Foraging Population and Territory of the Formosan Subterranean Termite (Isoptera: Rhinotermitidae) in an Urban Environment

by

Nan-Yao Su and Rudolf H. Scheffrahn[1]

ABSTRACT

Foraging populations of the Formosan subterranean termite, *Coptotermes formosanus* Shiraki, were determined using a multiple mark-release regime with a weighted mean method. The estimated foraging populations of seven *C. formosanus* colonies were 1.4 to 6.8×10^6 per colony. Foraging territories, occupying soil beneath concrete and asphalt pavement, encompassed from 162 to 3,571 m^2 per colony . A single colony may infest several multi-storied buildings within its foraging range.

INTRODUCTION

Subterranean termites include species of great economic importance. Of the $580 million spent on termite control in nine southeastern states of the United States in 1983, subterranean termites accounted for a $474 million share (Hamer 1985). Unlike mound-building termites whose nests are highly visible, subterranean species nest and forage underground. Census of excavated nests have been conducted to estimate population size of mound-building (Holdaway et al. 1935, Gay & Greaves 1940, Rohrmann 1977) and subterranean termites (Anonymous 1979, Howard et al. 1982). Excavation methods destroy termite nests, making it impossible to continuously monitor the population dynamics of the colony.

One alternative to destructive sampling is mark-recapture estimation (Baroni-Urbani et al. 1978). Mark-recapture sampling was used by Lai (1977) and Su et al. (1984) for the Formosan subterranean termite, *Coptotermes formosanus* Shiraki, and by Esenther (1980) for the eastern subterranean termite, *Reticulitermes flavipes* (Kollar). Their reliance on the simple Lincoln index, coupled with small (ca. 0.1%) marked proportions of the

[1]Fort Lauderdale Research and Education Center, University of Florida, IFAS, 3205 College Ave., Ft. Lauderdale, FL 33314

field population resulted in large variations in estimates. It should also be noted that only the foraging population can be sampled when the mark-recapture method is applied to social insects (Ayre 1962).

Foraging territories of subterranean termites have been mapped by the direct excavation (Ratcliffe & Greaves 1940, King & Spink 1969) or by tracing radioisotope-labeled foragers in their galleries (Li et al. 1976, Spragg & Paton 1980). Neither method is suitable for studying *C. formosanus* in densely populated urban environments where nests and foraging mainly occur under concrete slabs, asphalt pavement, and within the habited structures.

In this study we used a modified version of a baiting method (Su & Scheffrahn 1986), initially developed by Tamashiro et al. (1973) and La Fage et al. (1973) to examine the foraging populations and territories of Formosan subterranean termite colonies in an urban setting.

MATERIALS AND METHODS

A stake survey was conducted from April 1985 to July 1987 in a ca. 800,000-m^2 area of southeastern Broward County, FL (Fig. 1). Surveyed ground surrounded multi-storied (4-20) buildings and was extensively covered by concrete or asphalt. Wooden (*Picea* sp.) stakes were driven into soil in lawns and planters. Infested stakes were replaced by underground traps (Su & Scheffrahn 1986).

After a number of bait stations were established, a multiple mark-release program was conducted to estimate foraging territories and populations of *C. formosanus* colonies. Workers collected from a bait station were force-fed filter paper stained with 1% (wt./wt.) Sudan Red 7B (Lai et al. 1983) for ten days, then released to the same station. Seven days after the release, active traps in the vicinity were brought to the laboratory. Termites collected from the stations containing marked individuals were considered nestmates of the first released termites, and were stained for another ten days before being released to their respective stations. Three mark-release-recapture cycles, which required 41 days after the first release, were carried out for each colony. Our previous study indicated that *C. formosanus* retained the marking for at least 42 days after being stained with 1% dye for ten days (Su et al., in press). Traps in the vicinity (within 150m radius) were not surveyed within two months after the completion of the first census program to ensure all stained termites had lost the marking before the new mark-release cycle began.

Foraging territory of a colony was defined as the area encompassed by the stations containing marked termites during the three mark-release cycles. The weighted mean method (Begon 1979), which increases the estimate accuracy by adding more weight to the Lincoln index derived from the larger marked proportion, was used to determine the foraging populations of *C. formosanus* colonies. Mean worker biomass was determined by weighing five groups of ten individuals each. Foraging biomass was calculated as the product of mean worker weight and foraging population.

RESULTS AND DISCUSSION

Mark-release studies indicate the presence of seven colonies (A-G) within the survey area (Fig. 1). Foraging populations ranged from 1.4 to 6.8x10^6 workers per colony (Table 1). Standard errors of the estimates were ca. 6 to 13%, considerably smaller than those reported by Esenther (1980) who used the simple Lincoln index to assess populations of *R. flavipes* colonies.

Our population estimates were comparable to those reported previously for *C. formosanus* using the mark-recapture method (Lai 1977, Su et al. 1984), but were ca. 10-fold larger than those obtained by direct counts of excavated nests (Anonymous 1979). Lincoln index estimates for *R. flavipes* colonies were ca. 1 to 3x10^6 individuals (Esenther 1980), also ca. 10-fold larger than a direct count of this species (Howard et al. 1982). Darlington (1984) reported that counts of *Macrotermes* spp. in mounds excavated while termites were alive underestimated the population by up to an order of magnitude when compared to results obtained from counting dead termites in fumigated nests. The disruptive direct counts of *C. formosanus* and *R. flavipes* colonies may have presented an analogous problem. The gallery system of *C. formosanus* comprises a main nest interconnected with satellite nests by runways extending up to 100m (King & Spink 1969, Li et al. 1976). A direct count of *C. formosanus* populations is, therefore, not feasible.

Our estimates of *C. formosanus* populations (Table 1) were slightly greater than the following population estimates of mound-building species; 0.75 to 1.8x10^6 for *Nasutitermes exitiosus* (Hill) (Holdaway et al. 1935), 0.6 to 1.1x10^6 for *Coptotermes lacteus* (Frogg.) (Gay & Greaves 1940), and 1.4x10^6 for *Macrotermes subhyalinus* (Rambur) (Darlington 1984). *C. formosanus* colonies contained considerably larger populations than other subterranean species, estimated to be ca. 20,000 for *Heterotermes aureus* (Snyder) (Haverty et al. 1975), ca. 200,000 for *R. flavipes* (Howard et al. 1982), ca. 19,000 for a *Microcerotermes*

Table 1. Foraging populations of seven *C. formosanus* colonies in southeastern Broward County, FL, estimated by a multiple mark-release method, and associated foraging territories and biomasses.

Col.	Worker* Weight (mg, X±SE)	Number of Traps	Estimated Foraging Population (x 10^6, X±SE)	Maximum** Dist. (m)	Foraging Territory (m^2)	Foraging*** Biomass (kg)
A	5.0±0.4	15	6.86±0.67	115	3,571	34.3
B	4.2±0.3	8	2.05±0.16	111	2,221	8.6
C	3.9±0.5	3	3.98±0.55	106	-	15.5
D	3.4±0.2	7	3.65±0.46	56	967	12.4
E	2.8±0.1	7	1.61±0.13	63	1,355	4.5
F	3.5±0.5	5	3.04±0.18	50	438	10.6
G	4.5±0.3	11	1.44±0.97	43	162	6.5

* Means of five groups of ten individuals each.
** Linear distance between two furthest traps.
*** Mean worker weight x population number.

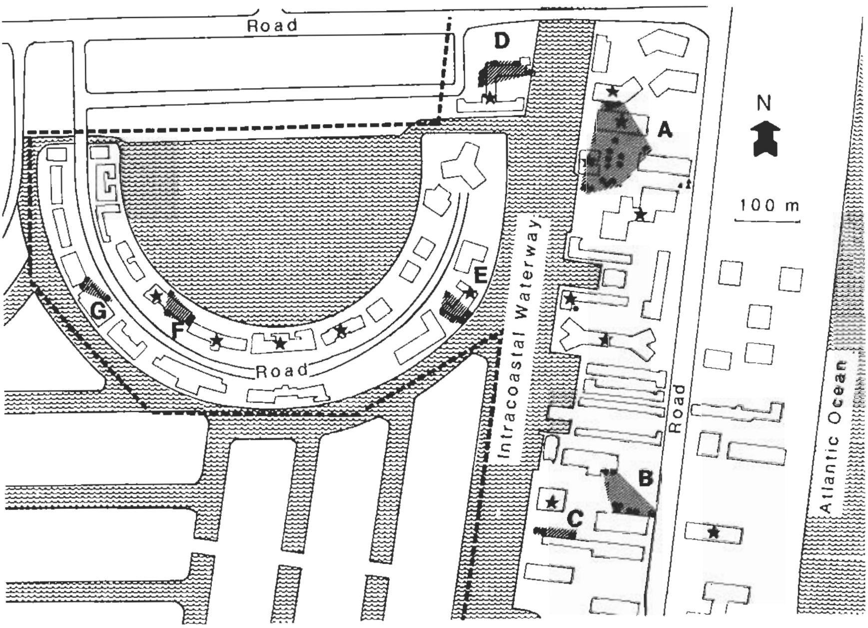

Fig. 1. Seven colonies (A-G) of *C. formosanus* in an urban site of ca. 800,000 m² (east of the broken line) studied for their foraging territories and populations. Stars denote buildings with previous structural infestations by *C. formosanus* and subsequent soil-termiticide treatments beneath the buildings. Solid circles (one circle may represent more than one trap) and triangles indicate active traps occupied by *C. formosanus* and *R. flavipes*, respectively, during the study.

sp., and ca. 50,000 for a *Microtermes* sp. (Badawi et al. 1984). Only *Mastotermes darwinensis* (Frogg.) has been reported to have colony populations (up to $7x10^6$) comparable to *C. formosanus* (Spragg & Paton 1980).

Live biomasses of the foraging populations of the seven *C. formosanus* colonies were between 4 and 34kg (Table 1), which is substantially larger than the reported foraging population biomass (1.4kg) of *Hospitalitermes umbrinus* (Haviland) (Collins 1979), but probably comparable to *Macrotermes* spp. and smaller than *M. darwinensis* due to the individual worker biomass of these large species.

C. formosanus is known to forage across a distance of up to 100m (King & Spink 1969, Lai 1977, Li et al. 1967). Our results confirm these earlier observations (Table 1). Ratcliffe & Greaves (1940) reported that *C. lacteus* forage up to 46m from the nest, with foraging territory occupying ca. 6,000 m^2 in a semi-arid environment. The recorded foraging territories of several subterranean species include $12.5m^2$ per colony for *H. aureus* (Haverty et al. 1975), and ca. $31.8m^2$ and $18.2m^2$ per colony for *Microcerotermes* and *Microtermes* spp., respectively (Badawi 1984). The observed foraging gallery lengths of >90m for *M. darwinensis* (Hill 1942) suggests this species has a foraging territory comparable to *C. formosanus*. The largest colony in our study (colony A) occupied ca. $3,500m^2$ under the predominantly man-made surfaces such as concrete and asphalt pavement (Table 1).

In this study we show that *C. formosanus* colonies maintain extensive foraging territories and populations in an urban ecosystem. A single colony may infest several multi-storied buildings within its foraging range. Records showed that soil beneath infested buildings (indicated by stars, Fig. 1) near colonies A, D, E, and F were treated with soil termiticides such as chlordane or chlorpyrifos. We did not notice any decline in colony foraging activities after these treatments. These results confirm previous speculation (Su et al. 1984) that conventional soil treatments provide only exclusion of existing colonies. The source of infestation remains viable in the vicinity of the structures even after soil-termiticide treatment. Reinfestations and occurrences of aerial infestations have been recorded from some structures in our study site.

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