NOTE

Formosan Subterranean Termite (Isoptera: Rhinotermitidae) Established in Grand Bahama[1]

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The Formosan subterranean termite, *Coptotermes formosanus* Shiraki (Isoptera: Rhinotermitidae), is a significant invasive pest that originates from southern China (Kistner 1985, Sociobiology 10: 93–104) and Taiwan (Li et al. 2009, Ann. Entomol. Soc. Am. 102: 684–693). It is one of the most widely distributed and destructive subterranean termite pest species in the world (reviewed by Evans et al. 2013, Annu. Rev. Entomol. 58: 455–474). It typically is found in warm, humid areas in temperate to subtropical regions within latitudes 35°N and 35°S (Su and Tamashiro 1987, Biology and Control of the Formosan Subterranean Termite, Univ. Hawaii, 3–15).

To date, *C. formosanus* has not been formally reported from the Caribbean Basin. An online search (16 June 2017) lists a single report of *C. formosanus* in the Caribbean (CABI/EPPO 2008, Distribution Maps of Plant Pests, Centre for Agriculture and Biosciences International, Map 710), but this U.S. Virgin Islands (USVI) record is in error since CABI's bibliographic reference (Su et al. 2003, Am. Entomol. 49: 20–32) describes a bait study targeting *Heterotermes* sp. on St. Croix, with only ancillary information regarding *C. formosanus*. Furthermore, *C. formosanus* is not reported in the two most recent termite surveys in the USVI (Nalepa and Jones 2002, Sociobiology 39: 155–163; Scheffrahn et al. 2003, Ann. Entomol. Soc. Am. 96: 181–201).

An invasive congener, *Coptotermes gestroi* (Wasmann), the Asian subterranean termite, is more widely distributed than *C. formosanus* and occurs on many islands throughout the Caribbean (Evans et al. 2013). *Coptotermes gestroi* is endemic to

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Southeast Asia and generally is found in tropical regions. In the continental United States, these two *Coptotermes* species are sympatric only in tropical south Florida (Scheffrahn 2013, Fla. Entomol. 96: 781–788). Although Florida and the Bahamas are separated by only 80.5 km, *C. gestroi* is the sole representative of the genus in the Bahama Archipelago and has been found only on Providenciales and Grand Turk (Scheffrahn et al. 2006, Ann. Entomol. Soc. Am. 99: 463–486). *Coptotermes formosanus* has not been formally documented from the Caribbean, and Scheffrahn et al. (2006) speculated that *C. gestroi* eventually would become established in the Bahamas.

Herein, we report that *C. formosanus* is the first member of the genus to become established in the Bahamas. H.S.F. discovered *C. formosanus* on Grand Bahama while inspecting a commercial establishment in Freeport on 31 August 2010. The discovery was reported 2 d later in a local Bahaman newspaper, *The Freeport News*.

We document *C. formosanus* infestation sites based on samples and records that H.S.F. and O.J.F. compiled while conducting termite inspections and treatments for their family-owned pest management company, which is the largest of six service providers on Grand Bahama and covers the entire island and cays. Termite samples were sent to S.C.J. to confirm species identification. Taxonomic characters and phylogenetic methodology were used to verify the species. We extracted DNA from termites using the DNeasy Blood and Tissue Kit (Qiagen Inc., Valencia, CA) then used polymerase chain reaction on a region of two maternal mitochrondrial genes, 16S rRNA and cytochrome oxidase subunit II (COII), for each of 18 individual termites as described in Eaton et al. (2016, J. Insect Sci. 16: 111). A phylogenetic tree was generated for each gene using our sequences and those from GenBank. Our Bahaman 16S and COII sequence data were deposited into GenBank (accession numbers: MF410719–MF410753).

Additionally, we analyzed a nuclear locus, the internal transcribed spacer (ITS) array, from 10 of the abovementioned termites, including soldiers, workers, and male and female alates. A nuclear locus provides genetic insights into both parents and therefore can reveal hybrids of *C. formosanus* and *C. gestroi* in the field. Chouvenc et al. (2015, PLoS One 10: e0120745) raised the concern of potential hybridization of these two invasive species after observing concurrent swarms in south Florida wherein *C. gestroi* males preferentially engaged in mating behavior with *C. formosanus* females. Furthermore, in the laboratory, these heterospecific incipient colonies had twice the growth rate of conspecifics, which suggested potential hybrid vigor. However, alate hybrid fertility is currently unknown, and it will take years before alates, if any, are produced in these laboratory colonies.

Fig. 1 indicates localities with *C. formosanus* in Freeport, Grand Bahama, from its discovery in May 2010 through mid-June 2017. To date, the majority of *C. formosanus* infestations and sites with identified alates have occurred in the general vicinity of Lucaya Beach and the Port Lucaya Marina in southcentral Freeport. This marina or the associated inlet may represent the initial introduction site of the species on Grand Bahama. Maritime activities play an important role in the spread of *Coptotermes* spp., and land-based infestations often are near marine docks with infested boats (Hochmair et al. 2013, Fla. Entomol. 96: 746–755). The three Bahaman infestations that are farthest from the marina include two near the western boundary of Freeport and one at the eastern boundary of the city, suggesting that

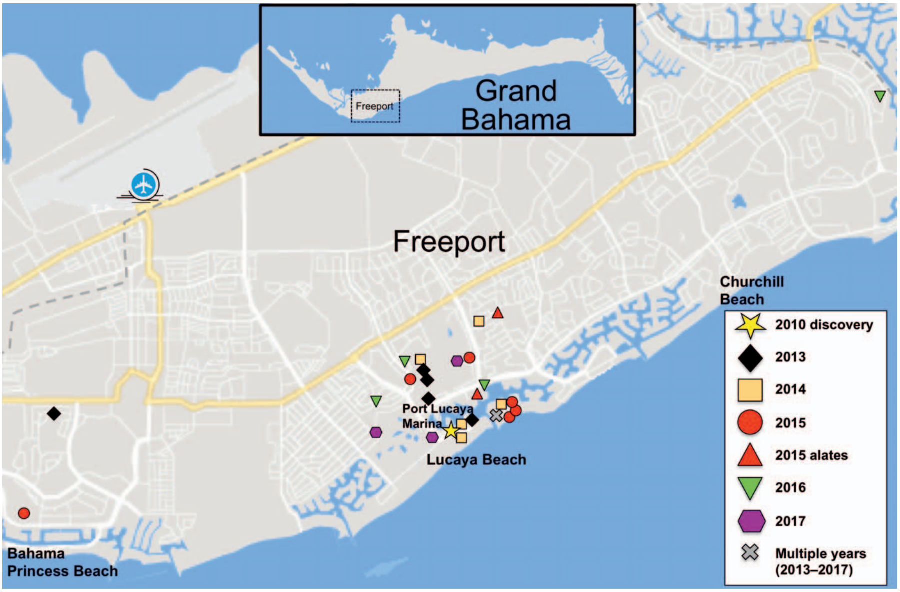
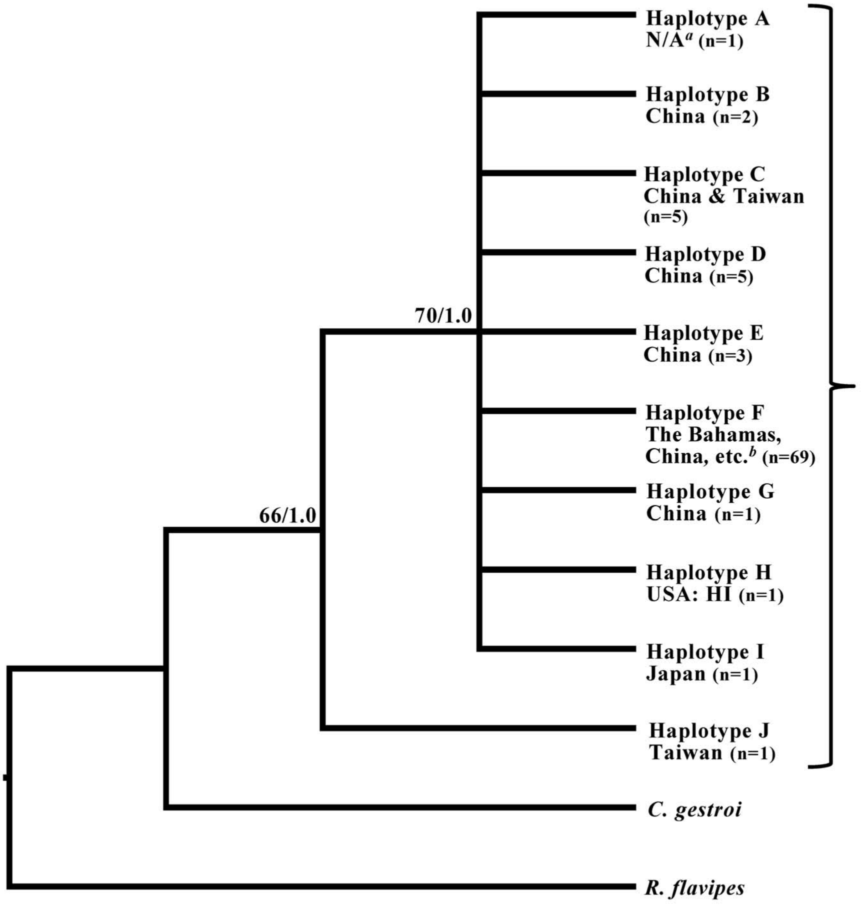


Fig. 1. ***Coptotermes formosanus*** **localities from 2010 to mid-June 2017 in Freeport, Grand Bahama. Inset shows the island of Grand Bahama, with the rectangle indicating the enlarged area.**

humans are further spreading the species on Grand Bahama. In the United States, the Formosan subterranean termite has spread inland primarily through movement of infested wood, especially reused railway ties, potted plants, and furniture (Evans et al. 2013).

The first alates (winged reproductives, imagos) of *C. formosanus* were collected in 2015 at two localities shown in Fig. 1. The initial collection was from a swarm that occurred at approximately 9–10 p.m. on 6 May 2015 at a residence in the Arden Forest subdivision inland from the marina; swarmers were reported as being seen for at least 2 yr at this residence. A week later, on 12 May 2015, *C. formosanus* swarmers, soldiers, and workers were collected from a condominium situated approximately 2 km SSE of the residence. In May, the wind direction is generally ESE or SE, and it is highly unlikely that swarmers were blown from a distant location to the condo. A recent study in Hawaii found that swarming of *C. formosanus* was reduced at higher wind speeds (Tong et al. 2017, Insects 8: 58). In 2017, *C. formosanus* alates were collected from late May through mid-June at three of four sites, including in multiple buildings on a large property indicated by the “X” (Fig. 1).

The presence of alates is significant because they indicate a mature parent colony, and swarms allow for potential outbreeding and further dispersal of the species. Colonies of *C. formosanus* take 5 to 10 yr to begin producing alates (King and Spink 1974, Ann. Entomol. Soc. Am. 67: 953–958), and the discovery of *C. formosanus* on Grand Bahama occurred 5 yr before swarms were recognized, indicating that this species may have been detected shortly after its introduction. Evans et al. (2013) note that new termites on islands tend to be more rapidly



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[a] Not available.

[b] . . ., Japan, Taiwan, Thailand, and USA: Florida, Georgia, and Louisiana.

Fig. 2. Fifty percent majority rule consensus tree of *Coptotermes formosanus* obtained from the 16S gene. The number of GenBank sequences in a haplotype is in parentheses. Support values are included at each node for maximum likelihood based on 1,000 replicates as well as Bayesian inference.

detected than those on continents. Nonetheless, the year and mode of this species' introduction into Grand Bahama are unknown.

Phylogenetic analyses revealed that alates from the 2015 collection sites in Freeport shared identical gene sequences at the 16S locus and the COII locus. The *C. formosanus* samples from Grand Bahama grouped together in a single, large haplotype (F) with 69 of 89 16S sequences from GenBank (Fig. 2), which represent *C. formosanus* samples from China, Japan, Taiwan, and the continental United

States, including Florida, Georgia, and Louisiana. Similarly, *C. formosanus* samples from Grand Bahama grouped together in a single, large haplotype with 54 of 170 COII sequences from GenBank, which also included collections from China, Japan, Taiwan, and the United States. This haplotype includes GenBank number EU805770, which is the *C. formosanus* mitochondrial marker inherited by hybrid offspring fathered by *C. gestroi* (Chouvenc et al. 2015). Neither of our two phylogenetic trees showed divergence of the *C. formosanus* haplotypes. This indicates low genetic diversity, which is a characteristic of invasive populations of *C. formosanus* (Husseneder et al. 2012, Biol. Invasions 14: 419–437).

Coptotermes formosanus alates from Grand Bahama are somewhat variable in color, but they tend to be very dark brown. The color of their head and thorax (dorsal view) is very similar to that of *C. gestroi* shown in Scheffrahn et al. (2015, Arthropod Syst. Phylo. 72: 333–348), although they lack the two lighter "antennal spots" of *C. gestroi* (Su and Scheffrahn 1998, Proc. Hawaii. Entomol. Soc. 33: 13–18). By contrast, in south Florida, the golden brown abdomen of the Formosan subterranean termite alate is easily distinguished from the nutty brown abdomen of the Asian subterranean termite alate (see supplemental data in Chouvenc et al. 2015). Although Scheffrahn et al. (2015) assert that *Coptotermes* spp. imagos can be "easily identified by wing and body coloration," our data indicate that imago body coloration is not a reliable character for distinguishing *C. formosanus* and *C. gestroi* in some regions. These similarities in imago body coloration may hamper the rapid detection of a future introduction of *C. gestroi* into the Bahamas.

Wing coloration is useful for identification of Bahaman *C. formosanus* alates, particularly if one focuses on venation near the basal suture of the forewings. In Bahaman *C. formosanus*, the media, cubitus, and subordinate veins are darker for approximately the first millimeter of their length whereas these veins are lighter and less obvious in *C. gestroi*. Alates have a brownish tint beneath the radial sector vein, but the brownish halo associated with the costal margin of the *C. formosanus* wing (Scheffrahn et al. 2015) is so limited on Bahaman alates as to have almost no utility in identification.

The darker color of *C. formosanus* alates from the Bahamas may indicate that the Bahaman population is a hybrid with *C. gestroi*, but our analyses of the ITS array from Bahaman alates do not seem to support this hypothesis because one allele, rather than two, is evident in the sequence chromatograms. Investigations are underway using microsatellites, which may shed additional insights into potential hybridization.

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