Seasonal Changes in the Caste Distribution of Foraging Populations of Formosan Subterranean Termite in New Orleans, Louisiana

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ABSTRACT. This study examined the relationship between temperature, precipitation, soil composition, levels of feeding damage, and the caste distribution (workers, soldiers, nymphs) of the Formosan subterranean termite, Coptotermes formosanus Shiraki, collected in underground monitoring stations over a 12 mo period. Because nymphs are the caste that develops into alates, the seasonal abundance of nymphs was examined over a 5 yr period. Numbers of workers, soldiers, and soldier/worker ratio were significantly affected by month. Recruitment and retention of foraging termites in stations was significantly affected by the level of feeding damage. The number of nymphs collected in monitoring stations was highly variable. In the 12 mo test, there was a significant correlation between numbers of nymphs and level of feeding damage, temperature, precipitation, and soil composition. Over a 5 yr period, significantly more nymphs were collected in 2011 than in 2007 and 2008. Peak nymph collections varied from year to year. Overall, peak nymph collections were more likely to occur in Mar., Sept., and Oct. Increasing our knowledge of the environmental factors that influence recruitment and retention of foraging termites in monitoring stations could influence termite bait placement and improve baiting strategies for termite control. Identifying the key factors that cause aggregations of nymphs in underground stations could increase our ability to predict the intensity and location of alate swarms.

Key Words: nymph, worker, soldier, feeding, monitoring

Formosan subterranean termite, Coptotermes formosanus Shiraki, is an invasive species and the most destructive structural pest in the southern United States (Lax and Osbrink 2003). Because Formosan subterranean termite colonies have extensive underground gallery systems (King and Spink 1969), it is difficult to eliminate entire C. formosanus colonies using soil insecticides (Su 2005; Osbrink et al. 2005; Osbrink et al. 2014). Baiting programs have been used successfully to eliminate subterranean termite colonies (Su et al. 1995; Messenger et al. 2005; Eger et al. 2012). Environmental factors such as temperature, humidity, soil type, and soil moisture affect termite activity at bait stations (Messenger and Su 2005; Santos et al. 2010; Cornelius and Osbrink 2011; Ruan et al. 2015). Seasonal variations in caste distribution of foraging populations of C. formosanus could also influence feeding and foraging behavior of termites on baits. For instance, soldier proportions affect wood consumption rates. In the Formosan subterranean termite, wood consumption decreased as soldier proportion increased from 30 to 40% (Su and La Fage 1987). There was a significant interaction of temperature and soil proportion on survival of C. formosanus. Termite survival declined significantly when soldier proportions exceeded 20% at 20 and 25°C, but not at 30 or 33°C (Fei and Henderson 2002). There was seasonal variation in caste distribution of foraging populations of the subterranean termite, Reticulitermes flavipes (Kollar). Workers were most abundant in the spring and summer months and soldiers were most abundant immediately preceding alate flights (Howard and Haverty 1981). Two studies have examined seasonal changes in soldier proportions of C. formosanus restricted to cypress trees submerged in the Calcasieu River, Lake Charles, Louisiana. Significantly more soldiers were produced at higher temperatures (Waller and La Fage 1988; Delaplane et al. 1991). Microsatellite markers determined that mean annual temperatures and soil moisture was correlated with the level of inbreeding in colonies of R. flavipes and R. grassei (Clément) (Vargo et al. 2012). Increasing our understanding of how environmental factors and changes in caste distribution affect termite foraging activity at bait stations will improve termite control strategies.

Nymphs are the caste that develops into alates (winged reproductive). Changes in the numbers of nymphs collected in monitoring stations could serve as an early indicator of the intensity of alate swarms. Also, increased numbers of nymphs in specific monitoring stations could be used to predict the flight dispersal location. In addition, it may take 4–6 yr for an incipient colony of C. formosanus to reach maturity and produce alates (Chouvenc and Su 2014). Thus, the presence of nymphs in a foraging population indicates that the colony has reached reproductive maturity.

Studies of alate production and dispersal of C. formosanus are important for predicting the spread of this invasive species. Formosan subterranean termites are slowly expanding their range throughout the southern United States (Jenkins et al. 2002; Hu and Oi 2004; Brown et al. 2007). Although human transport of termite infested material is the primary method of expansion to new regions, natural dispersal of C. formosanus occurs slowly through the annual nuptial flights of alates. A stochastic model simulating the spread of the invasive termite, Nasutitermes corniger (Motschulsky), determined that number of alates released from the nest, alate survival, maximum pheromone attraction distance between pairs, and mean flight distance were the key factors in predicting the spread of this invasive pest (Tonini et al. 2013). Alates of C. formosanus generally swarm from April through June to give rise to new colonies (Henderson and Delaplane 1994; Henderson 1996). Mullins et al. (2015) found that the average alate flight was 621 m and the longest recorded flight was 1.3 km from the parent colony.
The presence of nymphs in foraging populations of *R. flavipec* accounts for 3.0–8.4% of the population (Howard and Haverty 1981). Nymphs found in a survey of five entire colonies of *C. formosanus* restricted to cypress trees accounted for a much lower proportion of the population, ranging from 0 to 0.004% of the colony (Su and LaFage 1999). Reports on the abundance of nymphs in monitoring stations are limited. Numbers of *C. formosanus* nymphs were recorded from foraging populations in collections of three underground stations sampled at three different times of the year (Su and Scheffrahn 1986). Seasonal abundance of nymphs was also described from four monitoring stations over a period of 12 mo (Raina et al. 2004). Studies of the seasonal abundance of nymphs in mature colonies over long periods of time could increase our knowledge of the environmental factors that influence swarming behavior of alates.

Because of the cryptic nature of subterranean termites, it is difficult to study changes in the caste distribution of field populations. Underground monitoring stations offer a window into the feeding behavior and caste distribution of foraging populations of subterranean termites. The objective of this study was to examine the relationship between temperature, precipitation, soil composition, levels of feeding damage, and the caste distribution (workers, soldiers, nymphs) of *C. formosanus* collected in underground monitoring stations over a 12 mo period. This study also described the seasonal abundance of nymphs from 20 monitoring stations over a 5 yr period from 2007 to 2011 and examined the relationship between temperature and precipitation and nymph abundance.

### Materials and Methods

Two experiments were conducted in a 5.26 km² urban park, City Park, New Orleans, Louisiana and in two different areas immediately adjacent to the park. One area was located adjacent to the Orleans canal which borders the west side of City Park > 200 m outside of the park itself. The other area was located adjacent to Bayou St John which borders the east side of City Park > 500 m outside of the park. Both areas were > 2 km from the other monitoring stations located within City Park. For both experiments, populations of *C. formosanus* were monitored monthly using underground monitoring stations filled with blocks (7.5 by 3.8 by 0.8 cm) of spruce, *Picea* sp. Colonies located within 200 m of each other were delineated using mark-release-recapture techniques with the dye markers Nile Blue A and neutral red (Sigma-Aldrich, Milwaukee, WI) to determine which stations were part of a single, interconnected tunneling system (Su et al. 1993; Ruan et al. 2015). Average monthly temperature and precipitation was obtained for the NOAA station at the Lakefront airport located about 10 km from City Park (www.noaa.gov).

### Seasonal Changes in Caste Distribution (Workers, Soldiers, Nymphs) of *C. formosanus* in Monitoring Stations from June 2011 Through May 2012

Underground monitoring stations consisted of plastic cylindrical irrigation valve boxes (22.5 by 14.8 cm) with an open bottom to allow underground access by termites (NDS. World, ndspro.com). The monitoring stations were buried in the ground so that the lids were level with the surface of the soil and filled with 10–15 bundles of wood. Each bundle contained seven or eight individual blocks of spruce (7.5 by 3.8 by 0.8 cm) tied together with plastic ties. The stations were placed at the base of trees infested with *C. formosanus*.

A field test was conducted from June 2011 to May 2012. Termites were collected every month from 30 monitoring stations and 12 *C. formosanus* colonies, except data were missing from three stations in April and two stations in May due to construction projects. Nine colonies were located in four different areas within City Park that were > 200 m apart, one colony was located along the Orleans canal and two colonies were located along Bayou St John. Every month, all wood was collected from each station and immediately replaced with new wood. Collected wood was brought back to the laboratory. Individual blocks were separated from bundles, termites were removed from wood, carefully separated from soil and debris, and weighed. Individual worker and soldier weights were calculated by weighing four groups of ten workers and ten soldiers for each station. Numbers of workers and soldiers were estimated by dividing the total worker or soldier weight for each collection by the average worker or soldier weights for each station. The number of nymphs in each collection was counted. Out of a total of 355 collections, only a single alate was found. The feeding damage level in each station every month was recorded as none, low, medium, and high. Figure 1A shows a bundle of wood with no termite feeding damage. Feeding damage was recorded as low when termites had constructed shallow grooves on the surface of the wood blocks (Fig. 1B). Feeding damage was recorded as medium when the grooves were deeper and termites had constructed a gallery system within the wood blocks (Fig. 1C). Feeding damage was recorded as high when termites had consumed most or all of the wood blocks (Fig. 1D).

Soil composition was determined by taking a soil core sample of 20 cm depth within 0.5 m of each station. The composition of 15 g samples of soil was determined using a soil macronutrients kit (LaMotte Company, www.lamotte.com).

### Statistical Analysis

The effect of the level of feeding damage on the numbers of workers, soldiers, nymphs, and the soldier/worker ratio was determined using a Kruskal–Wallis ANOVA and means were separated using Dunn’s method on ranks. The number of workers, soldiers, nymphs, and the soldier/worker ratio collected in stations each month was compared a Kruskal–Wallis ANOVA. Because of missing data from three stations in April and two in May, means were separated using Dunn’s method of multiple comparisons on ranks for unequal sample sizes. Linear regression was used to examine the relationship between monthly average temperature and precipitation and monthly average of workers, soldiers, and nymphs. Also, the number of grams of sand, silt, and clay in 15 g samples of soil for each station was compared with the total number of workers, soldiers, and nymphs collected from those stations using linear regression. Data on nymphs were transformed by Log + 1 for linear regression analysis.

The number of nymphs per month and per year for data collected from 2007 to 2011 was compared using a Kruskal–Wallis ANOVA. Because data were not collected from every station every month, means were separated using Dunn’s method on ranks for unequal samples sizes. Linear regression was used to determine the relationship between the average monthly temperature and precipitation over 5 yr and the...
average numbers of nymphs. Data on nymphs were transformed by Log + 1 for linear regression analysis. All analyses were conducted using SigmaPlot 11.0 (Systat Software 2008).

Results and Discussion

Seasonal Changes in Caste Distribution of C. formosanus in Monitoring Stations from June 2011 Through May 2012. Recruitment and retention of foraging termites in monitoring stations changed as the level of feeding damage increased. There was a significant effect of feeding damage level on numbers of workers ($H = 134.9; P < 0.001$), soldiers ($H = 134.4; P < 0.001$), nymphs ($H = 43.2; P < 0.001$) and soldier/worker ratio ($H = 96.8; P < 0.001$). Numbers of workers, soldiers, and nymphs were significantly greater in stations with medium damage levels than stations with no or low damage levels and numbers of workers and soldiers were significantly greater in stations with medium damage than stations with high damage (Dunn’s Method on ranks) (Fig. 2A–C). The soldier/worker ratio was significantly greater in stations with high levels of feeding damage than in station with low levels of feeding damage occurred in April (Fig. 2D). When wood was replaced in monitoring stations every month, levels of feeding damage fluctuated as foraging termites gradually colonized the new wood in stations. From Mar. to Oct., there were stations where termites were collected after most of the wood had been consumed. Therefore, feeding rates increased as temperatures increased, resulting in a higher number of stations where foraging termites were depleting their food source and abandoning the monitoring stations before monthly collections. Wood consumption is a more reliable indicator of termite foraging activity in monitoring stations. A previous study measuring wood consumption found a significant correlation of feeding rates with air temperature, soil temperature, and soil moisture (Cornelius and Osbrink 2011). Messenger and Su (2005) also found that feeding rates of C. formosanus fluctuated seasonally. Fluctuations in recruitment and retention of foragers in monitoring stations due to changes in food availability act as a confounding factor in the evaluation of seasonal changes in caste distribution and foraging activity.

The number of workers was significantly lower in Dec. than in Feb., Mar., April and May, and the number of soldiers was significantly lower in Dec. than in July, Sept., and Mar. (Table 1). The number of workers collected in stations peaked in Mar. Numbers of nymphs per month were not significantly different. Although there was a large peak in nymph numbers in July, the variability in numbers per station was very high. In July, over 300 individuals were collected from two stations, whereas 16 stations had none. Soldier/worker ratios were significantly greater in Aug. than in April and May (Table 1).
Fig. 2. The effect of feeding damage levels on termite numbers and caste distribution in monitoring stations. Mean (± SE) number of (A) workers (B) soldiers (C) nymphs and (D) soldier/worker ratio at each level of feeding damage. Bars followed by the same letters were not significantly different ($P > 0.05$) (Dunn's test on ranks). Error bars ± SEM.

Fig. 3. Number of stations in each feeding damage level during each month from June 2011 to May 2012. Line represents average monthly temperatures.
Table 1. Mean (±SE) numbers of *Coptotermes formosanus* per month collected from 30 stations in City Park from June 2011 to May 2012 and average monthly air temperature and total monthly precipitation

| Month | Workers | Mean (±SE) numbers | Soldiers | Nymphs | Soldier/worker ratio | Temperature | Precipitation |
|-------|---------|-------------------|----------|--------|---------------------|-------------|---------------|
| June  | 2103.2 ± 465.7ab | 310.4 ± 50.0ab | 1.4 ± 0.7 | 0.35 ± 0.12ab | 29.44 | 11.94 |
| July  | 4762.6 ± 885.6ab | 469.7 ± 89.0b | 32.2 ± 20.5 | 0.10 ± 0.02ab | 29.00 | 33.02 |
| Aug.  | 1695.7 ± 463.8ab | 279.1 ± 45.8ab | 1.3 ± 0.7 | 0.59 ± 0.20ab | 30.72 | 4.09 |
| Sept. | 3283.7 ± 620.3ab | 321.0 ± 49.9b | 6.8 ± 4.2 | 0.35 ± 0.12ab | 25.78 | 33.71 |
| Oct.  | 2028.6 ± 319.0ab | 279.1 ± 50.2ab | 3.2 ± 0.8 | 0.24 ± 0.08ab | 20.78 | 0.56 |
| Nov.  | 2253.4 ± 692.3ab | 151.8 ± 30.4ab | 3.4 ± 2.2 | 0.12 ± 0.02ab | 17.83 | 8.08 |
| Dec.  | 717.6 ± 417.7a | 90.1 ± 24.5a | 0.07 ± 0.07 | 0.36 ± 0.14ab | 14.33 | 3.30 |
| Jan.  | 3172.3 ± 1013.4ab | 313.6 ± 98.1ab | 0.3 ± 0.1 | 0.15 ± 0.03ab | 16.00 | 4.60 |
| Feb.  | 6500.3 ± 1542.0bc | 245.6 ± 50.6ab | 1.0 ± 0.3 | 0.13 ± 0.04ab | 16.28 | 11.99 |
| Mar.  | 8838.0 ± 1177.3c | 348.4 ± 50.6b | 4.4 ± 2.1 | 0.12 ± 0.06ab | 21.50 | 20.57 |
| April | 7300.6 ± 1675.6bc | 249.5 ± 80.4ab | 3.8 ± 2.1 | 0.06 ± 0.02a | 22.72 | 18.90 |
| May   | 4231.4 ± 957.9bc | 163.8 ± 37.6ab | 5.2 ± 3.0 | 0.10 ± 0.04a | 26.28 | 4.50 |

* a: Mean (± SE) workers, soldiers, and soldier/worker ratios per month followed by the same letters were not significantly different (*P* > 0.05).

Table 2. Linear regression of temperature, precipitation, soil composition, and numbers of workers, soldiers and nymphs in monitoring stations from June 2011 to May 2012

| Variable | Source | n | y-intercept | Slope | R² | P |
|----------|--------|---|-------------|-------|----|---|
| Workers  | Temperature | 12 | 4191.5 | 12.60 | 0.00 | 0.93 |
|          | Precipitation | 12 | 2572.3 | 103.20 | 0.22 | 0.13 |
|          | Soil composition | | | | | |
|          | Sand | 30 | 5590.8 | 152.40 | 0.04 | 0.27 |
|          | Silt | 30 | 3577.8 | 155.60 | 0.02 | 0.45 |
|          | Clay | 30 | 3358.8 | 292.70 | 0.05 | 0.25 |
| Soldiers | Temperature | 12 | 193.9 | 5.80 | 0.43 | 0.02 |
|          | Precipitation | 12 | 189.5 | 7.20 | 0.02 | 0.42 |
|          | Soil composition | | | | | |
|          | Sand | 30 | 286.9 | 8.50 | 0.01 | 0.53 |
|          | Silt | 30 | 291.9 | 12.10 | 0.02 | 0.46 |
|          | Clay | 30 | 291.9 | 12.10 | 0.02 | 0.46 |
| Nymphs   | Temperature | 12 | –0.3 | 0.07 | 0.37 | 0.04 |
|          | Precipitation | 12 | 0.8 | 0.04 | 0.42 | 0.02 |
|          | Soil composition | | | | | |
|          | Sand | 30 | 2.4 | –0.10 | 0.16 | 0.03 |
|          | Silt | 30 | 1.0 | 0.14 | 0.15 | 0.03 |
|          | Clay | 30 | 1.0 | 0.13 | 0.08 | 0.14 |

**Fig. 4.** Percent sand, silt, and clay in 15 g samples of soil from each monitoring station.

**Fig. 5.** Mean (± SE) number of nymphs per year. Bars followed by the same letters were not significantly different (*P* > 0.05) (Dunn’s test on ranks). Error bars ± SEM.
Average soldier/worker ratios per month in monitoring stations ranged from 6 to 59%. Soldier/worker ratios are generally higher in monitoring stations than ratios in the entire colony. Soldier/worker ratios for entire colonies of *C. formosanus* ranged from 12 to 28% (Su and La Fage 1999), whereas soldier/worker ratios in traps ranged from 20 to 60% (Haverty 1977). Soldier/worker ratios were higher in Aug. compared with April and May. In Louisiana, Formosan subterranean termites generally swarm from April through June, with peak swarming in May (Henderson and Delaplane 1994; Henderson 1996; Guillot et al. 2010; Mullins et al. 2015). Previous studies of *C. formosanus* populations located in submerged cypress trees found that soldier/worker ratios were greater in the spring compared with the summer and fall (Waller and La Fage 1988; Delaplane et al. 1991). Soldiers congregate at swarming sites (Stuart 1969). Only a single alate was collected in the 30 monitoring stations throughout 2011–2012. Therefore, the low soldier proportion in stations in April and May was probably due to the movement of soldiers out of stations to congregate at swarming sites in the trees during April and May.

The number of workers in stations was not correlated with temperature, precipitation, or soil composition. There was a significant correlation between precipitation and the numbers of soldiers and nymphs in monitoring stations (Table 2). There was a negative correlation between numbers of nymphs and average temperatures. Although there were very low numbers of nymphs from Dec. to Feb., the average number of nymphs was higher in the fall and spring than in June and Aug. when average temperatures reached 29°C in June and peaked at 30.7°C in Aug.

Average number of nymphs collected in stations was extremely low. The highest number of nymphs collected occurred in July. The peak nymph number in a single collection of 545 nymphs accounted for 0.03% of termites in the collection and the average number of nymphs per month in July accounted for 0.006% of the average number of termites collected. In contrast, a study examining underground monitors on the campus of University of New Orleans found peak nymph numbers from one station in May that accounted for 21% of the collection (Raina et al. 2004). Also, the presence of nymphs in foraging populations of *R. flavipes* is much higher, accounting for 3.0–8.4% of the population (Howard and Haverty 1981).

The percent sand in soils at each station ranged from 36.6 to 93.3%. Most of the stations were located in soils containing >50% sand (Fig. 4). Soil composition had no effect on numbers of workers and soldiers in stations. However, the number of nymphs in stations was positively correlated with the amount of silt and negatively correlated with the amount of sand (Table 2).

### Seasonal Abundance of Nymphs in Monitoring Stations from 2007 to 2011

The percent sand in soils at each station ranged from 36.6 to 93.3%. Most of the stations were located in soils containing >50% sand (Fig. 4). Soil composition had no effect on numbers of workers and soldiers in stations. However, the number of nymphs in stations was positively correlated with the amount of silt and negatively correlated with the amount of sand (Table 2).

#### Table 3. Linear regression of temperature, precipitation and numbers of nymphs in monitoring stations from Jan. 2007 to Nov. 2011

| Variable  | Source          | y-intercept | Slope  | R²  | P   |
|-----------|-----------------|-------------|--------|-----|-----|
| Nymphs 2007 | Temperature     | 1.2         | 0.006  | 0.02 | 0.65|
|           | Precipitation   | 1.7         | -0.03  | 0.12 | 0.27|
| Nymphs 2008 | Temperature     | 1.2         | -0.001 | 0.003 | 0.96|
|           | Precipitation   | 1.3         | -0.02  | 0.11 | 0.30|
| Nymphs 2009 | Temperature     | 0.8         | 0.004  | 0.85 | 0.09|
|           | Precipitation   | 1.2         | -0.02  | 0.27 | 0.09|
| Nymphs 2010 | Temperature     | 1.3         | 0.006  | 0.15 | 0.70|
|           | Precipitation   | 1.7         | -0.01  | 0.58 | 0.04|
| Nymphs 2011 | Temperature     | 1.1         | 0.004  | 0.76 | 0.36|
|           | Precipitation   | 1.3         | -0.01  | 0.08 | 0.36|
| Nymphs 2012 | Temperature     | 1.0         | 0.01   | 0.57 |     |
|           | Precipitation   | 1.1         | 0.02   | 0.36 | 0.05|

Fig. 6. Mean (± SE) number of nymphs per month over a 5 yr period. Bars followed by the same letters were not significantly different (P > 0.05) [Dunn’s test on ranks]. Error bars ± SEM.
comparison test on ranks could not distinguish between monthly nymph collections (Dunn’s Method; Fig. 7A–C).

In 2010, the number of nymphs collected in April was significantly greater than the number collected in Jan. (Fig. 7D). In 2011, the number of nymphs collected in Oct. was greater than in Jan., and the number collected in Mar. was greater than the number collected in Jan., Feb., April, May, Aug., and Nov. (Fig. 7E). Overall, there was no correlation between number of nymphs collected in stations with either average monthly temperature \(R^2 = 0.02; \ P = 0.65\) or precipitation \(R^2 = 0.12; \ P = 0.27\). However, there was a significant negative correlation between precipitation and number of nymphs in 2009 \(R^2 = 0.58; \ P = 0.004\) and a marginally positive correlation between precipitation and number of nymphs in 2011 \(R^2 = 0.36; \ P = 0.53\) (Table 3). It is likely that numbers of nymphs in monitoring stations are related to nymph production by the colony. Environmental factors, such as precipitation, may influence nymph production weeks or months before changes occur in the number of nymphs in foraging populations.

The number of nymphs collected from stations was highly variable. Peak nymph collections varied from year to year. When Su and La Fage (1999) examined caste distributions from five entire colonies restricted to cypress trees, two colonies contained no nymphs, two colonies contained \(<\ four nymphs and one colony contained 322 nymphs. Collections of nymphs from foraging populations of Coptotermes gestroi (Wasmann) found a wide variation in the number of nymphs collected from different colonies and in different seasons (Albino and Costa-Leonardo 2011). In a study examining four stations on the University of New Orleans campus over a 12 mo period, numbers of nymphs were comparatively high, ranging from 4 to 21% in one station.

Fig. 7. Mean (± SE) number of nymphs per month collected over a 5 yr period (A) 2007 (B) 2008 (C) 2009 (D) 2010 (E) 2011. Bars followed by the same letters were not significantly different \(P > 0.05\) (Dunn’s test on ranks). Error bars ± SEM. Lines represent average monthly temperatures (black circle) and total monthly precipitation (white square).
0 to 4.3% in one station, and 0% to <1% in the other two stations (Raina et al. 2004).

Overall, collections of nymphs from 2007 to 2011 fluctuated significantly from year to year and were more likely to peak in May and have a secondary peak in Sept.–Oct. However, peak numbers of nymphs in stations varied by location and season. Raina et al. (2004) found that the timing of peak numbers of nymphs varied between four stations, with one station peaking in May, one station peaking in Oct., one station having a peak in Oct.–Nov. and a second peak in May, and one station having peak numbers of nymphs collected between June through Aug. Nymph numbers in most collections consisted of 0–2 nymphs, with rare collections of over 50 nymphs (nine collections over 5 yr). Because of the extremely low numbers and high variability of nymphs collected in monitoring stations, it is difficult to determine how seasonal and environmental factors affect their abundance in foraging populations of C. formosanus.

Conclusions

It is difficult to monitor 14 populations of subterranean termites in the field. Underground monitoring stations provide a method for sampling the foraging activity and caste distributions of subterranean termites. Recruitment and retention of termites to bait stations is a crucial component of baiting strategies for termite control. This study demonstrates that C. formosanus can rapidly deplete the bait matrix during the months with the highest levels of foraging activity. Depletion of the bait matrix and subsequent abandonment by termites increases the time needed to eliminate C. formosanus colonies. These results indicate that it is necessary to improve bait technology to maximize consumption of bait toxins by foraging populations of C. formosanus. Advances in the development of durable and fluid baits may provide better control of C. formosanus infestations than standard bait stations where rapid depletion of bait is a problem (Eger et al. 2014; Su 2015).

Because nymphs are a reproductive caste, it is important to identify the environmental factors that affect nymph production in order to improve strategies for termite control. However, there was no consistent correlation between either temperature or precipitation and nymph numbers in monitoring stations. Because nymphs in monitoring stations varied by year and location, it is possible that nymph production is affected by other factors, such as soil moisture or host availability. Further studies are needed to better understand the environmental factors that affect termite foraging behavior and caste distribution in monitoring stations could result in the development of novel methods for termite control.

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