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CUTICULAR HYDROCARBONS OF TERMITES OF THE BRITISH VIRGIN ISLANDS

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Abstract—A survey of the termites (Isoptera) of 17 islands of the British Virgin Island (BVI) complex yielded eight taxa belonging to three families. The Kalotermitidae include *Neotermes mona* (Banks), *Cryptotermes brevis* (Walker), *Procryptotermes corniceps* (Snyder), and an undetermined species of *Incisitermes*, likely *Incisitermes* nr *snyderi* (Light) or *I. incisus* (Silvestri). The only rhinotermitid collected is an undetermined species of *Heterotermes* (Froggatt). *Parvitermes wolcotti* (Snyder), *Nasutitermes costalis* (Holmgren), and *N. acajutlae* (Holmgren) comprise the Termitidae. Cuticular hydrocarbon mixtures were characterized for each of the taxa. Blends of abundant hydrocarbons are species-specific and can be used to identify a given taxon without the diagnostic castes, soldiers, or imagoes, although the species of *Incisitermes* were not separable on the basis of cuticular hydrocarbons.

Key Words—Cuticular hydrocarbons, chemotaxonomy, Isoptera, tropical termites, gas chromatography, mass spectrometry, Virgin Islands, Caribbean termites, olefins, methylalkanes.

INTRODUCTION

The termite fauna of the West Indies was summarized first by Banks (1919), who described termites collected from the larger islands, except Puerto Rico

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and other islands of the Puerto Rico Bank. Individual collections in the West Indies placed in the US National Museum were included in Snyder's compilation (Snyder, 1956). Scheffrahn et al. (1994) summarized the literature and unpublished records of the termites of the West Indies. From this survey it is clear that, until recently, little effort has been devoted to collecting the fauna of the Virgin Island complex, especially the British Virgin Islands (BVI).

The BVI are a complex of more than 50 land masses that are part of the Puerto Rico Bank. The BVI were apparently not intensively collected until M. S. Collins began systematic work in 1986 (Collins et al., 1997). In this paper we expand this work to include documentation of the cuticular hydrocarbon mixture of all termite taxa collected from the BVI. Characterization of the cuticular hydrocarbons of each taxon supports the species specificity of hydrocarbon mixtures for this region.

METHODS AND MATERIALS

Collection of Termites. Collecting periods of two to four weeks each were spent on Guana Island from 1986 to 1994, most often during the month of October. During those stays, short trips were made to other islands of the BVI complex. We attempted to sample termite colonies from every habitat that could be reached. Termite samples were bagged and brought to the laboratory on Guana Island where the termites were separated from soil, nest, and wood debris.

Samples of workers, soldiers, larvae, pseudergates, nymphs, or alates were placed in separate dishes or vials and dried. The number of termites in a sample varied by species; 15–20 nymphs or pseudergates of kalotermitids or up to 200 workers of the nasutes were dried. These samples were placed over a single incandescent light. Initially samples were dried in whatever vessel was available over whatever lamp was available in the guest cottages on Guana Island. From 1991 to 1994, we dried termite samples in 20-ml scintillation vials over a single 75-W, reflecting incandescent light. Vials were moved periodically in an attempt to make drying uniform (Haverty et al., 1996).

The amount of time required to completely dry termites varied slightly as a function of the number and size of the termites in the sample and the position of the vials over the bulb. With some of the kalotermitid species, drying was accelerated by decapitating termites. Internal hydrocarbons do not appear to affect characterization of cuticular hydrocarbons (Haverty et al., 1996). Once the termites were completely dry, specimens were placed in a vial that was tightly capped. Dried samples were returned to our laboratory in California for extraction and characterization of cuticular hydrocarbons. Concurrently, fresh (i.e., not dried) voucher samples from each collection were preserved in 85%

ethanol and deposited in the National Museum of Natural History, Smithsonian Institution, Washington, DC.

Species diagnoses were made primarily by M. S. Collins using keys, original references and descriptions, and by comparison with type and previously identified material. Much work needs to be done to develop usable keys for the Caribbean fauna, and new descriptions are needed for some species.

Extraction Procedure and Characterization of Cuticular Hydrocarbons. In this study cuticular lipids were extracted by immersing termites, as a group, in 10 ml of *n*-hexane for 10 min. After extraction, hydrocarbons were separated from other components by pipetting the extract through 4 cm of activated BioSil-A in Pasteur pipet mini-columns. An additional 5 ml of clean hexane was dripped through the BioSil-A. The resulting hydrocarbon extracts were evaporated to dryness under a stream of nitrogen and redissolved in 60 μl of *n*-hexane for gas chromatography—mass spectrometry (GC-MS) analyses. A 3-μl aliquot was injected into the GC-MS.

GS-MS analyses were performed on a Hewlett-Packard (HP) 5890 gas chromatograph equipped with a HP 5970B Mass Selective Detector interfaced with a computer and HP Chemstation data analysis software (HP59974J Rev. 3.1.2). The GC-MS was equipped with an HP-1, fused silica capillary column (25 m $\times$ 0.2 mm ID) and operated in split mode (with a split ratio of 8:1). Each mixture was analyzed by a temperature program from 200°C to 320°C at 3°C/min with a final hold of 11 or 16 min. Electron impact (EI) mass spectra were obtained at 70 eV.

n-Alkanes were identified by their mass spectra. Mass spectra of methylalkanes were interpreted as described by Blomquist et al. (1987) to identify methyl branch locations. Mass spectra of di- and trimethylalkanes were interpreted as described in Page et al. (1990) and Pomonis et al. (1980). Alkenes were identified by their mass spectra and/or retention times relative to *n*-alkanes. A typical alkene mass spectrum shows a molecular ion and a series of fragments at 14-mass-unit intervals (69, 83, 97), similar to those displayed by *n*-alkanes, less 2 mass units. Interpretation of the mass spectra of dienes and polyunsaturated hydrocarbons was extrapolated from this pattern, i.e., for each double bond, the molecular ion is decreased by 2 mass units.

Integration of the total ion chromatogram was performed using the HP Chemstation data analysis software. GC-MS peak areas were converted to percentage of the total hydrocarbon fraction. Summary statistics for percentages of each hydrocarbon for each taxon or geographic location of a taxon were computed using SAS (1990) to make comparisons.

In the text and tables, we use shorthand nomenclature to identify individual hydrocarbons or mixtures of hydrocarbons. This shorthand uses a descriptor for the location of methyl groups (X-Me), the total number of carbons (C_{XX}) in the hydrocarbon component excluding the methyl branch(es), and the number of double bonds following a colon ($C_{XX:Y}$). Thus, pentacosane becomes n-C_{25}; 3-methylpentacosane becomes 3-MeC_{25}; 3,13-dimethylpentacosane becomes 3,13-DimeC_{25}; and pentacosadiene becomes $C_{25:2}$. Hydrocarbons are presented in the tables for each taxon in the order of elution on our GC-MS system.

RESULTS AND DISCUSSION

In their survey of the termites of the West Indies, Scheffrahn et al. (1994) listed a total of nine species in seven genera and three families found in the BVI. We characterized cuticular hydrocarbons for all of these species, although we were unable to differentiate *Incisitermes incisus* (Silvestri) and *I. snyderi* (Light) (or *I.* nr *snydreri*). Most of the specimens used for these analyses were collected on Guana Island, and incidentally from many other islands in the BVI complex (Table 1). Whenever possible, we used collections from locations in addition to Guana Island to include interisland variation. We summarize the relative proportions of each hydrocarbon for eight taxa; hydrocarbons are presented in order of elution within a hydrocarbon class (Table 2). Hydrocarbon mixtures for pseudergates or workers are discussed for each taxon within the three families. Comparison of castes within a taxon or island-to-island variation are presented separately for select taxa.

TABLE 1. SPECIES OF TERMITES COLLECTED FROM VARIOUS LOCATIONS IN BRITISH VIRGIN ISLANDS FOR CHARACTERIZATION OF CUTICULAR HYDROCARBONS

Species	Collection sites
Neotermes mona	Guana
Cryptotermes brevis	Oahu, Hawaii[a]
Procryptotermes corniceps	Guana, Lesser Jost Van Dyke, Great Camino, Great Thatch
Incisitermes species	Guana, Lesser Jost Van Dyke, Greater Jost Van Dyke, Eustatia, Scrub, Anegada
Heterotermes sp.	Guana, Tortola, Great Thatch
Parvitermes wolcotti	Peter
Nasutitermes costalis	Guana, Tortola
Nasutitermes acajutlae	Guana, Great Camino, Scrub, Eustatia, Virgin Gorda, Lesser Jost Van Dyke, Greater Jost Van Dyke, Great Thatch, Cooper, Necker, Tortola

[a] *Cryptotermes brevis* occurs only in structures. We were not able to collect a sample from a building or furniture. We received these from a colleague in Hawaii, where this species is quite common.

TABLE 2. RELATIVE QUANTITIES OF CUTICULAR HYDROCARBONS FROM PSEUDERGATES (LARVAE AND NYMPHS) OR WORKERS OF 8 TERMITE TAXA FROM BRITISH VIRGIN ISLANDS[a]

	Termite species[b]							
Hydrocarbon	N mon	C bre	P cor	I spp[c]	Het sp	P wol	N cos	N aca
n-Alkanes								
C_{23}	0	tr	0	0/+	0	0	0	+
C_{24}	tr	0	tr	tr/+	0	0	0	tr
C_{25}	+++	+++	+++	+++	0	0	++	+++
C_{26}	+++	++	++	++	tr	0	0	tr
C_{27}	+++	+++	+++	+++	+++	+++	++	++
C_{28}	tr	+	tr	0/+	++	++	+	tr
C_{29}	+	++	+	+	++	++	++	+
C_{30}	0	0	0	0	tr	0	0	0
C_{31}	0	tr	0	0	tr	0	0	tr
Internally branched methylalkanes								
12-; 11-; 10-MeC_{24}	+	0	0	0	0	0	0	0
13-; 11-MeC_{25}	+++	+	0	+	0	0	0	tr
13-; 12-MeC_{26}	+++	0	0	0	0	0	0	0
13-; 11-; 9-; 7-MeC_{27}	+++	tr	tr	0/tr	+++	0	+	tr
14-; 13-; 12-; 9-; 7-MeC_{28}	+	0	0	0/tr	+++	0	+	0
15-; 13-; 11-; 9-; 7-; 5-MeC_{29}	tr	0	0	tr/+	+++	+	+++	0
15-; 14-; 12-; 11-; 10-; 9-MeC_{30}	0	0	0	0	+	0	+	0
15-; 13-; 11-; 9-MeC_{31}	tr	0	0	0	+	0	+++	0
14-MeC_{32}	0	0	0	0	0	0	+	0
13-MeC_{33}	tr	0	0	0	0	0	+	0
15-; 13-MeC_{35}	tr	0	0	0/tr	0	0	0	0
12-MeC_{36}	tr	0	0	0	0	0	0	0

TABLE 2. Continued

Hydrocarbon	Termite species[b]							
	N mon	C bre	P cor	I spp[c]	Het sp	P wol	N cos	N aca
Internally branched methylalkanes (Continued)								
17-; 15-; 13-MeC_{37}	tr	tr	0	0/tr	tr	0	0	0
12-MeC_{38}	tr	0	0	0	0	0	0	0
15-; 13-MeC_{39}	+	tr	+	0/+	0	0	0	tr
12-MeC_{40}	+	0	0	0	0	0	0	0
15-; 13-C_{41}	++	tr	+	0	0	0	0	tr
12-MeC_{42}	tr	0	0	0	0	0	0	0
13-MeC_{43}	+	0	0	0	0	0	0	0
Terminally branched methylalkanes								
2-MeC_{23}	0	+	0	0/tr	0	0	0	0
3-MeC_{23}	0	++	0	0	0	0	0	0
2-MeC_{24}	++	+++	+++	0/+++	0	0	0	0
3-MeC_{24}	tr	+	tr	0	0	0	0	0
2-MeC_{25}	+++	++	+++	+++	0	0	0	0
3-MeC_{25}	+++	+++	+++	+++	0	0	0	0
2-MeC_{26}	++	+	+++	+/++	+	0	0	0
3-MeC_{26}	+	tr	tr	0/tr	tr	0	0	0
2-MeC_{27}	0	tr	+	tr/+	++	++	0	tr
3-MeC_{27}	+	+	++	0/+	++	+	tr	0
2-MeC_{28}	0	0	tr	0	+	+++	0	0
2-MeC_{29}	0	tr	0	0	0	++	0	0
3-MeC_{29}	0	0	0	0	0	++	tr	0
Dimethylalkanes								
3,X-DimeC_{25}	++	tr	0	0	0	0	0	0
11,15-DimeC_{27}	++	0	0	0	+++	0	++	0
9,17-DimeC_{27}	0	0	0	0	+++	0	0	0

5,15-DimeC_{27}	tr	0	0	0	0	0	0	0
3,13-DimeC_{27}	tr	0	0	0	0	0	0	0
11,15-; 12,16-DimeC_{28}	tr	0	0	0	0	0	++	0
9,X-DimeC_{28}	0	0	0	0	+++	0	0	0
13,17-; 11,15-DimeC_{29}	0	0	0	0	0	0	+++	0
9,19-; 9,17-DimeC_{29}	0	0	0	0/+	+++	0	0	0
7,21-DimeC_{29}	0	0	0	0	+++	0	0	0
5,X-DimeC_{29}	tr	0	0	0	tr	++	0	0
3,21-DimeC_{29}	0	0	0	0	tr	0	0	0
11,15-; 12,16-; 13,17-DimeC_{30}	0	0	0	0	0	0	+++	0
9,X-DimeC_{30}	0	0	0	0	++	0	0	0
13,17-DimeC_{31}	0	0	0	0	0	0	+++	0
9,21-DimeC_{31}	0	0	0	0	++	0	0	0
3,X-DimeC_{31}	tr	tr	0	0	0	0	0	0
14,18-DimeC_{32}	0	0	0	0	0	0	+	0
11,21-; 13,21-; 15,19-DimeC_{33}	0	0	0	0/tr	0	0	+	0
13,X-; 11,23-DimeC_{35}	tr	0	0	0/+	0	0	0	0
12,24-DimeC_{36}	0	0	0	0/tr	0	0	0	0
17,X-; 15,X-; 13,X-DimeC_{37}	+	0	0	0/+	0	0	0	0
12,16-DimeC_{38}	tr	0	0	0	0	0	0	0
11,15-DimeC_{39}	++	0	0	0	0	0	0	0
12,16-DimeC_{40}	tr	0	0	0	0	0	0	0
13,17-DimeC_{41}	++	0	0	0	0	0	0	0
12,16-DimeC_{42}	tr	0	0	0	0	0	0	0
13,17-DimeC_{43}	+	0	0	0	0	0	0	0
Trimethylalkanes								
9,13,17-TrimeC_{27}	0	0	0	0	0	0	+	0
11,15,19-TriMeC_{29}	0	0	0	0	0	0	+	0
7,13,21-TrimeC_{29}	0	0	0	0	tr	0	0	0
5,11,21-TrimeC_{29}	0	0	0	0	tr	0	0	0
3,11,21-TrimeC_{29}	0	0	0	0	tr	0	0	0
13,17,21-; 11,15,21-TrimeC_{33}	0	0	0	0/tr	0	0	0	0
13,17,23-; 11,15,19-TrimeC_{35}	0	0	0	0/tr	0	0	0	0
13,17,21-TrimeC_{37}	0	0	0	0/tr	0	0	0	0

TABLE 2. Continued

Hydrocarbon	Termite species[b]							
	N mon	C bre	P cor	I spp[c]	Het sp	P wol	N cos	N aca
Olefins								
$C_{23:1}$	0	0	0	0	0	0	0	+
$C_{24:1}$	0	0	0	tr	0	0	0	0
$C_{25:1}$	0	0	++	+++	0	0	0	+
$C_{25:2}$	0	0	0	+	0	0	0	0
$C_{26:1}$	0	0	0	tr	0	0	0	0
$C_{27:1}$	0	0	0	+++	0	0	tr	+
$C_{27:2}$	0	0	0	tr	0	0	0	0
$C_{27:3}$	0	0	0	0/tr	0	0	0	0
$C_{29:1}$	0	tr	0	0/tr	0	0	0	0
$C_{31:2}$	0	0	0	0/+	0	0	0	0
$C_{31:1}$	0	tr	0	0/+	0	0	0	0
$C_{33:2}$	0	tr	0	0/tr	0	0	0	0
$C_{33:1}$	0	tr	0	0/tr	0	0	0	0
$C_{35:2}$	0	++	tr	0	0	0	0	0
$C_{35:1}$	0	tr	0	0	0	0	0	0
$C_{36:2}$	0	+	0	0	0	0	0	0
$C_{37:3}$	0	+	+	0	0	0	0	0
$C_{37:2}$	0	+++	++	0	0	0	0	0
$C_{37:1}$	0	++	tr	0	+	0	0	+
$C_{38:3}$	0	0	tr	0	0	0	0	0
$C_{38:2}$	0	++	+	0	0	0	0	0
$C_{38:1}$	0	0	0	0	0	0	0	+
$C_{39:5}$	0	0	0	0	0	0	0	+
$C_{39:4}$	0	0	0	0	0	0	0	++
$C_{39:3}$	0	++	++	0/tr	0	0	0	0

$C_{39:2}$	0	+++	+++	0/+	0	0	0	+
$C_{39:1}$	0	++	++	0/tr	tr	0	0	+++
$C_{40:5}$	0	0	+	0	0	0	0	0
$C_{40:3}$	0	+	0	0	0	0	0	0
$C_{40:2}$	0	++	++	0	0	0	0	0
$C_{40:1}$	0	0	0	0	0	0	0	+++
$C_{41:5}$	0	0	0	0	0	0	0	+++
$C_{41:4}$	0	0	0	0	0	0	0	+++
$C_{41:3}$	0	+++	+++	0/+	0	+++	0	0
$C_{41:2}$	0	+++	+++	0/++	0	0	0	++
$C_{41:1}$	0	++	+++	0/+	0	0	0	+++
$C_{42:3}$	0	+	++	0	0	0	0	0
$C_{42:2}$	0	+	+	0/tr	0	0	0	0
$C_{42:1}$	0	0	tr	0	0	0	0	++
$C_{43:6}$	0	0	0	0	0	0	0	tr
$C_{43:5}$	0	0	0	0	0	0	0	tr
$C_{43:4}$	0	0	+	0	0	+++	0	+++
$C_{43:3}$	0	++	++	0/+++	0	+++	0	0
$C_{43:2}$	0	++	++	+++	0	0	0	+
$C_{43:1}$	0	++	0	0/++	0	0	0	+++
$C_{44:2}$	0	0	0	0/tr	0	0	0	0
$C_{45:4}$	0	0	0	0/+	0	+++	0	0
$C_{45:3}$	0	++	0	0/++	0	+++	0	0
$C_{45:2}$	0	++	0	0/++	0	0	0	0
$C_{45:1}$	0	0	0	0/+++	0	0	0	++

[a]Relative proportions of the total hydrocarbon mixture for each species. +++ = >3.0%; ++ = 1.0–3.0%; + = 0.3–0.99%; and tr = <0.3%; 0 = not detected.
[b]N mon = *Neotermes mona*; C bre = *Cryptotermes brevis*; P cor = *Procryptotermes corniceps*; I spp = *Incisitermes* species; H sp = *Heterotermes* species; P wol = *Parvitermes wolcotti*; N cos = *Nasutitermes costalis*; N aca = *Nasutitermes acajutlae*.
[c]*Incisitermes* spp. displayed a wide range of hydrocarbon mixtures. For example, 0/+++ would denote the range from absent to above 3%.

Kalotermitidae

We characterized the cuticular hydrocarbons of Kalotermitidae identified as *Neotermes mona* (Banks), *Cryptotermes brevis* (Walker), *Procryptotermes corniceps* (Snyder), and *Incisitermes* spp. Species of the family Kalotermitidae, although commonly known as drywood termites, differ widely in their moisture requirements. The fauna of the BVI includes species at both ends of the moisture-dependence spectrum. In the BVI we feel that *N. mona* is dependent upon a high constant environmental moisture supply, usually obtained by inhabiting living trees, whereas *C. brevis*, the "furniture termite," is capable of living without access to free water and is unable to thrive when exposed to sustained presence of free water (Collins, 1969; Williams, 1977).

Neotermes mona *(Banks)*. This is the largest termite of the area. We found it on the relatively moist, north slope of Guana Island. The bulk of the colony developed excavations in living, as well as dead, wood. This species was once thought to be endemic to Mona Island, but its range was recently extended west through the Dominican Republic to the Turks and Caicos archipelago (Scheffrahn et al., 1990; Jones et al., 1995).

The cuticular hydrocarbon mixture of *N. mona* reflected a general pattern seen in most of the termite species examined thus far in the West Indies. Cuticular hydrocarbons occurred in two distinct groups: early eluting compounds (24–29 carbons in the parent chain) and late eluting compounds (37–43 carbons in the parent chain) (Table 3; Figure 1). In *N. mona* the early eluting compounds predominate, representing over 90% of the total hydrocarbon in nymphs and pseudergates (Figure 1). The hydrocarbon mixtures of pseudergates and nymphs were very similar to the one alate sample (Table 3).

n-Alkanes present were n-C_{24}, n-C_{25}, n-C_{26}, n-C_{27}, n-C_{28}, and n-C_{29}. The most abundant were n-C_{25} and n-C_{27}, comprising about 13% and 12% of the total hydrocarbons, respectively. Slightly lower amounts were seen in the alate sample. The other *n*-alkanes accounted for about 5% of the total hydrocarbons.

We identified isomeric mixtures of internally branched monomethylalkanes with parent chains ranging from C_{24} to C_{43}, except for C_{30}, C_{32}, and C_{34}. Positions of methyl branches ranged from C-10 to C-15. Internally branched monomethylalkanes were the most abundant class of hydrocarbons produced by *N. mona*, representing about 42% of the total hydrocarbon. One isomeric mixture, 13-; 11-MeC_{25}, accounted for 22–26% of the total hydrocarbon (Table 3; Figure 1).

2- and 3-Methylalkanes were identified for C_{24} to C_{29}. These terminally branched monomethylalkanes comprised approximately 17–20% of the total hydrocarbon. Internally branched dimethylalkanes constituted $<7\%$ of the total cuticular hydrocarbon fraction of *N. mona*. There was only one type of internally branched dimethylalkane, those with three methylene groups separating the

TABLE 3. RELATIVE QUANTITIES (MEAN, STANDARD DEVIATION, AND RANGE) OF CUTICULAR HYDROCARBONS OF PORTIONS OF COLONIES OF *Neotermes mona* (BANKS) FROM BRITISH VIRGIN ISLANDS[a]

Hydrocarbon	Larvae, nymphs, and pseudergates		Alates (mean)
	Mean ± SD	Range	
n-C_{24}	0.20 ± 0.17	0–0.30	0.24
12-; 11-; 10-MeC_{24}[b]	0.92 ± 0.31	0.68–1.27	1.18
2-MeC_{24}	1.74 ± 0.92	1.19–2.80	1.74
3-MeC_{24}	0.06 ± 0.10	0–0.17	0
n-C_{25}	13.00 ± 4.14	8.72–16.98	11.45
13-; 11-MeC_{25}[b]	21.39 ± 5.32	18.06–27.52	25.85
2-MeC_{25}	7.25 ± 0.66	6.79–8.01	7.58
3-MeC_{25}	4.78 ± 1.92	3.34–6.96	4.89
n-C_{26}	4.04 ± 1.41	2.41–4.97	3.00
3,13-DimeC_{25}	1.19 ± 0.35	0.82–1.51	1.38
13-; 12-MeC_{26}[b]	4.33 ± 1.06	3.11–4.95	5.17
2-MeC_{26}	2.34 ± 0.42	1.90–2.73	1.71
$C_{27:1}$ + 3-MeC_{26}[c]	0.47 ± 0.46	0–0.91	0.97
n-C_{27}	11.94 ± 6.20	7.65–19.06	9.55
13-; 11-MeC_{27}[b]	9.48 ± 2.95	7.72–12.89	11.51
11,15-DimeC_{27}; 2-MeC_{27}[d]	4.60 ± 1.31	3.40–6.00	4.79
3-MeC_{27}	0.35 ± 0.34	0–0.69	0.71
5,15-DimeC_{27}	0.06 ± 0.11	0–0.19	0
n-C_{28}	0.09 ± 0.15	0–0.27	0
3,13-DimeC_{27}	0.07 ± 0.12	0–0.21	0
12-MeC_{28}	0.56 ± 0.56	0–1.13	0.81
12,16-; 11,15-DimeC_{28}[e]	0.11 ± 0.19	0–0.33	0
n-C_{29}	0.66 ± 0.65	0–1.31	0.84
13-; 11-MeC_{29}[b]	0.25 ± 0.43	0–0.75	0.44
13,17-DimeC_{29}	0.10 ± 0.17	0–0.30	0
3-MeC_{29}	0.07 ± 0.12	0–0.21	0
5,17-DimeC_{29}	0.04 ± 0.08	0–0.13	0
15-; 13-MeC_{31}[b]	0.05 ± 0.08	0–0.14	0
3,7-DimeC_{31}	0.03 ± 0.06	0–0.10	0
13-MeC_{33}	0.06 ± 0.11	0–0.18	0
13-MeC_{35}	0.07 ± 0.13	0–0.22	0
13,17-DimeC_{35}	0.07 ± 0.13	0–0.22	0
12-MeC_{36}	0.06 ± 0.11	0–0.19	0
13-MeC_{37}	0.81 ± 0.40	0.53–1.26	0.57
13,17-; 11,15-DimeC_{37}[e]	0.38 ± 0.66	0–1.15	0
12-MeC_{38}	0.28 ± 0.30	0–0.59	0.20
12,16-DimeC_{38}	0.12 ± 0.20	0–0.35	0
13-MeC_{39}	0.94 ± 0.30	0.59–1.12	0.53
11,15-DimeC_{39}	1.51 ± 0.41	1.26–1.98	0.76

TABLE 3. Continued

Hydrocarbon	Larvae, nymphs, and pseudergates Mean ± SD	Range	Alates (mean)
12-MeC_{40}	0.53 ± 0.06	0.46–0.57	0.30
12,16-DimeC_{40}	0.22 ± 0.39	0–0.67	0.20
13-MeC_{41}	1.25 ± 0.62	0.59–1.81	0.77
13,17-DimeC_{41}	1.60 ± 0.80	0.84–2.44	1.10
12-MeC_{42}	0.07 ± 0.12	0–0.21	0
12,16-DimeC_{42}	0.11 ± 0.19	0–0.33	0
13-MeC_{43}	0.77 ± 0.21	0.53–0.89	0.72
13,17-DimeC_{43}	0.98 ± 1.41	0–2.23	1.04

[a]The data from this table are derived from separate samples taken in 1991 and 1992 from the same colony on Guana Island. Samples include combinations of large larvae, nymphs, and/or pseudergates. The single alate sample was extracted in hexane before drying. No soldiers are included in the hydrocarbon samples.
[b]An isomeric mixture. These monomethylalkanes coelute.
[c]This alkene and monomethylalkane coelute.
[d]This monomethylalkane and two isomers of this dimethylalkane coelute.
[e]An isomeric mixture. Two or more isomers of these dimethylalkanes coelute. Distinct, separate isomers can be distinguished from mass spectra.

methyl branches. Terminally branched dimethylalkanes were not abundant (<1.4% of the total hydrocarbon) and were trivial except for 3,13-DimeC_{25}. No trimethylalkanes were found. Only one alkene, $C_{27:1}$, was found in *N. mona.*

Cryptotermes brevis (*Walker*). The phragmatic heads of the soldiers, the presence of piles of dry fecal pellets in infested buildings, and the paper-thin outer surface of furniture or wood containing large colonies of *C. brevis* are characteristic of this termite. This species has never been reported in the BVI from habitats other than structural timber, furniture, and objects of art not exposed to moisture. This habitat limited our ability to collect samples in the BVI. Because *C. brevis* is very common in Hawaii, we were able to obtain a sample from Oahu, Hawaii, so that we could present the cuticular hydrocarbon mixture of this now circumtropical species.

C. brevis clearly reflects the general pattern of hydrocarbon mixtures of drywood termites of the West Indies. In this species hydrocarbons occurred in two groups: the early-eluting compounds consisted almost exclusively of *n*-alkanes and terminally branched monomethyl alkanes, and late-eluting compounds were primarily olefins (Table 2; Figure 2).

n-Alkanes present were *n*-C_{23}, *n*-C_{25}, *n*-C_{26}, *n*-C_{27}, *n*-C_{28}, *n*-C_{29}, and *n*-C_{30}. As in *N. mona*, *n*-C_{25} and *n*-C_{27} were the most abundant, comprising

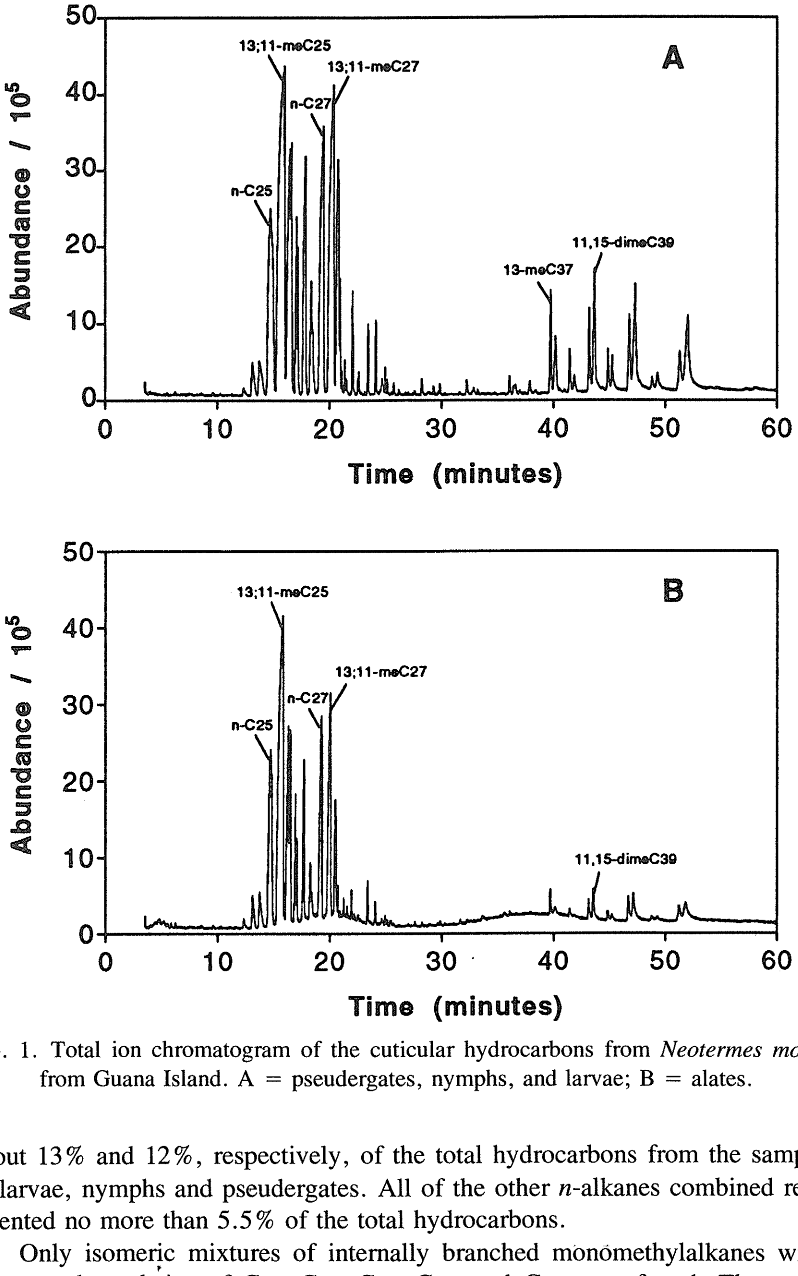

FIG. 1. Total ion chromatogram of the cuticular hydrocarbons from *Neotermes mona* from Guana Island. A = pseudergates, nymphs, and larvae; B = alates.

about 13% and 12%, respectively, of the total hydrocarbons from the sample of larvae, nymphs and pseudergates. All of the other *n*-alkanes combined represented no more than 5.5% of the total hydrocarbons.

Only isomeric mixtures of internally branched monomethylalkanes with parent carbon chains of C_{25}, C_{27}, C_{37}, C_{39}, and C_{41} were found. The early eluting components (C_{25} and C_{27}) of this class of hydrocarbons represented

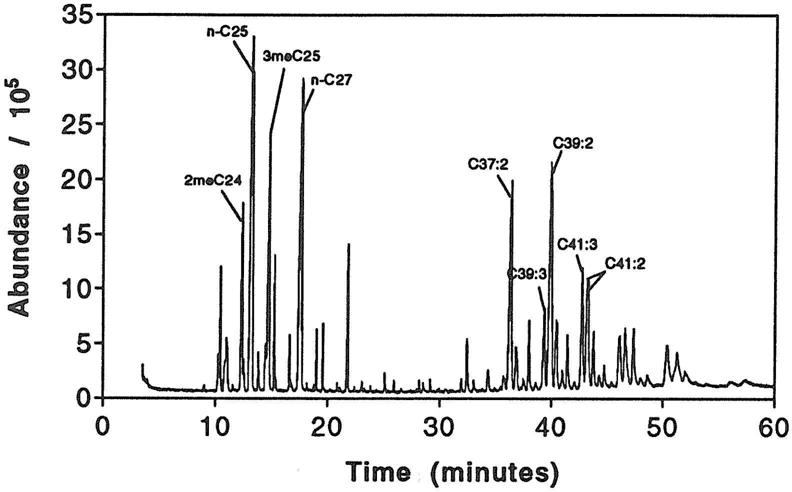

FIG. 2. Total ion chromatogram of the cuticular hydrocarbons from nymphs, pseudergates, and large larvae of *Cryptotermes brevis* from Honolulu, Hawaii.

<1.0% of the total hydrocarbon. The later eluting components (C_{37}, C_{39}, and C_{41}) coeluted with a diene and could not be separately quantified.

2- and 3-Methylalkanes were identified from C_{23} to C_{29}. These terminally branched monomethylalkanes comprised about 17% of the total hydrocarbon. In *C. brevis* the 2- and 3-methylalkanes almost always occurred in pairs. When the parent chain of these hydrocarbons contained an even number of carbons, the 2-methylalkane predominated; when the parent chain contained an odd number of carbons, the 3-methylalkane was more abundant (Figure 2).

No internally branched dimethylalkanes were found in our sample. Terminally branched dimethylalkanes were not very abundant (<0.3% of the total hydrocarbon) and occurred only at C-25 and C-31. All were found to have the first methyl branch on carbon 3. No trimethylalkanes were identified.

Alkenes, alkadienes, and alkatrienes were the predominant class of cuticular hydrocarbons, representing approximately 51% of the total hydrocarbons. The number of carbons ranged from 31 to 45 (Table 2).

Procryptotermes corniceps (*Snyder*). *P. corniceps* is moderately abundant in the BVI (Collins et al., 1997). Darlington (1992) and Krishna (1962) reported an extention of the known range of *P. corniceps* to Antigua, Guadeloupe, Jamaica, Montserrat, and Puerto Rico; Scheffrahn et al. (1990) added Turks and Caicos Islands. Soldiers of *P. corniceps* are distinctive with proportionally long, strongly curved, sharply pointed mandibles. The heads of the soldiers slope steeply in front and have short hornlike projections from the frons near the outer edge of the bases of the mandibles (Krishna, 1962).

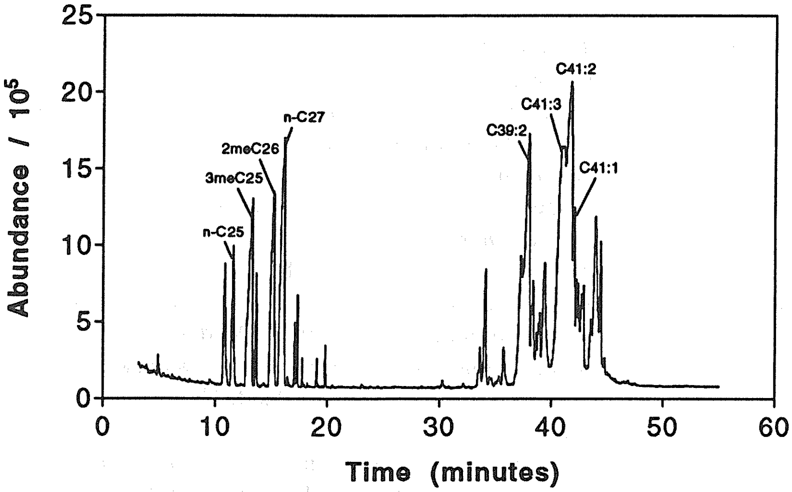

FIG. 3. Total ion chromatogram of the cuticular hydrocarbons from 20 pseudergates of *Procryptotermes corniceps* from Great Camino.

The cuticular hydrocarbon mixture of *P. corniceps* was very similar in gross comparison to that of *C. brevis*. The early-eluting components were almost exclusively *n*-alkanes and terminally branched monomethylalkanes, and the late-eluting compounds were primarily olefins (Table 2; Figure 3).

n-Alkanes present were *n*-C_{24}, *n*-C_{25}, *n*-C_{26}, *n*-C_{27}, *n*-C_{28}, and *n*-C_{29}. The most abundant hydrocarbons were *n*-C_{25} and *n*-C_{27}, comprising about 6.3% and 11.7% of the total hydrocarbon, respectively. All of the other *n*-alkanes represented <2.5% of the total hydrocarbons.

Internally branched monomethylalkanes were not common in *P. corniceps*. 13-MeC_{27} occurred in trivial amounts. The isomeric mixture of 15-; 13-MeC_{39} coeluted with $C_{40:2}$. In most samples 15-; 13-MeC_{41} made up an average of about 0.9% of the total hydrocarbons. 2- and 3-Methylalkanes were identified from C_{24} to C_{28}. These terminally branched monomethylalkanes comprise about 23% of the total hydrocarbon. As in *C. brevis* the 2- and 3-methylalkanes almost always occurred in pairs. When the parent chain of these hydrocarbons contained an even number of carbons, the 2-methylalkane predominated; when the parent chain contained an odd number of carbons, the 3-methylalkane was more abundant (Figure 3). Di- and trimethylalkanes were not detected.

As with *C. brevis*, the alkenes, alkadienes, and alkatrienes were the predominant class of cuticular hydrocarbons, comprising over 55% of the total hydrocarbons. The number of carbons ranged from 25 to 43. One sample contained a significant amount of pentacosadiene (> 15% of the total hydrocarbons); this compound was not seen in any of the other samples.

Incisitermes *spp*. Members of the genus *Incisitermes* are the most common kalotermitds found in the BVI. Collins et al. (1997) and Scheffrahn et al. (1994) list *I. snyderi* (or *I.* nr *snyderi*) from all of the islands in the BVI sampled by M. S. Collins, except for Eustatia, and *I. incisus* from Beef Island, Eustatia, Guana Island, and Virgin Gorda. Because of the morphological variation and the uncertainty of the taxonomy of *Incisitermes* in the BVI, we were unable to unambiguously assign specimens used for hydrocarbon characterization to a specific taxon within *Incisitermes* (Collins et al., 1997).

Specimens identified as *I.* nr *snyderi* were the most common found in the BVI. They live in sound, dead trees of many species, as well as in structural timber throughout much of its range (Light, 1993; Harris, 1961). Specimens identified as *I. incisus* were collected in the mangrove swamps fringing Beef Island and in trees on the wetter side of Guana Island. No records of attack on buildings were available for *I. incisus.*

After comparing the cuticular hydrocarbons of over 20 colonies of *Incisitermes* from the BVI including samples from Eustatia identified as *I. incisus*, we concluded that the mixtures of the cuticular hydrocarbons of these samples were as variable as the morphology of the termites. The general ''patterns'' of these chromatograms varied from one similar to *N. mona*, where $>95\%$ of the hydrocarbons have 23–29 carbons (Figure 4), to one similar to the kalotermitids found in drier conditions, where a significant proportion ($>30\%$) of the hydrocarbons were olefins with 33 or more carbons (Figure 5). We also found *Incisitermes* specimens with hydrocarbon mixtures that were intermediate to these extremes (Figure 6). Because of this broad variation, we report the extremes and discuss the classes of hydrocarbons in general terms, describing the range that we observed (Table 2).

n-Alkanes present were n-C_{23}, n-C_{24}, n-C_{25}, n-C_{26}, n-C_{27}, n-C_{28}, and n-C_{29}. The most abundant ones were n-C_{25} and n-C_{27} in all *Incisitermes* samples. Internally branched monomethylalkanes were rare and were found for C_{25}, C_{27}, C_{28}, C_{29}, C_{35}, C_{37}, and C_{39}; they were not detectable in most of the samples. Methyl branches were found on carbons, 7, 9, 11, 13, 15, and 17, occasionally in isomeric mixtures. The 2- and 3-methylalkanes were identified for C_{24}–C_{27}, with 2-MeC_{25} being the most abundant. Of the 3-methylalkanes, 3-MeC_{25} was the most abundant. These terminally branched monomethylalkanes comprised from about 16–32% of the total hydrocarbon.

Di- and trimethylalkanes were rare in *Incisitermes* from the BVI. Most of the dimethylalkanes were late-eluting (carbon numbers in the parent chain from 33 to 37). The dimethylalkanes were all internally branched with the first methyl branch occurring on 9, 11, or 13 carbon. The position of the first methyl branch tended to be more internal as the parent chain length increases. The second methyl group was usually separated from the first by nine methylene units.

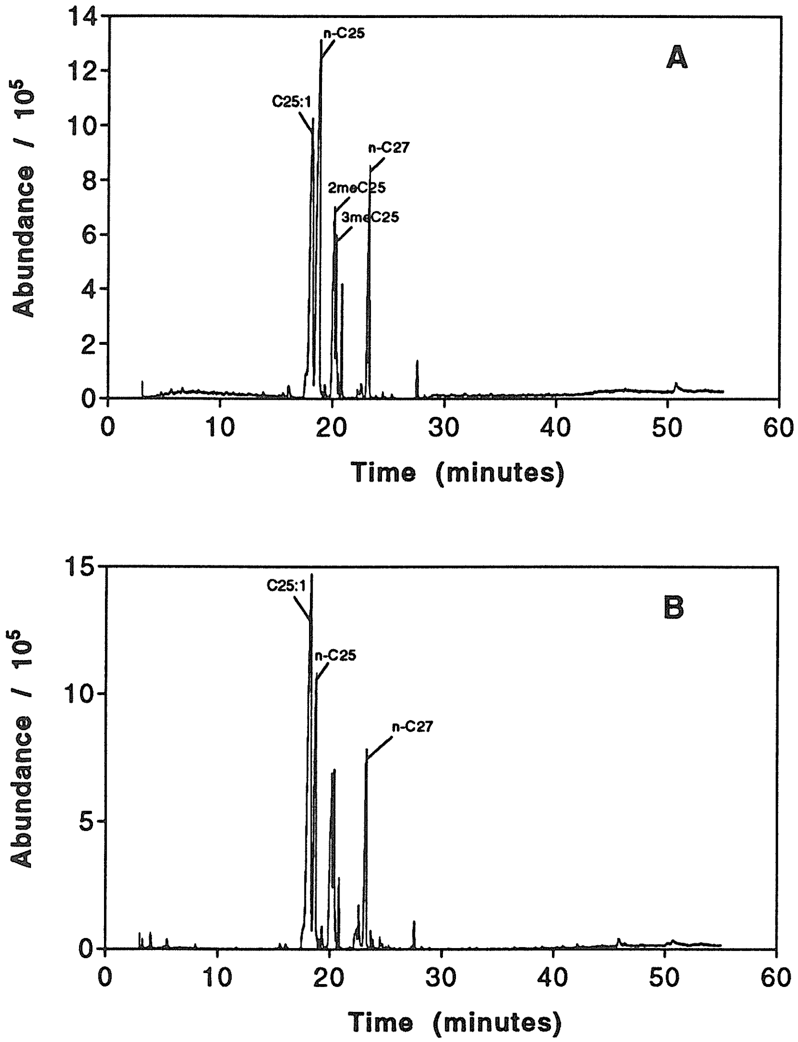

FIG. 4. Total ion chromatogram of the cuticular hydrocarbons from pseudergates from two separate colonies of *Incisitermes* from Guana Island.

Trimethylalkanes were found at C_{33}, C_{35}, and C_{37} in very few samples and were trivial in abundance when present.

The unsaturated components constituted about 30–60% of the total hydrocarbon. $C_{25:1}$ was the predominant olefin comprising as much as 25% of the

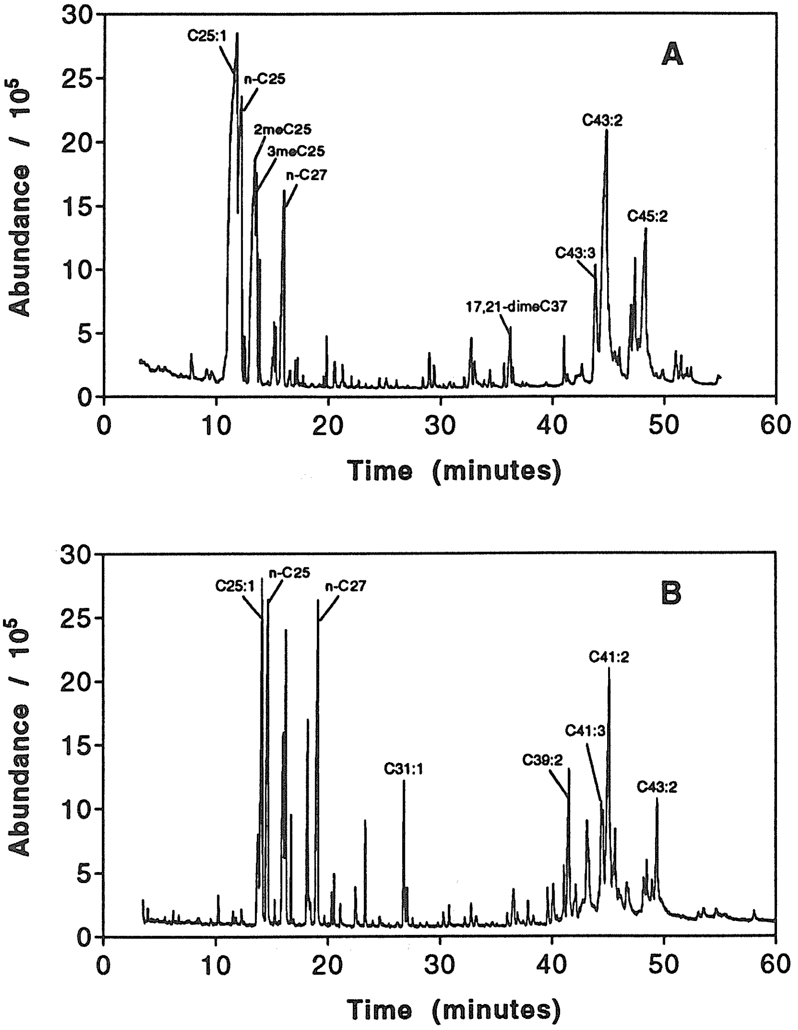

FIG. 5. Total ion chromatogram of the cuticular hydrocarbons from pseudergates of *Incisitermes* from Scrub Island (A) and Anegada (B).

total (Figures 4–6). Late-eluting olefins were either totally absent (Figure 4) or constituted 25–35% of the total hydrocarbons (Figures 5 and 6).

The results of our studies of *Incisitermes* from the BVI were equivocal. Cuticular hydrocarbons have proven useful in discriminating species of many groups of termites (Haverty et al., 1988, 1990, 1991, 1992; Howard et al., 1978, 1982, 1988; Thorne and Haverty, 1989; Thorne et al., 1993), but they

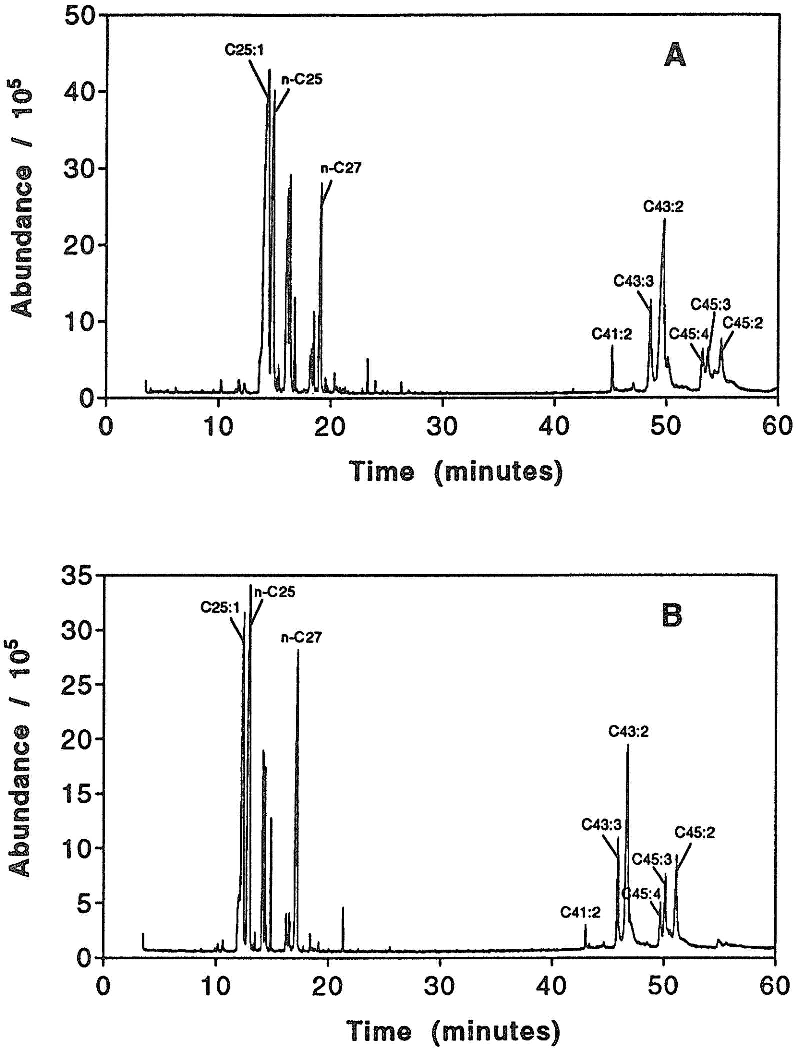

FIG. 6. Total ion chromatogram of the cuticular hydrocarbons from pseudergates and/or nymphs of *Incisitermes* from Guana Island (A) and Tortola (B).

were not diagnostic characters for sorting taxa in *Incisitermes* from the BVI. We saw no distinct differences between samples identified as *I. incisis* and many of those identified as *I.* nr *snyderi.* Further collections from the US Virgin Islands, the Greater Antilles, and mainland North America will be necessary to resolve the taxonomy of this refractory genus.

Rhinotermitidae

Thus far, only one taxon from this family has been collected in the British Virgin Islands.

Heterotermes *sp.* Samples of this genus are so morphologically variable that Snyder questioned whether the genus comprises a single, highly variable species or a complex of closely related species (Scheffrahn et al., 1994). There are three described species recorded from this region: *H. tenuis* (Hagen), *H. convexionotatus* (Snyder), and *H. cardini* (Snyder). Until the taxa are resolved, members of this genus collected in the BVI will be referred to as *Heterotermes* sp.

The cuticular hydrocarbon mixture of *Heterotermes* sp. from the BVI included mostly compounds with 26–31 carbons in the parent chain (Table 2; Figure 7). Late-eluting compounds accounted for only about 1% of the total hydrocarbons. Mono- and dimethylalkanes with 27 or 29 carbons in the parent chain accounted for >76% of the total. *Heterotermes* sp. from the BVI had a mixture of hydrocarbons very similar to that of *H. aureus* (Snyder) from the Sonoran Desert near Tucson, Arizona (Haverty and Nelson, unpublished observations).

n-Alkanes present were *n*-C_{26}, *n*-C_{27}, *n*-C_{28}, *n*-C_{29}, *n*-C_{30}, and *n*-C_{31}. *n*-C_{27} was the most abundant normal alkane comprising about 4.5% of the total hydrocarbon. The others combined represented <4% of the total. We identified

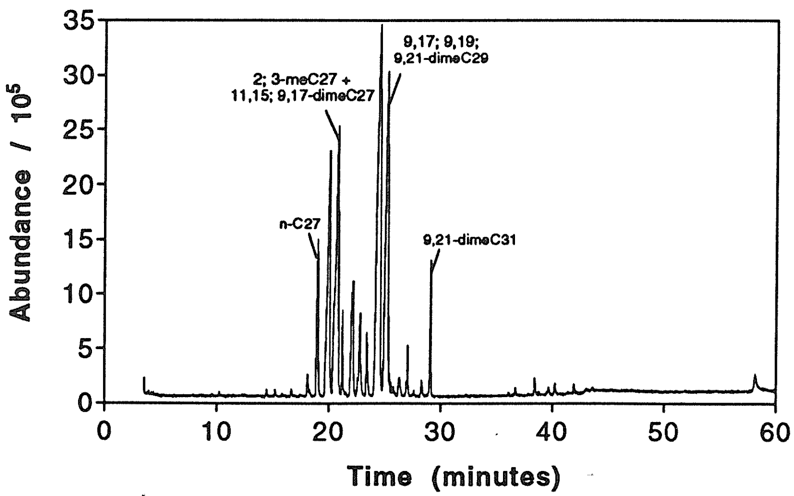

FIG. 7. Total ion chromatogram of the cuticular hydrocarbons from workers of *Heterotermes* sp. from Guana Island.

isomeric mixtures of internally branched monomethylalkanes with parent carbon chains ranging from C_{27} to C_{31}, and C_{37}. This class of compounds was very abundant, representing nearly 44% of the total. Two isomeric mixtures, 13-; 11-; 9-; 7-MeC_{27} and 13-; 11-; 9-; 7-MeC_{29}, were predominant and accounted for >37% of the total hydrocarbon. We identified 2- and 3-methylalkanes for C_{26} and C_{27}. Only the 2-methyl isomer occurred at C_{28}. Terminally branched monomethylalkanes comprise only 1.1% of the total hydrocarbon.

Internally branched dimethylalkanes predominated and accounted for over 45% of the total hydrocarbon fraction. The most abundant dimethylalkanes occurred in isomeric mixtures with 27 or 29 carbons in the parent chain (Figure 7). Only one terminally branched dimethylalkane (3,21-DimeC_{29}) was identified, and it coeluted with 7,13,21-TrimeC_{29} in trace amounts. Various isomers of trimethylnonacosane were detected, but in trivial amounts. Only two olefins were present, $C_{37:1}$ and $C_{39:1}$, constituting <1% of the total hydrocarbon.

Termitidae

Three species of termitids, belonging to two genera, were collected on Guana Island and nearby islands of the BVI complex.

Parvitermes wolcotti (*Snyder*). *P. wolcotti* is a small nasute that forages in dead wood or on the ground in areas with fairly dense tree cover on Guana Island, BVI (Collins et al., 1977). We were not able to collect large samples until a fortuitous collection of 173 workers from a colony on Peter Island allowed us to document the hydrocarbon mixture of this species. The pattern of the hydrocarbon mixture of *P. wolcotti* was an inverse of *N. mona* in that nearly 80% of the hydrocarbons were late-eluting olefins with 41–45 carbons (Figure 8).

n-Alkanes present were *n*-C_{27}, *n*-C_{28}, and *n*-C_{29}. In total the *n*-alkanes comprised only 6.5% of the total hydrocarbon. One internally branched monomethylalkane was detected, 5-MeC_{29}, and represented only 1% of the total hydrocarbon. 2- and 3-Methylalkanes were identified for C_{27} and C_{29}, but 2-MeC_{28} was the most abundant internally branched monomethylalkane (Figure 8). The five compounds in this group comprised over 11% of the total hydrocarbons. One dimethyalkane was noted (as isomeric mixture 5,19-; 5,17-DimeC_{29}) and amounted to <1.7% of the cuticular hydrocarbon fraction. No trimethylalkanes were observed.

Unsaturated components comprised the predominant class of hydrocarbons in *P. wolcotti*, making up nearly 80% of the total hydrocarbons present. All of the olefins had an odd number of carbons (41, 43, and 45) and possessed three or four double bonds.

Nasutitermes costalis (*Holmgren*). *N. costalis* is the less common of the two carton nest-building nasutes found in the BVI. It occurs primarily in wetter

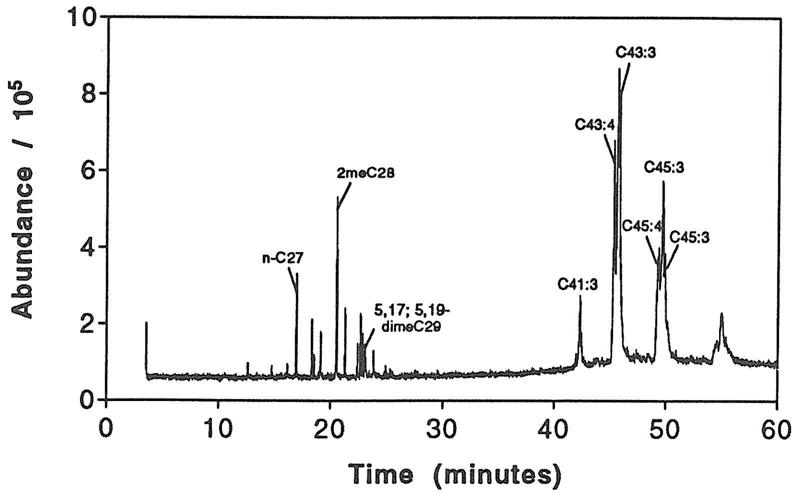

FIG. 8. Total ion chromatogram of the cuticular hydrocarbons from workers of *Parvitermes wolcotti* from Peter Island.

localities in the BVI; Tortola and Guana Island are the only islands where this species has been found (Collins et al., 1997; Scheffrahn et al., 1994). *N. costalis* occurs on many of the islands in the Greater and Lesser Antilles, from Cuba south to Trinidad and Tobago (Snyder, 1949; Araujo, 1977; Scheffrahn et al., 1994). The relative scarcity of *N. costalis* in the BVI may be related to the lower moisture availability on most of the islands of the complex. Krecek (1970) found that *N. costalis* distribution patterns and nest composition on Cuba indicated a relatively higher moisture demand than that shown by the other common nasute, *N. rippertii* (Rambur).

All of the cuticular hydrocarbons of *N. costalis* had parent chains ranging from 25 to 33 carbons. Those with 29–31 carbons in the parent chain comprised over 88% of the total hydrocarbon mixture (Figure 9).

n-Alkanes present were *n*-C_{25}, *n*-C_{27}, *n*-C_{28}, and *n*-C_{29}. *n*-C_{29} was the most abundant, comprising 1.9% of the total hydrocarbon. The other three *n*-alkanes represented only 3.2% of the total hydrocarbons.

We identified isomeric mixtures of internally branched monomethylalkanes with parent carbon chains ranging from C_{27} to C_{33}. Positions of methyl branches ranged from C-9 to C-15. Methyl branches located on even-numbered carbons were found only when the parent chain of the hydrocarbon had an even number of carbons, while branches on odd-numbered carbons were found to occur on hydrocarbons with either odd or even numbers of carbons in the parent chain. Internally branched monomethylalkanes were one of the most abundant classes

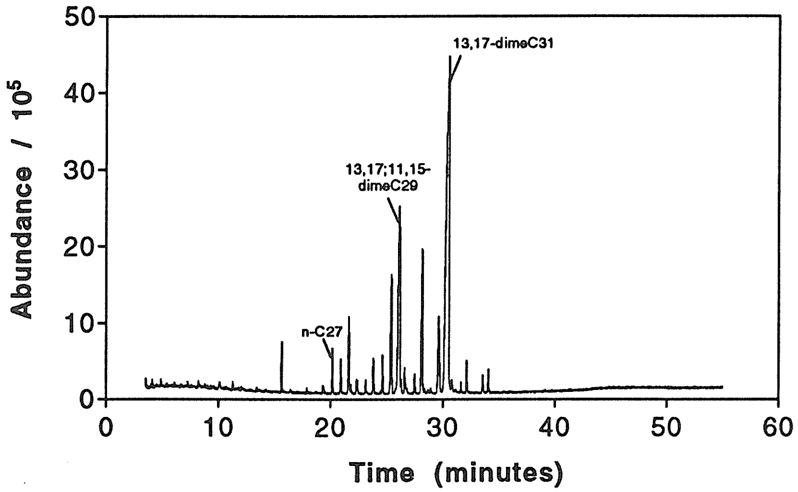

FIG. 9. Total ion chromatogram of the cuticular hydrocarbons from workers of *Nasutitermes costalis* from Tortola.

of hydrocarbons produced by *N. costalis*, representing about 15% of the total hydrocarbon. Two isomeric mixtures, 15-; 13-; 11-MeC_{29} and 15-; 13-; 11-MeC_{31}, accounted for nearly 80% of this class of hydrocarbon.

3-Methylalkanes were identified for C_{27} and C_{29}. 2-MeC_{27} coeluted with 11,15-$DimeC_{27}$. These terminally branched monomethylalkanes comprised at least 0.45% of the total hydrocarbons, but certainly less than 3.0%.

Internally branched dimethylalkanes were the predominant hydrocarbon class and constituted 78% of the total cuticular hydrocarbon fraction of *N. costalis* (Figure 9). All of these internally branched dimethylalkanes had three methylene groups separating the methyl branches. Dimethylalkanes had carbon numbers in the parent chain ranging from 27 to 33. Dimethylalkanes with 29 and 31 carbons in the parent chain accounted for nearly 64% of the total hydrocarbon complement. Terminally branched dimethylalkanes were not encountered.

Only two trimethylalkanes were identified. Each had three methylene groups between the methyl branches. Combined, they totaled $<1\%$ of the total hydrocarbon. $C_{27:1}$ was the only olefin found and represented only 0.24% of the total hydrocarbon.

Nasutitermes acajutlae *(Holmgren). N. acajutlae* is the most conspicuous, and apparently the most abundant, species of termite in the BVI complex. Colonies of this species construct enormous nests (up to 1.5 m in diameter, up to 2.0 m in height) composed of dark to silvery brown, delicate, friable, parchmentlike outer walls enclosing the variously sized, heavier-walled cells of the carton matrix. Nests are usually ellipsoidal or irregularly rounded.

N. acajutlae was recently resurrected as a species morphologically distinguishable from *N. nigriceps* (Thorne et al., 1994). Termites in the *N. acajutlae/ N. nigriceps* complex range from Mexico south into South America, then east and north through the Caribbean. Members of the two species have a tolerance for wide variations in moisture availability and use a variety of foods and nesting sites. Mature nests and individuals of *N. acajutlae* are larger than those of *N. costalis*. Soldiers of *N. acajutlae* have reddish to dark brown heads; alates are relatively large and chestnut brown in color (Thorne et al., 1994).

N. acajutlae was found on every island surveyed and has been found on even the smallest of islands, such as Carrot Rock (Scheffrahn et al., 1994; Collins et al., 1997). We obtained hydrocarbon samples of this species from 11 islands (Table 1). We extensively sampled workers and soldiers from 13 colonies on Guana Island, and collected alates when we encountered them (Haverty et al., 1996). To further assess interisland variability, we sampled *N. acajutlae* from diverse habitats on Tortola in 1994.

We identified 33 hydrocarbons from workers, 45 from soldiers, and 43 from alates of *N. acajutlae* (Haverty et al., 1996). The hydrocarbons found in all three castes aggregated into two distinct groups. The early-eluting components were primarily *n*-alkanes, methyl-branched alkanes, and a few normal alkenes. The late-eluting compounds consisted almost exclusively of unsaturated components, with chain lengths of 37–45 carbons and one to six double bonds, and a few monomethyl alkanes in trace amounts (especially in alates). Soldiers had considerably greater proportions of the early-eluting compounds (23–29 carbons) than did workers or alates (Figures 10 and 11). Whereas workers and alates had an average of 88–96% of the cuticular hydrocarbons with 33 or more carbons, soldiers had an average of about 69% of these late-eluting compounds. The predominant class of hydrocarbons was the olefin fraction, comprising greater than 89% of the total hydrocarbon component in workers and alates and about 76% in soldiers.

n-Alkanes present ranged from n-C_{23} to n-C_{33}. Usually n-C_{25} and n-C_{27} were the most abundant for workers, soldiers, and alates. The *n*-alkanes were least abundant in alates (1.8–4.3% of total), moderately abundant in workers (4–7.3% of total), and most abundant in soldiers (17.4–18.8% of the total hydrocarbon) (Figures 10 and 11).

Internally branched monomethylalkanes were nearly always encountered, in trivial amounts in workers (0.4–0.9% of total), and in significant amounts in soldiers (about 5.5% of total). Internally branched monomethylalkanes were usually present in alates, but accounted for only 0.4–1.7% of the total hydrocarbon. Only trivial amounts of 2- and 3-methylalkanes occurred in workers and soldiers. Alates usually had a significant component of 2-methylalkanes, com-

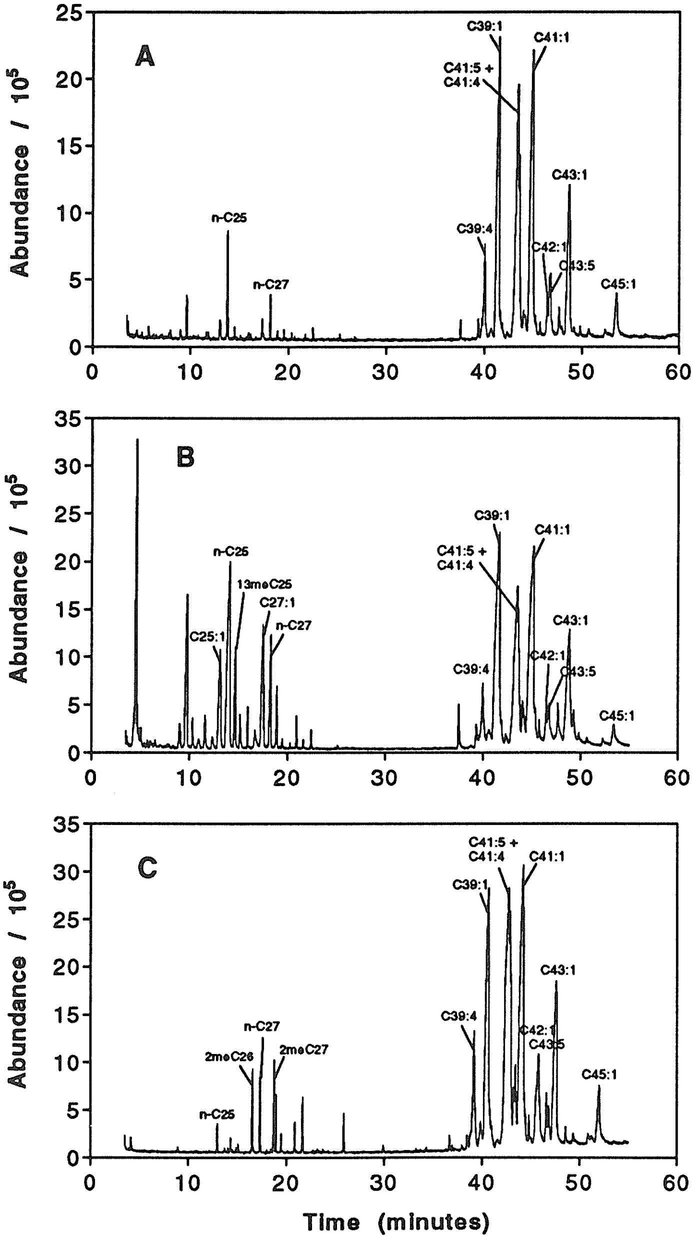

FIG. 10. Total ion chromatogram of the cuticular hydrocarbons from *Nasutitermes acajutlae* from Guana Island. A = workers, B = soldiers, C = alates.

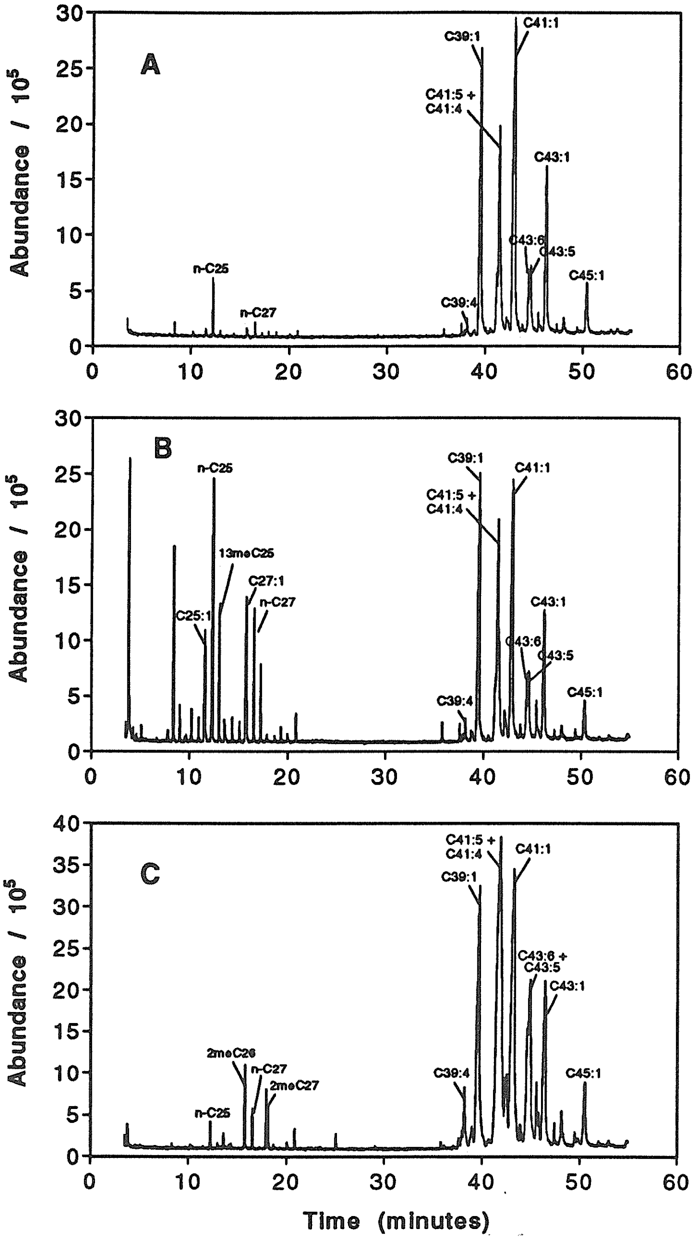

FIG. 11. Total ion chromatogram of the cuticular hydrocarbons of *Nasutitermes acajutlae* from Tortola, BVI. A = workers, B = soldiers, C = alates.

prising 1.8–4.6% of the total hydrocarbon, and were always found in the early-eluting constituents (Figures 10 and 11). No dimethyl- or trimethylalkanes were found in workers or soldiers; only 5,17-DimeC_{25} was found in alates in trivial amounts.

The unsaturated component was the paramount class of hydrocarbons in the cuticular lipids of *N. acajutlae.* Olefins comprised an average of 90–96% of the total hydrocarbon in workers and alates. Since soldiers contained a larger proportion of early-eluting *n*-alkanes, the olefin component amounted to about 76% of the total hydrocarbon in this caste. For all castes, $C_{39:1}$, $C_{41:5}$, $C_{41:4}$, $C_{41:1}$, and $C_{43:1}$ accounted for at least 70% of the total olefin (Haverty et al., 1996).

Intercaste Variation in N. acajutlae. We observed consistent intercaste differences in hydrocarbon mixtures of *N. acajutlae.* Workers and alates produced proportionally more olefins than did soldiers. Conversely, soldiers made proportionally more of the early-eluting hydrocarbons, such as *n*-alkanes and monomethylalkanes, than did workers and alates.

Cuticular hydrocarbons of workers, soldiers, and alates were not qualitatively identical. Soldiers had some early eluting compounds (11-; 9-MeC_{23}, 3-MeC_{23}, $C_{24:1}$, 11-MeC_{24}, 3-MeC_{25}, $C_{26:1}$, and 13-; 12-; 11-MeC_{26}) that were not found in workers or alates from Guana Island or Tortola (Tables 4 and 5; Figures 10 and 11). Samples of alates from both Guana Island and Tortola included hydrocarbons (5-MeC_{25}, 2-MeC_{25}, 5,17-DimeC_{25}, 2-MeC_{26}, and 3-MeC_{27}) not found in either workers or soldiers (Tables 4 and 5). Alates from Guana Island contained some abundant hydrocarbons ($C_{40:5}$, 15-MeC_{43}, and $C_{45:2}$) and trace hydrocarbons not seen in workers or soldiers from the same island (Table 4). Alates, workers, and soldiers from Tortola have these latter hydrocarbons as well as significant amounts (0.6–0.7%) of $C_{45:5}$, which was not seen in the Guana Island samples (Tables 4 and 5). Alates from both Guana Island and Tortola were also missing a few hydrocarbon components ($C_{25:1}$, $C_{27:1}$, and 13-; 11-MeC_{27}) that were commonly observed in workers and soldiers (Tables 4 and 5). $C_{40:1}$ and $C_{42:1}$ were not detected in alates from Guana Island, but were frequently found in workers and soldiers (Table 4).

$C_{43:6}$ was detected only in alates from Guana Island that were collected in 1993; however, this hydrocarbon was found in all castes collected on Tortola in 1994. It is curious that in preliminary work $C_{43:6}$ was also seen in workers, soldiers, and alates from specimens taken in 1994 from some of the same colonies on Guana Island that we sampled in 1993 (Haverty, Thorne, and Nelson, unpublished observations).

These obvious year-to-year differences could, in fact, represent distinct annual variation. They may be an artifact resulting from variations in handling of samples (for example, minor differences in drying technique or storage before and after processing). Whether these differences are real or an artifact of pro-

TABLE 4. RELATIVE QUANTITIES (MEAN AND STANDARD DEVIATION) OF CUTICULAR HYDROCARBONS OF SAMPLES OF WORKERS, SOLDIERS, AND ALATES OF *Nasutitermes acajutlae* (HOLMGREN) FROM GUANA ISLAND[a]

Hydrocarbon	Workers (mean ± SD)	Soldiers (mean ± SD)	Alates (mean ± SD)
$C_{23:1}$	0.32 ± 0.32	0.41 ± 0.17	0.00 ± 0.00
C_{23}	0.97 ± 0.33	4.04 ± 0.91	0.08 ± 0.04
11-; 9-MeC_{23}[b]	0.00 ± 0.00	0.51 ± 0.15	0.00 ± 0.00
3-MeC_{23} + $C_{24:1}$[c]	0.00 ± 0.00	0.18 ± 0.15	0.00 ± 0.00
C_{24}	0.22 ± 0.22	0.66 ± 0.19	0.00 ± 0.00
11-MeC_{24}	0.00 ± 0.00	0.37 ± 0.32	0.00 ± 0.00
$C_{25:1}$	0.68 ± 0.27	2.96 ± 0.69	0.00 ± 0.00
C_{25}	3.05 ± 1.14	9.16 ± 1.28	0.55 ± 0.14
13-; 11-MeC_{25}[b]	0.16 ± 0.17	1.98 ± 0.43	0.12 ± 0.03
5-MeC_{25}	0.00 ± 0.00	0.00 ± 0.00	0.07 ± 0.01
2-MeC_{25}	0.00 ± 0.00	0.00 ± 0.00	0.20 ± 0.03
3-MeC_{25} + $C_{26:1}$[c]	0.00 ± 0.00	0.57 ± 0.13	0.00 ± 0.00
5,17-DimeC_{25}	0.00 ± 0.00	0.00 ± 0.00	0.08 ± 0.01
C_{26}	0.26 ± 0.27	0.59 ± 0.16	0.14 ± 0.02
13-; 12-; 11-MeC_{26}[b]	0.00 ± 0.00	0.42 ± 0.35	0.00 ± 0.00
2-MeC_{26}	0.00 ± 0.00	0.00 ± 0.00	1.42 ± 0.16
$C_{27:1}$	0.86 ± 0.42	3.88 ± 0.63	0.00 ± 0.00
C_{27}	1.90 ± 1.60	3.67 ± 0.92	1.44 ± 0.28
13-; 11-MeC_{27}[b]	0.07 ± 0.11	1.14 ± 0.21	0.00 ± 0.00
5-MeC_{27}	0.00 ± 0.00	0.00 ± 0.00	0.08 ± 0.04
2-MeC_{27}	0.15 ± 0.13	0.14 ± 0.09	1.67 ± 0.29
3-MeC_{27}	0.00 ± 0.00	0.00 ± 0.00	0.72 ± 0.13
C_{28}	0.15 ± 0.19	0.13 ± 0.12	0.30 ± 0.08
2-MeC_{28} + $C_{29:1}$[c]	0.00 ± 0.00	0.19 ± 0.10	0.53 ± 0.11
C_{29}	0.73 ± 0.56	0.56 ± 0.25	1.08 ± 0.25
5-MeC_{29}	0.00 ± 0.00	0.00 ± 0.00	0.07 ± 0.05
2-MeC_{29}	0.00 ± 0.00	0.00 ± 0.00	0.03 ± 0.03
3-MeC_{29}	0.00 ± 0.00	0.00 ± 0.00	0.04 ± 0.05
C_{30}	0.00 ± 0.00	0.00 ± 0.00	0.05 ± 0.04
C_{31}	0.06 ± 0.15	0.02 ± 0.04	0.58 ± 0.08
C_{33}	0.00 ± 0.00	0.01 ± 0.03	0.12 ± 0.03
$C_{35:1}$	0.00 ± 0.00	0.00 ± 0.00	0.11 ± 0.06
13-MeC_{35}	0.00 ± 0.00	0.00 ± 0.00	0.12 ± 0.06
$C_{37:1}$	0.40 ± 0.17	0.65 ± 0.17	0.40 ± 0.14
$C_{38:1}$	0.53 ± 0.20	0.58 ± 0.13	0.47 ± 0.07
$C_{39:5}$[d]	0.36 ± 0.33	0.28 ± 0.25	0.00 ± 0.00
$C_{39:4}$[d]	2.00 ± 0.73	1.33 ± 0.61	3.89 ± 0.78
$C_{39:2}$	0.43 ± 0.48	1.29 ± 0.56	1.14 ± 0.11
$C_{39:1}$	20.01 ± 2.20	15.77 ± 2.79	14.40 ± 1.26
15-MeC_{39}	0.04 ± 0.12	0.36 ± 0.27	0.00 ± 0.00
$C_{40:5}$	0.00 ± 0.00	0.00 ± 0.00	0.90 ± 0.35
$C_{40:1}$	2.51 ± 0.42	2.89 ± 0.62	0.00 ± 0.00

TABLE 4. Continued

Hydrocarbon	Workers (mean ± SD)	Soldiers (mean ± SD)	Alates (mean ± SD)
$C_{41:4} + C_{41:5}$[e]	18.77 ± 3.81	11.01 ± 3.92	21.72 ± 2.41
$C_{41:2}$	1.21 ± 0.63	1.50 ± 0.49	3.31 ± 0.20
$C_{41:1}$	24.43 ± 2.74	17.42 ± 3.52	20.24 ± 1.18
15-MeC_{41}	0.13 ± 0.23	0.46 ± 0.24	0.76 ± 0.15
$C_{42:1}$	1.60 ± 0.65	1.99 ± 1.03	0.00 ± 0.00
$C_{43:6} + C_{43:5}$[f]	4.35 ± 1.37	2.41 ± 1.09	6.24 ± 1.11
$C_{43:2}$	0.83 ± 0.52	1.14 ± 0.43	2.63 ± 0.27
$C_{43:1}$	10.40 ± 1.61	7.66 ± 1.48	10.28 ± 1.09
15-MeC_{43}	0.00 ± 0.00	0.00 ± 0.00	0.43 ± 0.11
$C_{45:2}$	0.00 ± 0.00	0.00 ± 0.00	0.32 ± 0.11
$C_{45:1}$	2.41 ± 0.82	1.69 ± 0.64	3.26 ± 0.87

[a] Three subsamples of 100 workers from each of 13 colonies. Four subsamples of ca. 4 ml of soldiers from each of 13 colonies. Two subsamples of 25–31 alates from four colonies.
[b] An isomeric mixture. These monomethylalkanes coelute.
[c] This monomethylalkane and the olefin coelute.
[d] These two isomers did not completely resolve in alates. Therefore, the areas for the two isomers were summed for alates only.
[e] These two isomers did not completely resolve. Therefore, the areas for the two isomers were summed.
[f] $C_{43:6}$ was identified only in alates. There were two isomers of $C_{43:5}$ that did not completely resolve. Therefore, the areas for the two isomers were summed.

tocol, we must consider them when evaluating minor variations in hydrocarbon mixtures for taxonomic studies of termites.

Island-to-Island Variation in N. acajutlae. Our collections of *N. acajutlae* were much more extensive, both in numbers of samples and geographic coverage (Table 1), than for any other termite taxon in the British Virgin Islands. We observed qualitative differences between samples of soldiers from Guana Island and Tortola, two islands separated by a channel approximately 2 km wide (Tables 4 and 5). Soldiers from collections on Guana Island did not have $C_{40:5}$ or $C_{45:2}$, whereas soldiers from Tortola possessed small amounts of these olefins. We did not have samples of soldiers from other islands, and our alate collections from other islands were limited. However, comparison of hydrocarbon mixtures from workers indicated a range in variation, both qualitative and quantitative, possible within one species (Tables 4 to 6).

Workers from islands more distant from Tortola and Guana tended to have more of the terminally branched monomethylalkanes (Tables 4–6; Figures 10–12). Two samples in particular, those from Scrub Island and Great Camino, displayed hydrocarbon mixtures more similar to soldiers (Figure 12); however,

TABLE 5. RELATIVE QUANTITIES (MEAN AND STANDARD DEVIATION) OF CUTICULAR HYDROCARBONS OF SAMPLES OF WORKERS, SOLDIERS, AND ALATES OF *Nasutitermes acajutlae* (Holmgren) FROM TORTOLA[a]

Hydrocarbon	Workers (mean ± SD)	Soldiers (mean ± SD)	Alates (mean ± SD)
$C_{23:1}$	0.00 ± 0.00	0.38 ± 0.13	0.00 ± 0.00
C_{23}	0.47 ± 0.16	3.99 ± 0.56	0.08 ± 0.01
11-; 9-MeC_{23}[b]	0.00 ± 0.00	0.66 ± 0.11	0.00 ± 0.00
3-MeC_{23} + $C_{24:1}$[c]	0.00 ± 0.00	0.32 ± 0.06	0.00 ± 0.00
C_{24}	0.07 ± 0.08	0.65 ± 0.05	0.01 ± 0.03
11-MeC_{24}	0.00 ± 0.00	0.46 ± 0.10	0.00 ± 0.00
$C_{25:1}$	0.50 ± 0.18	3.23 ± 0.46	0.00 ± 0.00
C_{25}	2.11 ± 0.59	8.41 ± 0.86	0.57 ± 0.20
13-; 11-MeC_{25}[b]	0.27 ± 0.09	2.52 ± 0.38	0.07 ± 0.06
5-MeC_{25}	0.00 ± 0.00	0.00 ± 0.00	0.02 ± 0.03
2-MeC_{25}	0.00 ± 0.00	0.00 ± 0.00	0.19 ± 0.03
3-MeC_{25} + $C_{26:1}$[c]	0.00 ± 0.00	0.62 ± 0.07	0.00 ± 0.00
5,17-$DimeC_{25}$	0.00 ± 0.00	0.00 ± 0.00	0.07 ± 0.02
C_{26}	0.06 ± 0.09	0.49 ± 0.08	0.08 ± 0.02
13-; 12-; 11-MeC_{26}[b]	0.00 ± 0.00	0.35 ± 0.09	0.00 ± 0.00
2-MeC_{26}	0.00 ± 0.00	0.00 ± 0.00	1.04 ± 0.24
$C_{27:1}$	0.54 ± 0.17	3.47 ± 0.56	0.00 ± 0.00
C_{27}	0.74 ± 0.24	3.25 ± 1.00	0.47 ± 0.10
13-; 11-MeC_{27}[b]	0.08 ± 0.10	1.08 ± 0.26	0.00 ± 0.00
2-MeC_{27}	0.24 ± 0.15	0.12 ± 0.09	0.61 ± 0.17
3-MeC_{27}	0.00 ± 0.00	0.00 ± 0.00	0.45 ± 0.10
C_{28}	0.13 ± 0.10	0.00 ± 0.00	0.07 ± 0.02
2-MeC_{28}	0.07 ± 0.10	0.00 ± 0.00	0.12 ± 0.02
$C_{29:1}$	0.00 ± 0.00	0.13 ± 0.11	0.00 ± 0.00
C_{29}	0.33 ± 0.09	0.62 ± 0.43	0.41 ± 0.14
C_{31}	0.04 ± 0.07	0.02 ± 0.04	0.28 ± 0.05
C_{33}	0.00 ± 0.00	0.00 ± 0.00	0.06 ± 0.05
$C_{37:1}$	0.24 ± 0.12	0.38 ± 0.09	0.09 ± 0.02
$C_{38:1}$	0.39 ± 0.08	0.36 ± 0.09	0.26 ± 0.02
$C_{39:5}$	0.25 ± 0.15	0.15 ± 0.12	0.42 ± 0.08
$C_{39:4}$	1.36 ± 0.67	1.02 ± 0.46	2.60 ± 0.69
$C_{39:2}$	0.29 ± 0.29	0.59 ± 0.18	0.87 ± 0.10
$C_{39:1}$	18.06 ± 1.64	12.66 ± 1.68	12.40 ± 0.28
$C_{40:5}$	0.66 ± 0.30	0.44 ± 0.24	1.44 ± 0.29
$C_{40:1}$ + $C_{41:4}$ + $C_{41:5}$[d]	20.77 ± 3.01	18.98 ± 3.25	30.53 ± 2.19
$C_{41:2}$	1.43 ± 0.15	1.60 ± 0.22	3.39 ± 0.26
$C_{41:1}$	24.21 ± 2.06	15.27 ± 1.84	18.13 ± 0.29
15-MeC_{41}	0.39 ± 0.29	0.46 ± 0.25	0.83 ± 0.04
$C_{43:6}$	2.55 ± 0.76	2.05 ± 0.36	3.18 ± 0.64
$C_{43:5}$[e]	5.77 ± 1.19	4.07 ± 1.14	7.18 ± 0.90
$C_{43:2}$	1.12 ± 0.32	1.39 ± 0.15	2.17 ± 0.19
$C_{43:1}$	10.69 ± 0.80	6.77 ± 0.58	8.04 ± 0.34

TABLE 5. Continued

Hydrocarbon	Workers (mean ± SD)	Soldiers (mean ± SD)	Alates (mean ± SD)
15-MeC_{43}	0.20 ± 0.19	0.21 ± 0.10	0.43 ± 0.12
$C_{45:5}$	0.69 ± 0.37	0.59 ± 0.28	0.66 ± 0.31
$C_{45:2}$	0.19 ± 0.15	0.33 ± 0.06	0.26 ± 0.07
$C_{45:1}$	3.09 ± 0.31	1.94 ± 0.09	2.52 ± 0.36

[a]Three subsamples of 200 workers from each of seven colonies. Four subsamples of about 4 ml of soldiers from each of six colonies. Two subsamples of 25–31 alates from three colonies.
[b]An isomeric mixture. These monomethylalkanes coelute.
[c]This monomethylalkane and the olefin coelute.
[d]These three isomers did not completely resolve. Therefore, the areas for the isomers were summed.
[e]There were two isomers of $C_{43:5}$ that did not completely resolve. Therefore, the areas of the two isomers were summed.

TABLE 6. RELATIVE QUANTITIES (MEAN AND STANDARD DEVIATION) OF CUTICULAR HYDROCARBONS OF SAMPLES OF WORKERS AND ALATES OF *Nasutitermes acajutlae* (HOLMGREN) FROM BRITISH VIRGIN ISLANDS, EXCLUSIVE OF GUANA ISLAND AND TORTOLA[a]

Hydrocarbon	Workers (mean ± SD)	Alates (mean ± SD)
C_{23}	0.63 ± 0.47	0.15 ± 0.31
C_{24}	0.08 ± 0.15	0.00 ± 0.00
2-MeC_{24} + $C_{25:1}$[b,c]	0.32 ± 0.75	0.00 ± 0.00
$C_{25:1}$[c]	1.73 ± 4.45	0.00 ± 0.00
C_{25}	3.65 ± 2.47	0.67 ± 0.83
13-; 11-MeC_{25}[d]	0.27 ± 0.21	0.00 ± 0.00
2-MeC_{25}	0.56 ± 1.59	0.03 ± 0.06
3-MeC_{25} + $C_{26:1}$[b]	0.48 ± 1.29	0.00 ± 0.00
C_{26}	0.20 ± 0.36	0.00 ± 0.00
2-MeC_{26}	0.32 ± 0.60	0.78 ± 0.50
$C_{27:1}$	0.36 ± 0.44	0.00 ± 0.00
C_{27}	1.78 ± 1.22	0.51 ± 0.29
13-; 11-MeC_{27}	0.14 ± 0.18	0.00 ± 0.00
2-MeC_{27}	0.48 ± 0.42	0.63 ± 0.45
3-MeC_{27}	0.04 ± 0.13	0.34 ± 0.23
C_{28}	0.10 ± 0.12	0.04 ± 0.07
C_{29}	0.42 ± 0.31	0.38 ± 0.12
C_{31}	0.00 ± 0.00	0.09 ± 0.10

TABLE 6. Continued

Hydrocarbon	Workers (mean ± SD)	Alates (mean ± SD)
$C_{37:1}$	0.11 ± 0.13	0.05 ± 0.10
$C_{38:1}$	0.29 ± 0.21	0.24 ± 0.16
$C_{39:5}$	0.00 ± 0.00	0.19 ± 0.25
$C_{39:4}$	1.53 ± 1.00	2.08 ± 1.73
$C_{39:3}$	0.16 ± 0.28	0.24 ± 0.48
$C_{39:2}$	0.13 ± 0.43	0.63 ± 0.48
$C_{39:1}$	20.92 ± 4.61	18.18 ± 2.68
15-MeC_{39}	0.07 ± 0.23	0.21 ± 0.42
$C_{40:1}$ + $C_{41:4}$ + $C_{41:5}$[e]	22.28 ± 5.61	30.18 ± 3.38
$C_{41:3}$	0.24 ± 0.79	0.00 ± 0.00
$C_{41:2}$	0.83 ± 1.07	2.81 ± 1.93
$C_{41:1}$	27.65 ± 5.53	26.30 ± 2.54
15-MeC_{41}	0.17 ± 0.34	0.14 ± 0.28
$C_{42:X}$[f]	0.00 ± 0.00	0.25 ± 0.31
$C_{42:1}$	0.77 ± 0.43	0.79 ± 0.55
$C_{43:5}$[g]	3.49 ± 1.14	4.86 ± 0.99
$C_{43:3}$	0.23 ± 0.77	0.00 ± 0.00
$C_{43:2}$	0.81 ± 1.71	0.76 ± 0.55
$C_{43:1}$	8.73 ± 2.67	8.50 ± 1.89

[a] Mean for workers is derived from 11 samples from colonies of *N. acajutlae*: three from Necker Is. and one each from Great Camino, Scrub Is., Eustatia, Virgin Gorda, Lesser Jost Van Dyke, Greater Jost Van Dyke, Great Thatch, and Cooper. Mean for alates is derived from four samples from colonies of *N. acajutlae*: one each from Lesser Jost Van Dyke, Greater Jost Van Dyke, Great Thatch, and Necker Is.

[b] This monomethylalkane and this olefin coelute.

[c] Two separate isomers of $C_{25:1}$ occur in the samples from Great Camino and Scrub Island. This abundant, second isomer (maximum value of 15.1% in the Great Camino sample) was found only in these two samples.

[d] An isomeric mixture. These monomethylalkanes coelute.

[e] These three isomers did not completely resolve. Therefore, the areas for the three isomers were summed.

[f] An isomeric mixture. The exact number of double bonds is difficult to determine. In some instances two or three peaks were present with identical spectra. The areas for all isomers of the same olefin were summed.

[g] This olefin had two isomers that did not completely resolve. The areas for both isomers were summed.

examination of the extracted voucher specimens confirmed that only workers were extracted in these samples. The single sample from Great Camino displayed some distinct differences from samples collected on other islands. The later-eluting isomer of $C_{25:1}$ was present in great abundance, its peak area exceeding that of *n*-C_{25} (Figure 12B). This sample from Great Camino was the only one in which two isomers of $C_{43:3}$ were detected in measurable amounts.

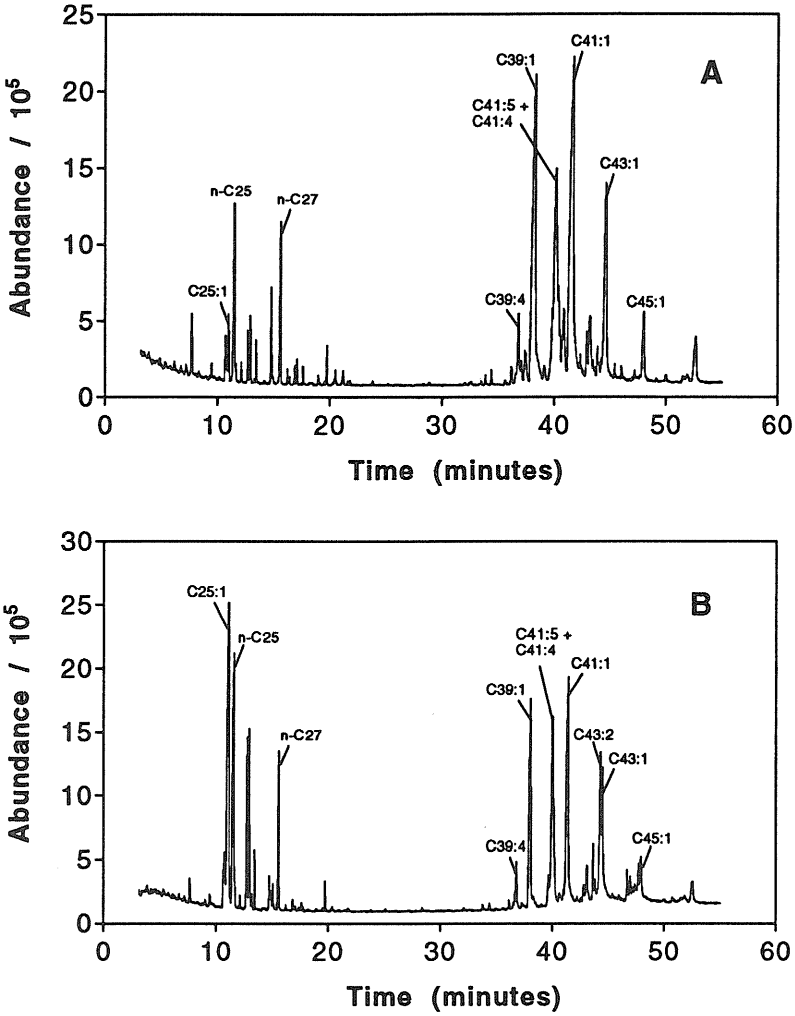

FIG. 12. Total ion chromatogram of the cuticular hydrocarbons from workers of *Nasutitermes acajutlae* from (A) Scrub Island and (B) Great Camino.

The retention time of $C_{43:2}$ in this sample indicated that this compound was a different isomer of $C_{43:2}$ than was seen in other samples of *N. acajutlae*. In the Great Camino sample, $C_{43:2}$ was not completely resolved from $C_{43:1}$; this is true for $C_{45:2}$ and $C_{45:1}$ as well (Figure 12B). The existence of island-to-island differences in hydrocarbon mixtures within one species should alert us to exercise caution when evaluating the use of cuticular hydrocarbons in termite taxonomy.

TABLE 7. DIAGNOSTIC CUTICULAR HYDROCARBONS (>1.0% OF TOTAL HYDROCARBON) FROM PSEUDERGATES (LARVAE AND NYMPHS) OR WORKERS OF 8 TERMITE TAXA FROM BRITISH VIRGIN ISLANDS[a]

Hydrocarbon	Termite species[b]							
	N mon	C bre	P cor	I spp[c]	H sp	P wol	N cos	N aca
C_{25}	+++	+++	+++	+++	0	0	++	+++
C_{26}	+++	++	++	++	tr	0	0	tr
C_{28}	tr	+	tr	tr	++	++	+	tr
C_{29}	+	++	+	+	++	++	++	+
13-; 11-MeC_{25}	+++	+	0	+	0	0	0	tr
13-; 12-MeC_{26}	+++	0	0	0	0	0	0	0
13-; 11-; 9-; 7-MeC_{27}	+++	tr	tr	tr	+++	0	+	tr
14-; 13-; 12-; 9-; 7-MeC_{28}	+	0	0	0	+++	0	+	0
15-; 13-; 11-; 9-; 7-; 5-MeC_{29}	tr	0	0	0/+	+++	+	+++	0
15-; 13-; 11-; 9-MeC_{31}	tr	0	0	0	+	0	+++	0
2-MeC_{24}	++	+++	+++	+++	0	0	0	0
2-MeC_{25}	+++	++	+++	+++	0	0	0	0
3-MeC_{25}	+++	+++	+++	+++	0	0	0	0
2-MeC_{26}	++	+	+++	+/++	+	0	0	0
3,X-DimeC_{25}	++	tr	0	0	0	0	0	0
11,15-DimeC_{27}	++	0	0	0	+++	0	++	0
9,17-DimeC_{27}	0	0	0	0	+++	0	0	0
9,X-DimeC_{28}	0	0	0	0	+++	0	0	0
13,17-; 11,15-DimeC_{29}	0	0	0	0	0	0	+++	0
9,19-; 9,17-DimeC_{29}	0	0	0	0/+	+++	0	0	0
7,21-DimeC_{29}	0	0	0	0	+++	0	0	0
11,15-; 12,16-; 13,17-DimeC_{30}	0	0	0	0	0	0	+++	0
11,15-DimeC_{39}	++	0	0	0	0	0	0	0
13,17-DimeC_{41}	++	0	0	0	0	0	0	0
$C_{25:1}$	0	0	++	+++	0	0	0	+
$C_{27:1}$	tr	0	0	+++	0	0	tr	+
$C_{37:2}$	0	+++	++	0	0	0	0	0
$C_{39:2}$	0	+++	+++	0/+	0	0	0	+
$C_{39:1}$	0	++	++	tr	tr	0	0	+++
$C_{40:1}$	0	0	0	0	0	0	0	+++
$C_{41:5}$	0	0	0	0	0	0	0	+++
$C_{41:4}$	0	0	0	0	0	0	0	+++
$C_{41:3}$	0	+++	+++	0/+	0	+++	0	0
$C_{41:2}$	0	+++	+++	0/++	0	0	0	++
$C_{41:1}$	0	++	+++	0/+	0	0	0	+++
$C_{43:4}$	0	0	+	0	0	+++	0	+++
$C_{43:3}$	0	++	++	0/+++	0	+++	0	0
$C_{43:2}$	0	++	++	+++	0	0	0	+
$C_{43:1}$	0	++	0	0/++	0	0	0	+++

TABLE 7. Continued

Hydrocarbon	Termite species[b]							
	N mon	C bre	P cor	I spp[c]	H sp	P wol	N cos	N aca
$C_{45:4}$	0	0	0	0/+	0	+++	0	0
$C_{45:3}$	0	++	0	0/++	0	+++	0	0
$C_{45:1}$	0	0	0	0/+++	0	0	0	++

[a]Relative proportions of the total hydrocarbon mixture for each species. +++ = >3.0%; ++ = 1.0–3.0%; + = 0.3–0.99%; and tr = <0.3%; 0 = not detected.
[b]N mon = *Neotermes mona*; C bre = *Cryptotermes brevis*; P cor = *Procryptotermes corniceps*; I spp = *Incisitermes* species; H spp = *Heterotermes* species; P wol = *Parvitermes wolcotti*; N cos = *Nasutitermes costalis*; N aca = *Nasutitermes acajutlae* (from Guana Island).
[c]*Incisitermes* spp. displayed a wide range of hydrocarbon mixtures. For example, 0/+++ would denote the range from absent to above 3%.

Taxonomic and Biogeographic Value of Cuticular Hydrocarbon Profiles. One of the objectives of our studies of the termite fauna of the British Virgin Islands was to begin to build a library of cuticular hydrocarbon profiles correlated with species determinations based on morphological characters. Much of this work will be published separately as in-depth studies of individual taxa (genera or species complexes) from the Caribbean Basin. BVI termite species that were readily identifiable on the basis of morphological characters of the soldiers or alates also had diagnostic cuticular hydrocarbon mixtures. Using only the consistently abundant hydrocarbons, one could unambiguously identify species based on characterization of the hydrocarbons of workers, larvae, pseudergates, or nymphs without the sometimes rare soldiers and alates needed for morphological diagnoses (Table 7). Separation of closely related taxa has been demonstrated for species of *Nasutitermes* from the Caribbean Basin and *Zootermopsis* from western North America using the consistently abundant hydrocarbons (Haverty et al., 1988, 1992).

Cuticular hydrocarbons may eventually help resolve one of the more difficult taxonomic problems among the termite species of the British Virgin Islands, i.e., separation of species within the genus *Incisitermes*. *Incisitermes* from the Cayman Islands identified as *I. tabogae* (Snyder) possess a distinct cuticular hydrocarbon mixture clearly separable from the *Incisitermes* examined from the BVI (Haverty et al., unpublished observations). Similarly, the taxonomy of *Heterotermes* might be clarified if consistent hydrocarbon mixtures can be used to presort specimens for morphological study.

CONCLUSIONS

All classes of hydrocarbons are seen among the eight termite taxa characterized from the BVI. All taxa have normal alkanes present in their cuticular hydrocarbon mixture: n-C_{25} and n-C_{27} are the most abundant. Internally branched monomethylalkanes are not commonly seen or are present in very small amounts relative to all other hydrocarbons; only *Neotermes mona* and *Heterotermes* sp. incorporate these components in relatively large quantities. Terminally branched monomethylalkanes are much more common in most of the species, but are present only in trace amounts in *Nasutitermes costalis* and *N. acajutlae.* Dimethylalkanes are present in relatively large quantities only in *N. mona*, *Heterotermes* and *N. costalis*, species with rather high moisture requirements, and are absent or present only in trace amounts in the other taxa. Trimethylalkanes are quite rare; they are completely absent in six of the taxa, present in trace amounts in *Incisitermes* and in small amounts in *N. costalis.*

In general, olefins are the most common of the hydrocarbons found in the termites of the BVI. Early-eluting alkenes are abundant in *Incisitermes* spp., but absent or rare in all other taxa. Late-eluting olefins, especially those with 39, 41, and 43 carbons, are quite abundant for many of the species. These late-eluting olefins have one to six double bonds. The positions of these double bonds were not determined, but for the purposes of this paper we feel it is not essential to know their location.

Polyunsaturated hydrocarbons are common in the termites of the BVI. This degree of unsaturation is not common in termites we have sampled from temperate or subtropical locations. For the termites that live in above-ground nests in dry habitats or entirely within dry wood, cuticular hydrocarbon mixtures consist of generally larger molecules, reflecting the moisture demands of this habitat (Collins et al., 1997; Hadley, 1980, 1985). Termites that live within wood on live trees or in situations with more available moisture generally have a hydrocarbon mixture composed mostly of lower-molecular-weight components with carbon numbers ranging from 23 to 33 (Collins et al., 1997).

Consistently abundant hydrocarbons can be used as taxonomic characters for separating the termites of the BVI. Variation in hydrocarbon components was shown for *N. acajutlae* from different islands, but the differences were relatively minor. *Incisitermes* presented the greatest challenge; the variation in cuticular hydrocarbons was as great as that of soldier morphology.

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