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Authors: Rhodes, Elena M., and Liburd, Oscar E.

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FLOWER THRIPS (THYSANOPTERA: THRIPIDAE) DISPERSAL FROM ALTERNATE HOSTS INTO SOUTHERN HIGHBUSH BLUEBERRY (ERICALES: ERICACEAE) PLANTINGS

ELENA M. RHODES AND OSCAR E. LIBURD
Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611

ABSTRACT

Frankliniella bispinosa (Morgan) is the key pest of southern highbush blueberries (*Vaccinium corymbosum* L. × *V. darrowi* Camp) in Florida. Thrips feeding and oviposition injury to developing flowers can result in fruit scarring that renders the fruit unmarketable. Previous studies have shown that flower thrips can disperse into cultivated crops from surrounding host plants. Therefore, the objectives of this study were to identify alternate hosts of *F. bispinosa* adjacent to blueberry plantings and to determine if *F. bispinosa* emigrates into blueberry plantings from these hosts. Plant surveys conducted in Apr of 2007 and from Nov 2007 until Mar 2008 revealed several reproductive hosts of *F. bispinosa*, including: Carolina geranium (*Geranium carolinianum* L.), white clover (*Trifolium repens* L.), and wild radish (*Raphanus raphanistum* L.). In a subsequent study, we monitored thrips population development in a blueberry planting and in an adjacent white clover field during early spring in 2009 and 2010. Flower thrips populations in the white clover and blueberry planting developed at the same time with the highest numbers of thrips recorded from the center of the blueberry field in both years. Although white clover grows abundantly adjacent to blueberry plantings in the spring our findings indicate that clover does not appear to be a significant source for thrips inoculation of southern highbush blueberry plantings in Northern Florida.

Key Words: flower thrips, *Frankliniella bispinosa*, southern highbush blueberries, *Vaccinium corymbosum* × *V. darrowi*

RESUMEN

Frankliniella bispinosa (Morgan) es la plaga clave del arándano del sur un arbusto alto (*Vaccinium corymbosum* L. × *V. darrowi* Camp) en la Florida. La alimentación de los trips y el daño asociado con la oviposición a las flores en desarrollo pueden resultar en cicatrices en la fruta que hace que la fruta no se pueda vender. Estudios previos han demostrado que trips de las flores pueden dispersarse a los cultivos desde los hospederos de plantas en el arrededor. Por lo tanto, los objetivos de este estudio fueron identificar hospederos alternativos de *F. bispinosa* adyacentes a las plantaciones de arándanos y el determinar si *F. bispinosa* en estas plantaciones plantaciones emigra desde esos hospederos. Un sondeo de plantas realizado en abril del 2007 y desde noviembre del 2007 hasta marzo del 2008 reveló varios hospederos que pueden soportar la reproducción de *F. bispinosa*, entre ellos: el geranio de Carolina (*Geranio carolinianum* L.), trébol blanco (*Trifolium repens* L.) y el rábano silvestre (*Raphanus raphanistum* L.). En un estudio posterior, monitoreamos el desarrollo de la población de trips en una plantación de arándanos y en un campo de trébol blanco adyacentes durante el principio de la primavera del 2009 y del 2010. La poblacion de trips de flores en el trébol blanco y en la plantación de arándanos desarrollaron al mismo tiempo con el mayor número de trips registrada en el centro del campo de arándanos por ambos años. A pesar que el trébol blanco crece en abundancia al lado de los campos de arándanos sembrados en la primavera, nuestros resultados indican que el trébol no parece ser una fuente importante para la inoculación de trips en los campos de arándano en el norte de la Florida.

Blueberries are a high value crop in Florida. During 2009, 6.4 million kg (14.1 million lbs) of fresh market blueberries were harvested from 1,295 ha (3,200 acres) at an average of $11.89 per kg ($5.40 per lb) (USDA 2010). The development of southern highbush (SHB) blueberries (*Vaccinium corymbosum* L. × *V. darrowi* Camp) allows Florida growers to take advantage of the highly profitable early season market (Williamson & Lyrene 2004). Southern highbush blueberry plants begin flowering in late Jan or early February and usually set fruit by mid to late Mar. Flower thrips, primarily *Frankliniella* spp., are the key pest of SHB blueberries.

A complex of flower thrips species causes injury to SHB blueberries in Florida (Arévalo-Rodriguez 2006). *Frankliniella bispinosa* (Morgan) is the most common species, accounting for approximately 90% of the adult thrips collected from both traps and flowers (Arévalo & Liburd 2007).

Flower thrips feed and reproduce on all parts of developing blueberry flowers. The resulting injury is magnified into scars when the fruit form, which make the fruit unsalable on the fresh market (Arévalo-Rodriguez 2006).

Thrips emigrate into crops from other cultivated plants that flower earlier and from wild plant species that also serve as hosts (Chellemi et al. 1994; Toapanta et al. 1996). Chellemi et al. (1994) found that 31 of 37 plant species adjacent to tomato fields contained thrips. Eighty-seven percent of the adult thrips collected were *Frankliniella* spp. *Frankliniella tritici* (Fitch) was the most common species collected, but species composition varied over time. *Frankliniella bispinosa* was the second most common species collected followed by *F. occidentalis* (Pergande), and *F. fusca* (Hinds).

It is often difficult to determine the true host range of a particular thrips species because thrips will often alight and feed upon many plants on which they cannot reproduce (Mound 2005; Paini et al. 2007). For example, although *F. fusca*, *F. occidentalis*, and *F. tritici* are found on tomato plants in Florida and can cause injury, only *F. occidentalis* reproduces on the tomato plants (Salguero-Navas et al. 1994).

Thrips will also use wild plant hosts when crop hosts are not flowering. Paini et al. (2007) found that *F. bispinosa* used 2 plant species, *Ligustrum sinense* Lour. and *Lagerstroemia indica* L., as reproductive hosts from May to Aug in north Florida. Similarly, Cockfield et al. (2007) found that native vegetation surrounding apple orchards supported *F. occidentalis* populations when apple trees were not flowering.

In blueberries, thrips are monitored using sticky traps or by direct sampling of the flowers. Although white, yellow, and blue traps attract thrips (Liburd et al. 2009), white traps are the best to employ. Yellow traps attract a large number of other insects including beneficials and the dark coloring of the blue traps can make it difficult to observe the thrips that are present on them (Liburd et al. 2009).

Flowers can be sampled in several ways. The simplest method involves gently tapping the flowers and allowing the thrips to fall onto a white sheet below for counting. Flowers can also be collected in a vial or plastic bag and then examined in the laboratory. Arévalo & Liburd (2007) developed a "shake and rinse" method that is as accurate as dissecting flowers and much more efficient.

The objectives of this study were 2 fold. 1) To examine blueberry plantings and adjacent fields for alternate hosts of thrips. 2) To investigate thrips dispersal from these host plants into blueberry plantings. The hypothesis of this study is: flowering plants support and sustain *F. bispinosa* populations when blueberry plants are not flowering and thrips disperse into blueberry plantings from these flowering plants when blueberries begin to flower and cause economic damage.

Materials and Methods

Preliminary Plant Survey

In our initial survey, flower samples from 3 of the most common flowering plants found at the University of Florida Plant Science Research and Education Unit (PSREU) in Citra, Florida, were collected in Apr 2007. These plants included cutleaf evening primrose (*Oenothera laciniata* Hill), white clover (*Trifolium repens* L.), and wild radish (*Raphanus raphanistum* L.). Based on size relative to each other, 8 primrose flowers, 6 clover flowers, and 25 wild radish flowers were collected randomly and placed into vials containing 70% ethanol. Thrips adults and larvae were extracted from flowers using the "shake and rinse" method developed by Arévalo & Liburd (2007). In this method, each vial was shaken vigorously for 1 min and then the contents of the vial were emptied onto a metal screen (6.3 × 6.3-mm mesh) placed over a 300-ml white polyethylene jar. The flowers were gently opened, rinsed with water, and then the rinsate was examined under a dissecting microscope. The numbers of thrips and other arthropods present were recorded. The flowers left on the screen were emptied into another 300-ml polyethylene jar containing 10 ml of water. Once the lid was placed on the jar, the jar was shaken vigorously for 1 min as before. The rinse procedure was repeated as before except that the flowers were rinsed with 70% ethanol. If thrips were found in the second rinse water, the procedure was repeated for a third time (shaking the flowers in 70% ethanol and rinsing with water). Thrips adults were identified to species using a key developed for Florida SHB blueberries by Arévalo et al. (2006). Thrips that did not match the character descriptions in the key were sent to the Division of Plant Industry (DPI) in Gainesville, Florida for identification.

Plant Survey 2

In our second survey, the flowering plant species within a 0.52-ha (1.2 acre) blueberry planting and the surrounding area at the Citra PSREU site were flagged and sampled to determine whether or not they were suitable hosts for *F. bispinosa*. For the purposes of this study, a suitable host was defined as 1 in which *F. bispinosa* reproduces and is abundant. Plants were identified to genus and species (if possible).

Ten 27-m transects were taken from the blueberry planting and surrounding area described above. Two transects were on the border of the blueberry field and 8 were within the field (Fig. 1).

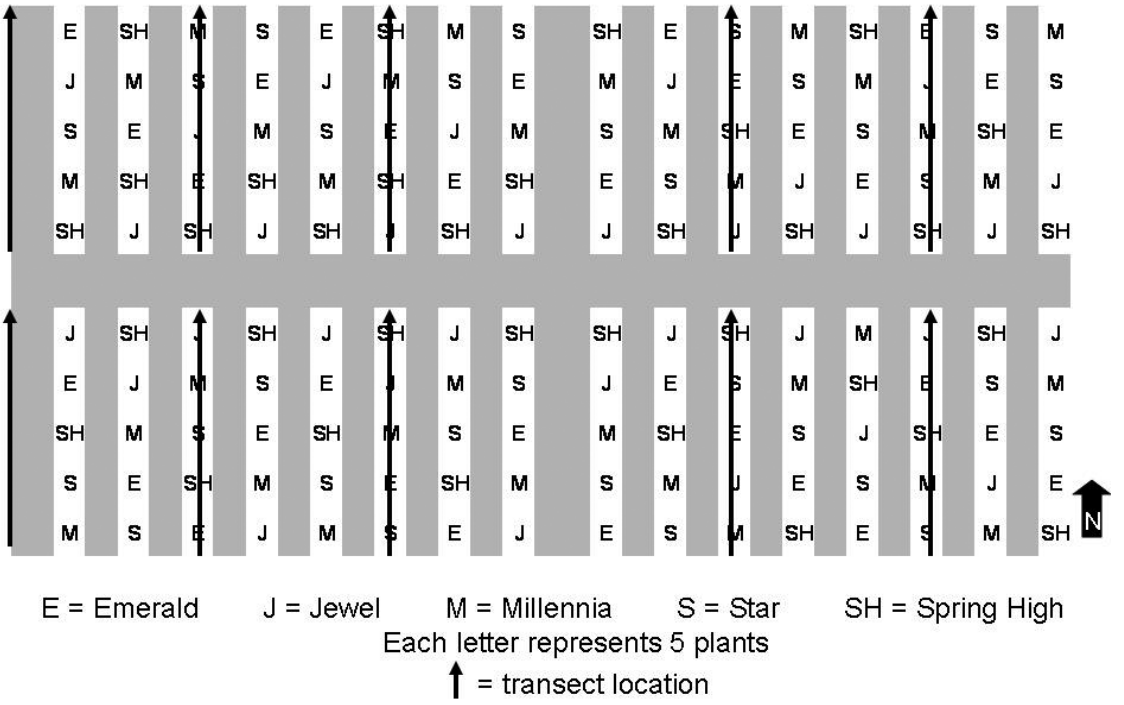

Fig. 1. Locations of transects (arrows) in blueberry planting. The letters indicate different southern highbush blueberry varieties (E = Emerald, J = Jewel, M = Millennia, S = Star, and SH = Spring High).

Flowering plants within a 0.6-m (2-ft) radius were sampled every 3-m (10-ft). The height and maximum width of the plants and percent coverage were measured. Plant samples were collected in small press and seal bags and brought back to the University of Florida Small Fruit and Vegetable IPM laboratory for identification.

Twenty flowers were collected from each plant species and placed in 50-ml plastic vials containing 70% ethanol. If less than 20 flowers were present, then all available flowers were collected. Samples were taken from the third week of Nov until the first week of Mar, during the first and third full week of each month. This time period encompasses the period 2 months before and during the blueberry flowering season. The samples were brought back to the laboratory at the University of Florida in Gainesville, FL. The "shake and rinse" method described above was used to collect the thrips from the flowers. Adults and larvae were counted and adults were identified to species as detailed previously.

Flower samples were also collected from an adjacent strawberry field to the west of the blueberry plots and from the blueberry bushes themselves. Ten strawberry flowers were collected from each of 4 rows. This was done once a month in Dec, Jan, and February. Twenty to 25 flowers were collected from SHB blueberries in each plot on each sample collection date.

Field Study

This study was conducted at a commercial blueberry farm in Windsor, Florida, during the spring of 2009 and 2010. This site was selected because white clover grows in the grassy areas adjacent to the blueberry bushes and our preliminary plant survey indicated that it is a reproductive host of *F. bispinosa* (see results section). All samples in the blueberry plot were collected from the same variety. In north Florida, white clover flowers from Dec through Jun. (Northfield et al. 2008). In contrast, southern highbush blueberries in north Florida flower from late Jan until early Mar. No insecticides were applied in either year during the course of the study.

The study area consisted of a field of white clover and part of a large blueberry planting that contained plants approximately 7 years old. In 2009 (Fig. 2a), 6 sampling sites within a 625-m^2 area of the clover and 12 sampling sites within a 2,400-m^2 area of the blueberry planting were selected. Four traps were placed in the corners of the clover sampling area and the other 2 were placed in the center, 8-m apart. The blueberry research area consisted of 3 rows of blueberries containing traps spaced 15 m, 30 m, 45 m, and 60 m from the clover with a buffer row between each replicate row. In 2010 (Fig. 2b), the setup was expanded to include 10 sampling sites in the clover

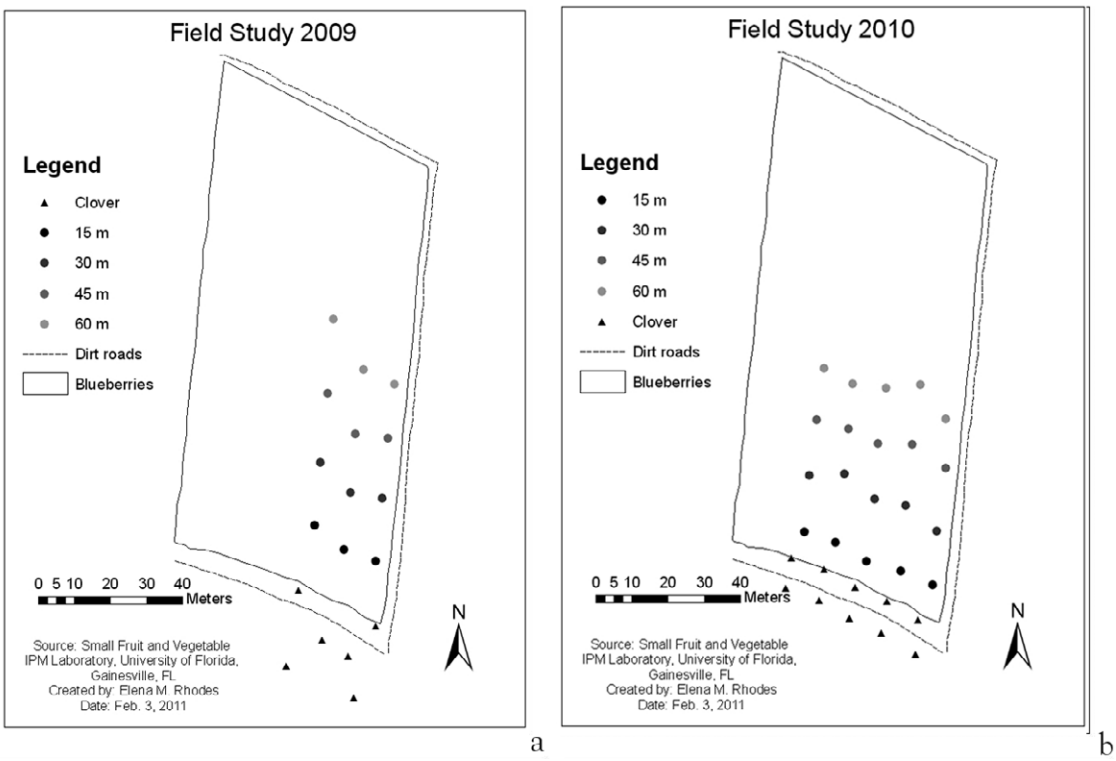

Fig. 2. Sampling point locations for the field study in a) 2009 and b) 2010. The block of blueberries continued to the west. Other blocks were located across the north and east dirt roads.

(660-m^2) and 5 rows (2,464-m^2) in the blueberry planting. All of the traps in the clover were spaced 10-m apart and hung so that the bottom of the trap was only a few centimeters from the tops of the clover plants. The traps in the blueberry rows were spaced as in 2009.

In 2009, white sticky traps with an 18 × 22 cm sticky surface (Great Lakes IPM, Vestaburg, MI) were set out every week and collected weekly for 5 weeks from Jan 31 to Mar 5 in the clover and blueberries. In 2010, traps were set out every week and collected weekly for 7 weeks from Feb 4 to Mar 25. When the traps were replaced, flower samples were collected from both the clover and blueberries adjacent to traps. Three to 5 clover flowers and 4 to 5 blueberry flower clusters (~20-25 flowers) per sample were collected each week.

Data analysis

The treatments included the 15 m, 30 m, 45 m, and 60 m samples in the blueberry planting in all data sets and the clover (0 m) only in the sticky trap data set. Clover and blueberry flowers differ too much in size and structure to allow for statistical comparison between them. Treatments were compared each week using a one-way analysis of variance (ANOVA) (SAS Institute 2002) and means were separated using the Least Significant Differences (LSD) test. Sticky trap data (x) were $\log_{10}$x transformed to meet the assumptions of the analysis. In 2009, the $\log_{10}$ (x +1) transformation was also used for thrips adults per flower (x), while thrips larvae per flower were transformed using the equation $1/\sqrt{}$ (thrips per flower +1). For the 2010 flower sample data, transformation was not enough to cause the data to meet the ANOVA assumptions. Therefore, the nonparametric Friedman, Kendall-Babington Smith test (Hollander & Wolfe 1999) for general alternatives in a randomized complete block design was used to analyze the data.

RESULTS

Preliminary Plant Survey

In our initial survey, all of the adults collected were *F. bispinosa*. Forty seven percent of the thrips recorded were found in clover flowers consisting of 12 adults and 9 larvae whereas 49% of the thrips collected were from wild radish flowers consisting of 15 adults and 7 larvae. Only 4% of the thrips, 2 adults and no larvae, were collected from primrose flowers.

Plant Survey 2

Twelve different species of plants were found in the blueberry planting during our second survey (Table 1). Of these, 8 species flowered during the sampling period and thrips were found on 3 {Carolina geranium (*Geranium carolinianum* L.), hairy indigo (*Indigofera hirsuta* L.), and pusley (*Richardia* sp.)}. Thrips were also found in the blueberry and strawberry flowers.

Both adult and larval thrips were found in the Carolina geranium, pusley, strawberry, and blueberry flowers. The single adult found in the Carolina geranium was *F. bispinosa*. *Frankliniella fusca* and *Haplothrips graminis* Hood were found in the pusley (1 *F. fusca*, 18 *H. graminis*), and strawberry (4 *F. fusca*, 2 *H. graminis*) flowers. Most of the 60 adult thrips in the blueberry flowers were *Thrips* species, either *T. hawaiiensis* (Morgan) (24) or *T. pini* Karny (23). Seven *Frankliniella bispinosa*, three *Franklinothrips* sp., and 3 *H. graminis* were also present in the blueberry flowers. Three *H. graminis* adults were collected from the hairy indigo flowers, but no larvae were present.

Field Study 2009

Traps

On Feb 12, significantly more thrips per trap were collected at 45 m compared with the clover, at 15 m, and at 60 m (F = 3.92, df = 4, 17, P = 0.0267, Fig. 3a-b).

Flowers

No significant differences were found in thrips adults (all $F \leq 1.51$, df = 3, 11, $P \geq 0.29$) or larvae (all $F \leq 1.45$, df = 3, 11, $P \geq 0.30$) per blueberry flower among treatments on any sampling date. There were an average of 0.23 ± 0.08 thrips adults and 0.33 ± 0.12 thrips larvae per blueberry flower over the flowering season in the blueberry research area. Numbers of both adult and larval thrips increased as the season progressed.

A total of 65 thrips adults and 16 larvae were collected from the clover flowers during the blueberry flowering period. Larval numbers remained low throughout the flowering period, while adult numbers increased as the flowering period progressed.

Of all of the adult thrips sampled, 98% were identified as *F. bispinosa*. In the clover and 30 m samples respectively, all of the 65 and 50 thrips sampled were *F. bispinosa*. In the 15 m samples, 52 of the 54 thrips sampled were *F. bispinosa*. The remaining 2 were a *T. hawaiiensis* and a *T. pini*. In the 45 m samples, 60 of the 61 thrips sampled were *F. bispinosa*. The remaining thrips was a *Franklinothrips* sp. In the 60 m samples, 57 of the 59 thrips sampled were *F. bispinosa*. The remaining 2 were a *Franklinothrips* sp. and a *T. hawaiiensis*.

Field Study 2010

Traps

On Feb 11, there were significantly higher numbers of thrips per trap in the clover field compared with 15 and 60 m (F = 3.12, df = 4, 29, P = 0.0327, Fig. 4a-b). On Feb 25, there were significantly more thrips per trap at 30 and 45 m compared with the clover field (F = 2.89, df = 4, 29, P = 0.0429). On Mar 11, there were significantly higher numbers of thrips per trap at 30, 45, and 60 m compared with 15 m and the clover field (F = 5.95, df = 4, 29, P = 0.0017). On Mar 25, there were significantly higher numbers of thrips per trap at 45 m compared with all of the other treatments and at 60 m compared with 15 m and the clover field (F = 6.86, df = 4, 29, P = 0.0007).

TABLE 1. COMMON AND SCIENTIFIC NAMES OF THE PLANTS FOUND IN THE BLUEBERRY PLANTING, THE MONTHS WHEN THEY WERE FOUND, AND THE MONTHS WHEN THEY FLOWERED.

Common name	Scientific name	Months present	Months flowering
Carolina geranium	*Geranium carolinianum* L.	Nov-Mar	Feb and Mar
coffee senna[1]	*Senna occidentalis* L	Nov	none
hairy indigo	*Indigofera hirsuta* L	Nov and Dec	Nov
narrowleaf cudweed	*Gnaphalium falcatum* Lam.	Dec-Mar	Jan-Mar
oldfield toadflax	*Nuttallanthus canadensis* (L.)	Jan-Mar	Jan-Mar
pennywort (dollarweed)	*Hydrocotyle umbellata* L	Nov-Mar	none
pigweed[1]	*Amaranthus* sp.	Nov	none
pusley	*Richardia* sp.	Nov-Mar	Nov-Mar
red sorrel	*Rumex Acetosella* L.	Jan-Mar	none
spurge	*Euphorbia* sp	Nov	Nov
thistle	*Circium* spp.	Nov-Mar	Jan and Feb
wandering cudweed	*Gnaphalium pensylvanicum* Willdenow	Dec-Mar	Mar

[1]Identification is uncertain because flowers were not present.

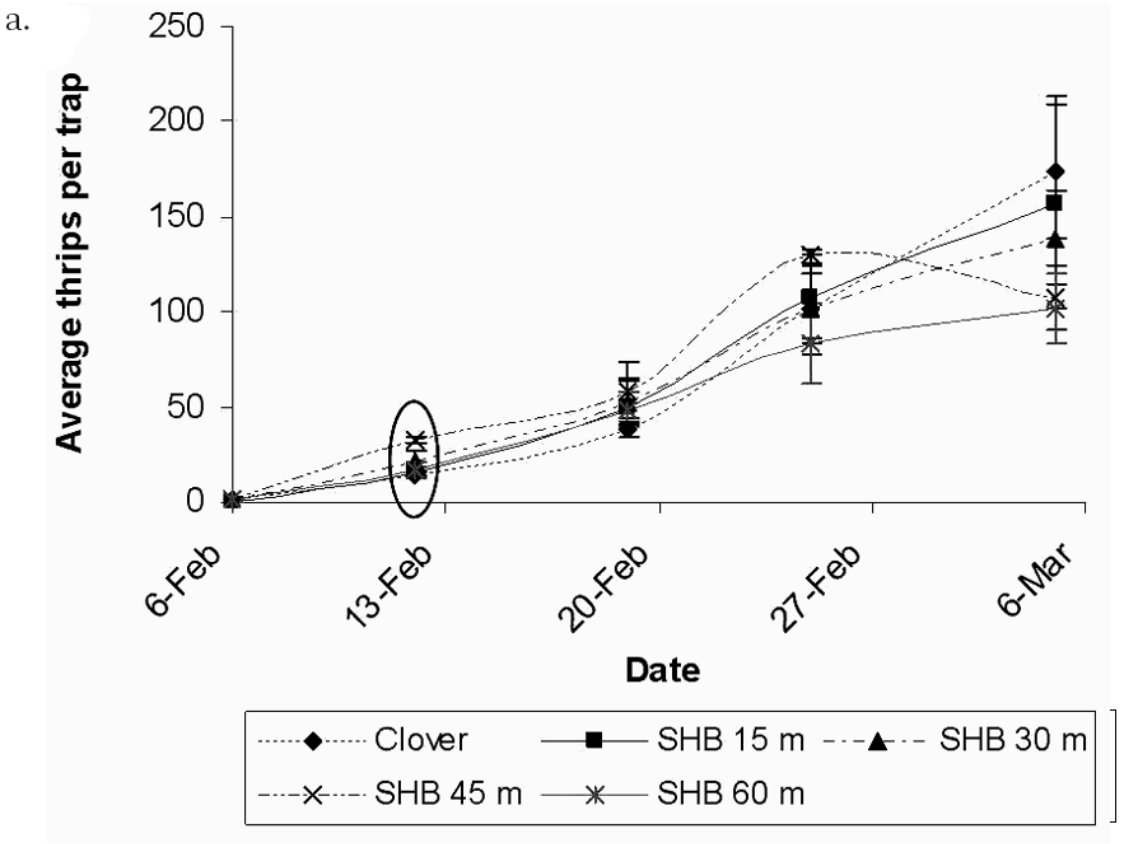

Fig. 3. a) Average thrips per trap in each treatment on each sampling date in 2009. Circled data indicate significant differences ($P \leq 0.05$). b) Average thrips per trap on Feb 12, 2009. Means with the same letter are not significantly different from each other at $P = 0.05$. Error bars indicate standard error of the mean. SHB = southern highbush.

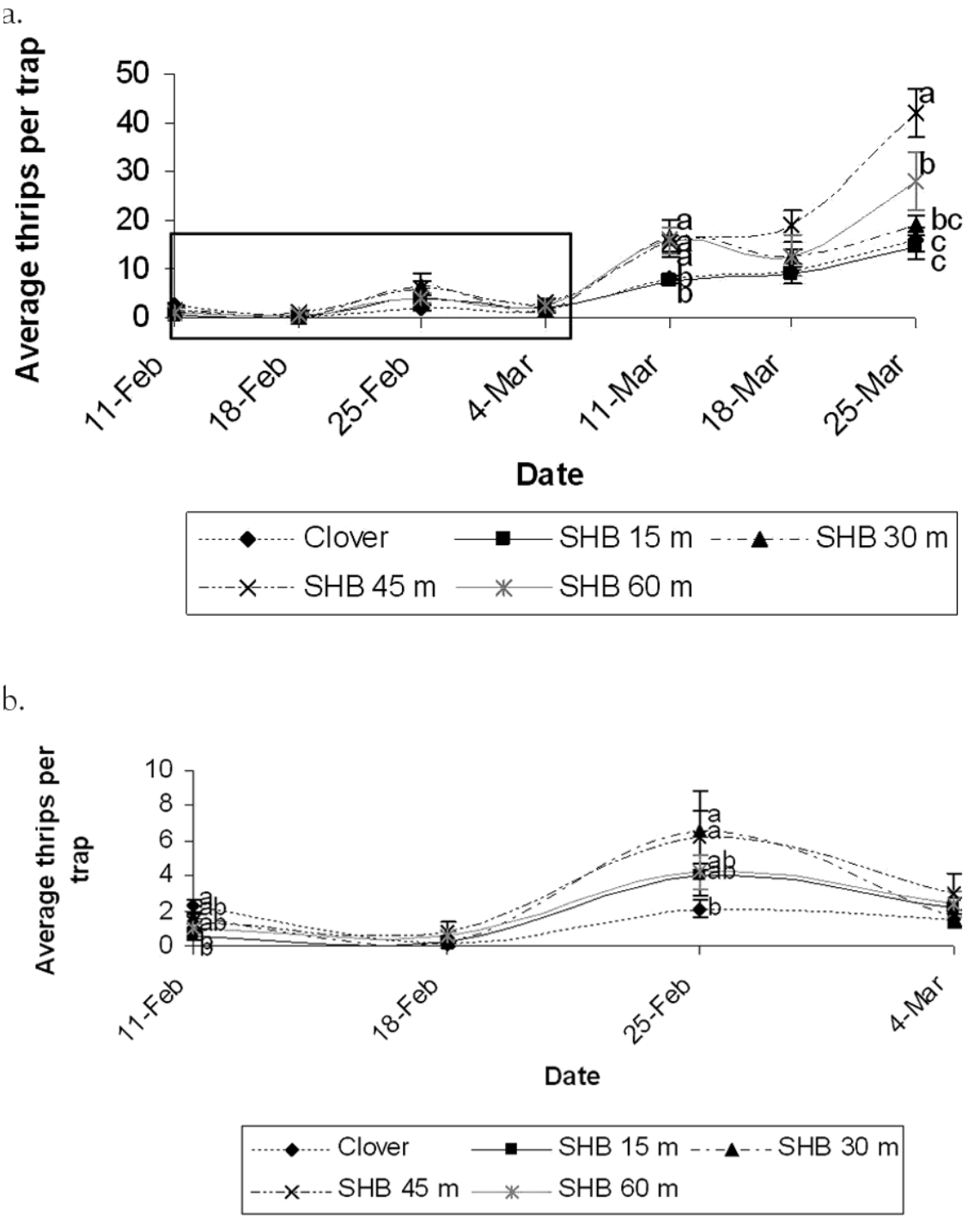

Fig. 4. Average thrips per trap a) throughout the flowering period and b) during the first 4 weeks of the flowering period (indicated by the box in a) in 2010. Treatments with the same letter are not significantly different from each other at P = 0.05. Error bars indicate standard error of the mean. SHB = southern highbush.

Flowers. There were no significant differences in thrips adults (all $S' \leq 6$, k, n = 5, 4, $P > 0.1$) or larvae (all $S' \leq 6.43$, k, n = 5, 4, $P \geq 0.09$) per blueberry flower on any sampling date. Average thrips adults per blueberry flower did not exceed 0.08 ± 0.04 during the sampling period and only a few adults were collected until Mar 4. A single thrips larva was collected on Feb 11 and another was collected on Feb 18. Thrips larvae were not collected again until Mar 18. Average thrips larvae per blueberry flower did not exceed 0.13 ± 0.06 larvae during the sampling period.

One, 3, and 8 thrips adults were present in the clover flowers on Feb 11, Mar 18, and Mar 25 respectively. In contrast, only a single larva was collected from the clover flowers on Feb 18.

As in 2009, most of the thrips (89%) collected during the blueberry flowering period in 2010 were *F. bispinosa*. Eight of the 12 adult thrips sampled from the clover were *F. bispinosa*. The remaining 4 were a single *F. fusca* and 3 specimens of an unknown species. In the 15 m samples, 14 out of 17 thrips were *F. bispinosa*. The other thrips sampled at 15 m were 2 *Franklinothrips* sp. and a single *Limothrips* sp. All of the 11, 7, and 19 thrips in the 30, 45, and 60 m samples respectively were *F. bispinosa*.

Discussion

Flower samples were collected from Carolina geranium, hairy indigo, narrowleaf cudweed (*Gnaphalium falcatum* Lam.), oldfield toadflax (*Nuttallanthus canadensis* (L.)), pusley, spurge (*Euphorbia* sp.), thistle (*Circium* spp.), white clover, and wild radish. However, it appears that only Carolina geranium, white clover, and wild radish are reproductive hosts of *F. bispinosa* due to the presence of immature stages. Northfield et al. (2008) also found that white clover and wild radish are reproductive hosts of *F. bispinosa*, especially in the spring (Apr-Jun). In contrast, Paini et al. (2007) found only adult *F. bispinosa* on wild radish (white clover was not sampled in this study). Carolina geranium was not sampled in either of these studies. Cutleaf evening primrose appears to be only a feeding host, since no larvae were found in the flowers.

Several other species of thrips were found on other plants that flowered during the sampling period. Hairy indigo had only *H. graminis* adults, which are predatory and may have been feeding on the large number of aphids also present in the flowers (data not shown). *Haplothrips graminis* adults were also frequently found in the pusley flowers. A single *F. fusca* adult was also found in the pusley flowers, as were a number of thrips larvae. Whether the *H. graminis* were feeding on the thrips larvae or other insects present in the flowers is not known. The same 2 species of adult thrips and a few thrips larvae were also found in the strawberry flowers.

The 2 thrips species, *T. hawaiiensis* and *T. pini*, were the dominant species collected from the blueberry flowers early during the survey. The blueberry flowering season at the Citra PSREU began during the last week of Jan. Most of the blueberry flowers collected during the survey were scattered, early blooms. A study conducted at the Citra PSREU following the survey showed that *F. bispinosa* quickly became the dominant species in the SHB blueberry flowers once the flowering season had begun (Liburd unpublished data).

Carolina geranium is a common weed in disturbed areas, agricultural land, and on roadsides (Hall et al. 1991). Since it does not begin to flower until February, it is unlikely that it is a source of *F. bispinosa* inoculation in blueberry fields. Similarly, wild radish is also an unlikely source of *F. bispinosa* in blueberries because it does not flower until early spring (Ferrell et al. 2005). In contrast, white clover is a cool-season plant (Newman et al. 2006) that flowers throughout the late fall, winter, and spring in north Florida. Therefore, it could serve as a source for thrips in blueberry plantings. If clover was a primary source of inoculation, initial thrips population (larvae and adults) would have been recorded in the clover followed by 15 m from the clover field, 30 m from the clover field, etc.

In 2009, the thrips population in the clover appeared to develop at the same time as the population in the blueberry planting. Two extreme cold events, 1 in late Jan and the second in early February (FAWN 2009), may have contributed to this population growth pattern. The cold may have reduced the thrips population in both the clover and blueberry flowers to very low levels, which then rebounded together. The difference in thrips per trap occurred on Feb 12, approximately 1 week after the second extreme cold event. The traps spaced 45 m from the clover, which had higher numbers of thrips per trap compared with those at 15 m, 60 m, and the clover, were in the center of the sampled blueberry block. It is possible that the thrips were better sheltered from the cold there.

Thrips numbers were low throughout the 2010 SHB blueberry flowering season. Thrips adults were collected from the blueberry flowers in low numbers throughout the flowering season, but the population did not begin to increase until Mar 11. In the clover flowers, a single adult unknown was collected on Feb 11. Thrips adults were not found in clover flowers again until Mar 18. Thrips larvae were not collected from blueberry flowers until Mar 18 and the only larvae collected from the clover flowers was found on Feb 18.

The flowering season itself began later than the average and was extended until the end of Mar. Both of these factors were most likely due to the extended extreme winter temperatures that occurred during Jan and February of 2010 (FAWN 2010).

Despite their low numbers, we recorded statistically significant differences in thrips per trap on Feb 11 and 25 and Mar 11 and 25. As in the previous year, thrips numbers were higher in the middle of the field. However, in 2010, they remained higher instead of equalizing as occurred in 2009.

In both years, there were significant differences in thrips per trap but not in thrips per flower. Rodriguez-Saona et al. (2010) found that sticky trap data were useful for predicting thrips' flight activity. Flower samples, in contrast, provide information on how many thrips are feeding and reproducing in the flowers. Arévalo-Rodriguez (2006) found a strong correlation (r = 0.7621) between thrips per flower and thrips per trap in rabbiteye blueberries. The presence of so few thrips per flower in both years may have masked any differences among the treatments.

From these studies, it would appear that clover is not a significant source of *F. bispinosa* inoculation in SHB blueberry fields. This is supported by Northfield et al. (2008) who found that *F. bispinosa* uses white clover as a reproductive host in the spring, particularly in Apr and May. Southern highbush blueberries in Florida flower from late Jan through early Mar. Most likely the flower thrips utilize the clover after the blueberry flowering season has ended.

Since they are found almost exclusively in flowers (Northfield et al. 2008), *F. bispinosa* may move from 1 or a few hosts to different hosts as they flower. *Frankliniella occidentalis* also exhibits this pattern of behavior in Washington apple orchards (Cockfield et al. 2007). Further research is needed to determine which plants are sources of *F. bispinosa* for SHB blueberry plantings and if controlling these plants could reduce flower thrips numbers in blueberry bushes.

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