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SURVEY AND ECOLOGICAL STUDIES OF THE TERMITES (ISOPTERA: KALOTERMITIDAE) OF MONA ISLAND

SUSAN C. JONES[1]
Southern Forest Experiment Station
P. O. Box 2008 GMF
Gulfport, MS 39505

CHRISTINE A. NALEPA
Entomology Department
North Carolina State University
Raleigh, NC 27695

ELIZABETH A. MCMAHAN
Department of Biology
University of North Carolina
Chapel Hill, NC 27599

JUAN A. TORRES
International Institute of Tropical Forestry
Call Box 25000
Río Piedras, PR 00928
and
Department of Biology
Bayamón Technological University College
Bayamón, PR 00959

ABSTRACT

A survey of eight sites on Mona Island revealed four termite species in the family Kalotermitidae: *Incisitermes* nr. *bequaerti* (Snyder), *I.* nr. *incisus* (Silvestri), *Neotermes mona* (Banks), and *Procryptotermes corniceps* (Snyder). *Incisitermes* nr. *bequaerti* is a new record for the island. Identifiable wood hosts are reported. All species were found in dead wood, which is typical of drywood termites, but *N. mona* and *P. corniceps* were also collected from live wood. Examination of dead wood in three 9.3 m^2 plots in a dense stand of *Leucaena leucocephala* (Lam.) de Wit. revealed that an average of approximately three-quarters of the wood pieces were attacked by termites. Although the total volume of dead wood was almost six times greater in Plot 1 than in the other two plots, the number of termites per unit volume of dead wood was very similar (0.4 per cm^3). Total numbers of individuals per colony ranged from 11 to 3,359 termites. Caste composition is reported for each colony, and large variations among colonies were noted. Alates as well as eggs were more common in larger colonies. Soldier percentages ranged from 0.7% to 20.5% in 16 *P. corniceps* colonies. The largest colonies occurred when the greatest volume of dead wood was available.

Key Words: Caste, colony size, subtropical dry forest, West Indies, wood decomposition.

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[1]Current address: P.O.Box 58417, Salt Lake City, Utah 84158

RESUMEN

Un muestreo de ocho sitios en la Isla Mona reveló cuatro especies de termitas de la familia Kalotermitidae: *Incisitermes* nr. *bequaerti* (Snyder), *I.* nr. *incisus* (Silvestri), *Neotermes mona* (Banks), y *Procryptotermes corniceps* (Snyder). *Incisitermes* nr. *bequaerti* es un nuevo registro para la isla. Son reportadas las maderas hospedantes. Todas las especies fueron encontradas en madera muerta, lo cual es típico para las termitas de madera seca, pero *N. mona* y *P. corniceps* fueron también colectados en madera viva. El exámen de la madera muerta en tres parcelas de 9.3m^2 en un denso grupo de *Leucaena leucocephala* (Lam.) de Wit. reveló que un promedio de aproximadamente tres cuartos de los pedazos de madera estaban atacados por las termitas. A pesar de que el volumen total de madera muerta fué casi seis veces mayor en la parcela 1 que en las otras dos, el número total de termitas por unidad de volumen de madera muerta fue muy similar (0.4/cm^3). El número total de individuos por colonia varió de 11 a 3359 termitas. La composición de las castas es reportada para cada colonia. Fueron observadas grandes variaciones dentro de las colonias. Los porcentajes de soldados variaron de 0.7 a 20.5% en 16 colonias de *P. corniceps*. Las mayores colonias fueron encontradas cuando el mayor volumen de madera muerta era disponible.

Mona Island is a 55 km^2 limestone plateau that rises 60 to 100 m above sea level in the Mona Passage between the Caribbean islands of Puerto Rico and Hispaniola. It has no permanent settlements and, since 1973, has been under the administration of the Puerto Rican Department of Natural Resources, which has emphasized the value of Mona Island as a wilderness and research site. An overview of the history, geography, and ecology of Mona Island is provided by Cintrón (1991). The vegetation of Mona Island, which belongs within the subtropical dry forest life zone, is described in Cintrón & Rogers (1991).

A main purpose of this study was to continue a survey of the termites of Mona Island begun in the early 1990's by Jones (1991). It is the first since Ramos' (1946) extensive survey of the insects of Mona Island in 1935 and 1944. Three of the four termite species he collected were identified by A. E. Emerson as *Incisitermes snyderi* (Light), *Neotermes mona* (Banks), and *Procryptotermes corniceps* (Snyder). The identity of the fourth species was tentatively given as *I. incisus* (Silvestri), but Emerson noted that he could not be certain because he had not examined the type specimens.

Incisitermes snyderi is distributed extensively, not only in the West Indies, but also in Mexico and the southern United States (Scheffrahn et al. 1994, Snyder 1956, Weesner 1965). *Incisitermes incisus* is reported from Barbados, Dominica, Guadeloupe, Montserrat, Puerto Rico, and the Virgin Islands (British: Beef, Eustatia, Guama, Virgin Gorda; U.S.: St Croix) (Snyder 1956, Scheffrahn et al. 1994).

Procryptotermes corniceps, the only Neotropical representative of this genus, is reported from many islands in the West Indies (Scheffrahn et al. 1994). It is listed as the most common kalotermitid in natural vegetation on Providenciales and Grand Turk Islands in the British West Indies (Scheffrahn et al. 1990). The original description of *N. mona* was by Banks (1919) from soldiers collected on Mona Island, which remained for several decades the species' only reported locality (Ramos 1946, Snyder 1956). *Neotermes mona* is now known to be common on Providenciales and Grand Turk Islands (Scheffrahn et al. 1990), and it also has been reported from the Dominican Republic (Hispaniola) and Guana (British Virgin Islands) (Scheffrahn et al. 1994).

The four termite species found on Mona Island are drywood termites belonging to the primitive family Kalotermitidae. Colonies live within their food sources of dry

wood, chiefly dead branches and tree trunks. They do not require contact with the soil for moisture. Rather, the termites obtain water as a metabolic by-product of cellular metabolism and also from external water and, possibly, living plant tissue. Colonies consist of a pair of primary reproductives (king and queen) or replacement reproductives, soldiers, nymphs, pseudergates, larvae, and eggs. Winged imagoes (alates) may be produced and, if so, they swarm seasonally to establish new colonies. Mature dry-wood colonies generally do not exceed a few thousand individuals (Nutting 1969, Lenz 1994). Because of their habit of living within dry wood and their relatively small colony sizes, it is possible to collect entire colonies. This made it feasible to collect entire colonies on which to base the other major purposes of this study, which were to determine: kalotermitid colony size, caste composition, and the relationship between the number of termites and available dead wood volume.

MATERIALS AND METHODS

Survey

Our survey of the termites of Mona Island was conducted from March 24 through 30, 1993. We intensively sampled in the vicinity of eight collection sites including the airstrip, Carabinero Beach, El Faro, Pájaros Beach, Sardinera Beach, Uvero Beach, Vereda del Centro, and Vereda India (Fig. 1). These sites were selected because of ease of access via roads or trails.

Termites were removed from standing or fallen dead wood using hatchets, wood chisels, saws, and forceps. Groups of termites with representative castes were placed in vials containing 85% ethanol. We collected soldiers and pseudergates, and alates if available. The host plant was identified whenever possible using keys and figures in Little & Wadsworth (1964) and Little et al. (1974); we also relied on local expertise.

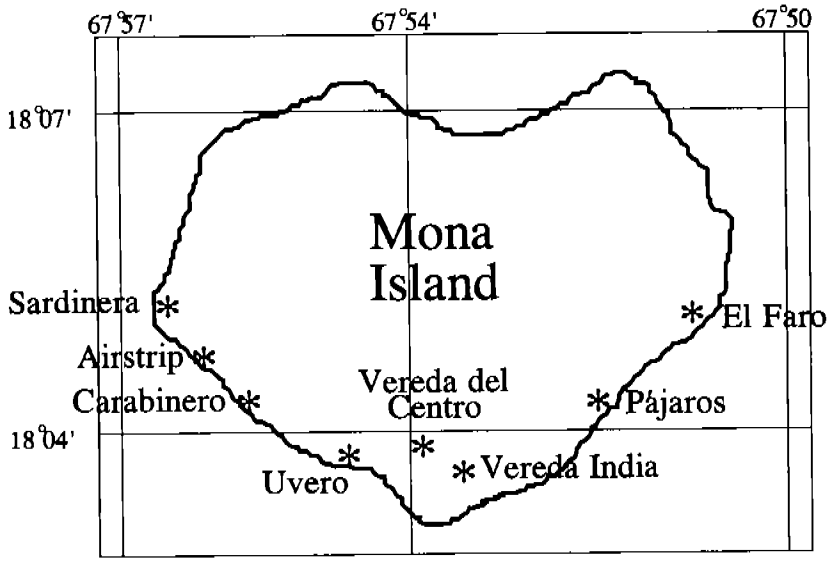

Fig. 1. March 1993 termite collection sites (*) on Mona Island.

Termites were identified to species with the aid of taxonomic keys (Banks 1919, Snyder 1956). A majority of determinations were verified by R. H. Scheffrahn (University of Florida) and J. Krecek (University of Florida) and included comparisons with reference specimens. Voucher specimens have been deposited in laboratory collections of the senior author, as well as with the International Institute of Tropical Forestry in Río Piedras, Puerto Rico and with the Puerto Rican Department of Natural Resources museum on Mona Island.

Volume of Available Dead Wood, Colony Density, and Caste Composition

A site was selected SSW of the airstrip in a large stand of leadtrees [*Leucaena leucocephala* (Lam.) de Wit.]. Live trees in the stand averaged 2.7 cm diam breast height (n = 32) (Fig. 2). Three points were randomly selected, then used as centers for three 3.05 × 3.05 m plots with borders aligned along compass points. All dead wood ≥1.2 cm in diam was collected (standing dead trunks, branches or trunks on the ground, dead branches on live trees, and dead branches detached but suspended in undergrowth), except for two dead branches that could not be reached in the crowns of trees in Plot 1 and thus were excluded from all calculations. The length (longest continuous dimension) and midpoint of branches were measured and used to calculate wood volume ($\pi r^2 L$). Standing dead trunks were measured at breast height. Because live wood was extremely dense and difficult to split, it generally was not feasible to determine live wood volume when termite galleries extended into living portions of trees.

Each piece of dead wood was split open and examined for any signs of termite activity. Termite galleries, termite fecal pellets, and/or body parts were noted as evidence of former termite activity. When live termites were observed, every attempt was made to collect the entire colony into 85% ethanol. Each entire colony collection was

Fig. 2. A dense stand of *Leucaena leucocephala* along the airstrip on Mona Island.

later examined in the laboratory using dissecting microscopes. All termites were sorted by categories: 1) primary reproductives, 2) alates and de-alates, 3) soldiers, 4) pseudergates and nymphs with short wing pads (tip of mesothoracic wing pad not extending beyond thoracic segments), 5) nymphs with long wing pads, and 6) larvae (first three instars). We were unable to differentiate lightly pigmented replacement (neotenic) reproductives. Exact counts of each category were made. The presence of eggs was noted.

Results and Discussion

Survey

Seventy-seven termite samples were collected during the survey. Members of the family Kalotermitidae were the only termites collected on Mona Island. Four species were identified: *I.* nr. *bequaerti* (Snyder), *I.* nr. *incisus*, *N. mona*, and *P. corniceps*. At least one collection of each species included alates. *Incisitermes* nr. *bequaerti* represents a new record for Mona Island. The other species collections corroborate previous records for the island (Banks 1919, Ramos 1946, Jones 1991). However, termites reported as *I.* nr. *snyderi* by Jones (1991) should have been classified as *I.* nr. *incisus*.

Procryptotermes corniceps was the most common and widely distributed species; it was found at every site sampled. Our observations suggest that *P. corniceps* more readily tolerates hot, dry conditions than the other termites on Mona Island. Among the hosts of *P. corniceps* were dead *Coccoloba uvifera* (L.) L., *Gossypium barbadense* L., *Hippomane mancinella* L., *Tamarindus indica* L., dead and live wood of *L. leucocephala*, and others that were unidentifiable.

Our collections suggest that *N. mona* is neither widely nor commonly distributed and occurs primarily along the west coast of Mona Island. Of the sites sampled, this species was found only in the Sardinera Beach area and the airstrip (Fig. 1). *Neotermes mona* was previously collected at Uvero Beach (Ramos 1946, Jones 1991) and the airstrip (Jones 1991). We recovered *N. mona* from dead and live wood of *L. leucocephala* and from dead wood of *Bursera simaruba* (L.) Sarg. We also identified this termite species from a sample collected by G. Hernández (P.R. Dept. Natural Resources) during April 1993 in *Melicoccus bijugatus* Jacq. at Sardinera Beach.

Incisitermes nr. *incisus* was found at all eight sites, and was particularly common at El Faro. Many colonies included two soldier morphs: long- and short-headed forms. This termite was found in *H. mancinella*, *L. leucocephala*, and dead wood that was unidentifiable.

Incisitermes nr. *bequaerti* was collected at Carabinero Beach, Uvero Beach, Vereda del Centro, and Vereda India. It was collected from *C. uvifera* and dead wood that was unidentifiable to species.

Volume of Available Dead Wood, Colony Density, and Caste Composition

The total volume of available dead wood in the three plots was 20,671 cm^3; 3,242 cm^3; and 3,153 cm^3, respectively. A large percentage of the wood showed current or past signs of termite occupation: Plot 1, 74.3%, n = 35; Plot 2, 87.5%, n = 24; Plot 3, 66.7%, n = 21. Overall, slightly more than three-quarters of the available pieces of dead wood showed evidence of termites. Of these, however, current termite infestations were less common than colonies that had met their demise (Plot 1, 26.9% live; Plot 2, 28.6% live; Plot 3, 42.9% live).

TABLE 1. MONA ISLAND DRYWOOD TERMITE COLONY COMPOSITION IN DEAD WOOD.

Species[1]	Sample #	Wood Volume (cm^3)	Larvae	Pseudergates & Short Wing-pad Nymphs	Long Wing-pad Nymphs	Soldiers	Primary Reproductives	Eggs[2]	Alates	Total
PLOT 1										
Pc	113	1,079.9	0	24	44	3 (4.2%)	0	0	0	71
Pc	132	3,315.8	18	117	98	7 (2.8%)	0	0	13 (5.1%)	253
Pc	114	862.1	36	298	3	26 (7.1%)	2	+	0	365
Pc	118	3,541.9[3]	21	801	91	64 (6.4%)	0	+	15 (1.5%)	992
Pc	117	1,012.8 3,607.0[3]	102	1,574	189	76 (3.8%)	2	+	50 (2.5%)	1,993
Pc	131	2,491.4[4]	123	2,322	439	117 (3.8%)	2	+	81 (2.6%)	3,085[5]
Pc	116	7,458.2	216	2,346	526	173 (5.2%)	2	+	96 (2.9%)	3,359
Undet.	115	112.3	3	31	23	0 (0.0%)	0	0	0	57
PLOT 2										
Pc	168	40.8[4]	0	8	1	2 (18.2%)	0	0	0	11
Pc	164	133.6	0	8	0	2 (16.7%)	2	0	0	12
Pc	163	274.1	13	58	0	1 (1.4%)	0	+	0	72
Pc	166	53.8	9	62	0	18 (20.2%)	0	+	0	89
Pc	165	59.9	5	78	31	1 (0.7%)	0	+	11 (8.7%)	126
Pc	167	345.4[4]	39	784	254	17 (1.5%)	2	+	51 (4.4%)	1,147
PLOT 3										
Pc	172	128.7[4]	0	189	2	22 (10.3%)	0	0	0	213
Pc	173	370.0[4]	11	143	16	50 (20.5%)	0	+	24 (9.8%)	244
Pc	174	386.2[4]	31	468	1	77 (13.3%)	2	+	0	579
Ii	171	19.3	0	8	0	5 (38.5%)	0	0	0	13
Ii	169	77.4	31	178	0	23 (9.8%)	2	+	0	234
Undet.	170	76.3	0	46	0	0 (0.0%)	0	0	0	46

[1]Pc = Procryptotermes corniceps; Ii = Incisitermes nr. incisus; Undet. = Undetermined.
[2]Presence (+) or absence of eggs noted.
[3]Total volume of live wood containing termite galleries.
[4]Live wood volume that contained termite galleries was not assessed.
[5]Includes one damaged and unidentifiable.

Procryptotermes corniceps and *I.* nr. *incisus* were the only species found in the sample plots, although *N. mona* was found outside the plots in the same stand of leadtrees. *Procryptotermes corniceps* was by far the predominant termite.

In some cases (n = 8) of dead branches on live trees, termite galleries extended into the living portion of the tree (Table 1). Because this live wood either was not sampled or was incompletely sampled, totals for these colonies are underestimated. However, our observations of *N. mona* and *P. corniceps* in live wood indicated that colonies probably were initiated in an attached dead branch, then extended into the living portion of the tree as the colony grew. Whereas dead wood was extensively riddled with galleries, often just a single termite gallery penetrated into the core of the live wood. Drywood termite species that can extend foraging galleries from the originally colonized dead wood into regions of live wood in a tree attain larger colony sizes than species that remain solely in the dead wood that initially was invaded (Lenz 1994). Maximum colony size of *P. corniceps* greatly exceeded that of *I.* nr. *incisus*, although the latter species was much less common in the plots (Table 1).

Total termite counts and caste composition for the 20 colonies found in the 3 plots are reported in Table 1. These data, which indicated that colony size of these two drywood termite species did not exceed 3,500 individuals, are consistent with previous reports for the Kalotermitidae (Nutting 1969, Lenz 1994).

Although the total volume of dead wood was approximately six times greater in Plot 1 than in the other two plots, the number of termites per unit volume of dead wood was very similar: 0.37 termites per cm^3 in Plot 1, 0.45 termites per cm^3 in Plot 2, and 0.42 termites per cm^3 in Plot 3. The similarity of these data likely stems from the fact that average colony size coupled with average available wood volume per colony was greater in Plot 1 than in the other two plots. In Plot 1, colonies averaged 1,198 termites, and dead wood volume per colony averaged 2,553 cm^3; in Plot 2, colonies averaged 243 termites, and wood volume averaged 151 cm^3; in Plot 3, colonies averaged 222 termites, and wood volume averaged 176 cm^3. These calculations exclude colonies 117 and 118 in Plot 1, because some of these termites were extracted from live wood.

Linear regression indicates a positive relationship between the $\log_{10}$ of dead wood volume and the $\log_{10}$ of colony size ($y = 0.783x + 0.351$) (Fig. 3). With an R^2 of 0.501, linear regression explains more than half of the variation in the data. Thus, drywood termite colonies on Mona Island attain larger sizes in larger pieces of dead wood. The size of mature drywood termite colonies typically is positively correlated with food resource size (Lenz 1994).

Colony density ranged from 0.6 colonies per m^2 in Plots 2 and 3, to 1.2 colonies per m^2 in Plot 1. These high densities probably are representative of the termite population in the *Leucaena* stand but not of Mona Island as a whole. Observations during our survey, however, indicate a relatively high density of drywood termite colonies in other habitats on the island.

Termite densities in the dry forests of Mona Island were severalfold higher than those observed in *Cyrilla racemiflora* L. in the Luquillo tropical montane forest of Puerto Rico (Torres 1994). This tends to support the hypothesis that termites are more important as wood decomposers in dry forests, whereas fungi are more important in wet forests (Chudnoff & Goytía 1972, Bultman & Southwell 1976). The dry forest life zone is a significant component in the tropics and subtropics, comprising approximately 42% of forest lands (Murphy & Lugo 1986).

Caste composition varied with colony size (Table 1). All colonies with ≥992 individuals (n = 5) contained eggs as well as alates. Small colonies with both these developmental stages could be found, but not consistently; alates and eggs were found in 2 small colonies, one with n = 126 termites and the other with n = 244 termites. The

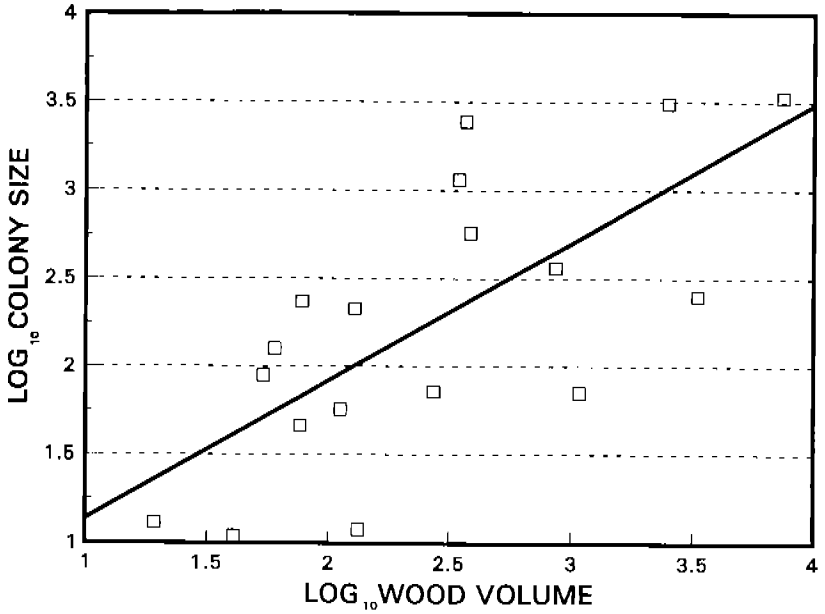

Fig. 3. Relationship between the $\log_{10}$ of dead wood volume and the $\log_{10}$ of drywood termite colony size on Mona Island ($y = 0.783x + 0.351$; $R^2 = 0.501$), ($n = 18$).

smallest colony with alates present was comprised of 126 termites. The 6 smallest colonies (≤71 termites) had neither eggs nor alates and may represent incipient colonies or those on the decline. We suspect that these colonies were at the end of their colony cycle because of the absence of primary reproductives and early instars. Only one of the six smallest colonies contained primary reproductives.

Soldier percentages ranged from 0.7% to 20.5% for the 17 *P. corniceps* colonies and were 9.8% and 38.5% for the two colonies of *I.* nr. *incisus*. Soldier percentages were more variable for small colonies than for large colonies.

In conclusion, this survey revealed four species of kalotermitids, including *I.* nr. *bequaerti*, which is a new record for Mona Island. These termites were found in a variety of tree species. Drywood termites apparently are important wood decomposers in the subtropical dry forest life zone of Mona Island, with an average of approximately three-quarters of dead wood branches showing signs of termite attack. Approximately 0.4 termites per cm^3 of dead wood were noted. Colony size of *P. corniceps* ranged from 11 to 3,359 individuals, with large variations in caste composition among colonies. Data on wood volume together with total termite counts support the hypothesis that kalotermitid colony size is closely attuned to the size of the food resource.

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