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OVERVIEW AND CURRENT STATUS OF NON-NATIVE TERMITES (ISOPTERA) IN FLORIDA[§]

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ABSTRACT

The origins and status of the non-endemic termite species established in Florida are reviewed including *Cryptotermes brevis* and *Incisitermes minor* (Kalotermitidae), *Coptotermes formosanus*, *Co. gestroi*, and *Heterotermes* sp. (Rhinotermitidae), and *Nasutitermes corniger* (Termitidae). A lone colony of *Marginitermes hubbardi* (Kalotermitidae) collected near Tampa was destroyed in 2002. A mature colony of an arboreal exotic, *Nasutitermes acajutlae*, was destroyed aboard a dry docked sailboat in Fort Pierce in 2012. Records used in this study were obtained entirely from voucher specimen data maintained in the University of Florida Termite Collection. Current distribution maps of each species in Florida are presented. Invasion history suggests that established populations of exotic termites, without human intervention, will continue to spread and flourish unabatedly in Florida within climatically suitable regions.

Key Words: Isoptera, Kalotermitidae, Rhinotermitidae, Termitidae, non-endemic

RESUMEN

Se revisa el origen y el estatus de las especies de termitas no endémicas establecidas en la Florida incluyendo *Cryptotermes brevis* y *Incisitermes menor* (Familia Kalotermitidae); *Coptotermes formosanus*, *Co. gestroi* y *Heterotermes* sp. (Familia Rhinotermitidae) y *Nasutitermes corniger* (Familia Termitidae). Una colonia individual de *Marginitermes hubbardi* revisada cerca de Tampa fue destruida en 2002. Una colonia madura de una termita exótica arbóreal, *Nasutitermes acajutlae*, fue destruida a bordo de un velero atracado en seco en Fort Pierce en 2012. Se obtuvieron todos los registros utilizados en este estudio de los datos de las especímenes comprobantes que se mantienen en la Colección de Termitas de la Universidad de Florida. Se presentan mapas de distribución actual de cada especie en la Florida. La historia de las invasiones sugiere que las poblaciones establecidas de termitas exóticas, sin intervención humana, se continuará extendiéndose y creciendo sin cesar en la Florida dentro de las regiones climáticamente adecuadas.

Palabras Clave: especies invasoras, arbórea, embarcaciones de recreo, inspecciones reguladores

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Florida has the most diverse non-endemic termite fauna of any state, country, or continent in the world (see Fig. 1 in Evans et al. 2013). At this writing, 6, possibly even 7 exotic species are established in Florida, and all are structural pests both within and outside of the state. A lone colony of an enigmatic curiosity, *Marginitermes hubbardi* (Banks), found in an Odessa, Florida, house in 2002 (Scheffrahn & Postle 2013) was destroyed. Florida is a haven for non-endemic insects (Frank & McCoy 1995) and is especially suited for exotic termite establishments because of its subtropical to tropical climate, its popularity as a domestic and international port of call for pleasure boats, extensive coastline, proximity to the Caribbean Basin, spotty regulatory inspections, and unfettered growth and economic development in the latter 20th century (Scheffrahn & Crowe 2011).

The first survey of structure-infesting termites in Florida (Scheffrahn et al. 1988) yielded only 2 non-native species, *Cr. brevis* and *Co. formosanus*, collected as part of a 785-sample survey from structures in Orlando/Daytona, the Tampa area, and southeastern Florida. At that time, *Cr. brevis* was already widespread, while *Co. formosanus* had been recorded only from Broward, Dade, Es-

cambia, Okaloosa, and Orange Counties. In this article, I update the current composition and distribution of Florida's non-endemic termites and review their invasion history and relevant comparative biology.

Materials and Methods

The University of Florida termite collection housed at the Fort Lauderdale Research and Education Center in Davie, Florida, was established in 1985 and currently houses over 37,000 colony samples from around the world. All sample vials are inventoried with an electronic spreadsheet containing all collection data, including precise decimal-degree localities. Over 3,800 Florida samples from about 1,200 localities (Fig. 1) are deposited in the collection. A 1,050 sample subset of data for non-endemic species collected in Florida was used to produce the distribution maps (Figs. 1-5). These samples were predominantly collected from or near human habitations. Most samples were submitted to the author for identification by pest control professionals, property owners, and entomologists.

Only land-based samples were used in the current study. Scheffrahn & Crowe (2011) provide separate data of species collected on seaworthy boats in water. Maps were generated using ArcGIS Desktop 10.1 software and online base maps (ESRI, Redlands, California). Termites were identified by the author and can be keyed to species using published works which include photographs or drawings of each species mentioned herein (Scheffrahn & Su 1994, Scheffrahn et al. 2003, and Scheffrahn, et al. 2006). Uncited accounts herein are from collection data and observations made by the author.

Results and Discussion

Cryptotermes brevis (Walker)

The West Indian drywood termite, *Cr. brevis*, is an ubiquitous drywood termite of the world's tropics but with the glaring absence from Asia. It is endemic to the Pacific coastal deserts of southern

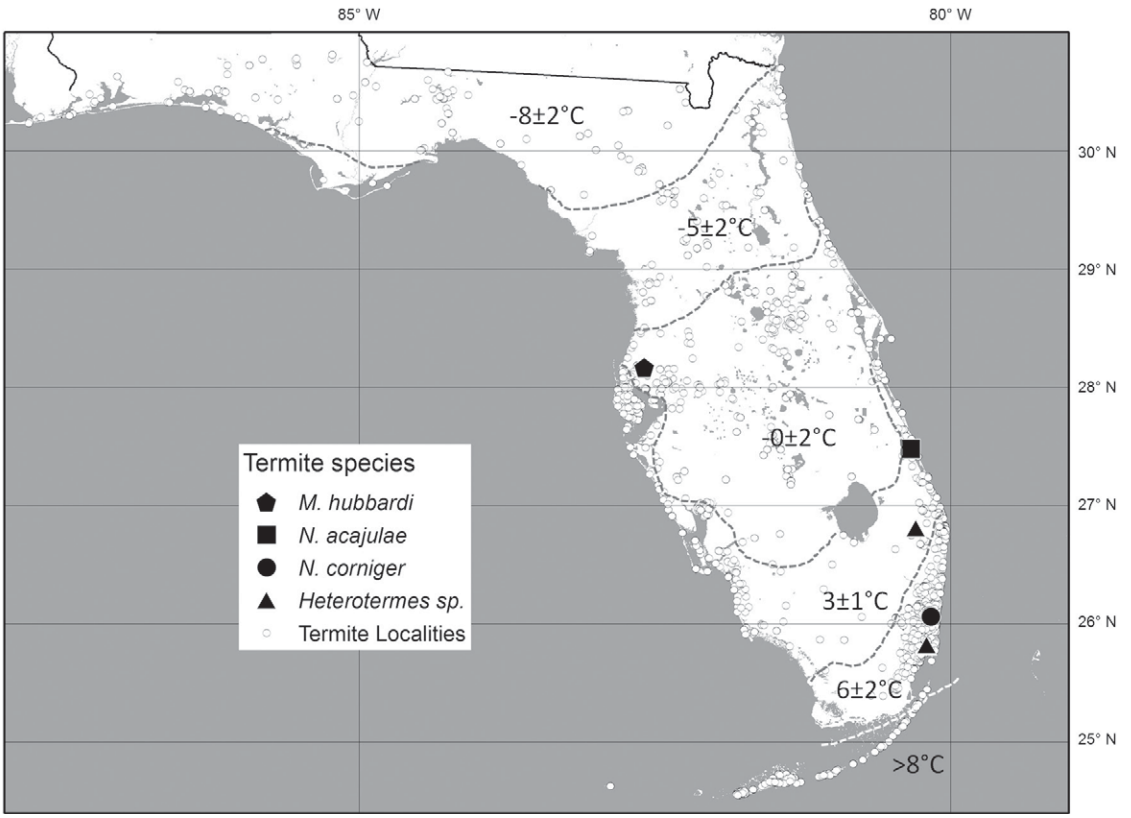

Fig. 1. Recorded localities of minor non-endemic termite species in Florida. Data are from the University of Florida Termite Collection (all Florida termite localities also shown). Broken lines represent the USDA plant hardiness zones based on mean annual extreme minimum temperatures (USDA 1965). The *Marginitermes hubbardi* colony from an Odessa, Florida house, was destroyed.

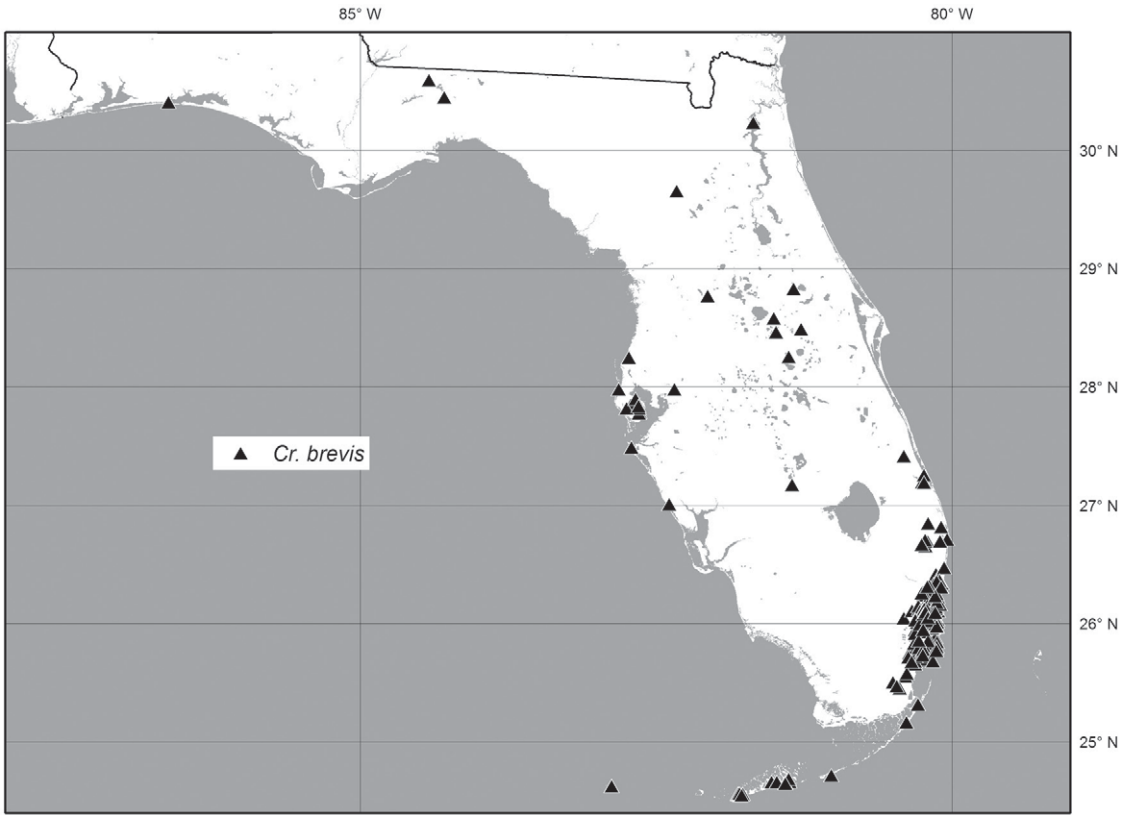

Fig. 2. Recorded localities of *Cryptotermes brevis* in Florida. Data are from the University of Florida Termite Collection.

Peru and northern Chile (Scheffrahn et al. 2009). This species requires no free water during its entire life cycle and is usually detected in structures when expelling fecal pellets from infested wood or when undergoing dispersal flights between dusk and dawn. Mature colony populations may only be a few hundred members, but multiple colonies can inhabit a single piece of wood. Any tightly-bound cellulose object, e.g. stack of playing cards, toilet paper rolls, picture frames, or heavy supportive beam, can be suitable for colonization.

Peak flights in Florida occur in May and Jun. First reported in Florida in Key West in 1918 (Banks & Snyder 1920), *Cr. brevis* declines in abundance wherever extreme minimum temperatures average below freezing (Fig. 1). The lack of localities in southwestern Florida (Fig. 2) is an artifact of sample submission, not abundance. Newer construction in that area may also contribute to lower *Cr. brevis* densities. Common in older coastal neighborhoods, *Cr. brevis* seldom flies more than 100 m (Guerreiro 2009). *Cryptotermes brevis* will not survive in wood exposed to consistent rainfall or other free water sources.

Incisitermes minor (Hagen)

Like *Cr. brevis*, the western drywood termite, *I. minor*, can survive in structures without free water but will also infest wood exposed to precipitation. This species is endemic to the southwestern Nearctic Region from extreme southwestern Texas to coastal California and northern Mexico and has been found in several other states (Austin et al. 2012). It has been introduced into southern Japan (Indrayani et al. 2004), and has been collected on the island of Oahu (Loa Ridge neighborhood, University of Florida Termite collection no. HI109). Hicken (1971) gave the first published account of this termite occurring in Florida (Miami). As with other drywood termites, its presence is detected by expulsion of fecal pellets. Flights of *I. minor* in Florida occur in the daylight hours from August through November. Although occurring in isolated localities statewide (Fig. 3), this termite seems incapable of establishing incipient colonies by way of outdoor dispersal flights as no concentrations of "neighborhood" or area-wide infestations have yet been observed. In addition to boat infestations (Scheffrahn & Crowe 2011),

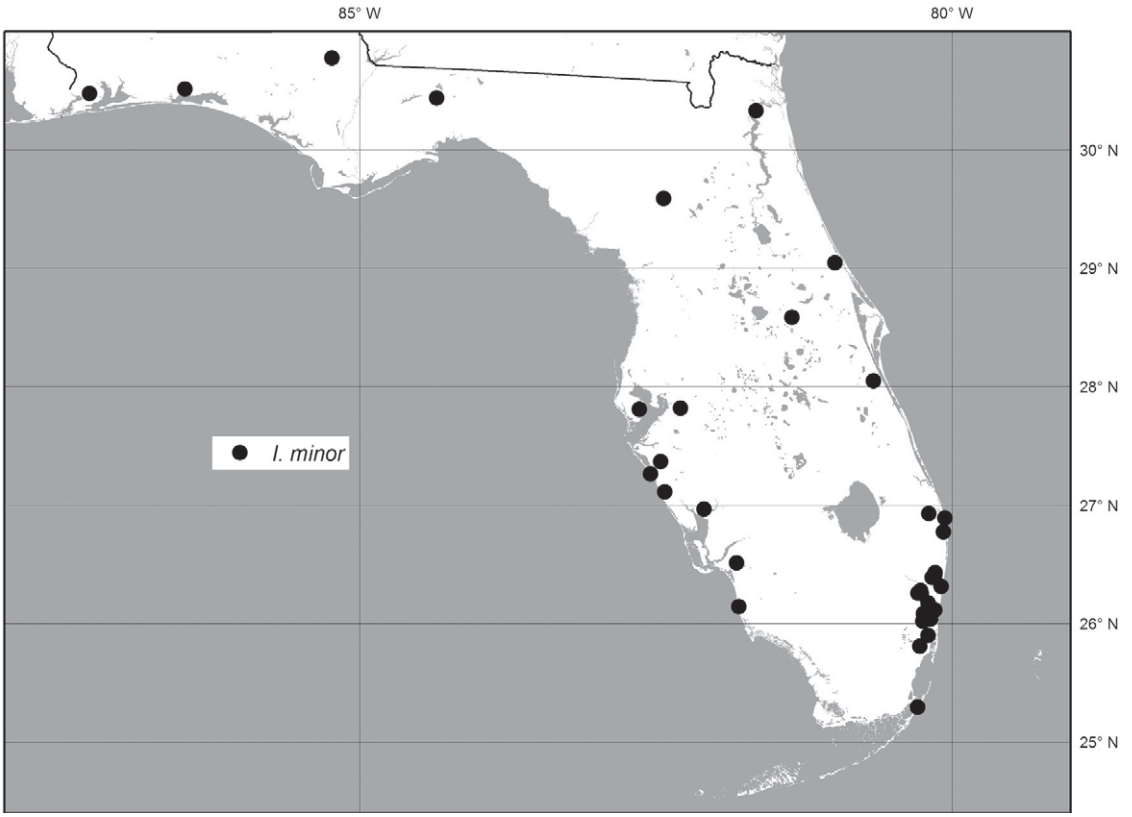

Fig. 3. Recorded localities of *Incisitermes minor* in Florida. Data are from the University of Florida Termite Collection.

colonies of *I. minor* found in Florida result from the transport of infested wood products from the southwestern U.S.

Coptotermes formosanus Shiraki

The Formosan subterranean termite, *Co. formosanus*, was first introduced to Japan, followed by the Hawaiian archipelago, and, finally, the southeastern U.S. This species is endemic to eastern China and Taiwan (Li et al. 2009; Rust & Su 2012). *Co. formosanus* has disappeared from tenuous establishments in poorly suited climates (low humidity and dew points) in both South Africa and southern California (Vivienne Uys & Eric Paysen, pers. comms., respectively). In Florida, *Co. formosanus* was first discovered in Hallandale in 1980 (Koehler 1980) and in a 2005 survey, was found in 20 counties throughout Florida (Scheffrahn & Su 2005). In this report, the Counties of Bay, Brevard, Clay, Pinellas, St. Lucie, and Washington have been added and, by addition of 2 Pinellas discoveries, places this pest in all major urban regions statewide (Fig. 4). Because it is distributed so widely, *Co. formosanus* is the most important exotic subterranean termite in Florida. In south Florida, especially Miami-Dade county, *Co. gestroi* may be more common in some areas (Fig. 5).

On land, this species colonizes moisture-proximate voids in buildings or hollows the piths of dooryard trees where workers fill the voids with fecal nest material called "carton". As the colony ages and grows, the carton becomes progressively denser. Foraging tubes are often hidden from view and dispersal flights are usually the first signs of structural infestations. *Coptotermes formosanus* flies during balmy and still evenings, often engulfing neighborhoods in a blizzard of hundreds of thousands of light-attracted alates. A single colony may ultimately occupy large areas (Su & Scheffrahn 1988) resulting in foraging territories spanning entire city blocks. The great majority of flights in Florida have been recorded in May and June. *Coptotermes* are strong fliers and may cover a distance of about one kilometer (Messenger & Mullins 2005).

Co. formosanus thrives in temperate climates with hot humid summers but lacking a distinct dry season (Köppen-Geiger climate classification reviewed by Peel et al. 2007). On a world-

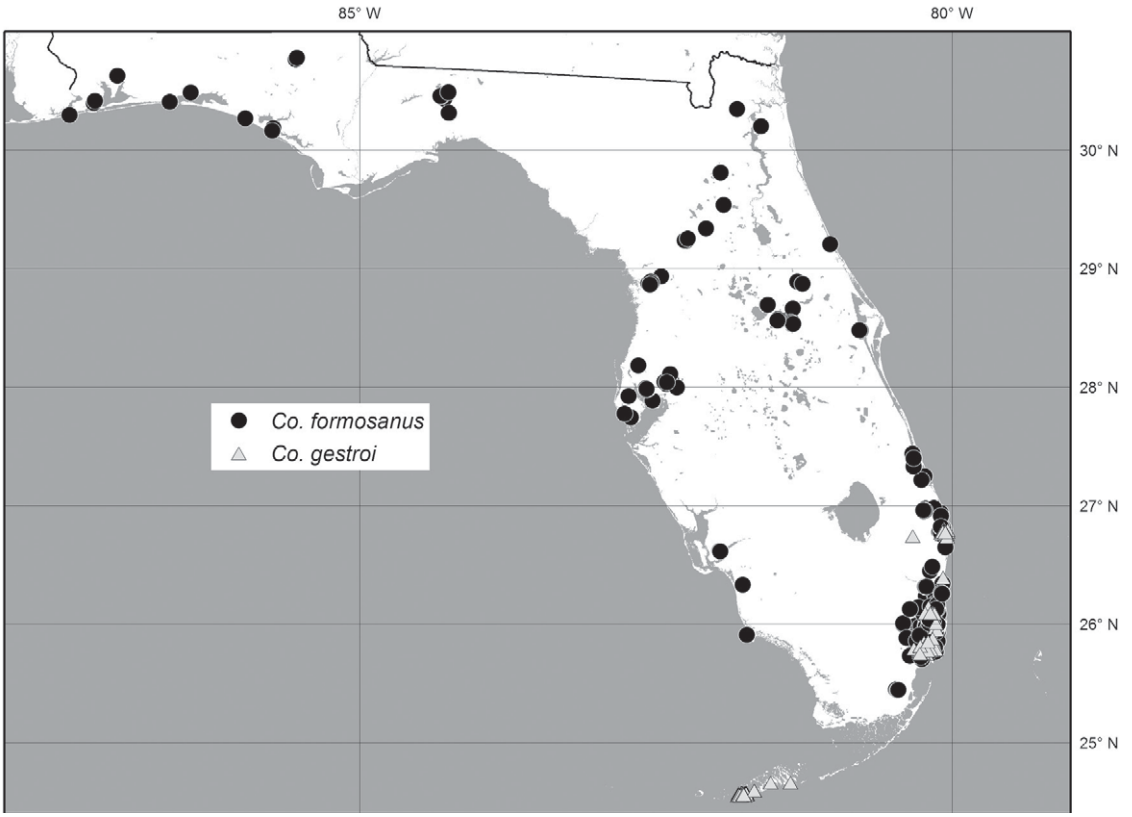

Fig. 4. Recorded localities of *Coptotermes formosanus and Co. gestroi* in Florida. Data are from the University of Florida Termite Collection.

wide scope, *Co. formosanus* is sympatric with *Co. gestroi* (see below) only in Taiwan, Hawaii, and mainland tropical Florida. Land-based infestations of *Co. formosanus* in south Florida are geographically correlated with marine boat dockage, implicating recreational boats in their dispersal (Hochmair & Scheffrahn 2010). Transportation of infested railroad ties containing incipient colonies was shown to be a common mode of anthropogenic dispersal in Georgia (Forschler et al. 2001). Railroad ties may also be a non-maritime source of *Co. formosanus* infestations in Florida, especially in landlocked central and northern parts of the state where ties are used as retaining walls on hilly landscapes.

Scheffrahn et al. (1988) postulated the following: "Considering its present distribution and affinity for structural lumber in coastal settings, *C. formosanus* has vast potential to establish in urban and resort locations along Florida's 13,547 km of tidal shoreline and connected inland waterways". Twenty-five years later, these predictions are realized, and, with the possible exception of the Florida Keys, *Co. formosanus* remains destined to saturate the entire state.

Coptotermes gestroi (Wasmann)

Endemic to southeastern Asia, the Asian subterranean termite, *Co. gestroi*, has a greater worldwide distribution than *Co. formosanus*. Two junior synonyms, *Co. havilandi* Holmgren and *Co. vastator* Light were combined under *Co. gestroi*, by Kirton & Brown (2003) and Yeap et al. (2007), respectively. *Coptotermes gestroi* occurs throughout the Caribbean Basin, eastern South America and islands in the Pacific and Indian Ocean. It could very likely be in tropical Africa. In Florida, *Co. gestroi* was first detected in 1995 in Miami (Su et al.1997).

Consistent with its tropical origins, *Co. gestroi* in Florida is known only from the 4 extreme southeastern counties of Palm Beach, Broward, Miami-Dade (Fig. 5) and Monroe (Florida Keys, Fig. 4). It has come to dominate some communities near commercial and recreational sea ports and along the Miami River where many smaller vessels from the West Indies dock (Fig. 5). First collected on Key West in 1999 (Scheffrahn & Su 2005), *Co. gestroi* now occupies over 50% of the island and is established on several Keys to the

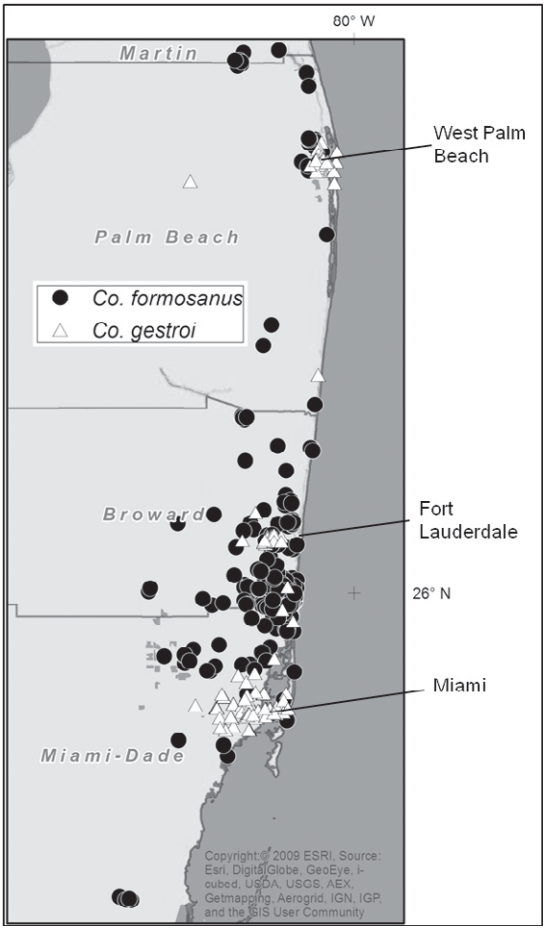

Fig. 5. Recorded localities of *Coptotermes formosanus and Co. gestroi* in Palm Beach, Broward, and Metro-Dade Counties, Florida. Locations of major seaports shown. Data are from the University of Florida Termite Collection.

east. As with *Co. formosanus*, land-based infestations of *Co. gestroi* are geographically correlated with marine boat dockage (Hochmair & Scheffrahn 2010). Alates of *Co. gestroi* are dark brown on their dorsal surface whereas the slightly larger *Co. formosanus* alates have an orange-brown dorsal coloration.

Co. gestroi is similar in biology to *Co. formosanus* in all respects except that *Co. gestroi* flies earlier in the season beginning as early as February, with more typical flights in March and April. Flight data from southern Florida suggest that as soon as *Co. formosanus* begins its first flights, those of *Co. gestroi* cease. Like its congeners, *Co. gestroi* is characterized by dense frenetic flights. A pest control operator who witnessed a *Co. gestroi* flight emanating from the eaves of a Key West house indicated that the cloud of emerging alates resembled smoke pouring out of the structure.

Heterotermes sp.

Heterotermes is a pantropical genus of subterranean termites. In the Caribbean Basin, the group has not been fully described, however the species discovered in Florida in 1994 (Scheffrahn & Su 1995) is most closely aligned with genetic markers of a species from Jamaica and several other West Indian islands (Szalanski et al. 2004). In the Bahamas, *Heterotermes* is mutually exclusive with the distribution of *Reticulitermes* (Scheffrahn et al. 2006). First discovered in Miami, (Scheffrahn & Su 1995), a new population was found in 2012 from a rural house in Loxahatchee (Fig. 1) where small plant nurseries abound.

In Florida and elsewhere, *Heterotermes* spp. build characteristic narrow and cylindrical foraging tubes. They are unique among subterranean termites in building free-hanging ceiling tubes in inhabited buildings. Peak flight season for the *Heterotermes* sp. in Florida is May through July, with the golden colored alates emerging during crepuscular hours. This species nests below ground and can infest areas in buildings that are free of excess moisture.

Nasutitermes corniger (Motschulsky)

The subject of an ongoing eradication effort (Scheffrahn et al. 2013), *N. corniger* or the "tree termite" was the first record of a higher termite established on a non-native landmass when it was discovered in Dania Beach, Florida, in 2001 (Scheffrahn et al. 2002). Two junior synonyms, *N. polygynus* Roisin from New Guinea and *N. costalis* (Holmgren) from the West Indies were synonymized with *N. corniger* by Scheffrahn et al. 2005a and Scheffrahn et al. 2005b, respectively. *Nasutitermes corniger* is widespread in the New World where it is considered a major pest (Constantino 2002). Its pest status in New Guinea is unknown (Roisin & Pasteels 1985).

As an arboreal species, i.e., one that nests and forages on or above ground level, *N. corniger* fills a niche not occupied by the existing drywood or subterranean termites in Florida. Flights of the dark-winged alates begin at dusk, typically after the first convective rains of the wet season in May or June with sporadic flights continuing into July. In Dania Beach (Fig. 1) and elsewhere, *N. corniger* fecal nests are almost exclusively epigeal and situate at the base of trees, palms, or on other standing objects and structures. The nest carton surface is thin and irregular and can be broken open with a finger. The dark-brown foraging tubes contrast with exterior building surfaces and tree trunks. Although presently restricted to several neighborhoods in Dania Beach, if not eradicated, the species is expected to expand throughout tropical Florida.

Nasutitermes acajutlae (Holmgren)

This arboreal termite is endemic to Puerto Rico, the U.S. Virgin Islands (Scheffrahn et al. 2003), and the Caribbean mainland. In October 2012, a robust colony of *N. acajutlae* was discovered in Fort Pierce, Florida, infesting a 16 m sailboat in dry dock (Fig. 1). According to the boat's owner, the vessel had been in the boat yard for over one year. Unlike earlier interceptive discoveries of *N. acajutlae* in Florida (Scheffrahn & Crowe 2010), this infestation remained undiscovered for a period encompassing at least one dispersal flight season. It is possible that incipient colonies are established in or near the boatyard located on the cusp of Florida's northern neotropical limits (Fig. 1). The habits of *N. acajutlae* are otherwise similar to those of *N. corniger*.

Conclusions

Populations of exotic termites in Florida and elsewhere have not experienced declines as has been observed with other established exotic organisms (Simberloff & Gibbons 2004). It may be that the termites' resistance to pathogens (Chouvenc et al. 2011), resource and nesting site abundance, and defenses against predation and parasitism have promoted unfettered population expansion constrained only by climatic conditions noted above. Therefore, is seems very probable that spread of populations of exotic termites, without human intervention, will remain unabated in Florida.

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