Bionomics of the Crapemyrtle Aphid (Homoptera: Aphididae)[1, 2]

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ABSTRACT Populations of the crapemyrtle aphid, *Tinocallis kahawaluokalani* (Kirkaldy), in South Carolina develop from overwintering eggs which are distributed near new emerging leaves. Seasonal abundance is typically bimodal and locally concurrent within a season, but without consistency in timing or intensity of occurrence between seasons or host plant cultivars. On leaves of *Lagerstoemia indica* L. ('Carolina Beauty' [CB]) in the laboratory, time of development was temperature-dependent, requiring 14 d for development through four instars to the adult at 18°C, 6 d at 26°C, and 5 d at 32°C. Longevity of adult virginoparae was ca. 17 d, 13 d, and 8 d, at these temperatures, respectively, and was at least as long on leaves of the apparently less susceptible 'Natchez' (N) cultivar. Fecundity was greatest at 18° and 26°C, averaging 56 and 61 offspring/female, respectively, on CB leaves and 54 and 71 offspring/female on N leaves. Fecundity declined sharply to 27 and 18 offspring/female on CB and N, respectively, at 32°C. Maximum daily fecundity rates were attained within 5 d of adult reproductive age on both host cultivars, then declined at temperature-dependent rates. Male and female sexuales were produced in early fall as mixed progeny with sexuparae at a ratio of 12.2: 9.7: 3.5 sexuparae: oviparae: males. Longevity of males was 7 d; oviparae lived 8 d and produced 1 to 6 eggs each. Syrphids and coccinellids were principle components of the predator complex associated with dynamics in the crapemyrtle aphid populations. Population dynamics in the absence of predators was characterized by a maximum density of ca. 200 aphids/leaf on CB attainable within 5 wk of inoculation with a single aphid followed by a sharp decline. Population development potential decreased as the season progressed. A braconid, *Lysiphlebus testaceipes* (Cresson) (Hymenoptera: Braconidae), reared from mummies of the crapemyrtle aphid in a greenhouse, constitutes the first reported parasitoid.

KEY WORDS Life history, population dynamics, development, ornamental plants, *Lagerstromia*, parasitoids, crapemyrtle aphid, *Tinocallis kahawaluokalani.*

The crapemyrtle aphid, *Tinocallis kahawaluokalani* (Kirkaldy), was first described from the Hawaiian Islands (Kirkaldy 1907, Fullaway 1909), but is known throughout the range of its host, *Lagerstroemia indica* L. (crapemyrtle), in China, Japan, Formosa, and North America (Takahashi 1924, Zimmerman 1948). It is the most serious arthropod pest of the crapemyrtle cultivars planted

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extensively in the southern US (Dozier 1926). Infested plants are made unsightly by black sooty molds that grow on honeydew excretions. By mid summer nursery plants may be in unsalable condition, and foliage may drop prematurely. All cultivars of *L. indica* are susceptible to the aphid, but we have observed differences in field infestation levels between *L. indica* cultivars and more recent *L. indica* × *L. fauriei* Koehne cultivars.

Little is known about the biology of the crapemyrtle aphid. It is monoecious and holocyclic with multiple summer generations occurring from April to October in South Carolina (Alverson and Allen 1991). Sexually produced eggs overwinter in crevices on the stems, partially exposed and often in loose clusters of about four eggs. Several population peaks may be observed in the summer season, usually accompanied by a general complex of predator populations (Mizell and Schiffhauer 1987). No parasitoids (other than those reported here) are known. These studies describe the life history and biology of the crapemyrtle aphid and parameters affecting population development and seasonal dynamics on popular crapemyrtle cultivars.

Materials and Methods

In the spring of 1990, the distribution and abundance of overwintering eggs were determined as a function of distance from terminals. We sectioned previously infested *L. indica* ('Carolina Beauty' cultivar) shrubs into 10-cm lengths from terminals to main stems to a distance of 1 m. An initial comparative sample from 'Carolina Beauty', 'Byers' White', and 'Hardy Lavender' was taken on 15 March in separate nursery fields, and a subsequent sample was taken from 'Carolina Beauty' on 27 March. One thousand stem sections (decreasing in number of sections per incremental distance from terminals because of confluence of branches) were examined microscopically, and the number and the location of eggs were recorded. Surface areas of stem sections were calculated using measurements of mean diameters and stem length.

Population development in the field was recorded from the time of bud break in late March, which was coincident with first observed eclosion of eggs. Aphid counts were made weekly on terminal shoots of field-grown crapemyrtle nursery stock (5-yr-old, 2.5 m tall) in Pickens and Greenville counties, SC. At each site and for each cultivar assessed, a minimum of 100 leaves were counted (10 leaves on 10 plants minimum). In 1990, counts were made on *L. indicia* cultivars 'Carolina Beauty' at two locations and on 'Byers' White' at another. In 1991, aphid densities were assessed on 'Carolina Beauty' in one nursery, and on 'Natchez' cultivar, *L. indica* × *L. fauriei,* at another, both near Easley, SC.

The seasonal activity of alate aphids was monitored in 1990 on 'Carolina Beauty' near Piedmont, Easley, and Dacusville, SC, by sticky traps composed of plastic yellow cups (454 ml) wrapped in a sheet of polyethylene and coated with a non-drying adhesive. Cups were placed on 1 m bamboo stakes between rows of shrubs, and the number of adult aphids trapped was counted weekly.

Leaf and aphid samples were returned to the laboratory each week on cut terminals for detached leaf studies in environmental chambers. Single leaves were held on water agar plates as described by Reilly and Tedders (1990).

Development times were determined daily for isolated neonate nymphs produced by laboratory-held adults. Fecundity and adult longevity were determined by inoculating each leaf with a single third instar female and recording the date and number of offspring produced daily after the adult stage was reached. All nymphs were destroyed after counting. Comparisons of temperature effects were made using leaves held in separate environmental chambers with a 14:10 (L:D) photoperiod at 18°, 26°, and 32°C, using inoculative cohorts of field-collected aphids for each set of comparative observations. In each laboratory study, inoculations of leaves of any cultivar were made using nymphs taken from leaves of same cultivar host. Mean comparisons were made by ANOVA (Statview 512II, Abacus Concepts, Berkeley, CA).

Production of sexual forms under a shortened photoperiod of 10:14 (L:D) was assessed by placing first instar nymphs individually on fresh leaves on agar plates, and holding them in an environmental chamber at 26°C for development to adult. A history of the offspring of these and the subsequent nine generations of non-sexual adults produced under this regime was also recorded. Sex ratios were determined for fourth generation viviparae produced in this way.

Population dynamics in the absence of predators was observed in 1990 by enclosing selected 'Carolina Beauty' leaves in predator-exclusion chambers as described by Alverson and English (1990). Each insect-free chamber housed a five-leaf lateral stem cleared of insects by wiping with a soft cloth and inoculated with a single fourth instar nymph. Four chambers were inoculated on 22 May, four on 19 June, and four on 14 August. Subsequent population development growth and decline in chambers was assessed weekly by counting the number of aphids present on leaves contained within them.

In 1991 seasonal abundance of predator species associated with crapemyrtle aphids was monitored by approaching single 'Carolina Beauty' terminals in the field and quickly placing 2 L plastic zip-lock bags over them. Once entrapped and sealed to the stem, these terminals were clipped and returned to the laboratory where samples were frozen prior to sorting.

On 'Carolina Beauty' crapemyrtle plants which were kept in a greenhouse, mummified crapemyrtle aphids were found in large number in September-October, 1991. These were collected and placed in vials for emergence and subsequent identification of parasitoids. Voucher specimens of all species have been placed in the Clemson University arthropod collection.

Results and Discussion

Over 3400 overwintering eggs were counted on the stem sections collected in the spring, 1990. The oval, shiny black eggs were observed primarily along crevices and under sloughing bark, but they were also found attached to unprotected stem surfaces (Fig. 1). In the initial comparative sample from *L. indicia,* 77% of 434 total eggs were collected from 'Carolina Beauty', 20% from 'Byers White', and 2% from 'Hardy Lavender' cvrs. Of 2700 eggs counted on 'Carolina Beauty' from another location on 27 March, 35% were found within 20 cm of limb terminals, and 54% were within 40 cm (Fig. 2). This distribution is significantly related to the surface

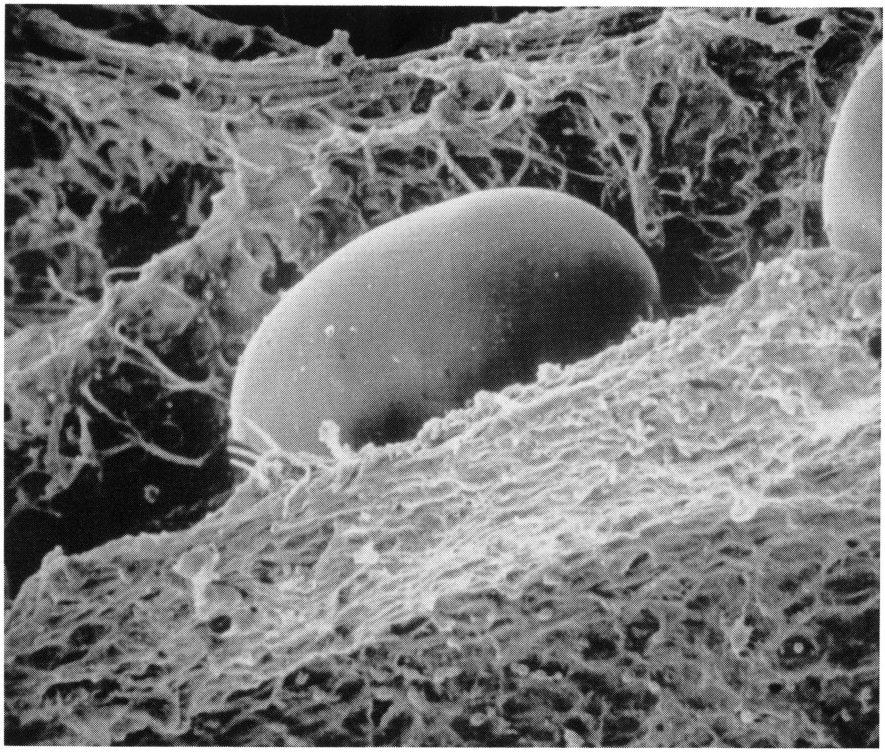

Fig. 1. Egg of *T. kahawaluokalani* (120X) in stem crevice, one of four in typically loose cluster, showing relatively featureless surface.

area available for oviposition ($P = 0.001$, $r^2 = 0.76$); i.e., 31% of surface area sampled was within 20 cm; 54% of the stem surface area sampled was within the first 40 cm of host terminals. Mean egg density (± SEM) ranged from a high of 0.63 ± 0.14 eggs/cm^2 in the first 20 cm of stem to a low of 0.21 ± 0.08 eggs/cm^2 at a distance of 81-90 cm from the terminal.

In 1990, the earliest appearance of a fundatrix was recorded on 19 March on 'Carolina Beauty', but most eclosion of eggs occurred in late March to early April, coinciding with bud break in crapemyrtles in upstate SC. The seasonality of subsequent virginoparae infesting the undersides of leaves was characterized by a single synchronous population peak in two of three locations in Pickens and Greenville Cos. (SC) during July-August, 1990 (Fig. 3). Both similarly infested fields were comprised of 'Carolina Beauty'. The Easley field, comprised of 'Byers White', exhibited a peak population four weeks later. No indigenous aphids were found in the Easley field until after alate activity was evidenced in the others. A second smaller peak in early fall on 'Carolina Beauty' in Piedmont was dominated by sexuales and sexual forms. Although sexual forms were

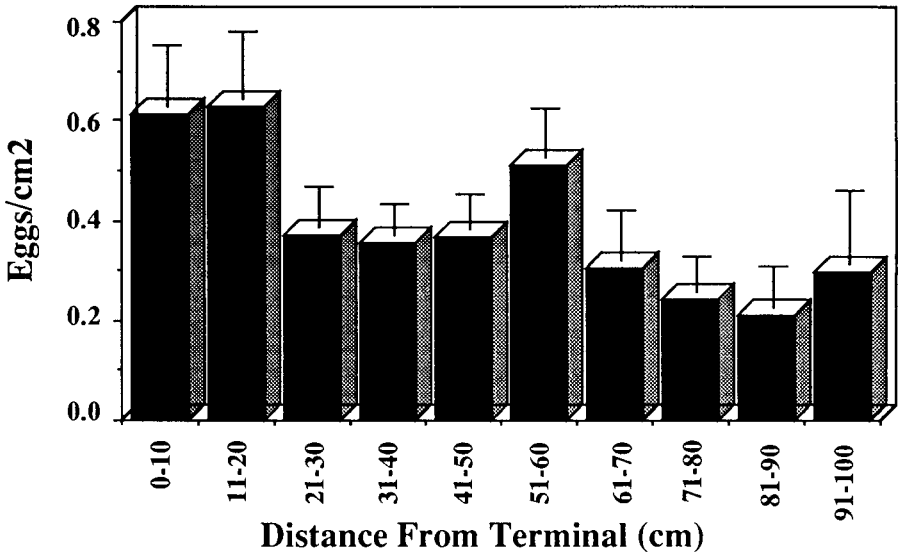

Fig. 2. Egg distribution ($\bar{X}$/cm^2 ± SEM) on 10 cm stem sections of previously infested 'Carolina Beauty' cvr. crapemyrtles, measured from terminal tips towards main stem, March 1990.

observed in the other locations also, overall population densities were noticeably lower. The reasons for differences in expressed seasonality by locale are unknown, but senescence or condition of leaves as well as differences in predator efficiency by site would be possible explanations.

The accompanying activity of alatae, measured by captures on yellow sticky traps, was generally coincident with changes in infestation density on plants, although peak flight activity lasted several weeks beyond peak leaf densities. Captures of high numbers of alatae/trap/week demonstrate the dispersal propensity of the crapemyrtle aphid. All adults are winged and fly readily when disturbed, especially when ambient temperatures are greater than 30°C (Alverson and Allen 1991). In 1991, peak populations of aphids were observed in June and August on *L. indica* ('Carolina Beauty'); populations on *L. indica* × *fauriei* ('Natchez') were present in relatively low numbers with little expressed seasonal modality (Fig. 4).

Crapemyrtle aphid development proceeds through four nymphal instars to the adult. Development time of aphids on 'Carolina Beauty' leaves in the laboratory was temperature-dependent, requiring ca. 14 d from birth to adult at 18°C, 6 d at 26°C, and 5 d at 32°C (Table 1). Significantly ($P < 0.05$) more time was spent in the fourth instar than in any other stage of development at all temperatures.

In 1990, adult longevity on 'Carolina Beauty' leaves ranged from 1 to 34 d in the laboratory at 26°C, averaging 16.47 d (± 0.60, n = 190). These aphids produced a mean (± SEM) of 76.57 (± 2.99) offspring per adult in this period.

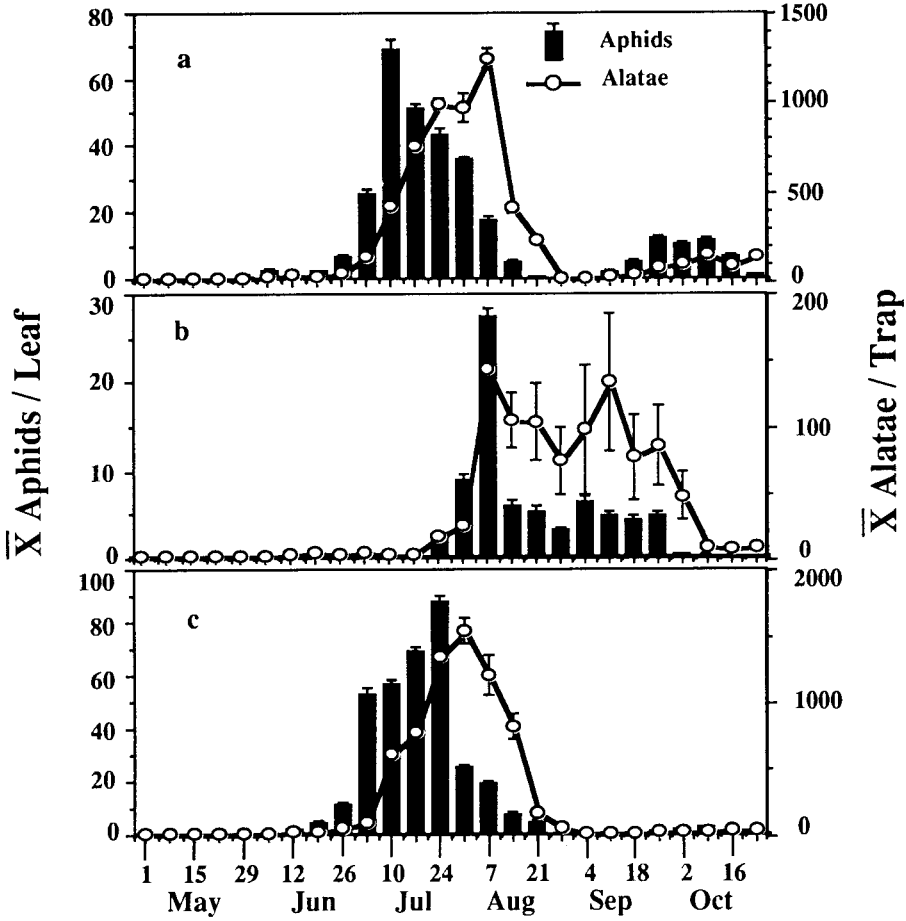

Fig. 3. Seasonal abundance of *T. kahawaluokalani* on crapemyrtle cultivars and associated alate activity at three locations, 1990: a. Piedmont, SC, 'Carolina Beauty'; b. Easley, SC, 'Byers' White'; c. Dacusville, SC, 'Carolina Beauty'. Standard errors of means are indicated by vertical lines.

The average daily production of offspring per female reached a peak of 7 nymphs/day within a week of adulthood, and declined thereafter for the duration of adult life (Fig. 5).

A comparison of adult longevity and fecundity in 1991 for three temperatures on 'Carolina Beauty' and 'Natchez' leaves (Table 2) shows a sharp decline in both variables between 26° and 32°C on either host, with less extreme, but significant ($P < 0.0001$) declines in longevity between 18°C and

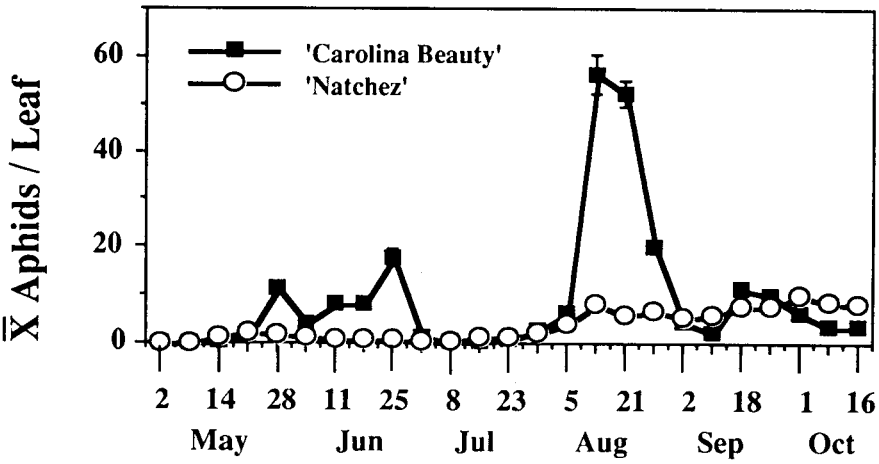

Fig. 4. Seasonal abundance of *T. kahawaluokalani* on 'Carolina Beauty' and 'Natchez' cvrs. near Easley, SC, 1991.

Table 1. Time (days) in stage (± SEM) for the four developmental instars of *T. kahawaluokalani* virginoparae on 'Carolina Beauty' crapemyrtle leaves at three constant temperatures.*

Temperature	n	Instar 1	Instar 2	Instar 3	Instar 4
18°C	22	3.55 a (0.18)	2.82 a (0.17)	2.71 a (0.24)	4.50 a (0.32)
26°C	25	1.72 b (0.12)	1.55 b (0.13)	1.32 b (0.10)	1.67 b (0.17)
32°C	26	1.58 b (0.10)	1.24 b (0.11)	1.04 b (0.10)	1.60 b (0.10)
LSD		0.53	0.62	0.73	0.93

* Means in any column followed by different small case letters were significantly different ($P < 0.001$); F (n,d) values left to right: 35.72 (2,28); 16.29 (2,20); 10.91 (2,20); 38.84 (2,16).

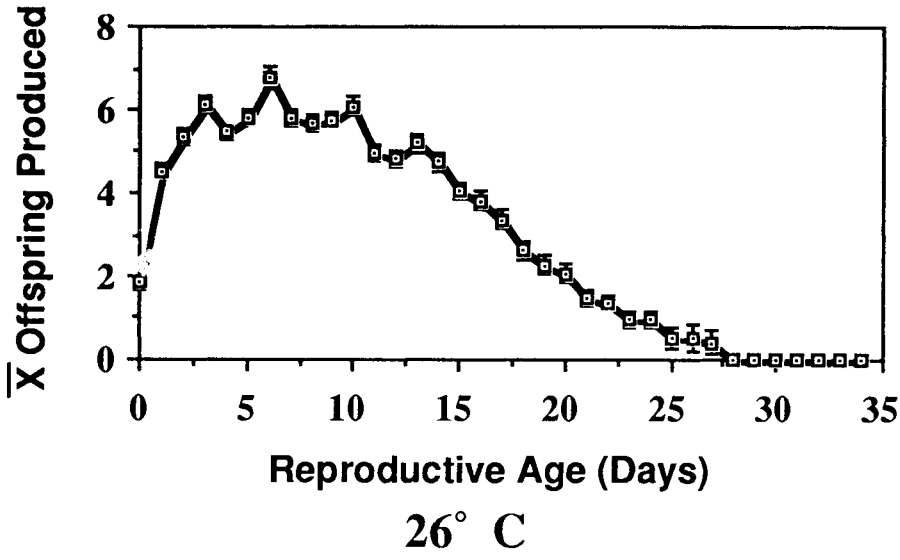

Fig. 5. Daily offspring production by *T. kahawaluokalani* on 'Carolina Beauty' leaves held in vitro at 26°C, 1990.

Table 2. *T. kahawaluokalani* fecundity and longevity at three temperatures on leaves of 'Carolina Beauty' (CB) and 'Natchez' (N) crapemyrtle cvrs.

		$\overline{X}$ (± SE) Offspring/male		Adult Longevity (± SE) (days)	
Temperature	n	CB	N	CB	N
18°	58	56.3 (5.8) a	53.6 (3.7) a	16.9 (1.3) a	23.5 (1.2) a
26°	60	60.9 (5.4) a	77.1 (5.3) b	12.8 (0.8) b	19.1 (1.6) b
32°	56	27.4 (2.1) b	18.4 (2.3) c	7.6 (0.5) c	7.5 (0.8) c
LSD*		12.5	11.7	2.7	3.3

* Means in any column differing by the LSD at the P = 0.0001 level are indicated by differing small case letters. F (n,d) values left to right: 17.29 (2,106); 46.85 (2,100); 23.73 (2,98); 48.35) (2,88).

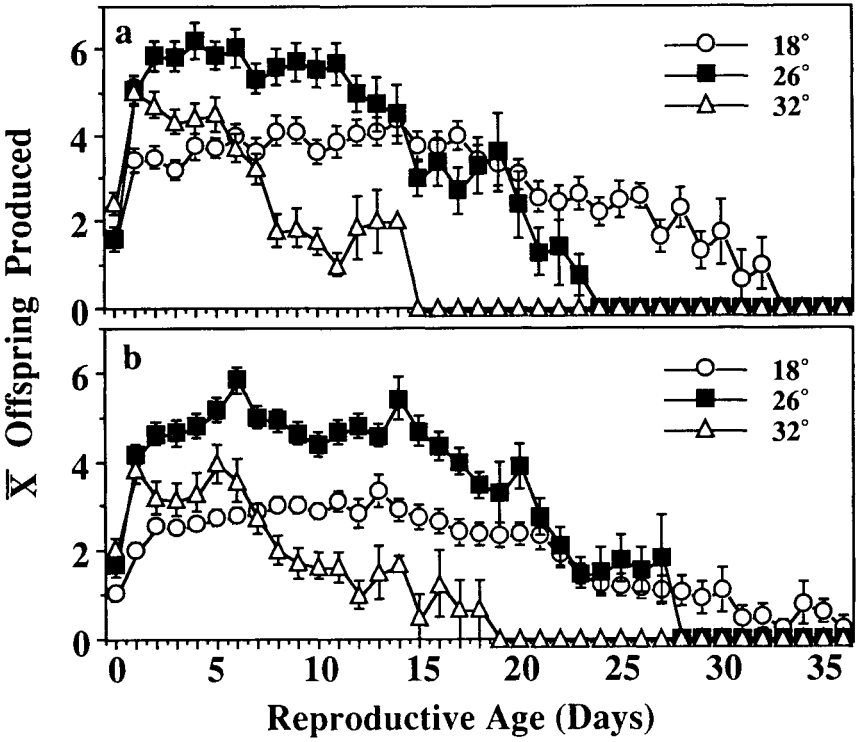

Fig. 6. Fecundity rates of *T. kahawaluokalani* virginoparae on a. 'Carolina Beauty' and b. 'Natchez' leaves at three temperatures in 1991.

26°C. Fecundity was highest at 26°C. The surprising result was the apparent suitability of 'Natchez' as a host in the laboratory, contrasted with consistently observed low field infestations. Longevity of adults was significantly greater on 'Natchez' at 18°C and 26°C, and the range of longevity extended from 1 d to 42 d and 34 d, respectively, at these temperatures compared to 34 d and 27 d, respectively, on 'Carolina Beauty'. Fecundity was significantly greater on 'Natchez' than 'Carolina Beauty' at 26°C but significantly lower at 32°C. Nymphs produced on 'Carolina Beauty' were usually observed in close proximity to the adult, but on 'Natchez' nymphs were sometimes found widely dispersed on the leaf. The significance of such settling behavior in relation to host material is unknown.

The average daily production of offspring by virginoparae throughout the adult life span is shown in Fig. 6. The pattern for 26°C was the same as in 1990 observations. Peak production occurred within a few days of adult life, followed by a steady decline that is more precipitous with increasing temperature. At 18°C, daily production of nymphs was relatively consistent for ca. 3 weeks.

Each of the sexuparae held under shortened light regimes [10:14 (L:D) photoperiod] on 'Carolina Beauty' leaves in the laboratory produced additional sexuparae as well as male and female sexuales. Sexuparae are identical in appearance to the viviparous summer forms. Sexual females (oviparae) are wingless with a deeper olive color than virginoparous forms, even in developmental stages. Males are similar to their female parents, but they have smaller abdomens and noticeably darker coloration. The ratio of offspring produced by ninth generation aphids held under these conditions was 110:86:31 viviparae: oviparae:males, with means (± SE) of 12.2 (± 3.5), 9.7 (± 2.3) and 3.5 (± 1.2) offspring per female parent. There was also a progression in the production of sexual forms with succeeding generations. Sexuales were produced by one of nine adults reared in the first generation from field-collected first instars placed under the reduced light regime. No sexual forms were observed in the second generation; 40% of the offspring from third and fourth generations were oviparae. The first males occurred in the fifth generation, with a ratio of sexuales:oviparae:males of 49:9:7.

Longevity of males (± SE) was 7 ± 1.0 d (range 1-19, n = 16); oviparae lived 8.1 ± 0.7 d (range 4-14, n = 15), and produced a mean of 3.7 ± 0.5 eggs each (range 1-6, n = 10). By mid-October in both years, sexuales comprised the dominate component of field populations. Mating occurred on leaf surfaces.

Figure 7 demonstrates a seasonal difference in population growth-decline patterns in the absence of predators. Within predator-exclusion chambers inoculated early in the season, populations developed from a single aphid reached a maximum density of ca. 1000 aphids/5 leaves within 4 - 5 wks of inoculation. Of course, emigration of alatae was prevented, forcing rapid growth on contained leaves. Though growth rates to maximum density were the same for caged infestations on later dates, maximum densities were significantly lower. This is opposite to the expressed dynamics of the black-margined aphid, *Monellia caryella* Fitch, which developed to successively higher seasonal densities in similar field chambers on pecan (Alverson and English 1990). Because leaves were not protected from infestations prior to inoculation, it is probable that there was a decrease in host plant suitability as the season progressed. Bumroongsook and Harris (1992) demonstrated such a leaf conditioning effect brought about by seasonal aphid infestations on pecans. It is possible also that other seasonal environmental factors such as prolonged periods at higher ambient temperatures or phenological patterns could affect host suitability.

A number of potential regulating mechanisms are coincident with the seasonal changes in *T. kahawaluokalani* populations, including predacious Coccinellidae, Syrphidae, Chrysopidae and Anthocoridae (Dozier 1926, Mizell and Schiffhauer 1987). Fig. 8 shows the relative abundance of predator populations in relation to seasonal crapemyrtle aphid populations on 'Carolina Beauty' in 1991. Populations of coccinellids, syrphids and lacewings were concurrent with the early summer population peak of aphids. Though coccinellids were associated to a lesser degree with the August aphid population peak, spiders, syrphids, and lacewings were more predominant.

A large number of parasitized aphids were collected from greenhouse-held 'Carolina Beauty' plants kept for leaf material in the fall months. Specimens of

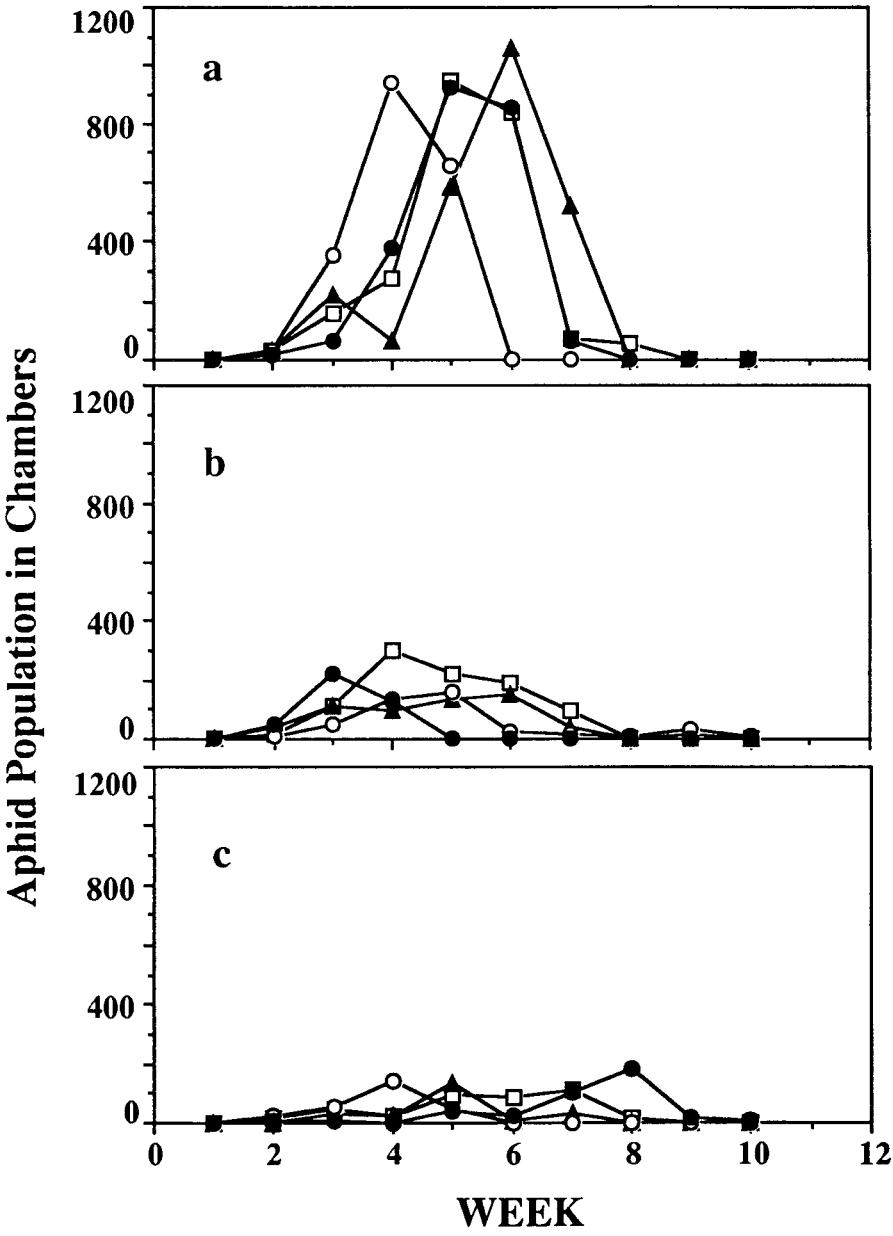

Fig. 7. Populations of *T. kahawaluokalani* in field chambers inoculated early (22 May), mid-season (19 June), and late season (14 August).

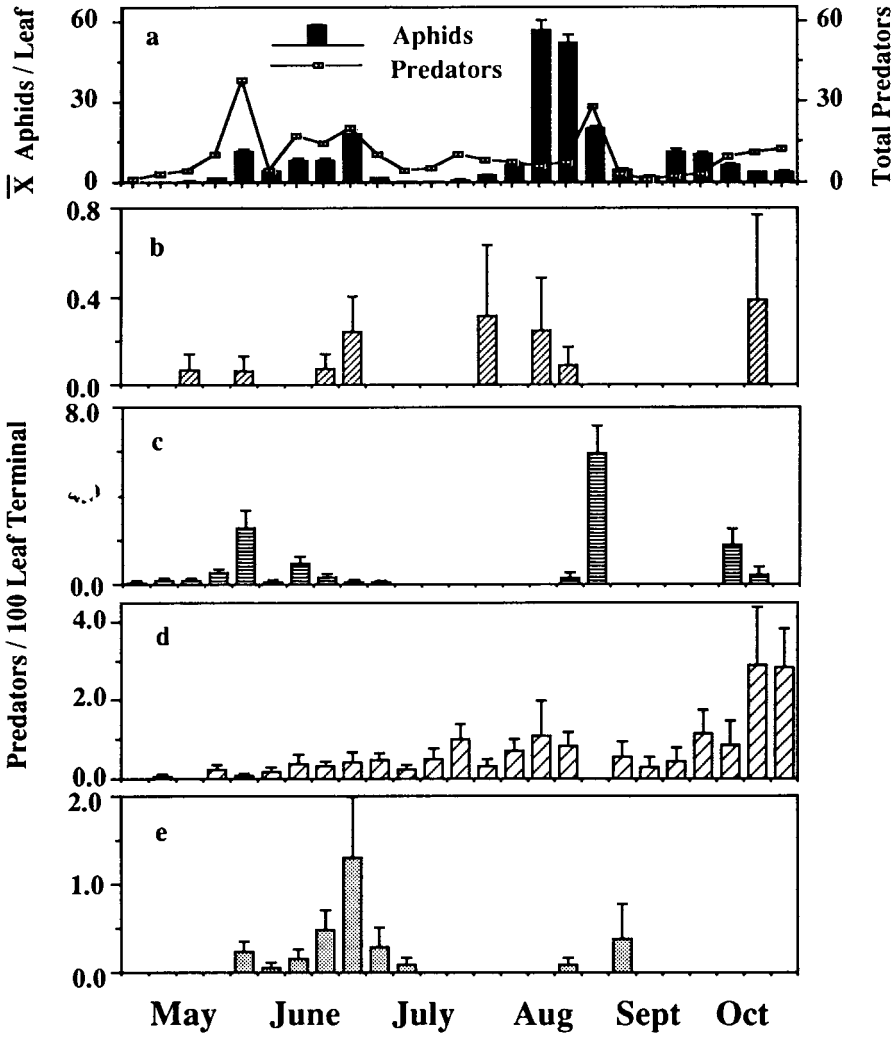

Fig. 8. Seasonal dynamics of crapemyrtle aphids and associated predacious arthropods, 1991. a. Aphids/leaf and total predators; b. lacewings; c. syrphids; d. spiders; e. coccinellids.

adult braconids reared from aphid mummies were identified as *Lysiphlebus testaceipes* (Cresson) (P. M. Marsh, SEL). This is the first known record of parasitization of *T. kahawaluokalani.* In addition an *Aphilinus* sp. was observed inserting an ovipositor into several aphids, with no subsequent parasitoid development.

Acknowledgments

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