Combined Proceedings IPPS 70:71-80. 2020.

# Biological Parameters of Crapemyrtle Bark Scale (*Acanthococcus lagerstromiae*) on *Lagerstroemia* 'Tuscarora' and Seedlings of 'Natchez' and 'Fantasy'

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*Keywords*: CMBS, crapemyrtle, ecology, life table, scale insect

**Summary**

Crapemyrtle bark scale [(CMBS); *Acanthococcus lagerstroemiae*], an exotic pest insect in the United States, causes damage to popular crapemyrtle landscape plants - as well as other economically important or native plant species, such as pomegranate, apple, and American beauty-berry. Age-stage, two-sex table study analysis was conducted to evaluate the biological parameters of CMBS on different species and cultivars of *Lagerstroemia* under laboratory conditions at 25$^{o}$ C and 250 µmol m$^{-2}$ s$^{-1}$ light with a photoperiod of 12:12 (light: dark). Crapemyrtle bark scale development was found to be greatly influenced by plant host. This study aimed to provide important biological and ecological data of CMBS. A comprehensive life table study was conducted for the first time - in order to gain a thorough understanding of CMBS development, survival, and fecundity on different plant species and cultivars of *Lagerstroemia*.

## INTRODUCTION

*Lagerstroemia spp.* (Myrtatles: Lythraceae), commonly known as crapemyrtle, is a genus consisting at least 80 known species of trees or shrubs (Cabrera, 2002). Despite many cultivation purposes including timber production (Knox, 2000) and medicinal usage (Al-Snafi, 2019), crapemytles are mostly valued as ornamental plants with their versatile landscape use. Crapemytles are originally native species in tropical and subtropical regions of southeastern Asia (Pooler, 2007). Since its introduction to the western world in the 1600s, worldwide breeding and cultivation has resulted in more than 200 cultivars in the United States, Europe, Australia, and Asia (Pooler, 2007). The majority of naturalized or commercially available crapemyrtle cultivars in the U.S. are the selections made from *L. indica* seedlings, or progenies from hybridizations between *L. indica* and *L fauriei* (Wang et al., 2011).

Crapemyrtles are praised for various growth patterns and plant architectures, flower color and duration, attractive bark features, as well as disease and pest tolerance (Knox, 2000). The plant height of crapemyrtles ranges from 1 to 6.1m (3 to 20 ft) (Wade and Williams-Woodward, 2009), which makes it highly suitable for a variety of urban settings. The flowers are often the defining characteristics of crapemyrtle cultivars, which are determined by the flower colors and various types of inflorescences (Pooler, 2007). Many years of breeding effort and interspecific hybridization have produced cultivars with a wide range of flower colors, including red, purple, white, and other combined variants such as pink and lavender (Wang et al., 2010). However, the aesthetic value of crapemyrtles could be greatly undermined by serious infestation of crapemyrtle bark scale [(CMBS); *Acanthococcus lagerstroemiae*] (Borchsenius, 1960).

*Acanthococcus lagerstroemiae*, native to East Asia, was originally categorized under the genus *Eriococcus*, and it was first described from specimens of adult females collected by Kuwana in Japan in 1907 (Kuwana, 1907). The binomial name *Acanthococcus lagerstroemiae* was first used by Borchsenius in 1960, where he also provided description and keys based on the morphology of adult female sample collected in China (Borchsenius, 1960b). Since its introduction to the United States, the infestation of this scale insect has been distributed widely and confirmed in at least 13 states (EDDMapS, 2019; Wang et al., 2016).

Heavy infestation caused by CMBS could hinder plant performance, which is associated with slow and weakened plant growth due to the active phloem-feeding by the insect, and/or reduced photosynthesis resulting from black sooty mold development on accumulated CMBS honeydew secretion on leaves. The damage caused by CMBS is not restricted to crapemyrtle, as economic plants such as apple, soybean, pomegranates, and native plant species such as American beautyberry and *Heimia* are also suitable hosts of CMBS (Wu; Xie et al., 2020).

In order to better manage and control CMBS, important ecological information regarding the development and life cycle of this pest is needed. However, previous studies are unclear about basic ecological data such as developmental stages of CMBS, as incongruent reports on CMBS life history were found. For example, Zhang reported only two instars before the female become sexually mature (Zhang and Shi, 1986), while other studies claimed the existence of the 3rd instar in female development (Jiang and Xu, 1998; Jiao and Zhang, 2011).

The study of the biology and life table is a system of record keeping, as well as analytical and mathematical approaches, to collect and interpret the data of an insect population (Harcourt, 1969). The construction of life tables enhances knowledge foundation and provides insight of the population dynamic of a certain arthropod of interest. However, such information for CMBS is currently lacking.

This study on the biology of CMBS focused on acquiring critical biological information in terms of a fertility life table, in order to expand the current knowledge related to the interaction between CMBS and its host plants in *Lagerstroemia*. This is needed for development of an effective integrated pest management (IPM) program in controlling CMBS.

## MATERIALS AND METHODS

*Insect source and handling*

Branches/twigs infested with crape-myrtle bark scale were collected from crape-myrtle trees on campus (Texas A&M University, College Station, TX), and stored in zip-lock bags under constant temperature (25°C). White coverings of the female scales were carefully lifted using a fine pin/needle. All existing eggs inside the ovisacs were removed, and the gravid females were transferred, using a fine brush, onto a moist filter paper placed in a petri dish. All newly laid eggs were collected the next day (after 24 hours) and kept under 25°C for incubation until hatched.

*Plant material and insect rearing chamber*

*Lagerstroemia* species and cultivars, including *L.* 'Tuscarora' or the seedlings of *L.* 'Natchez' and *L.* 'Fantasy', were used as host/food sources for the CMBS rearing experiment.

Rearing chambers were constructed with small petri dishes (Falcon® Disposable Petri Dishes, 60 mm x 15 mm) and clear plastic food wrap. Around half of petri dish was wrapped by clear plastic food wrap to create space for the medium. Water agar (1%) was poured into the bottom of the petri dish, using an electronic pipette, to fill around one third portion of the petri dish. Stem cuttings with bud nodes were collected from different *Lagerstroemia* species and cultivars and stuck in agar medium to stay turgid. The rearing chambers were placed in Conviron growth chambers set at 25° C and 250 μmol $m^{-2}$ $s^{-1}$ light with a photoperiod of 12:12 (light: dark).

*CMBS rearing experiment*

Egg incubation times were recorded, which was considered from the day when the eggs were first laid by gravid females to the day 1st instars were hatched. One or two newly hatched crawlers/nymphs, per rearing chamber, were transferred onto stem cuttings using a fine brush. Daily observations were made to record the settling status for nymphs. Rearing chambers with nymphs that failed to settle on the plants were discarded when the mortality or escaping were confirmed.

Insect rearing experiments on different *Lagerstroemia* were conducted from April to December 2019. Daily observations were made as nymphs start feeding, and the duration of each developmental stage (including nymphal stages, pupa, and adult stages) were recorded. When a male reached adult stage, it was transferred to pair with a female for mating in order to complete the life cycle of the female. Fecundity data (the number of eggs that an adult female produces), and longevity (the number of days a female lives) were recorded as the gravid females complete their life cycle.

*Data analysis*

The developmental stages of both male and female CMBS were determined by the number of times the nymphs molt, which were obtained by keeping track of the exuviates. According to the age-stage, two-sex life table theory (Chi and Liu, 1985; Chi, 1988), the fecundity data (number of eggs each adult female produced) and longevity data (the number of days each CMBS nymph lives) can be obtained to calculate population (life table) parameters of CMBS.

To obtain population (life table) parameters, the life history data of CMBS was analyzed using TWOSEX-MS Chart, a computer program for the age-stage, and two-sex life table analysis (Chi, 2020), according to the method described in Chi and Su (2006). The raw data were used to calculate the age-stage specific survival rate ($s_{xj}$, where $x$ = age in days and $j$ = stage; the first stage is egg, the second stage is 1st instar, the third stage is 2nd instar, the fourth stage is male pupa 1, the fifth stage is male pupa 2, the sixth stage is male pupa 3, the seventh and eighth stages are female and male), age-specific survival rate ($Sxj$), and population (life table) parameters, including mean generation time ($T$), net reproduction rate ($R_o$), the intrinsic rate of increase ($r$), and the finite rate of natural increase ($\lambda$), to construct the age-stage, two-sex life table. The biological parameters and population parameters of CMBS reared on different *Lagerstroemia* hosts were compared using Student's $t$ test and All Pair, Tukey HSD with JMP software (JMP Pro15, Statistical Analysis System, Cary, NC, USA).

## RESULTS AND DISCUSSION

The development of a male consists of egg, two nymphal stages (1st and 2nd instar), three different stages of pupa and the winged adult stage. The development of a female undergoes four major stages: egg, two nymphal stages (1st and 2nd instar) and adult stage. The egg incubation time for both males and females are a little over 12 days at 25 °C. Crapemyrtle bark scale showed variable development times based on different crapemyrtle species and cultivars. For example, the average development duration of the male 1st instar was 15.0 ± 1 days (± SE) and 18.4 ± 0.7 days (± standard error) on 'Natchez' seedling and 'Fantasy' seedling, respectively (Table 1). No male had developed into adult on 'Tuscarora' during this study (Fig. 1). For the females, the average development duration was 32.3 ± 2.7 days (± SE), 12.8 ± 0.6 days (± SE), and 19.5 ± 1.4 days (± SE) on 'Tuscarora', 'Natchez' seedling, and 'Fantasy' seedling, respectively (Table 2).

**Table 1.** Means ± standard errors, and sample size of development duration of males of *Acanthococcus lagerstroemiae* at laboratory conditions of 25° C and 250 µmol $m^{-2}$ $s^{-1}$ light with a photoperiod of 12:12 (light:dark).

| | Development duration (days), males | | | | | | |
|---|---|---|---|---|---|---|---|
| | Natchez seedling | | Fantasy seedling | | | | |
| Stage | Mean ± SEM | N | Mean ± SEM | N | *t* | df | *P* |
| 1st instar | 15.0 ± 1 | 3 | 18.4 ± 0.7 | 5 | 2.93 | 6 | 0.027 |
| 2nd instar | 21.1 ± 7.4 | 3 | 64.2 ± 13.2 | 5 | 2.35 | 6 | 0.057 |
| Pupa1 | 4.7 ± 0.3 | 2 | 5.4 ± 0.4 | 5 | 1.25 | 6 | 0.258 |
| Pupa2 | 3.5 ± 0.5 | 2 | 3.6 ± 0.4 | 5 | 0.14 | 5 | 0.895 |
| Pupa3 | 4.5 ± 1.5 | 2 | 7.8 ± 1.7 | 5 | 1.15 | 5 | 0.304 |

There are significant differences at 0.05 confidence level in 1st instar duration between *A. lagerstroemiae* reared on 'Natchez' seedlings and 'Fantasy' seedlings according to Student's *t*-test.

**Table 2**. Means ± standard errors, and sample size of development duration of females of *Acanthococcus lagerstroemiae* at laboratory conditions of 25° C and 250 µmol $m^{-2}$ $s^{-1}$ light with a photoperiod of 12:12 (light: dark).

| | Development duration (days), females | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Tuscarora | | Natchez seedling | | Fantasy seedling | | | | |
| Stage | Mean ± SEM | N | Mean ± SEM | N | Mean ± SEM | N | *F* | df | *P* |
| 1st instar | 32.3 ± 2.7 a [Z] | 3 | 12.8 ± 0.6 c | 4 | 19.5 ± 1.4 b | 6 | 21.73 | 2,9 | <0.01 |
| 2nd instar | 14.5 ± 2.5 a | 2 | 39.8 ± 18.7 a | 4 | 62.8 ± 4.6 a | 6 | 3.554 | 2,9 | 0.07 |

[Z] Means within each row followed by the same letter are not significantly different according to All Pairs, Tukey Honestly Significant Difference at 0.05 confidence level.

According to the life table analysis of CMBS on different *Lagerstroemia*, the insect population developed fastest on 'Natchez' seedlings, with shortest mean generation time (*T*) of 41.88 ± 21.07 days (± SE), compared to the longest *T* (103.77 ± 14.42 days ± SE) found on 'Fantasy' seedlings (Table 3), which suggests that the development rate of CMBS infestation could be nearly tripled on different hosts. The lowest fecundity of CMBS was also observed on 'Fantasy' seedlings (22.07±10.22 offspring per individual), which was relatively low as compared to the highest mean fecundity found on 'Natchez' seedlings (69.97±43.26 offspring per individual) (Table 3).

The development and survival of CMBS was also greatly influenced when reared on different species or cultivars of crapemyrtles (Figs 1, 2 and 3), which suggests that the population dynamics of CMBS could vary drastically based upon the host selection.

**Table 3.** Intrinsic rate of increase (*r*) ± standard errors, finite rate of increase (*λ*) ± standard errors, net reproduction rate ($R_o$) ± standard errors, mean generation time (*T*) ± standard errors, and gross reproductive rate (GRR) ± standard errors of *Acanthococcus lagerstroemiae* at laboratory conditions of 25° C and 250 µmol $m^{-2}$ $s^{-1}$ light with a photoperiod of 12:12 (light: dark).

| Plants | N | *r* ($days^{-1}$) | *λ* | *Ro* | *T* (days) | GRR (offspring/individual) |
|---|---|---|---|---|---|---|
| Tuscarora | 10 | 0.04 ± 0.009 b [Z] | 1.04 ± 0.009 b | 8.95 ± 4.38 b | 50.33 ± 0.02 b | 39.81 ± 15.38 b |
| Natchez seedling | 15 | 0.09 ± 0.04 a | 1.09 ± 0.04 a | 21.42 ± 11.05 a | 41.88 ± 21.07 c | 69.97 ± 43.26 a |
| Fantasy seedling | 35 | 0.01 ± 0.007 c | 1.01 ± 0.007 c | 4.98 ± 2.87 c | 103.77 ± 14.42 a | 22.07 ± 10.22 c |

[Z] Means within each column followed by the same letter are not significantly different according to All Pairs, Tukey Honestly Significant Difference at 0.05 confidence level.

Less than 20% of CMBS population reached adult stage on 'Tuscarora', 'Natchez' seedlings, and 'Fantasy' seedlings (Figs 1, 2 and 3). The majority of pupae and male adults observed on 'Natchez' seedlings were from day 20 to day 60 (Fig. 2), while all the pupae and adults were observed after day 50 on 'Fantasy' seedlings (Fig. 3).

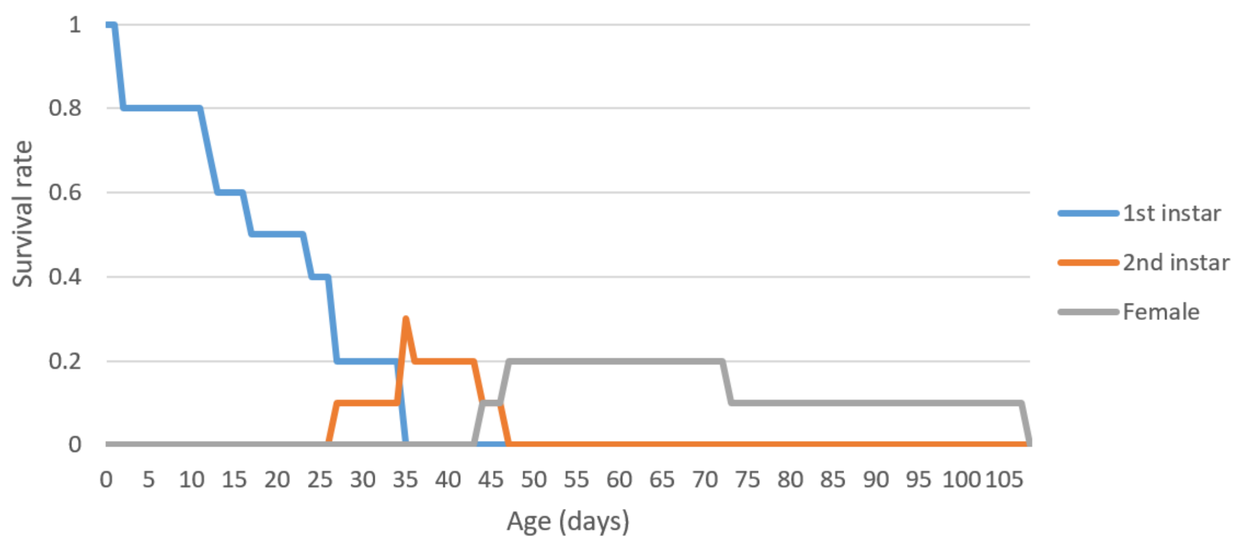


**Figure 1.** Age-stage specific survival rate (*Sxj*) of *Acanthococcus lagerstroemiae* reared on *Lagerstroemia* 'Tuscarora' at laboratory conditions of 25° C and 250 µmol $m^{-2}$ $s^{-1}$ light with a photoperiod of 12:12 (light: dark).

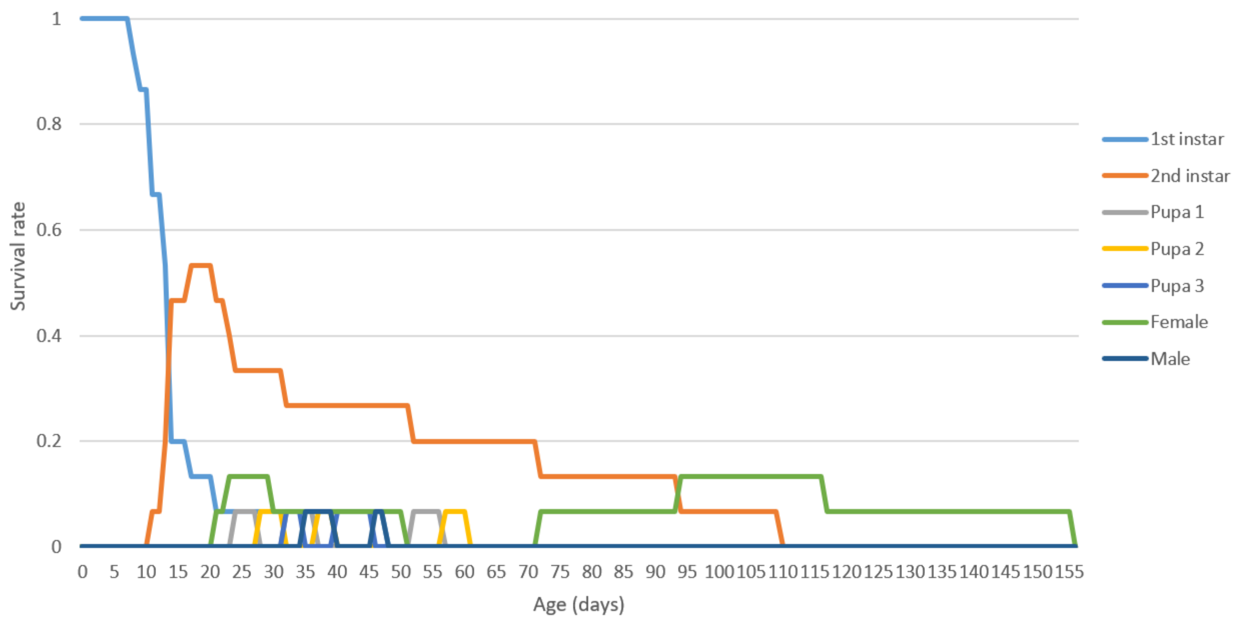


**Figure 2**. Age-stage specific survival rate (*Sxj*) of *Acanthococcus lagerstroemiae* reared on *Lagerstroemia* 'Natchez' seedlings at laboratory conditions of 25° C and 250 µmol $m^{-2}$ $s^{-1}$ light with a photoperiod of 12:12 (light: dark).

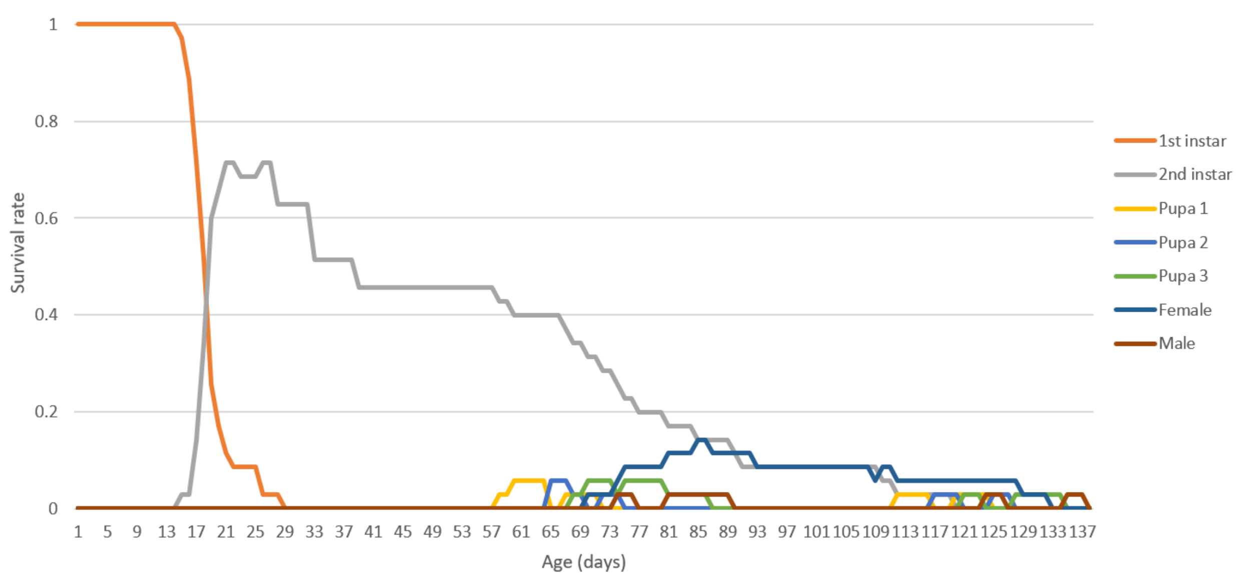


**Figure 3.** Age-stage specific survival rate (*Sxj*) of *Acanthococcus lagerstroemiae* reared on *Lagerstroemia* 'Fantasy' seedlings at laboratory conditions of 25° C and 250 µmol $m^{-2}$ $s^{-1}$ light with a photoperiod of 12:12 (light: dark).

Net reproduction rate ($R_o$), the intrinsic rate of increase ($r$), and the finite rate of natural increase ($\lambda$) are population parameters used for projecting the reproductive potential of insects. $R_o$ represents the number of offspring that an individual (including male and female) within the population could produce over its lifetime, while $r$ and $\lambda$ describe the population growth rate as time approaches infinity and population reaches stable status. Crapemyrtle bark scale with highest population growth rate was found on 'Natchez' seedlings, while the lowest was on 'Fantasy' seedlings (Table 3).

Overall, the males had shorter life spans compared to the females, which suggested the specific role of adult male in the sexual reproduction of CMBS. The longest-lived females observed were 128, 156, and 143 days on 'Tuscarora, 'Natchez' seedlings, and 'Fantasy' seedlings, respectively. The rearing experiments were proven successful in supporting the development of CMBS as the insect was able to complete its life cycle under the experimental conditions in this study.

In this study, the detailed life history data of CMBS on different *Lagerstroemia* hosts were collected and subjected to the age-stage, two-sex life table analysis, in order to provide a comprehensive understanding of CMBS population development at laboratory conditions. The ecological data of CMBS obtained in this study could aid field observations to project the insect population dynamics in the field, and to develop effective control and management strategies for CMBS.

**Acknowledgement**

This work is supported by the Specialty Crop Research Initiative project 'Systematic Strategies to Manage Crapemyrtle Bark Scale, An Emerging Exotic Pest' [grant no. 2017-51181-26831/project accession no. 1013059] from the U.S. Department of Agriculture (USDA) National Institute of Food and Agriculture. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.

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