# Seasonal Population Patterns of a New Scale Pest, *Acanthococcus lagerstroemiae* Kuwana (Hemiptera: Sternorrhynca: Eriococcidae), of Crapemyrtles in Texas, Louisiana, and Arkansas.[1]

**Erfan Vafaie[2], Michael Merchant[3], Cai Xiaoya [4], John D. Hopkins[5], James A. Robbins[5], Yan Chen[6], and Mengmeng Gu[4]**

## Abstract

The crapemyrtle bark scale, *Acanthococcus lagerstroemiae*, is an invasive scale insect pest of crapemyrtles. Crawler populations were monitored using double-sided sticky tape on established crapemyrtle trees in Tyler (TX), Huntsville (TX), Dallas (TX), College Station (TX), Shreveport (LA), and Little Rock (AR) from 2015 - 2017 to determine crawler activity and determine if degree-day models could predict the first peak in crawler activity. Difference in crawler densities on upper and lower branches of trees was also determined by using double-sided sticky tapes. The first peak in crapemyrtle bark scale crawler activity was between March 26th and May 22nd across all locations and years, with multiple subsequent peaks per season frequently found, suggesting multiple generations. Using the average date (May 2nd) to predict the first peak crawler activity resulted in the lowest variance and was subsequently considered a better predictor compared to any degree-day model. There was no apparent difference in crawler activity between upper and lower branches of crapemyrtle trees across an entire season. This study provides the first set of population dynamics data for crapemyrtle bark scale in the U.S. and will help with future bark scale management decisions.

**Index words:** Crapemyrtle bark scale, invasive insect, population dynamics, *Lagerstroemia* spp.

**Species used in this study:** Crapemyrtle bark scale (*Acanthococcus lagerstroemiae* Kuwana); Crapemyrtle (*Lagerstroemia* spp.).

### Significance to the Horticulture Industry

Crapemyrtle (*Lagerstroemia* spp. L.) is an economically important crop with 4.8M plants sold and a $66M wholesale value in 2014 (Vilsack and Reilly 2015). Crapemyrtle sales continue to increase as new cultivars are continuously developed to meet consumer needs.

A relatively new exotic pest, *Acanthococcos (=Eriococcus) lagerstroemiae* Kuwana (Hemiptera: Sternorrhyncha: Eriococcidae), commonly referred to as the crapemyrtle bark scale (CMBS), threatens the commercial viability and landscape aesthetics of crapemyrtles. CMBS can reportedly infest 17 plant genera in 13 families, including economically important crops such as pomegranate (*Punica granatum* L.) (Ma 2011), soybean (*Glycine max* (L.) Merr.) and apple (*Malus domestica* Borkh) (Hua 2000). Crapemyrtle bark scale was recently confirmed (unpublished data, Allen Szalanski, University of AR) on Callicarpa sp. (beautyberry) in Texarkana, TX, Dallas, TX, and Shreveport, LA, and on Hypericum kalmianum L. (St. Johnswort) in Virginia (Schultz and Szalanski 2019). Crapemyrtle, which is currently the primary host of CMBS, was grown for retail in 33 states in 2014 (Vilsack and Reilly 2015), including all west coast states (Washington, Oregon and California), and east coast states from Florida north to Connecticut and Massachusetts. This is the first study published on crapemyrtle bark scale seasonal population dynamics in the U.S. and provides the foundation for timing pesticide applications for management of this pest with contact and systemic spray applications.

### Introduction

The crapemyrtle bark scale (CMBS) is a relatively new scale pest of crapemyrtles in the U.S. The first sightings of CMBS were reported in McKinney, Texas in 2004 (Gu et al. 2014), and have since spread to at least 11 states in the U.S, from New Mexico to Virginia (EDDMapS 2019). The adult CMBS ovisacs remain present and visible throughout much of the year as unsightly white spots covering branches. In addition to its appearance, CMBS can further decrease the aesthetics of crapemyrtles via promotion of sooty mold (Gu et al. 2014), may cause branch dieback (Wang et al. 2016), and limited evidence suggests CMBS may reduce growth rate, flower size and flower abundance (informal observations by the authors). Management of CMBS requires a good understanding of the scale's biology and phenology, and recognition of natural predators that may help suppress CMBS populations.

Scale insects in the genus *Acanthococcus* are typically mobile as the first instars (crawlers), but become sessile within hours (Miller 1991). Subsequently, a white felt sac is produced to cover the bodies of 2nd instar males and

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[2]Texas A&M AgriLife Extension Service, 1710 N. FM 3053, Overton, TX 75684. erfan.vafaie@ag.tamu.edu.

[3]Texas A&M AgriLife Extension Service, 17360 Coit Road, Dallas, TX 75252-6599.

[4]Department of Horticultural Sciences, Texas A&M AgriLife Extension, MS 2134, College Station, Texas 77843.

[5]University of Arkansas Coop. Ext. Serv., 2301 S. Univ. Ave., Little Rock, AR 72204.

[6]Hammond Research Station, Louisiana State University, Agricultural Center, Hammond, LA 70403.

  

Table 1. Trapping sites, number of trees, start and end date for the crapemyrtle bark scale collections.

| Site | Trees Sampled | USDA Plant Hardiness Zone | Weather Station Code | Year | Crawler Trap Collection Start Date | Crawler Trap Collection End Date | Total Collections |
|---|---|---|---|---|---|---|---|
| Tyler, TX | 3 | 8b | KTYR | 2015 | 2/13/15 | 11/7/15 | 34 |
| | | | | 2016 | 03/28/2016 | 12/19/2016 | 34 |
| | | | | 2017 | 01/23/2017 | 11/27/2017 | 30 |
| McKinney, TX | 3 | 8a | KTKI | 2015 | 6/12/15 | 12/31/15 | 14 |
| | | | | 2016 | 01/15/2016 | 11/11/2016 | 15 |
| | | | | 2017 | 01/26/2017 | 10/10/2017 | 15 |
| College Station, TX | 12 | 8b | KCLL | 2015 | 3/6/15 | 12/22/15 | 40 |
| | | | | 2016 | 01/06/2016 | 12/21/2016 | 51 |
| | | | | 2017 | 01/19/2017 | 12/22/2017 | 49 |
| Huntsville, TX | 6 | 8b | KUTS | 2015 | 2/26/15 | 11/26/15 | 43 |
| | | | | 2016 | 01/07/2016 | 12/29/2016 | 51 |
| | | | | 2017 | n/a | n/a | n/a |
| Shreveport, LA | 3 | 8b | KSHV | 2015 | 02/27/2015 | 08/26/2015 | 25 |
| | | | | 2016 | 03/24/2016 | 11/04/2016 | 30 |
| | | | | 2017 | 03/16/2017 | 11/30/2017 | 13 |
| Little Rock, AR | 3 | 8a | KLIT | 2015 | 02/18/2015 | 12/10/2015 | 41 |
| | | | | 2016 | 01/08/2016 | 11/03/2016 | 22 |
| | | | | 2017 | n/a | n/a | n/a |

adult females (Miller 1991), making them less vulnerable to contact insecticides (Muegge and Merchant 2000). As a result, knowing the times of peak crawler activity is critical for effective management of this pest with contact insecticides. In addition, research data could be used to predict timing of peak activity times by calendar date or by a degree-day model. Phenology models have been used for many years to predict the first-generation crawler emergence of scale insects (e.g., Jorgensen et al. 1981, Hodges and Braman 2004). By calculating the degree-days to CMBS crawler peaks, we can determine whether degree-day models can provide better timing of contact insecticides compared to the calendar date for effective management.

Double-sided sticky tape is an effective method of monitoring the crawler stages of scale insects to develop phenology models (Grafton-Cardwell and Reagan 1995, Taylor et al. 2002, Hodges and Braman 2004, Sazo et al. 2008). This technique has also been used to measure scale density differences between the upper and lower tree canopy (Wright and Conant 2009). Determining whether CMBS crawlers are evenly distributed between upper and lower branches of crapemyrtles throughout the season will inform effective trap placement and management programs.

For several years, we have observed ladybird beetles (Coccinellidae) appearing to prey on CMBS. Scale insects (Hemiptera: Coccidae) are the dominant prey for 36% of ladybird beetle species globally and listed as secondary prey for 16 primarily aphidophagous species (Hodek and Honěk 2009). Future research on impact of native natural enemies may benefit from an initial survey of native species of natural enemies associated with CMBS in the landscape.

In this study, we had four main objectives: 1) determine seasonal crawler activity of CMBS crawlers on crapemyrtles, 2) determine whether a degree-day model can provide a more accurate estimate of the first crawler peak compared to a calendar date, 3) evaluate the difference in CMBS crawler activity on upper and lower branches throughout a season, and 4) conduct an initial survey of native natural enemies currently associated with CMBS in Texas and Arkansas.

## Materials and Methods

*Crawler activity.* A total of 30 trees across Dallas, TX (3), Tyler, TX (3), College Station, TX (12), Huntsville, TX (6), Shreveport, LA (3), and Little Rock, AR (3) were monitored during the 2015 to 2017 calendar years (Table 1). Each tree was monitored for crawlers using double-sided 1.9 cm-wide (3/4-in) Scotch tape (3M, Maplewood, MN) wrapped around at least five trunks or branches, which is commonly used for monitoring crawler populations (Grafton-Cardwell and Reagan 1995, Dreistadt 1996, Taylor et al. 2002, Hodges and Braman 2004, Sazo et al. 2008). Tapes were replaced weekly-to-biweekly (dependent on sampling location) on the same branch and the removed tape was placed on 1.6 square cm (¼ square in) grid-paper for subsequent crawler quantification under a dissecting microscope. The number of crawlers were counted, and length of tape was measured to approximate number of crawlers per square cm. When crawler counts exceeded 1,000 per tape, number of crawlers were approximated by sub-sampling number of crawlers in several 1.6 $cm^2$ (¼ $in^2$ ) squares.

*Degree-Day model.* Temperature data was acquired using airport weather station data from the same city as the monitoring site using the Degree Days.net desktop app (BizEE Software Limited, Uplands, UK). Weather stations were all within 15 miles of trapping locations, except for the Little Rock (AR) location in 2017, which was 32 miles away. Since the base temperature threshold is unknown for CMBS, we used a method to calculate the cumulative degree days to the first crawler peak activity using a range of base temperatures (Arnold 1959, Hubbard and Potter 2005): 1.7, 4.4, 7.2, 10, 12.8, and 15 C (35, 40, 45, 50, 55, 59 F). Degree day accumulations were calculated using the

**Table 2. Mean number of crapemyrtle bark scale (CMBS) crawlers per cm$^{-2}$ sticky tape trap of the first crawler peak for each year and location, and maximum mean crapemyrtle bark scale/cm$^2$ sticky tape trap for each sampling year and location.**

| | | First peak | | Highest peak | |
|---|---|---|---|---|---|
| Location | Year | Mean No. CMBS/cm$^2$ | Date | Mean No. CMBS/cm$^2$ | Date |
| Tyler, TX | 2015 | 7.18 | 5/22 | 7.18 | 5/22 |
| | 2016 | 12.74 | 5/2 | 12.74 | 5/2 |
| | 2017 | 3.15 | 4/24 | 3.15 | 4/24 |
| McKinney, TX | 2015 | N/A*[z] | - | 2.29 | 9/17 |
| | 2016 | N/A* | - | 48.04 | 6/30 |
| | 2017 | N/A* | - | 4.53 | 5/18 |
| College Station, TX | 2015 | 6.40 | 5/8 | 6.40 | 5/8 |
| | 2016 | 3.45 | 4/27 | 6.98 | 9/15 |
| | 2017 | 0.37 | 4/13 | 1.99 | 7/28 |
| Huntsville, TX | 2015 | 4.96 | 5/7 | 10.89 | 7/23 |
| | 2016 | 1.02 | 5/5 | 1.02 | 5/5 |
| Shreveport, LA | 2015 | 1.61 | 4/15 | 1.61 | 4/15 |
| | 2016 | 2.48 | 5/19 | 2.48 | 5/19 |
| | 2017 | 2.25 | 5/18 | 2.25 | 7/13 |
| Little Rock, AR | 2015 | 20.58 | 3/26 | 20.58 | 3/26 |
| | 2016 | 0.03 | 6/2 | 2.14 | 11/3 |
| | 2017 | 0.30 | 5/25 | 0.30 | 5/25 |

[z]*Trapping started too late to determine first peak in crawler activity.

integration method (as calculated for weather stations with frequent, regular, and accurate temperature readings, defined as best-quality weather stations by Degree Day-s.net) with January 1st of each year used as the biofix date. The first crawler peak activity was defined as the maximum average crapemyrtle bark scale per cm$^2$ before June 1st for a given year and location. The first peak date was not included for a specific year at a given location if crawler data before June 1st was incomplete. For each base temperature, we calculated cumulative degree days to the first crawler peak activity for all locations and years and calculated the average. We then determined the predicted crawler peak date for each location and year based on the weather station data and calculated the variance between the forecasted peak date based on the average cumulative degree days for each base temperature (degree-day model) and actual peak crawler date. We also created a predictive model based on Julian date by averaging the Julian date till the first peak emergence for all years and locations. We calculated variance between predicted peak crawler date (Julian date mode) and actual peak date.

To compare differences in crawler activity with trap height, double-sided sticky tape was placed either on upper (1.5 m (4.9 ft) from the soil line, 3 per tree) or lower (under 1.5 m from the soil line, 3 per tree) branches of 12 crapemyrtles in College Station, Texas. All 12 trees were within 1.9 km (1.2 miles) of each other in commercial landscapes. Tape was removed weekly and placed on 1.6 cm$^2$ (¼ in$^2$ ) grid paper for counting. While collecting tapes, predators crawling on branches infested with crapemyrtle bark scale were collected and photographed for subsequent identification.

Crawler counts were pooled (mean) for each tree to get an overall estimate of numbers of crawlers per cm$^2$ of tape per tree. In the case of differences in crawler activity with trap height, tapes from upper branches and lower branches were pooled (mean) separately within each tree. Data was standardized to seven-day intervals by dividing the number of crawlers per cm$^2$ by the number of days the tape was exposed, and multiplying by 7.

## Results and Discussion

Crapemyrtle bark scale crawler populations were active as early as the first tape collections on January 7th (Huntsville, TX; 2016). The earliest crawler activity in 2015 was minor and occurred in the latter half of February in Tyler, Shreveport, and College Station (Fig. 1). First-generation crawlers often represented the largest peak in CMBS populations within a location and year, except for College Station in 2016 and 2017, Huntsville in 2015, and Little Rock in 2016 (Table 2). Trees in Little Rock, AR exhibited the earliest recorded initial peak in CMBS crawler activity on March 26th (2015), equivalent to 50% of the major peak during that same year (Fig. 1). This early peak was unique among locations and years. This anomaly may have been due to tape traps being unintentionally placed on a CMBS egg sac, creating a microhabitat between the tape and tree that was warmer than ambient temperature; this could have easily resulted in inflated scale crawler numbers. For all other sites, the first major peak in crapemyrtle bark scale crawler activity ranged from March 26th to May 25th between all locations and years (Table 3).

In China, crapemyrtle bark scale is reported to have 3 to 4 overlapping generations per year (Luo et al. 2000, He et al. 2008, Ma 2011). Multiple peaks of crawler activity seen in Figure 1 suggest that CMBS has two or more overlapping generations per year, and possibly up to four generations as previously reported. Monitoring of crawler activity across additional states will be important to determine if CMBS bark scale population trends are similar across the USA or whether timing, amplitude, and frequency of crawler activity varies across climatic regions.

Lab studies have evaluated physiologically relevant proxies for lower temperature tolerance of CMBS, such as the super-cooling point; however, the lower developmental threshold for this insect is still unknown (Wang, Chen, and Diaz 2019a, 2019b, Wang, Chen, Diaz, et al. 2019). For this reason, we used six different proxy base temperatures to estimate degree days to the first peak crawler emergence (Table 4).

To determine the best base temperature to predict crapemyrtle bark scale crawler activity, we used the least variability method (Arnold 1959). The mean cumulative degree days until the first peak crawler activity across all locations and years for six base temperatures are summarized in Table 4. We did not find a linear trend between sample variance and the different base temperatures, with the two extreme base temperatures, 1.7 C and 15.6 C, providing the lowest variance (536.1 and 533.9, respectively) from actual peak date compared to all of the other base temperatures (Table 3). Predicted date of first crawler peak varied from 2 to 15 days within location and year depending on the base temperature used in the degree-day model (Table 3). Using mean Julian date calculated across all years and locations, May 2nd provided the lowest

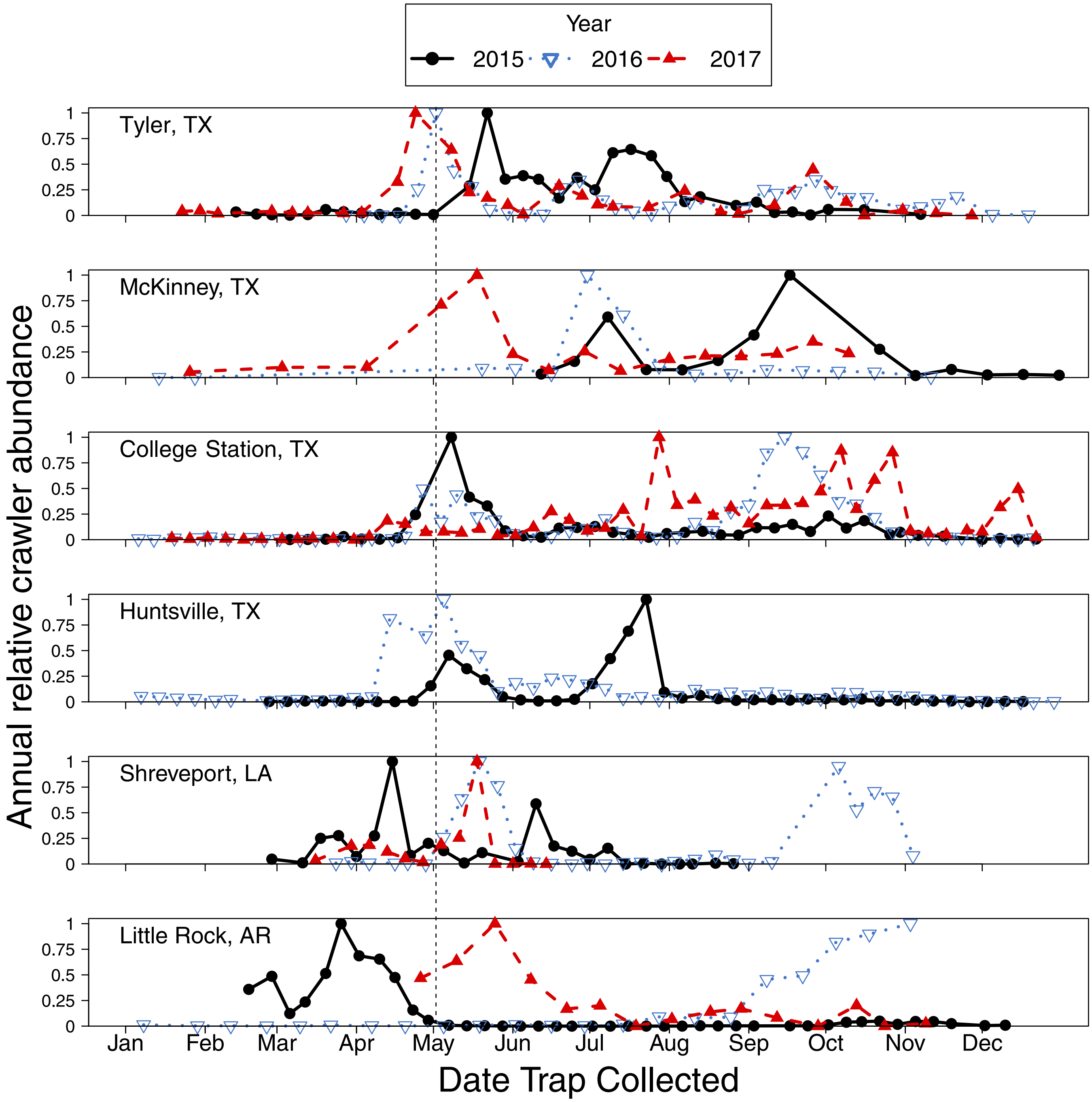


**Fig. 1.** **Relative abundance of crapemyrtle bark scale crawlers counted on double-sided sticky tapes collected from several (5-6) branches per tree weekly by Gregorian date in Tyler TX (n=3), McKinney TX (n=3), College Station TX (n=12), Huntsville TX (n=6), Shreveport LA (n=3), and Little Rock AR (n=3).**



variance of 304.2 (Table 3) from actual peak crawler activity dates, suggesting that using the average date may currently be the most effective and simplest model to predict peak CMBS crawler activity.

Understanding when the first-generation nymphs are active and susceptible to insecticides can help time spraying applications to impact the most vulnerable scale life stages (Vafaie and Knight 2017, Vafaie 2019, Vafaie and Gu 2019). Additionally, systemic insecticides might be more effective if applied prior to crawler emergence and settling (Vafaie and Knight 2017, Merchant et al. 2018, Vafaie 2019, Vafaie and Gu 2019). Assuming several weeks lag-time for translocation, these data suggest systemic insecticides might be most effective if applied by when crapemyrtle leaves begin to bud, and that contact insecticides should be applied during the weeks leading up to the peak crawler activity in the last two weeks of April.

Degree-day models for the San Jose Scale, *Quadraspidiotus pernicisosus* (Comstock) have provided effective timing for control of susceptible life stages (Jorgensen et al. 1981, Mague and Reissig 1983). The first capture of flying spring males with pheromone traps as the biofix date

Table 3. **Date of the first crapemyrtle bark scale crawler peak activity, deviation of cumulative degree-day model for each given base temperature from the first peak date (in days), deviation of actual first peak date from overall mean first peak date, overall mean first peak date, and sample variance of each predictive parameter from actual first peak date.**

| | | | Deviation between CDD model and actual peak date (in days)[z] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Location | Year | First peak date | 1.7 C (35 F) | 4.4 C (40 F) | 7.2 C (45 F) | 10 C (50 F) | 12.8 C (55 F) | 15.6 C (59 F) | Mean peak date (5/02) – actual peak date[y] |
| Tyler, TX | 2015 | 5/22 | -18 | -16 | -15 | -14 | -14 | -14 | -20 |
| | 2016 | 5/2 | -10 | -9 | -8 | -6 | -5 | -3 | 0 |
| | 2017 | 4/24 | -13 | -13 | -13 | -12 | -12 | -11 | 8 |
| College Station, TX | 2015 | 5/8 | -12 | -10 | -9 | -9 | -9 | -9 | -6 |
| | 2016 | 4/27 | -12 | -12 | -11 | -9 | -8 | -5 | 5 |
| | 2017 | 4/13 | -11 | -13 | -14 | -15 | -15 | -16 | 19 |
| Huntsville, TX | 2015 | 5/7 | -11 | -9 | -8 | -8 | -7 | -7 | -5 |
| | 2016 | 5/5 | -21 | -21 | -20 | -19 | -18 | -16 | -3 |
| Shreveport, LA | 2015 | 4/15 | 20 | 22 | 23 | 23 | 24 | 24 | 17 |
| | 2016 | 5/19 | -28 | -26 | -25 | -23 | -22 | -20 | -17 |
| | 2017 | 5/18 | -39 | -39 | -40 | -40 | -39 | -38 | -16 |
| Little Rock, AR | 2015 | 3/26 | 53 | 54 | 55 | 57 | 58 | 57 | 37 |
| | 2017 | 5/25 | -24 | -21 | -18 | -16 | -13 | -10 | -23 |
| | | **Mean Peak Date** | | | | **Sample variance** | | | |
| | | 5/02 | 536.1 | 541.4 | 550.6 | 559.5 | 560.8 | 533.9 | 304.2 |

[z]Forecasted date based on degree-day model occurred before actual peak date for negative values and after actual peak date for positive values.

[y]Mean first peak date for all locations and years.

is used in the San Jose Scale degree-day model (Jorgensen et al. 1981). This approach could help decrease the variance of our degree-day models; however, no pheromone traps are currently available for CMBS. If the degree-day model was based on the Texas sites exclusively, the model may have been a better predictor of peak crawler activity due to the lower deviation between predicted and actual peak dates for all Texas sites compared to Louisiana and Arkansas. Based on climate alone, we did not expect Tyler and Shreveport to differ in first peak crawler emergence, due to proximity (<100 miles) and similarity in climate between the two locations. Accounting for other abiotic factors immediately surrounding the crapemyrtles in Shreveport and Little Rock, such as impervious surface cover (e.g., concrete), could increase the predictive power of our degree-day model by accounting for the increased fecundity and population growth rate due to elevated temperatures (Dale and Frank 2014).

Monitoring strategies using double-sided sticky tape for CMBS crawlers may not be readily adopted by growers due to labor and training requirements. However, an approximate date and plant phenology are likely the most relevant and time-effective methods for determining when to apply pesticides until more effective models or monitoring strategies are developed.

Crawler counts and population trends from upper and lower branches did not appear different throughout the entire season on 12 trees in College Station (Fig. 2). These data suggest that the location of the double-sided sticky tapes will not have any large impact on measuring relative crawler activity. Because upper branches on larger trees can be inaccessible or hard to reach, our data suggests that tapes on accessible lower trunks and branches (i.e. breast height) should provide an accurate estimate of changes in relative numbers of crawlers present on trees.

The most commonly encountered coccinellids observed on CMBS infested trees included *Harmonia axyridis* (Pallas), *Scymnus* sp., *Hyperaspis lateralis* (Mulsant), and *Chilocorus cacti* L. (data not shown). On multiple occasions, these species were observed associated with, and possibly feeding on, ovisacs. More research is needed to determine suppression by native natural enemies on CMBS, with subsequent work on determining pesticide application timing to reduce the impact on natural enemies, similar to work by Quesada and Sadof (2019). Additionally, the opportunity for promoting natural predators, through landscape management, early releases, or providing alternate hosts earlier in the season have not yet been explored.

This study provides the first record of CMBS population activity in the southern USA but does not capture the population activity in the full range of CMBS in the US to date. Additional years and monitoring across a larger climatic range will assist in understanding whether peak CMBS crawler activity can be reliably predicted using

Table 4. **Mean cumulative degree-days to first peak crapemyrtle bark scale crawler activity for the different base temperatures for all years and locations combined.**

| | Base Temperature | | | | | |
|---|---|---|---|---|---|---|
| | 1.7 C (35 F) | 4.4 C (40 F) | 7.2 C (45 F) | 10 C (50 F) | 12.8 C (55 F) | 15.6 C (59 F) |
| Mean CDD till the first crawler peak | 1383.9 | 1121.9 | 871.1 | 645.8 | 447.2 | 282.6 |

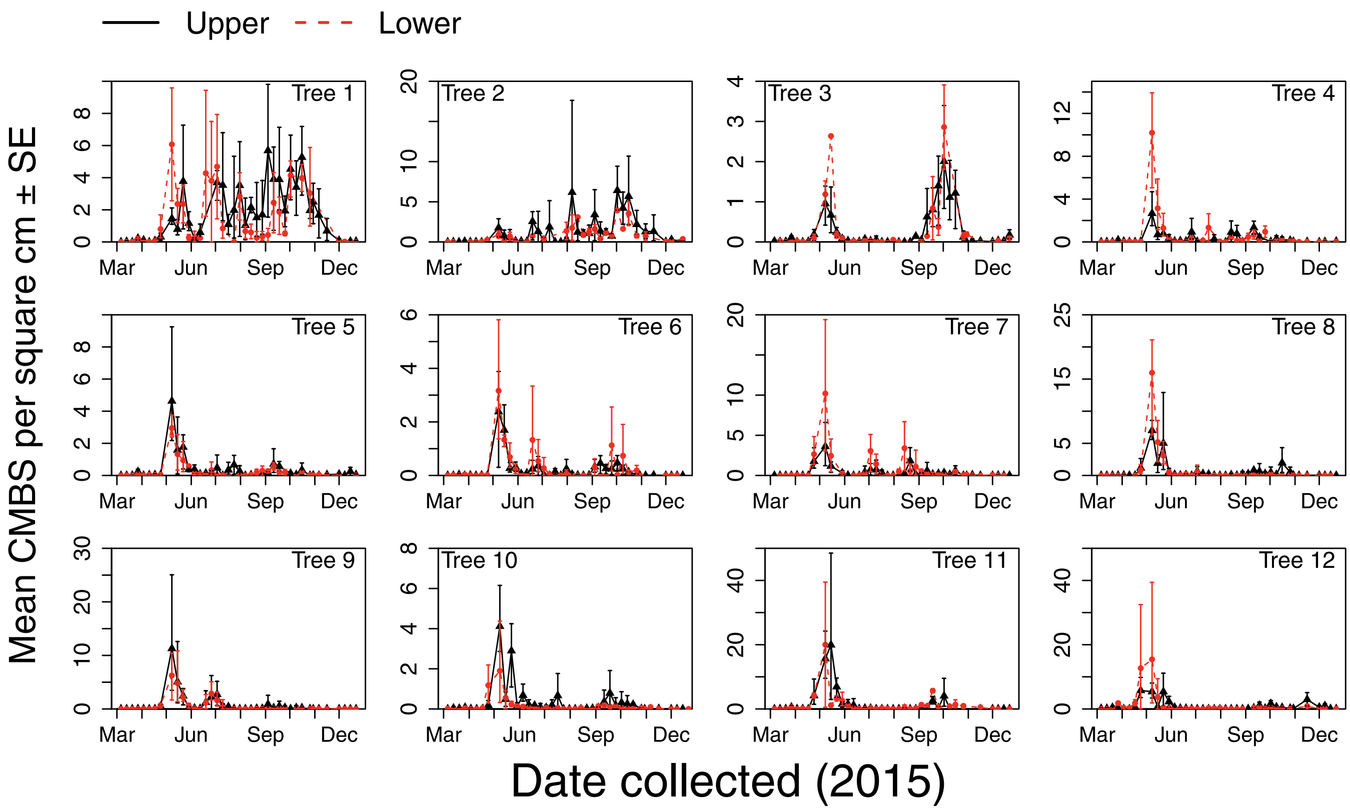


**Fig. 2. Mean crapemyrtle bark scale crawlers per cm$^2$ (± SE) trapped on double-sided sticky tapes collected from three upper (solid line with triangle) and three lower (dashed line with circle) branches per tree collected weekly in College Station, TX (n=12). Data from each tree is separated into an individual pane.**

calendar date or degree-day models, and whether a reduction in crawler activity by insecticides results in fewer adults and sooty mold on the tree. Initial observations suggest that lady beetles may be an important mortality factor for CMBS and the role of natural enemies in CMBS suppression should be investigated further.

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