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Authors: Hall, David G., Roda, Amy, Lapointe, Stephen L., and Hibbard, Ken

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PHENOLOGY OF *MACONELLICOCCUS HIRSUTUS* (HEMIPTERA: PSEUDOCOCCIDAE) IN FLORIDA BASED ON ATTRACTION OF ADULT MALES TO PHEROMONE TRAPS

DAVID G. HALL[1], AMY RODA[2], STEPHEN L. LAPOINTE[1] AND KEN HIBBARD[3]
[1]United States Department of Agriculture, Agricultural Research Service, U.S. Horticultural Research Laboratory, Subtropical Insects Research Unit, 2001 South Rock Road, Fort Pierce, FL 34945

[2]USDA, APHIS, Miami, FL

[3]Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Fort Pierce, FL

ABSTRACT

Research was conducted in Florida to assess the phenology of pink hibiscus mealybug, *Maconellicoccus hirsutus* (Green), based on numbers of adult males captured in traps baited with a synthetic pheromone. Trapping was conducted at 3 locations in east central Florida in ornamental plantings of hibiscus (*Hibiscus rosa-sinensis* L.) infested by the mealybug, with traps hung directly within plants. Trapping was also conducted in southeast Florida near Miami in a tropical fruit tree planting. Males were highly attracted to traps baited with the lure, consistent with reports in the literature. Numbers of adult males captured in traps indicated that *M. hirsutus* was consistently most abundant during late summer and early fall with peak populations occurring anytime during late Aug through early Oct. Populations of *M. hirsutus*, based on captures of males, were consistently low during winter and spring from Jan through mid Apr.

Key Words: phenology, trapping, sampling, pink hibiscus mealybug

RESUMEN

Se investigó la fenologia de la cochinilla rosada *Maconellicoccus hirsutus* (Green) basado en el número de machos adultos atrapados en trampas con cebos de feromona sintetizada. Se mantuvieron trampas en tres sitios en el centro-este del estado de Florida con trampas puestas directamente sobre plantas ornamentales de *Hibiscus rosa-sinensis* L. infestadas por el piojo. Tambien se pusieron trampas en el sur-este de Florida a cerca de la ciudad de Miami en una siembra de frutas tropicales. Se atrayeron machos a las trampas tal como se indica en la literatura. La captura indicó que *M. hirsutus* se encuentra con mayor abundancia con picos en agosto y octubre. Poblaciones de *M. hirsutus* fueron menores durante el periodo de enero y abril.

Translation provided by the authors.

The pink hibiscus mealybug *Maconellicoccus hirsutus* (Green) was first found in Florida during Jun 2002 (Hoy et al. 2006) and is now established at a number of locations across the state. *Maconellicoccus hirsutus* has a wide host range that includes more than 125 plant species (Ghose 1972), but the mealybug can be especially damaging to hibiscus (*Hibiscus rosa-sinensis* L.) (Stibick 1997; Kairo et al. 2000). Left uncontrolled, the economic impact of *M. hirsutus* to U.S. agriculture has been estimated at $750 million per year (Moffitt 1999). It can reach very high population levels in the absence of natural enemies (Stibick 1997). Michaud & Evans (2000) reported that, in the presence of effective natural enemies, the host range of the *M. hirsutus* is reduced to the point where noticeable damage occurs only to hibiscus, the mealybug's preferred host.

A synthetic sex pheromone was recently developed as an attractant for adult male *M. hirsutus* (Zhang et al. 2004). Field studies indicated that the pheromone, (*R*)-lavandulyl (*S*)-2-methylbutanoate and (*R*)-maconelliyl (*S*)-2-methylbutanoate blend in a ratio of 1:5, applied to rubber septa attracted large numbers of males and remained active for up to 6 months for a 1-µg dose and up to 12 months for a 10-µg dose (Zhang & Amalin 2005).

The purpose of research presented herein was to investigate the phenology of *M. hirsutus* at four sites in Florida based on counts of adult males in traps baited with synthetic pheromone.

MATERIALS AND METHODS

Pheromone lures were prepared (lab synthesized) at the USDA-ARS-BARC facility, Beltsville, MD. Gray halo-butyl rubber septa (5 mm, West Pharmaceutical Services, Kearney, NE) were treated with 1 µg of *M. hirsutus* synthetic sex

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pheromone in ~40 µL of hexane (Zhang et al. 2004; Zhang & Amalin 2005). The purity level of the pheromone was previously reported to be 97% (Zhang & Amalin 2005). After loading, the solvent was allowed to evaporate from septa in a fume hood for 30 min. Lures were then wrapped in aluminum foil, stored in 20-mL plastic vials, and shipped to the Subtropical Horticulture Research Station (USDA-ARS) in Miami-Dade County by express carrier on the same day. On arrival, the lures were kept in a refrigerator at 4.4°C until used in the field. Lures were periodically shipped by express carrier to the U.S. Horticultural Research Laboratory (USDA-ARS) in Saint Lucie County where they were kept in a freezer at -10.8°C until used in the field.

Saint Lucie County Site 1. This study site (N 27°20.243', W 080°23.595') consisted of hedges of 20 to 40 hibiscus plants separated by similar hedges of other ornamental plant species. Traps (San Jose scale traps, Great Lakes IPM, Inc., Vestaburg, MI) were deployed on 25 Mar 2004. The traps were suspended directly in plants (1.0 to 1.5 m above ground) with long twist ties. A rubber septum impregnated with pheromone was placed inside a plastic mesh basket commonly provided with Jackson or Pherocon VI traps (Trécé, Inc., Adair, OK) and attached to the twist tie at the top of each trap. A trap with a lure was deployed in each of 4 hibiscus hedges infested by the mealybug. A trap without a lure was deployed as a control in each of 2 additional infested hibiscus hedges. Traps were replaced at weekly intervals and lures were transferred to new traps. Care was taken in the laboratory and field to prevent contaminating unbaited traps with pheromone. Disposable gloves were worn whenever new lures were deployed or transferred to new traps. Unbaited traps were always deployed or serviced before handling lures or baited traps. Traps were collected and taken to a laboratory to count numbers of trapped males. At least 10 males (fewer if 10 were not present) were removed from each trap, mounted on a microscope slide, and inspected to confirm that they were *M. hirsutus* based on morphology of the genitalia. A drop of lemon extract was used to dislodge the males from the sticky surface of the traps. New lures were deployed periodically during the study (Fig. 1). The traps were rearranged among hedges of hibiscus on 22 Feb 2005, reducing the number of traps with lures to 3 (1 per hedge) and increasing the number of traps without lures to 3 (1 per hedge). New lures were deployed periodically (Fig. 1) until Sep 2005 and thereafter monthly until the end of the study on 5 Apr 2006. Mean numbers of males captured per trap per week were calculated and examined graphically to identify periods of time that males were abundant. The mean ± SEM number of males per trap per week among all sample dates was determined.

Brevard County Site. The ornamental plantings at this site (N 28°17.412', W 080°43.309') were similar to the first study site. Test procedures were the same as those described above except delta traps (white Pherocon VI, Trécé, Inc., Adair, OK) were used based on concurrent research later published by Francis et al. (2007),

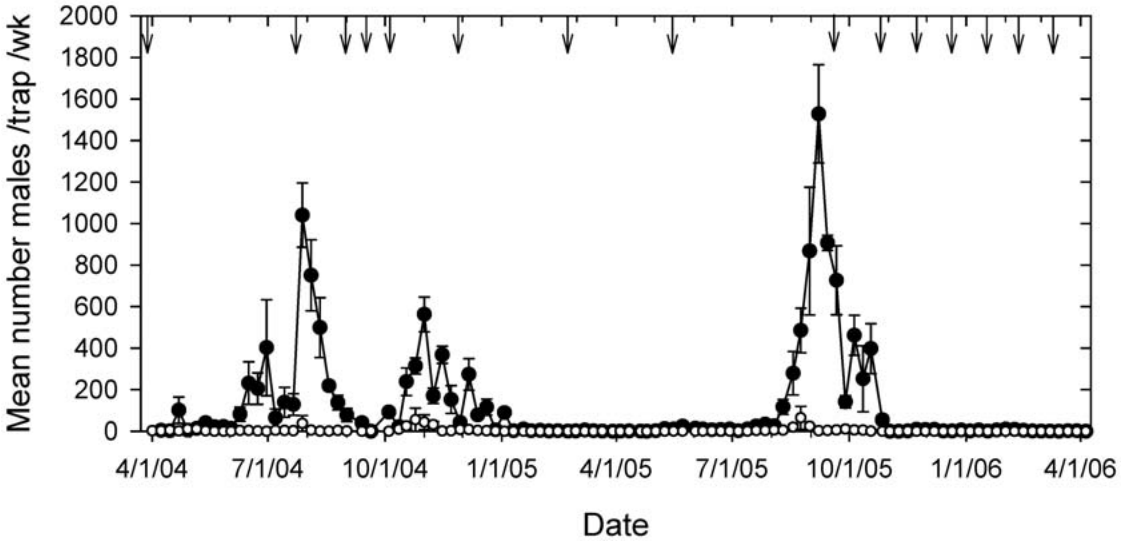


Fig. 1. Seasonal activity of adult male *Maconellicoccus hirsutus* based on numbers collected from San Jose scale traps baited with synthetic pheromone. The data are from traps hung in hibiscus plants at the first study location in Saint Lucie County. Solid data points are for traps with lures, open data points are for traps without lures. Arrows indicate new lure deployment dates. Error bars reflect standard error of the mean number of males per trap per date.

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and traps were deployed and checked at two-week intervals. Lures were suspended inside traps by a lure holder provided with the trap. A trap with a lure was deployed on 23 Feb 2005 in each of 3 mealybug-infested hibiscus hedges, and a trap without a lure was deployed in 1 infested hedge. Lures were replaced on 21 Sep 2005 and thereafter monthly until the end of the study on 21 Feb 2007. Mean number of males captured per trap per 2 weeks was converted to mean number per trap per week.

Saint Lucie County Site 2. This study site (N 27°20.053', W 080°23.860') was similar to the other sites in that hedges of mealybug-infested hibiscus were interspersed with hedges of other plants. Test procedures at this location were the same as those used at Saint Lucie County Site 1, except delta traps were used and traps were deployed and checked at two-week intervals like the Brevard County site. A trap with a lure was deployed on 24 Aug 2005 in each of 3 hibiscus hedges, and a trap without a lure was deployed in 1 hedge. Lures were replaced monthly until the end of the study on 21 Feb 2007. Mean number of males captured per trap per 2 weeks was converted to mean number per trap per week.

Miami-Dade County Site. This site (N 25°38.30.1', W 080°17.45.9') was located on the grounds of the Subtropical Horticulture Research Station (USDA-ARS) in Miami-Dade County. A variety of plant species were present, including tropical and subtropical fruit host plants such as mango and avocado. Hibiscus was not present on the station. Sampling procedures and mealybug verification at this location were similar to those used at Saint Lucie County Site 1, except delta traps were hung approximately 1.5 m above ground in host plant species dispersed throughout the experiment station. Prior sampling with lure-baited traps showed large numbers of *M. hirsutus* males in the area despite the lack of any visual signs of infestation at the station. Trapping was conducted from early Jan 2005 through Oct 2006. Eleven traps with lures were monitored during much of the study, but there were some weeks during which only 5 traps with lures were monitored. Three traps without lures were monitored throughout the study for comparison purposes. Lures were replaced monthly.

Results

Saint Lucie County Site 1. Male captures in 2004 indicated that *M. hirsutus* was abundant Jun through Aug and Oct through Dec (Fig. 1). During 2005, males were abundant Aug through Oct. Numbers of males per trap per week during 2005 averaged <1 per trap from mid Jan through Apr and during Nov and Dec. Similar low population levels were present in 2006 from Jan through the end of Mar, when the study was terminated. A mean ± SEM of 128.0 ± 24.8 males per trap per week were collected over all sample dates (n = 104) at traps with lures (3 or 4 traps per sample week). The phenology of *M. hirsutus* based on captures of males in traps with pheromone lures was not reflected in captures of males in traps without lures (Fig. 1). Means ± SEM of 112.3 ± 6.7 and 2.9 ± 1.0 males per trap per week were collected in baited and unbaited traps, respectively, over 58 weeks that equal numbers of each type of trap were operated. Over all sample dates, a mean ± SEM of 4.5 ± 1.1 males per trap per week were collected at unbaited traps (2 or 3 traps per sample week). A total of 321 males examined during the study indicated that *M. hirsutus* was the only mealybug species collected in traps.

Brevard County Site. During 2005 males were abundant in traps from Jun through Nov, with peak populations from Aug through mid Oct (Fig. 2). During 2006, males were abundant from mid Apr through Dec, with peak populations during Sep, Oct, and Nov. Means ± SEM of 190.1 ± 37.5 and 1.8 ± 1.4 males per trap per week were collected over all sample dates (n = 52) in baited (data from 3 traps per date) and unbaited traps (data from 1 trap per date), respectively. The phenology of *M. hirsutus* based on captures of males in traps with pheromone lures was not reflected in captures of males in traps without lures. All of 605 males examined during the study were identified as *M. hirsutus*.

Saint Lucie County Site 2. Male captures indicated that *M. hirsutus* was abundant when the study was initiated in late Aug and continued to be abundant through mid Oct of 2005 (Fig. 3). During 2006, males were abundant from late Apr through Oct, with peak populations during Sep. Means ± SEM of 249.2 ± 55.0 and 1.2 ± 1.0 males per trap per week were collected over all sample dates (n = 38) in baited (data from 3 traps per date) and unbaited traps (data from 1 trap per date), respectively. The phenology of *M. hirsutus* based on captures of males in traps with pheromone lures was not reflected in captures of males in traps without lures. All of 458 males examined during the study were confirmed to be *M. hirsutus*.

Miami-Dade County Site. In 2005 males were most abundant during the months of Jul through Oct, with a large peak during late Aug and early Sep (Fig. 4). In 2006, males were generally abundant during May and Jun and again during Aug-Oct. There was no large peak in male captures during 2006 comparable to the one observed during 2005. Means ± SEM of 84.7 ± 15.2 and 0.1 ± 0.03 males per trap per week were collected over all sample dates (n = 90) in baited (data from 5 to 11 traps per date) and unbaited traps (data from 3 traps per date), respectively. All of 250 males examined during the study were confirmed as *M. hirsutus*.

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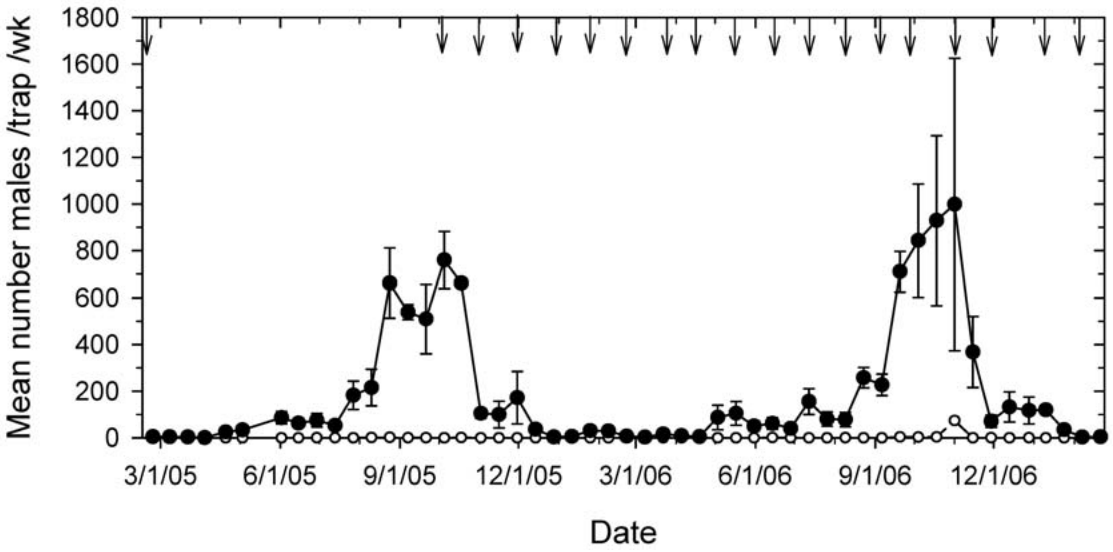


Fig. 2. Seasonal activity of adult male *Maconellicoccus hirsutus* based on numbers collected in delta traps baited with synthetic pheromone. The data are from traps hung in hibiscus plants at a study location in Brevard County. Solid data points are for traps with lures, open data points are for traps without lures. Arrows indicate new lure deployment dates. Error bars reflect standard error of the mean number of males per trap per date.

Discussion

Captures of male *M. hirsutus* at traps with pheromone lures indicated that the mealybug was consistently most abundant during late summer and early fall with peak populations occurring anytime during late Aug through early Oct. Populations of *M. hirsutus* were consistently low during winter and spring from Jan through early Apr. Goolsby et al. (2002) used a cardboard trapping approach to gauge the phenology of *M. hirsutus* in Queensland, Australia. Their results were similar to ours with respect to identifying late summer as the peak period of *M. hirsutus* populations, but comparisons with peak numbers they observed could not be made due to different sampling procedures. With respect to captures of males in traps deployed in infested hibiscus plants, peak numbers of male *M. hirsutus* captured at our Brevard study site were similar in magnitude to those at our Saint Lucie West Site 2, in the range of 600 to 1,300 males per trap per week. Comparisons of the magnitude of peak numbers of males captured at these 2 locations to those at Saint Lucie West Site 1 were not made due to variations in how frequently new lures were deployed at this site and because a different type of trap was used at this site. Comparisons to the magnitude of peaks observed at the Miami-Dade County site were not made because the traps at this location were not deployed in infested hibiscus. However, the magnitude of male captures at the Miami-Dade County site was notable given that there were no known infestations of the mealybug at the site. The relationship between captures of male *M. hirsutus* and infestation densities of the mealybug remains to be investigated. Low numbers of male *M. hirsutus* were sometimes captured in traps not baited with pheromone, but so few that traps without lures were of no value in assessing population dynamics of *M. hirsutus*. Captures at unbaited traps were probably a consequence of males accidentally coming in contact with the traps, with a greater incidence of captures when unbaited traps were deployed directly in infested hibiscus.

Our studies in hibiscus at 2 locations were initiated with a planned lure replacement schedule of about 6 months based on research presented by Zhang & Amalin (2005). On several occasions, some traps were found to be missing due to wind or other reasons, so new lures were deployed more frequently. Concurrent research later published by Frances et al. (2007) showed that rubber septa impregnated with the same pheromone rate had a long residual life but that statistically significant reductions in captures of males occurred 2 months after lure deployment. We therefore switched to replacing lures on a monthly schedule at these 2 sites and used the monthly schedule when our third hibiscus study was later initiated. According to the findings of Zhang & Amalin (2005) and Francis et al. (2007), replacing lures every 2 months or less often in our first 2 studies may have been sub-optimal reducing the magnitude of male catch; however, it did not prevent detection of male presence. Population trends at different times of the year in traps that had lures re-

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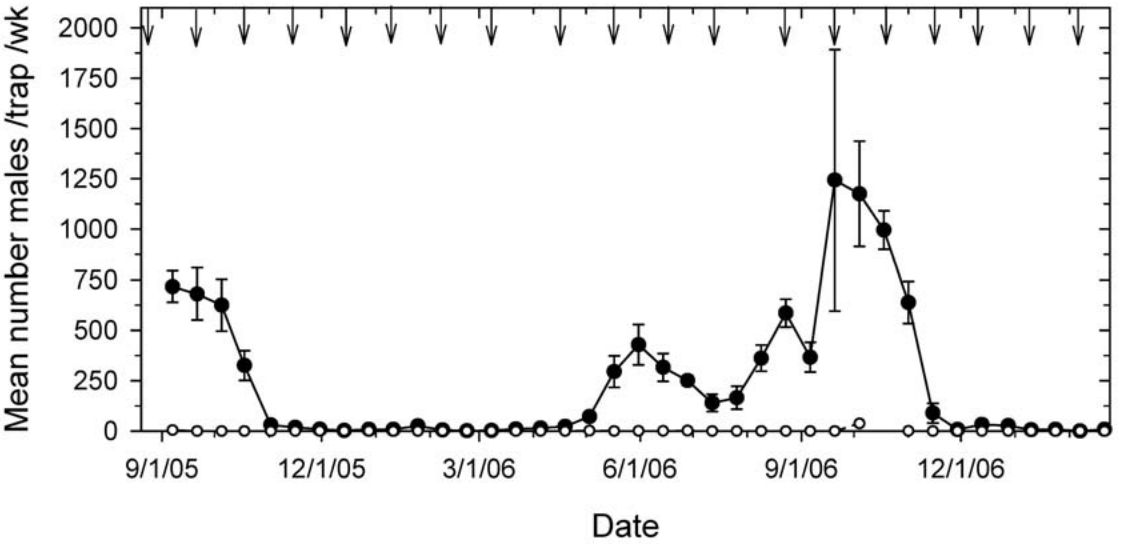


Fig. 3. Seasonal activity of adult male *Maconellicoccus hirsutus* based on numbers collected in delta traps baited with synthetic pheromone. The data are from traps hung in hibiscus plants at a second study location in Saint Lucie County. Solid data points are for traps with lures, open data points are for traps without lures. Arrows indicate new lure deployment dates. Error bars reflect standard error of the mean number of males per trap per date.

placed less frequently than every month were similar to those recorded by traps that had lures replaced monthly.

We conducted research at our first study site with the San Jose scale trap because it was similar to traps used by Serrano et al. (2001) during the discovery stages of the *M. hirsutus* pheromone. Zhang & Amalin (2005) assessed attractiveness of the synthetic lure with Pherocon V traps (Trécé, Salinas, CA), similar to the San Jose scale trap. We used delta traps at our other 3 study locations based on concurrent research later published by Francis et al. (2007). Francis et al. (2007) found that delta traps and double-sided

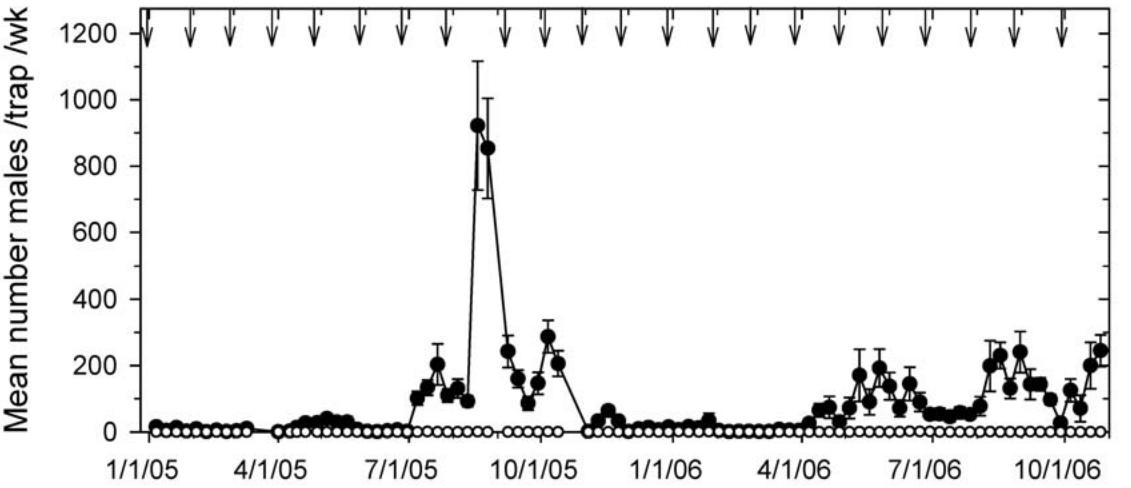


Fig. 4. Seasonal activity of adult male *Maconellicoccus hirsutus* based on numbers collected in delta traps baited with synthetic pheromone. The data are from traps hung in fruit trees such as mango and avocado located at the ARS Subtropical Horticulture Research Station in Miami-Dade County. Hibiscus plants were located only in the neighborhoods surrounding the experiment station. Solid data points are for traps with lures, open data points are for traps without lures. Arrows indicate new lure deployment dates. Error bars reflect standard error of the mean number of males per trap per date.

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sticky cards captured more males than Jackson traps, but delta traps and Jackson traps caught fewer non-target insects. Vitullo et al. (2007) recently identified the Jackson trap as more suitable for monitoring male *M. hirsutus* than several other trap designs including the delta trap, largely due to ease in trap servicing.

Applied management strategies for infestations of *M. hirsutus* such as insecticide treatments or augmentative releases of biological control agents might best be timed to coincide with the onset of peak mealybug abundance or during peak flight, which should be anytime from mid summer to late fall based on male captures in pheromone traps recorded in the current study. The synthetic pheromone may have potential as a tool for mating disruption (Zhang & Amalin 2005; Francis et al. 2007).

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