage *et al.* 1973; Johnson & Whitford 1975; Haverty *et al.* 1976; Schaefer & Whitford 1981; Ferrar 1982; Nutting *et al.* 1987; Abensperg-Traun 1993; Nash & Whitford 1995). Corrugated cardboard placed inside of PVC pipes has also been used to trap large numbers of termites to estimate colony or foraging group size (LaFage *et al.* 1983). Other methods of using cellulose, such as wooden stakes, wooden blocks, and sawdust (Sands

1972; Su & Scheffrahn 1986; and Abensperg-Traun 1993), circular quadrats (Haverty & Nutting 1975b; Buxton 1981a; Abensperg-Traun 1993), and fir wood blocks (La Fage 1973) have also been used in the study of termites and have proven to be very effective. The greatest limitation of these methods is that they require long periods of time to detect termite activity.

Cardboard Blocks: All of the 144 samples that were originally set up were recovered from the three sites. The highest number of samples attacked by termites was in the slightly disturbed plot. Only one sample was attacked at the heavily disturbed plot, and none of the samples at the moderately disturbed plot showed evidence of termite activity (Table 3). A total of 45 hours were required to prepare, set up and process all 144 cardboard samples. The cardboard block method proved to be a very ineffective method, as an average 6% of the samples were attacked at the three study sites. There are several possible reasons for the results. Even though cardboard does contain cellulose, the construction of the sheets may not provide termites with the moisture and protection that they need during the hot summer days in the desert. Another possible reason is that the blocks were not held in place firmly, and natural events such as strong winds, heavy rains, and wildlife activity in the plot disturbed the cardboard.

Rolls of Toilet Paper: The moderately disturbed and the heavily disturbed plots had the most number rolls attacked. Only one sample showed evidence of the presence of termites at the slightly disturbed plot. A total of 44 hours was required to prepare, set up and process 144 rolls of toilet paper. The roll of toilet paper method showed a higher percentage of termite activity at the three study sites than the cardboard block method. The method proved to work well, despite pack rat (*Neotoma* sp.) disturbance, and removal of the aluminum foil covers from a large number of samples (slightly disturbed 63%, moderately disturbed 40% and heavily disturbed 83%).

Natural Baits

Fluff grass is abundant in the desert and has been used as a natural bait in soil pits to predict the effects of soil moisture and soil temperature on termite activity (MacKay *et al.* 1986). *Gnathamitermes tubiformans* has a strong attraction to fluff grass (Whitford 1982; Silva *et al.* 1985; Silva *et al.* 1989). Natural baits have also been found to be very effective, for example: cattle dung has been used to investigate the mechanism used by subterranean termites to locate food (Ettershank *et al.* 1980), and the foraging activity of termites (Johnson & Whitford 1975).

The greatest limitation in both of these cases, is the lack of quanti-

Table 3. Results of baits attacked by termites on samples at the slightly, moderately and heavily disturbed sites.

Type of Bait	Total Samples set up	Total samples collected	Number Samples attacked	Average %
SLIGHTLY DISTURBED				
Artificial Baits				
Cardboard blocks	48	48	7	15
Toilet paper	48	48	1	2
Natural Baits				
Fluff grass	48	48	14	29
Small dung	48	46	36	78
Large dung	48	46	46	100
Yucca stalks	48	45	31	69
MODERATELY DISTURBED				
Artificial Baits				
Cardboard blocks	48	48	0	0
Toilet paper	48	48	11	23
Natural Baits				
Fluff grass	48	48	3	6
Small dung	48	32	12	38
Large dung	48	45	34	76
Yucca stalks	48	48	45	94
HEAVILY DISTURBED				
Artificial Baits				
Cardboard blocks	48	48	1	2
Toilet paper	48	48	10	21
Natural Baits				
Fluff grass	48	46	26	57
Small dung	48	37	27	73
Large dung	48	45	31	69
Yucca stalks	48	48	7	15

tative information on the composition, density, moisture content and dimensions of the dung patches. Without this information it is not possible to make an accurate assessment for the preference for one patch over another by the termites. Johnson & Whitford (1975) have also used soap-tree yucca stalks to measure termite activity. There are a few limitations involved with soap-tree yucca stalks, the most important being that the cylindrical bait does not provide a large surface area in contact with the soil to promote the construction of gallery, resulting in a reduced estimate of termite activity (Johnson & Whitford 1975).

Fluff Grass Pits: Two samples were lost from the heavily disturbed site. A total of 287 hours were required to prepare, set up and process 144 grass samples. This method proved to be effective in attracting termites (Table 3), and can be recommended for use in future studies of termites, although it is very labor intensive. This method presents a number of limitations, the most important being the loss of litter due to handling, to natural elements such as wind and rain and to animals that inhabit the area.

Cattle Dung (Small & Large): Eighty seven percent of dung patches were recovered. Of these, 74% showed evidence of termite activity (Table 3). Attack rates were higher at all three sites and sample recovery was higher at two of the three sites for large samples. This suggests that large (12.5 cm diameter) dung samples are more effective than small dung samples (6.25 cm diamter). A total of approximately 25 hours was required to prepare, set up, and process 288 cattle dung samples. The cattle dung method is the most efficient in estimating termite activity, and the second most cost effective based on the total number of hours required to process the samples. The baits can be examined for evidence of termites by simply breaking the bait open in the field. Once the data are recorded, the dung sample can remain in the field.

Soaptree yucca stalk method: All of the 144 samples set up were recovered at the end of the study period. The moderately disturbed plot had the highest number of samples attacked by termites, and the heavily disturbed plots had lowest (Table 3). A total of 30 hours was required to prepare, set up and process all the yucca stalks. The yucca stalk method proved to be effective, and it proved to be not only efficient in estimating termite activity, but also was the second least labor intensive after cattle dung.

Litter Sweeps Method: A total of 13 litter samples with termites were collected from the three sites out of 750 litter sweeps. Only six litter samples from the heavily and the slightly disturbed plots had termites. Only one litter sample from the moderately disturbed plot had termites. Approximately 15 hours were required to collect and inspect 750 sweeps. The litter sweeps method proved to be the least effective in identifying the presence of termites. Litter sweeps may work very well in areas where vegetation is abundant, but not in desert habitats where litter accumulation is scarce on the surface, except under shrubs. This method, however, was the most cost effective of all six methods.

CONCLUSIONS

The six methods compared in this study showed different patterns across the three sites. Based on the overall results, it was determined that the natural baits were attacked more than the artificial baits. The response of termites to natural baits may be due to the fact that the baits were not mechanically and chemically processed like cardboards and rolls of toilet paper. We recommend the use of cattle dung as it was the most efficient as well as one of the most cost effective of the methods.

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