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Research Article

Swarming of the Formosan Subterranean Termite (Isoptera: Rhinotermitidae) in Southern Mississippi

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Abstract: Swarms of Formosan subterranean termites, *Coptotermes formosanus* Shiraki, (FST) in Southern Mississippi were monitored from mid-April through late June, 2007-2009. Distribution of swarming colonies was recorded at 69 traps within Poplarville (Pearl River County) and an additional 45-65 traps, along transects in Pearl River, Lamar, Forrest, and Stone Counties. Swarms were first detected during the week ending April 27 and continued through the final collection dates in late June. In Poplarville, FST colonies were ubiquitous, with 68 of 69 traps catching alates on at least one of the 2009 sampling dates. Along highway transects, FST was collected from 36% of traps in 2007, 37% of traps in 2008, and 48% of traps in 2009. On transects running north to south, from Hattiesburg (Forrest County) to Picayune (Pearl River County.), the highest percentage of traps containing FST occurred south of Poplarville. On a transect running west to east, along Highway 26, 50% of traps between Bogalusa, LA (Washington Parish) and Poplarville collected FST, while FST were found on only 26% of traps between Poplarville and Wiggins, MS (Stone County).

Keywords: *Coptotermes formosanus*, alate monitoring, distribution, invasive species

Introduction

Since its introduction to the United States from Asia, the Formosan subterranean termite (FST), *Coptotermes formosanus* Shiraki, has become a devastating pest, with economic losses due to property damage, repairs, and control estimated at over $1 billion per year (Su and Scheffrahn 1990). In addition to structural infestations, *C. formosanus* causes unquantifiable damage through infestation of living trees (Osbrink et al. 1999), creosote-treated poles (La Fage 1987), and underground utility lines (Henderson and Dunaway 1999). In Mississippi, FST was first reported in Lauderdale County (Meridian) in 1984 (Jarratt 2001). Infestations have since been discovered in 25 Mississippi counties (Sun et al. 2007). The known range of this invasive species continues to expand (Woodson et al. 2001, Hu and Oi 2004, Scheffrahn and Su 2005, Brown et al. 2007, Sun et al. 2007) indicating the need to minimize FST establishment in new areas.

As typical of introduced species (Lilleskov et al. 2008), FST occurrences are positively correlated with human populations and proximity to coasts. Primary introductions frequently occur through infested boats and shipping containers (Spink 1967, Lee et al. 2009). Without further human assistance, FST would spread slowly, as maximum flight distances of alates are approximately 1 km (Messenger and

Mullins 2005, Husseneder et al. 2006). However, infestations have spread inland more rapidly than would be expected and are associated with the ground transport of infested wood products (Chambers et al. 1988, Sponsler et al. 1988, Jenkins et al. 2002, Su 2003, Scheffrahn and Su 2005). Many of the early Mississippi infestations, including the initial colony in Lauderdale County and additional sites in Rankin and Jones Counties, were associated with railroad crossties (Jarratt 2001).

Further research on the mechanisms of spread and ways to mitigate new introductions is needed. Collection of alates is one of the most efficient methods to determine FST distribution and population size. FST reproductives swarm on spring nights and are attracted toward light, allowing traps equipped with a light source to be used as the standard method for monitoring alate swarms (Henderson and Delaplane 1994, Lax and Osbrink 2003, Lax et al. 2007, Sun et al. 2007). For the period from 2000 to 2004, Sun et al. (2007) used alate trapping and a survey of pest management professionals to determine the geographic extent of FST infestations in Mississippi. Based on data from this study and additional ground surveys, we intensified the survey for FST in Mississippi to determine the spread and intensity of local infestations. In addition, we continued to monitor a subset of locations from the earlier study of Sun et al. (2007) (Poplarville, Pearl River County).

Materials and Methods

Site selection. Sites were selected by using two methods. Within Poplarville, we monitored alate populations at 69 locations that were part of the Sun et al. (2007) study (Figure 1). Additionally, 3 transects were established in 2007 to examine the spatial distribution of FST infestations in the surrounding counties. Transects 07W and 07E ran in roughly a southwesterly to northeasterly direction, paralleling the Norfolk Southern railroad (Figure 2). Traps were placed between 0.04 and 6.5 km (mean = 2.2 km) from the railroad in transect 07W and between 5.02 and 9.84 km (mean = 7.01 km) from the railroad in transect 07E. In 2007, 07W and 07E each had 12 traps in Pearl River and Lamar Counties. In 2008, transects 07W and 07E were extended northward to include 15 traps each, running from Picayune on the south to Hattiesburg on the north. Transect 26 ran west to east along highway 26 and had 16 traps west of Poplarville (26W) and 5 traps east of Poplarville (26E), spaced at approximately 1.6 km (1 mi) intervals. Transect 26 was extended in 2008 to include a total 19 traps east of Poplarville, running from Bogalusa, LA on the west to Wiggins, MS on the east. With the exception of one lost trap on 07W, the same locations were monitored again in 2009. Transect traps were placed along roadsides in residential, commercial, pasture, and wooded areas. Sites were not selected for habitat characteristics, but were chosen because of easy access and the presence of trees or utility poles for hanging traps.

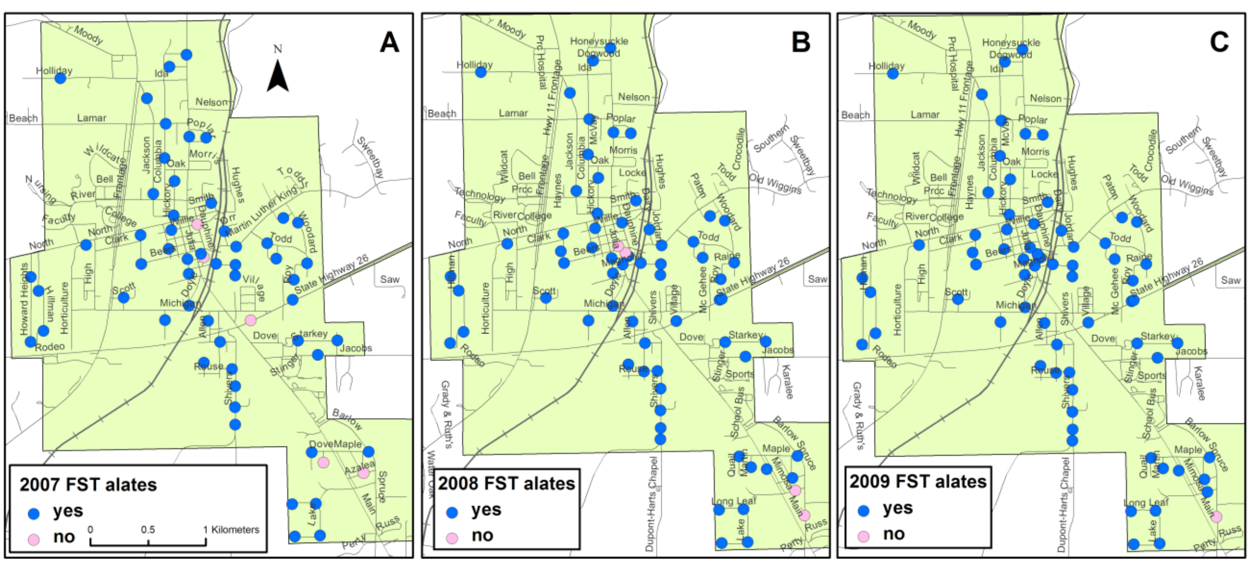

Figure 1. Locations of Poplarville traps containing FST alates on one or more collection dates during A) 2007, B) 2008, or C) 2009.

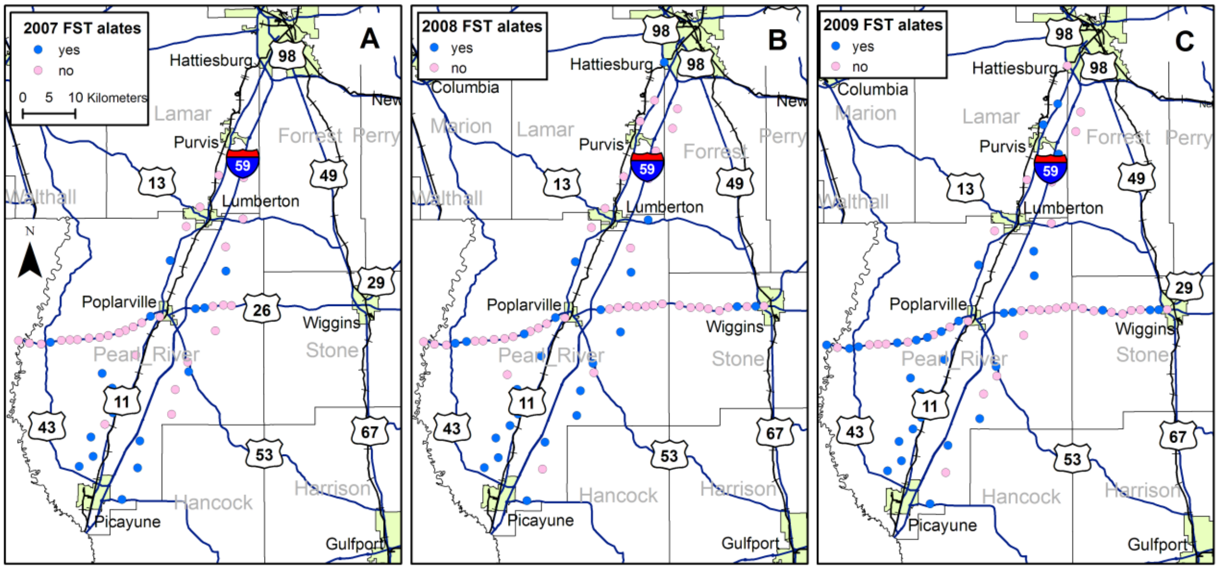

Figure 2. Locations of transect traps containing FST alates on one or more collection dates during A) 2007, B) 2008, or C) 2009. Transects 07W and 07E run parallel to I-59. Transects 26W and 26E are located on highway 26, west and east of Poplarville.

Alate Monitoring. Alates were collected with glue boards (Trapper, Bell Laboratories, Inc., Madison, WI) mounted on 30- by 6-cm wooden boards. In Poplarville, the boards were hung on nails below private utility lights or public street lights. Protective wire barriers were placed over the glue boards to prevent the unintentional capture of vertebrates. Along transects, boards were hung below street lights, where they were available. Where there were no lights, the glue boards were mounted on 30- by 6-cm boards hung beneath solar-powered white LED lights (model 822-0421-W, The Brinkmann Corporation, Dallas, TX).

Traps were collected once a week for 9 wk in 2007 and 11 wk in 2008 and 2009 starting in mid-April and ending in mid to late June. This sampling period was selected based on swarm dates reported for Louisiana and Mississippi (Henderson and Delaplane 1994, Sun et al. 2007). Alates were identified by using wing characters (Scheffrahn and Su 1994). The number of alates per card was recorded as an indication of relative swarm sizes between sampling dates.

Analysis. Differences in light sources prevented analysis of termite count data. Presence of FST on transect traps was analyzed by proximity to the railroad and proximity to the nearest trap with FST. Distances were measured by using ArcMap 9.2 (ESRI Inc, Redlands, CA) and logistic regression was performed by using SAS 9.2 (SAS Institute, Cary, NC), analyzing the effect of distance from potential infestation sources on termite presence.

Results

Poplarville. Because of the loss of some traps, data were collected from 60 Poplarville locations in 2007. FST alates were found on 55 of these traps (Figure 1A). No alates were collected in April (Figure 3A). Most of the swarms occurred during May, with the week ending May 15 having both the greatest number of traps active (49 of 60) and the greatest total number of alates collected (3506). Flight activity appears to have peaked earlier in 2007 than in the following two years. Although sampling ended two weeks earlier in 2007, few traps had FST alates on either of the June collection dates (15% on June 5 and 2% on June 12).

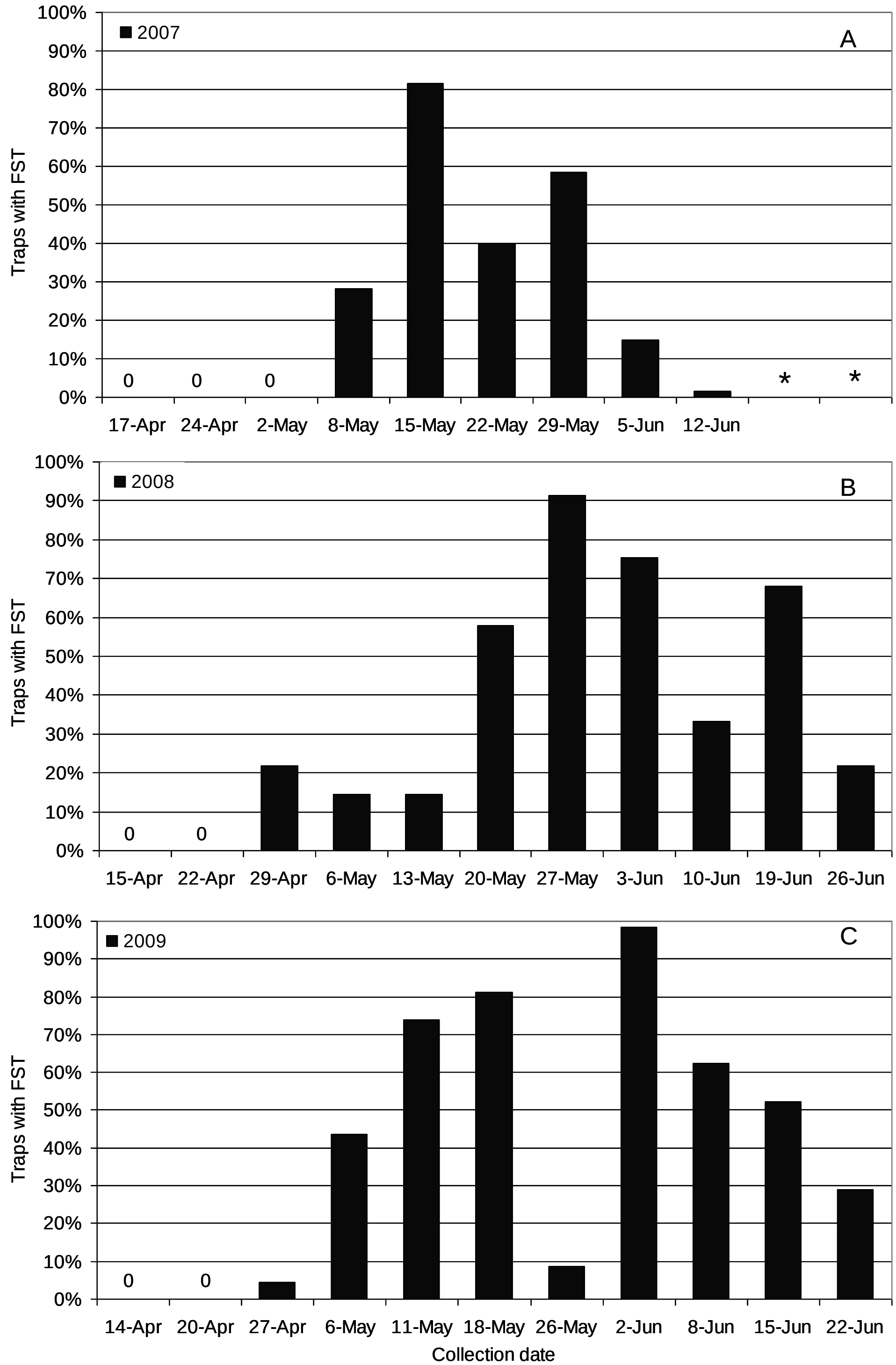

Figure 3. Percentage of Poplarville traps with FST alates, by collection date. Collections represent swarms occurring during the preceding 7 day period. Total trap numbers = 60 (2007) or 69 (2008, 2009). *In 2007, June 12 was the final inspection date.

In 2008, FST alates were collected on 65 of 69 traps and were found during 9 of the 11 sampling weeks (Figures 1B and 3B). While we detected swarms over a longer period of time than in 2007, the numbers of alates per trap were smaller than in 2007 or 2009. Swarming activity was greatest during the week ending May 27, with 2213 total alates collected from 63 of 69 traps.

In 2009, FST were collected from 68 of the 69 Poplarville traps and were present during 9 of 11 sampling weeks (Figures 1C and 3C). With the exception of low activity the week ending May 26, timing of swarms in 2009 was similar to 2008. There were two peaks in the total number of alates in 2009. On May 11, a total of 2285 alates were collected. Following a week of low swarm activity, a second peak occurred on June 2 with a total of 6780 alates collected from 68 traps.

Transects. In 2007, FST were collected from 16 of the 45 transect traps (Figure 2A). Of traps on 07W and 07E, 50% had alates, while only 19% of the 26W and 26E traps had alates. Sixty-three percent (62.5%) of the traps on transects 07W and 07E south of Poplarville had FST alates, while only 25% of the traps on these transects north of Poplarville had alates. Activity along 26W and 26E was concentrated near Poplarville, with the exception of a single trap in front of a church near the western end of 26W (Figure 2A).

In 2008, 24 of the 65 traps had FST (Figure 2B). Again, there were more active traps (57% active) on the 07W and 07E transects than on the 26W and 26E transects (20% active). For 2008, alate presence along transects 07W and 07E could not be predicted by proximity to the railroad, other FST sites, or an interaction of these factors (logistic regression, all $p > 0.05$). In an analysis of all transect traps, there was no relationship between FST presence and the distance from the nearest FST collection site (all $p > 0.05$). Formosan termites were widespread from Picayune to Lumberton, with isolated infestations along highway 26 and at the northernmost trap, in South Hattiesburg. The termite is well established immediately north of our study area, in parts of Lamar and Forrest Counties near Hattiesburg (Jarrat 2001, Sun et al. 2007). FST alates were collected during 8 of the 11 weeks in 2008 (Figure 4A). The greatest swarming activity of 2008 (29% of traps active) occurred during the week preceding the May 28 collection. In 2008 the May 20, 28, and June 2 collections were similar in total number of alates collected (196, 244, and 218, respectively).

The greatest FST swarming activity occurred in 2009, with 31 of 64 traps active on the 07 transects (60%) and on the 26 transects (40%), respectively (Figure 2C). In 2009, proximity to the railroad, other FST sites, and an interaction of these factors were significant predictors of FST presence on the 07 transects (Table 1). However, when all transect traps were included in the analysis, there was no relationship between FST presence and distance to the nearest FST collection site (all $p > 0.05$). Alates were collected during 9 of the 11 weeks in 2009 (Figure 4B). The largest number of active traps was found on June 2. However, based on alate numbers, there was no clear peak in activity. Large numbers of alates were collected throughout the month of May, with 202, 280, 179, and 179 alates being collected on May 11, 19, 27, and June 2, respectively.

Table 1. Logistic regression of FST presence on 07W and 07E alate traps in 2009 versus distance to railroad and distance to nearest trap with FST.

Term	Coefficient	Standard error	Df	Wald X^2	*P*
Intercept	8.8580	3.8050	1	5.4197	0.0199
RR	–1.7524	0.7311	1	5.7460	0.0165
FST	–1.2373	0.5584	1	4.9099	0.0267
RR x FST	0.2653	0.1147	1	5.3517	0.0207

Discussion

Timing of *C. formosanus* swarms varies with location, but usually occurs in the spring when temperatures are 20–30 °C (Su and Tamashiro 1985). Nix (2005) found a correlation between the onset of termite swarming and heat accumulation since July 1 of the previous year. While the exact timing of individual flights cannot be predicted, other studies have concluded that swarming is influenced by high humidity,

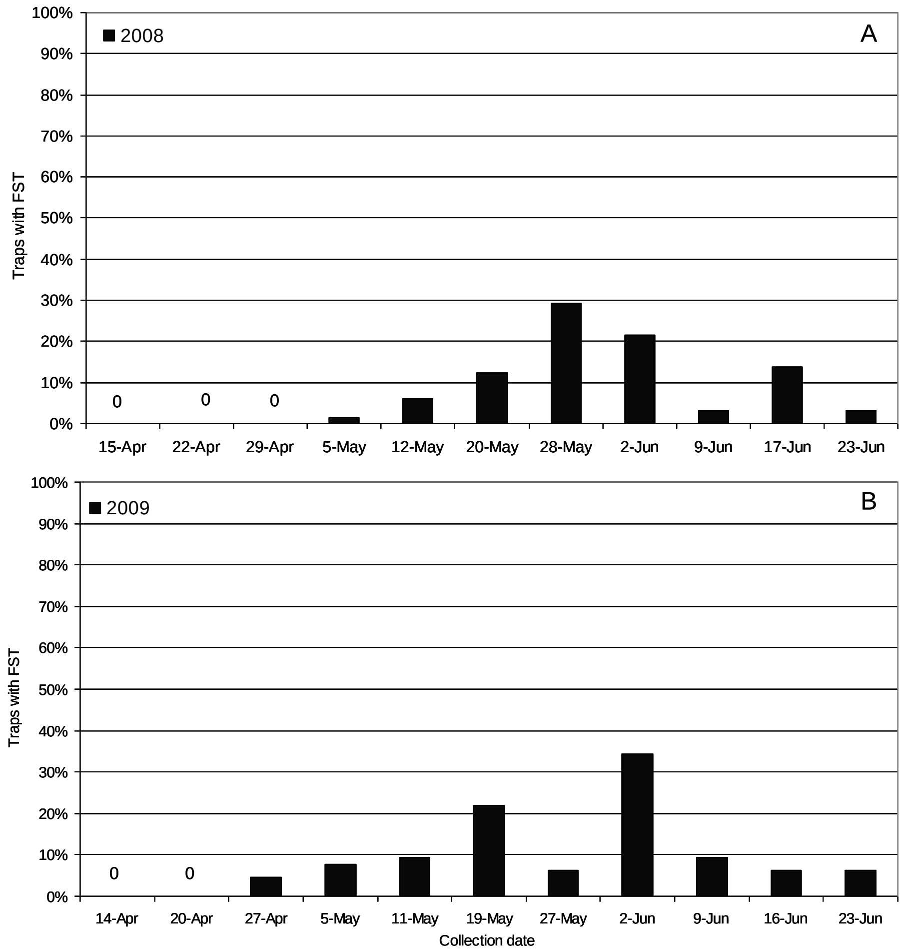

Figure 4. Percentage of transect traps with FST alates, by collection date. Collections represent swarms occurring during the preceding 7-day period. Total trap numbers = 65 (2008) or 64 (2009).

low wind velocity, and time since last peak swarm (Higa and Tamashiro 1983, Leong et al. 1983, Nix 2005). In addition, Sun et al. (2007) speculated that large swarms might be triggered by “muggy” conditions or rainfall during the preceding week. In surveys conducted in New Orleans from 1989–2003, FST alates were collected as early as the second week of April (Henderson and Delaplane 1994, Henderson 1996, Nix 2005). The largest swarms of the year were reported between May 3 and June 11, with most occurring during the second or third week of May. Although we did not collect FST in Mississippi until late April or early May, peak swarming dates for our transects and the Sun et al. (2007) survey were similar to those seen in New Orleans. While the number of active traps and the total number of alates were smaller on the transects than in Poplarville, peaks in swarm activity were easier to detect in traps on the transects. Elevated activity in Poplarville was sometimes sustained for periods of 2–3 weeks. This is likely due to the close placement of traps and high colony density in the area. Consequently, termites on a single glue card might have been associated with multiple colonies (Husseneder et al. 2006). Our small trap size and weekly collections have the advantage of making it possible to determine spatial distribution and timing of general swarming events over a large number of sites. However, surveys with daily collection are better suited for documenting specific swarms. The standard light traps traditionally used in alate surveys (Higa and Tamashiro 1983, Henderson and Delaplane 1994, Osbrink et al. 2008) have a comparatively large capacity, improving comparison of swarm sizes. Using sticky cards to distinguish between moderate and heavy swarms is difficult because the cards can quickly become covered with termites and other flying insects.

In 2009, we found a positive relationship between alate presence along transects 07W and 07E and the proximity of active traps to the railroad and other FST collection sites. Differences between the results in 2009 and the lack of such a relationship in 2008 can probably be attributed to a previously undetected cluster of activity close to the railroad in Lamar County in 2009. The two 07 transects parallel three major transportation corridors: the railroad, interstate 59, and highway 11. Because this route connects FST-infested cities including New Orleans, Picayune, and Hattiesburg, it is not surprising to find FST at all locations along the transects. It is possible that proximity to railroad depots is more important than proximity to the railroad itself. While more labor intensive, the use of in-ground monitors would provide data to pinpoint the termite activity along railroads and provide estimates of colony density in non-urban settings.

This study provides information on the density of FST infestations in Southern Mississippi that is more precise than was previously available (Sun et al. 2007). Our results indicate an urgent need for area-wide FST population control in Poplarville, as nearly all of the traps collected FST alates at some time during the three years. Total percentage of traps active and number of weeks when > 50% of traps were active increased each year. Such a high concentration of FST colonies, combined with human activity, poses an infestation threat to the surrounding area. Our results provide a baseline for evaluation of future control measures in Poplarville. Transect data indicate widespread infestations between Picayune and Hattiesburg and isolated pockets of activity along highway 26. Analysis of distance from the railroad led to inconclusive results regarding the proximity of active traps to the railroad since only in 2009 was there a significant correlation between location of active traps and distance from the railroad. We plan to expand this study through the addition of sites near railroad depots and along other sections of active railroad as well as abandoned railroad.

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