Abundance and Distribution of Subterranean Termites in Southern Mississippi Forests (Isoptera: Rhinotermitidae)

by

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ABSTRACT

Termites were surveyed in pine and mixed forests in 4 southern Mississippi counties during 1999-2000. Branches, logs, and stumps in eleven plots were examined for termite activities. Pine stakes were installed in soil plots at 5 m intervals. They were examined for signs of termite infestation and foraging termites at 4.5, 10.5, and 16 months after installation. Three subterranean termite species in the family Rhinotermitidae, namely, *Reticulitermes flavipes* (Kollar), *Reticulitermes virginicus* Banks, and *Reticulitermes hageni* Banks were observed from dead wood materials and the installed pine stakes in each of the 4 counties. *Reticulitermes flavipes* was the most abundant species with an average percentage from 39.4% to 66.5% of the termite occurrences in pine stakes installed in the forests. There was not a detectable significant difference between the relative abundances of the three termite species among the 4 counties ($P > 0.05$). Termite infestation rates varied with the sizes of the wood materials. The small wood materials (1.9-2.9 cm diameter) had a significantly lower infestation rate than the larger wood materials (≥ 3 cm diameter). Among the wood materials of ≥ 3 cm diameter, 68.2% to 79.6% had signs of termite damage and 29.5% to 39.9% had foraging termites. The cumulative percentage of stakes attacked by termites escalated as the duration of the stakes after installation increased. The average percentages of stakes with signs of termite activity were 44.4%, 64.2%, and 80.5% at 4.5, 10.5, and 16 months after installation, respectively. The average percentages of stakes with foraging termites were 32.7%, 35.8%, and 47.7% at 4.5, 10.5, and 16 months after installation, respectively.

Key Words: *Reticulitermes flavipes*, *Reticulitermes virginicus*, *Reticulitermes hageni*, wood infestation.

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INTRODUCTION

Termites are ubiquitous insects in tropical and subtropical regions and play an important role in ecosystems (Wood & Sands 1978). Their diversity and abundance become less prominent as the latitude increases. Many studies have documented their abundance and diversity in tropical regions (Wood & Sands 1978). However, there is much to be learned and understood about the termite fauna and their abundance in subtropical and warm temperate areas.

In the state of Mississippi, 61.0% of the land is covered by forests, of which 48.4% are pine or pine-oak mixed forests and 51.6% are hardwood forests (http://www.msforestry.net/forestryfacts.html). Previous studies have indicated that termites were common wood feeders in Mississippi forests (Howard *et al.* 1982, Wang & Powell 2001). Four subterranean termite species, e.g., *Reticulitermes flavipes* (Kollar), *R. virginicus* (Banks), *R. hageni* Banks, and *Coptotermes formosanus* Shiraki, have been recorded from Mississippi (Snyder 1954, Su & Scheffrahn 1986). *Reticulitermes flavipes* and *R. virginicus* were commonly found in Mississippi forests. *Coptotermes formosanus* is mainly found in coastal counties but is spreading northward from the coast (Carroll *et al.* 2001). It has been found around residential areas, parks, and forests immediately surrounding infested buildings. There have been no comparative studies on termite fauna and occurrence in various regions in Mississippi. In an effort to understand the termite species diversity, abundance, and distribution in southern Mississippi, we investigated termites in 4 counties in Mississippi from June 1999 to October 2000. Here we report our results on termite fauna and their occurrence patterns over time in pine and mixed forests in southern Mississippi.

MATERIALS AND METHODS

Selection of study plots and installation of pine stakes

Four counties were selected in this study: Pearl River, Harrison, Stone, and Hancock counties (Fig. 1). *Coptotermes formosanus* infestations in Pearl River, Harrison, and Hancock counties have been recorded based on results from sticky trap collections during the alate swarming season in 2000 (Carroll *et al.* 2001). In each county, three 30 × 40 m plots (2 plots in Stone county) were selected and marked out. They were loblolly pine (*Pinus taeda* L.), longleaf pine (*P. palustris* Mill.), or mixed forests of at least 20 years of age (Table 1). There were abundant snags, branches, and some logs and stumps in the stands except for plot 3 in Hancock county, which had much less wood material on the ground than other plots. Forests with extremely dense

shrub coverage were avoided in selection of the study plots for ease of the survey. All of the selected plots were near level or with < 5° slopes. They received controlled burning at various periods in the past. Plots in Pearl River county were burned twice within the last 12 months of the survey of wood materials. The soil type was sandy loam. The distance between plots of the same county varied from 50 m to 3 km.

According to the Köppen climate classification, the entire southeastern U.S., including Mississippi, is humid subtropical (Cfa) (Strahler & Strahler 1992). This is characterized by hot, muggy summers with periodic thunderstorms and relatively mild winters with precipitation distributed evenly throughout the year. Normal weather data of the study plots based on 30-year (1961-1990) data from the nearest 2 weather stations (Poplarville & Saucier), which are within 70 km from the study plots, were as follows: the average high and low temperatures in January were 16.1°C and 4.1°C, respectively; the average high and low temperatures in July were 33.2°C and 21.8°C, respectively; and average annual precipitation was 169.3 cm (http://www5.ncdc.noaa.gov/climatenormals/clim81/MSnorm.pdf).

Survey of termites in branches, logs, and stumps

The survey was carried out during June 10-30, 1999. Branches, logs, and tree stumps of ≥ 1.9 cm diameter within 225-1,200 m^2 of each plot were examined for presence of termites and evidence of termite damage using an axe (Table 1). The areas surveyed in each plot varied because of the variance in abundance of wood materials. Wood materials in Stone county plots were only examined for signs of termite infestation.

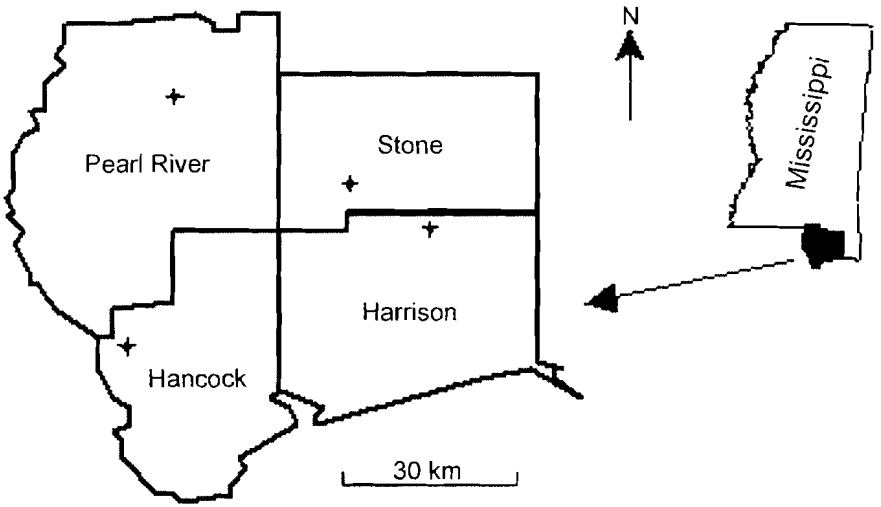

Fig. 1. Map of the study area.

Table 1. Vegetation characteristics of the study plots.

County	Plot	Tree coverage	Major shrubs	Area surveyed for existence of termite activities (m^2)
Pearl River Co.	1	Loblolly pine (95%, DBH[1] 23.2 cm), post oak (*Q. stellata* Wangenh.), water oak (*Q. nigra* L.).	Yaupon (*Ilex vomitoria* Aiton), *Baccharis* sp., winged sumac (*Rhus copallinum* L.), hickory (*Carya* spp.), oaks (*Quercus* spp.), blackberry (*Rubus* spp.).	975
	2	Loblolly pine (95%, DBH 22.5 cm), blackgum (*Nyssa sylvatica* Marshall), water oak.	Chinese privit (*Ligustrum sinense* Lour.), red maple (*Acer ruburum* L.), winged sumac, *Ilex* sp.	600
	3	Loblolly pine (95%, DBH 21.6 cm), blackgum, white oak (*Q. alba* L.), water oak.	*Ilex* sp. winged sumac, blackberry, black cherry (*Prunus serotina* Ehrh.).	225
Harrison Co.	1	Longleaf pine (95%, DBH 11.8 cm), oaks (5%).	*Ilex*, sparkleberry (*Vaccinium arboreum* Marshall), *Ilex* sp., winged sumac.	450
	2	Water oak (40%), longleaf pine, sparkleberry, flowering dogwood (*Cornus florida* L.).	Sparkleberry, huckleberry (*Gaylussacia* sp), *Ilex* sp.	450
	3	Longleaf pine (60%), flowering dogwood, water oak.	Sparkle berry, huckleberry, *Ilex* sp., southern wax myrtle (*Myrica* sp.).	225
Hancock Co.	1	Loblolly pine (50%, DBH 25.3 cm), blackgum (50%, DBH 15.9 cm).	*Smilax* sp., *Ilex* sp.	225
	2	Loblolly pine (95%, DBH 17.2 cm), southern red oak (*Q. falcata* Michaux) (5%).	Yaupon, sparkleberry.	225
	3	Loblolly pine (DBH 10.9 cm).	*Ilex* sp.	1,200
Stone Co.	1	Longleaf pine (DBH 27.0 cm).	*Ilex* sp.	1,200
	2	Longleaf pine (DBH 14.5 cm).	*Ilex* sp., flowing dogwood.	1,200

[1] Diameter at breast height.

The maximum diameter of the wood materials was measured and recorded. Termite infested wood materials typically had galleries or channels and sometimes had soil particles in the channels. Extremely decayed wood materials were not examined. Representatives of the different termite species and species of uncertainty in each county were collected and preserved in 85% ethanol.

Installation and inspection of wood stakes

In each plot, 63 pine stakes (2.5 × 5.1 × 30.5 cm) (#39514, Forestry Supply, Inc., Jackson, MS) were installed with half of their length inserted into soil from June 10 to June 30, 1999. The stakes were arranged in 7 × 9 grids at 5 m intervals, so that there were 7 stakes in a row and 9 stakes in a column and the stakes covered 30 × 40 m in each plot. They were examined carefully on November 3-4, 1999; May 8-9, 2000; and October 10-12, 2000 for signs of termite infestations and existence of termites. The stakes had been installed in the plots for approximately 4.5, 10.5, and 16 months at the time of inspection. On last inspection (October 10-12, 2000), termites from all of the infested stakes were collected and preserved in 85% ethanol for later identification.

Identification of termites

Termite specimens collected from wood materials and infested stakes on last inspection (October 2000) were examined under an Olympus SZX12 dissecting microscope. Soldiers from each sample were measured and were used to determine species identities. Samples without soldiers were not included in the final analysis of species relative abundance. Determination of species was based on the keys by Scheffrahn and Su (1994). Voucher specimens from this study were deposited at the Insect Collection, Fort Lauderdale Research and Education Center, University of Florida, FL 33314, USA.

Statistical analysis

The presence or absence of live termites or signs of termite activity in dead wood materials were recorded as 1 or 0, respectively. The wood materials were grouped into 4 categories according to their size measured at the largest section. The actual diameters of the 4 categories were 1.9-2.9, 3-5.9, 6-8.9, and ≥ 9 cm, respectively. Analysis of Variance (ANOVA) was performed to test for differences in termite infestation rate and percentage of wood materials with foraging termites among counties and categories of the wood materials. Means were compared by Fisher's LSD after a significant ANOVA. One-way ANOVA was also used to analyze differences in species relative abundance among the four counties. Percentage of stakes with signs of

infestation and foraging termites among counties at various inspection periods were analyzed using repeated measures ANOVA. Percentage data were arcsine of the square root transformed before analysis. All analyses were conducted using SAS software (SAS Institute 2000).

RESULTS

Occurrence of termites in wood materials

Three species were found in wood materials, namely, *R. flavipes*, *R. virginicus*, and *R. hageni*. The wood materials were grouped into 4 categories according to their sizes. Percentages of the wood materials with signs of termite infestation and with foraging termites varied significantly with the size of the wood materials (with signs: $F = 7.1$; df = 3, 506; $P < 0.01$; with termites: $F = 4.5$; df = 3, 426; $P < 0.01$). The 1.9-2.9 cm diameter category had a significantly lower termite infestation rate and lower percentage of wood with foraging termites than the larger categories (LSD, $P < 0.05$) (Fig. 2).

The survey of termite infestations in branches, logs, and stumps on the forest floor revealed abundant termite activities (Table 2). The

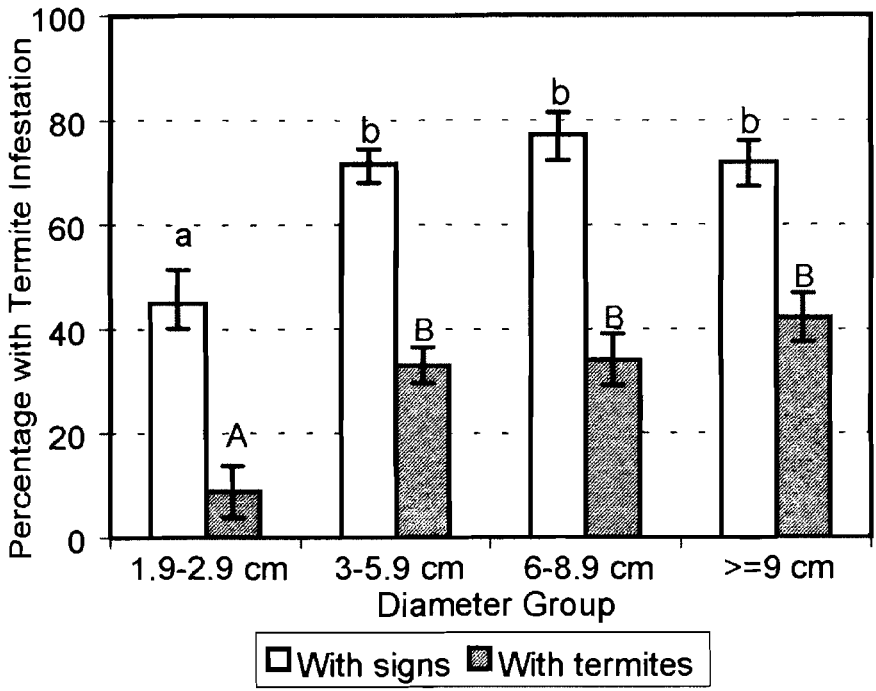

Fig. 2. Association between wood size, termite infestation rate and percentage (mean ± SE) of wood with foraging termites. Bars with different same case letters are significantly different (LSD, $P < 0.05$).

percentage of wood materials ≥ 3 cm diameter with signs of termite infestation ranged from 68.2% to 79.6% among the 4 counties. The percentage of wood materials ≥ 3 cm diameter with foraging termites ranged from 29.5% to 39.9% among the 4 counties. No significant differences were detected in percentages with signs of infestation (F = 1.7; df = 3, 446; P = 0.17) and percentages with foraging termites (F = 1.9; df = 2, 393; P = 0.16) among the counties (Table 2).

Occurrence of termites in wood stakes

A total of 327 of the 693 pine stakes had foraging termites at 16 months after installation. Of the 259 termite collections with soldiers from pine stakes in 4 counties, 3 termite species were found. They were *R. flavipes*, *R. virginicus*, and *R. hageni*. Among the stakes with foraging termites, the percentage of *R. flavipes* varied from 39.4% to 66.5% and it was the most abundant among the 3 termite species (Table 3). There were no detectable differences in relative abundance of *R. flavipes* (F = 1.6; df = 3, 7; P = 0.27), *R. virginicus* (F = 1.1; df = 3, 7, P = 0.43), and *R. hageni* (F = 3.2; df = 3, 7; P = 0.10) among the 4 counties at α = 0.05. However, *R. hageni* was more abundant in Pearl River county plots at α = 0.10.

Table 2. Abundance of termites in wood materials (≥ 3 cm diameter) in four counties of Mississippi.

County	Number of wood materials examined	Percentage with signs of termite infestation[1]	Percentage with foraging termites[1]
Pearl River	158	77.2 ± 3.3a	39.9 ± 3.9a
Harrison	129	68.2 ± 4.1a	29.5 ± 4.0a
Hancock	109	68.8 ± 4.5a	38.5 ± 4.7a
Stone	54	79.6 ± 5.5a	Not recorded

[1] Mean ± SE; means within a column followed by same letters are not significantly different (P > 0.05)

Table 3. Termite species distribution in wood stakes in four counties of Mississippi.

County	Number of wood stakes with termites[1]	Percentage of *R. flavipes*[2]	Percentage of *R. virginicus*[2]	Percentage of *R. hageni*[2]
Pearl River	89	39.4 ± 6.4a	34.8 ± 4.3a	25.8 ± 9.7a
Harrison	66	49.0 ± 11.3a	48.0 ± 12.2a	3.0 ± 1.5a
Hancock	40	66.5 ± 9.8a	28.5 ± 9.4a	5.0 ± 5.0a
Stone	63	47.7 ± 5.8a	45.9 ± 5.9a	6.4 ± 0.1a

[1] Stakes without termite soldiers were not included.

[2] Mean ± SE; means within a column followed by same letters are not significantly different (P > 0.05)

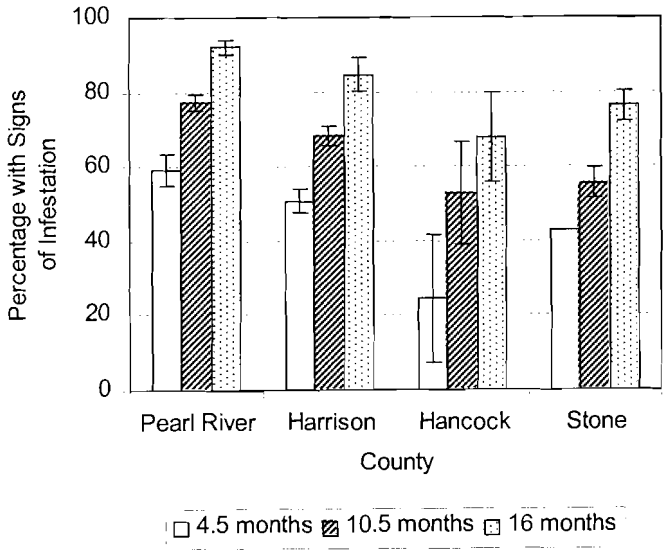

Fig. 3. Temporal changes in termite infestation rate (mean ± SE) in pine stakes.

The cumulative percentage of stakes infested by termites escalated as the age of the stakes increased ($F = 40.1$; df = 1, 25; $P < 0.01$) (Fig. 3). The average percentages of the infested stakes were 44.4%, 64.2%, and 80.5% at 4.5, 10.5 and 16 months, respectively. The percentage of stakes with foraging termites also increased as the age of the stakes increased ($F = 13.3$; df = 1, 25; $P < 0.01$) (Fig. 4). The average percentages of the stakes with foraging termites were 32.7%, 35.8%, and 47.7% at 4.5, 10.5, and 16 months, respectively. This increase was not as obvious as that of the percentage of wood materials with signs of termite infestations.

DISCUSSION

The percentage of wood materials or wood stakes with signs of termite infestation was much greater than that with foraging termites. This might be related to the termite foraging behavior, change in suitability of wood materials for termite foraging, and other factors such as weather and predators. Because of the small size of wood materials and the stakes, termites might not stay inside the wood materials at the time of examination. We found that some of the branches previously fed upon by termites were occupied by imported fire ant (*Solenopsis invicta* Buren). Some branches were nearly hollowed out by termites and were no longer moist enough for termites to feed on.

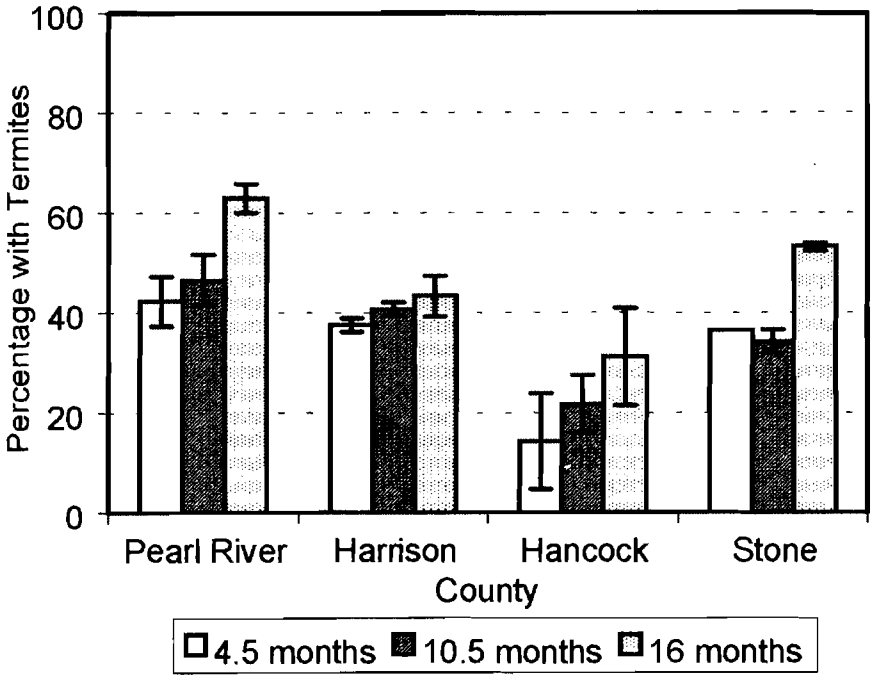

Fig. 4. Temporal changes in percentage (mean ± SE) of stakes with foraging termites.

The survey of logs (> 10 cm diameter) by Howard *et al.* (1982) also indicated a slightly higher number of *R. flavipes* than *R. virginicus* colonies in longleaf pine stands in Harrison county. Surveys by Wang and Powell (2001) and Gentry and Whitford (1982) indicated a variable proportion of *R. flavipes* in southern forests.

In this study, the termite infestation rates in branches, logs, and stumps were similar to that in wood stakes at 16 months after installation. Jones *et al.* (1995) found 75% of the wood pieces in forests were infested by termites on Mona Island (18°N, 67°W). Gentry and Whitford (1982) reported a 90% termite attack rate to preconditioned pine blocks buried in soil for 7 months in longleaf pine forests 40 km SE of Aiken, SC. These numbers demonstrated the abundance of termites in the forests. *Coptotermes formosanus* was not found in this survey. Based on its ecology in its native country (China), we expect that it is very likely to occur in these forests in the future. The speed of wood material removal by termites in southern U.S. forests is poorly known (Gentry & Whitford 1982). The high percentage of infested wood materials in these forests indicates that termites may have a dominant role in wood decomposition in southern U.S. forests where termites are

abundant.

ACKNOWLEDGMENTS

We would like to thank Fannie Williams and Ben Hailey for their assistance in field work; and Weste Osbrink, M. Guadalupe Rojas, and Maureen Wright for review of the manuscript. This research is supported by USDA Agricultural Research Service.

REFERENCES

Carroll, J.B., C.Z. Holloman, J.E. Powell & J.L. Etheridge 2001. Formosan termite infestation in south Mississippi. The Entomological Society of America 2001 Annual Meeting. http://esa.confex.com/esa/2001/techprogram/programs.htm (Abstract only).

Gentry, J.B. & W.G. Whitford 1982. The relationship between wood litter infall and relative abundance and feeding activity of subterranean termites *Reticulitermes* spp. in three southeastern coastal plain habitats. Oecologia. 54: 63-67.

Howard, R.W., S.C. Jones, L.K. Mauldin & R.H. Beal 1982. Abundance, distribution, and colony size estimates for *Reticulitermes* spp. (Isoptera: Rhinotermitidae) in southern Mississippi. Environ. Entomol. 11: 1290-1293.

Jones, S.C., C.A. Nalepa, E.A. McMahan & J.A.Torres 1995. Survey and ecological studies of the termites (Isoptera: Kalotermitidae) of Mona Island. Florida Entomol. 78: 307-313

SAS Institute. 2000. SAS OnlineDoc™, Version 8. SAS Institute, INC. Cary, NC.

Scheffrahn, R.H. & N-Y. Su 1994. Keys to soldier and winged termites (Isoptera) of Florida. Florida Entomol. 77: 460-474.

Snyder, T.E. 1954. Order Isoptera - The termites of the United States and Canada. National Pest Control Association. New York. 64 pp.

Strahler, A.H. & A.N. Strahler 1992. Modern physical geography. 4th edition. John Wiley & Sons. New York, NY. 320 pp.

Su, N-Y. & R.H. Scheffrahn 1986. The Formosan subterranean termite, *Coptotermes formosanus* (Isoptera: Rhinotermitidae), in the United States 1907-1985. pp 31-38. *In:* Proceedings of the National Conference on Urban Entomology. University of Maryland, College Park, MD.

Wang, C. & J.E. Powell 2001. Survey of termites in the delta experimental forest of Mississippi. Florida Entomol. 84: 222-226.

Wood, T.G. & 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.